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Original scientific paper

Meat quality parameters of wild boar and commercial pig breeds

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A b s t r a c t: In recent decades pork production has increased in Serbia, and pork is the most widely consumed meat. Pig meat quality is affected by several factors: breed, sex, production performance, stress adaptation, and factors related to animal management. The aim of this study was to compare the meat quality characteristics from wild boar and pig breeds improved by selection. Samples of m. longissimus dorsi were obtained from three different pig breeds — Yorkshire, Landrace and wild boar. Chemical composition, pH, fatty acid profile, volatile compounds, color, and overall sensory meat quality were determined. Chemical composition, pH, fatty acid profile, and volatile compounds differed significantly ($p<0.05$) among the pig breeds. Yorkshire meat had the most favorable ratio of unsaturated to saturated fatty acids and the highest nutritional value. On the other hand, wild boar meat had the lowest intramuscular fat content. Determined differences among different pig breeds indicated the impact of breed on meat quality of pork. The results obtained could be used to meet consumer's needs regarding fatty acid composition and sensory properties of meat.

Keywords: *meat quality, Yorkshire, Landrace, wild boar.*

Introduction

Pork is the most commonly consumed meat in Serbia. Pork accounts for 66.2% of meat production, followed by beef (31%), poultry (14.4%), and sheep and goat meat (8.4%) (*Statistical Office of the Republic of Serbia*, 2019). Furthermore, pig production is almost entirely based on Yorkshire and Landrace breeds that are used for production of F1 gilts and further cross-breeding with some of the terminal meat pig breeds, such as the Pietrain, Duroc and Hampshire.

Meat from Landrace and Yorkshire pigs, the most common pig meat breeds farmed in Serbia, is available in trade markets, while wild boar meat is mainly prepared as traditional products for the hunters' own consumption, or is sold through local restaurants, agritourism or semi-legal direct marketing (*Stevanović and Milosević*, 2018). Wild boar meat is of increasing importance in human nutrition worldwide due to consumers' preference for lean meat. It is considered as naturally organic and is highly appreciated. Wild boar meat is characterized by higher heme iron content and lower fat level than meat from domestic pig breeds. In many studies, a low fat content was determined in wild boar meat (2.62% (*Szmańko et al.,* 2007); 2.27% (*Jukna and Valaitienė,* 2012); 1.8%–3.5% (*Postolache et al.,* 2011); 2.82% (*Strazdina et al.,* 2013); 1.87% (*Ivanovic et al.,* 2013)), but low total fat did not contribute to a beneficial ratio of saturated to unsaturated fatty acids.

On the other hand, some of the major breeding goals are to reduce carcass fatness, fattening time, and feed to gain ratio (*Furman et al.,* 2010). Achieving these goals can provoke changes in fatty acid profiles of intramuscular fat. Furthermore, intramuscular fat cannot be removed before consumption. Nowadays, consumer concerns about the quality and healthfulness of meat and meat products have greatly increased during recent decades (*Min and Ahn, 2005*), especially regarding the health impact of consumed animal fats. The recommended ratio between all polyunsaturated to saturated fatty acids in human diets is 0.4 or higher (*Wood et al.,* 2008), and the total fat intake should provide 15–30% of total energy intake or less (*FAO*, 2010).

Pig meat quality is affected by several factors, including biological factors: breed, sex, production performance, and stress adaptation, along with; factors related to production systems: environmental conditions, animal management, nutrition, and body

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weight; slaughter factors and; treatment of carcasses after the slaughter (*Kasprzyk*, 2007; *Ivanović et al.,* 2012; *Mukumbo et al.,* 2014; *Nuernberg et al.,* 2015; *Čobanović et al.,* 2016; *Cirne et al.,* 2019).

The aim of this study was to compare meat quality parameters (chemical composition, pH, fatty acid composition, volatile compound content, color, and sensory properties) for wild boar meat and meat from two commercial breeds (Landrace and Yorkshire).

Materials and Methods

All the experimental procedures and animal handling used in this study were in accordance with European Community guidelines (Directive 86/609/EEC).

Animals and sampling

A total of 30 male pigs were included in the study: 10 castrated Yorkshire pigs, 10 castrated Landrace pigs, and 10 wild boars. All Yorkshire and Landrace pigs were bred under the same environmental and feeding conditions. Compositions of feed mixtures are presented in Table 1. Animals were slaughtered at final live weight of 89–93 kg, at the age of 180 days. The animals were slaughtered in accordance with legally approved procedures (the distance from the farm to the slaughterhouse was 200 km, pigs underwent a rest period of about 2 h in the lairage, and automatic electric stunning and exsanguination in a vertical position were used). After evisceration and washing, pig carcasses were chilled at 2°C for up to 24 h. Samples of *m. longissimus*

Table 1. Composition and analyzed nutrient content of complete feed mixtures for Yorkshire and Landrace pigs

Diet composition (%)	Pigs 20–40 kg	Pigs 40–70 kg	Pigs >70 kg
Ground wheat	39.7	51.1	57.5
Ground barley	22.0	20.0	18.6
Ground corn	20.0	-	-
Extracted ground soybean	20.0	22.0	17.5
Fish meal	2.5	-	-
VG60	3.0	4.5	4.5
Phosphate 17.5%	0.8	0.8	0.3
Calcium carbonate	1.1	0.8	0.8
Salt	0.3	0.3	0.3
Lysine HCl	0.1	0.075	0.05
Methionine	-	0.015	-
Premix	0.4	0.4	0.4
Copper sulfate	0.05	-	-
Salocin 12%	0.05	-	-
Analyzed nutrient content (%)			
Energy, MJ/kg	9.35	9.39	9.32
Crude protein	18.3	17.7	16.5
Crude fat	4.0	4.5	4.7
Crude cellulose	4.5	4.8	5.0
Crude ash	6.0	5.2	4.8
Daily feed intake (kg/day)			
Feed intake Landrace	1.89	2.25	2.97
Feed intake Yorkshire	1.88	2.23	2.89

Legend: VG60 — minimum 5.0% protein, minimum 60.0% fat, maximum 0.8% cellulose, maximum 1.2% ash, minimum 7.5% linoleic acid, energy 24.0 MJ/kg

dorsi were collected and stored at –20°C until determination of chemical composition, fatty acid content, volatile compound content, color, and sensory analyses.

Hunted wild boars weighed between 120 and 140 kg and were about one year old. Animals were hunted by shotgun during the hunting season in 2018 in accordance with the hunting law in Serbia (*Official Gazette*, 18/2010 and 95/2018), and the carcasses were not polluted by digestive tract contents. Carcasses were eviscerated in the 24 h after hunting, and were marked according to Regulation 853 (2004) and 854 (2004). Ten samples of *m. longissimus dorsi* were collected and stored at –20°C until determination of chemical composition, fatty acid content, volatile compound content, color, and sensory analyses. Wild boars were hunted from the southwest and southeast parts of the Šumadija region in Serbia. Nutrition of wild boars was determined by the region's feed sources, which primarily consisted of deciduous trees – oak, elk, linden, Austrian oak, chestnut and hazel. Herbaceous species in the region were dominated by *Graminaceae*, *Asteraceae*, and *Poaceae*, and corn, wheat, and barley were the most common species of grains (*Jovanović*, 1992). This region is also known for fruit cultivation – apple, plum, pear, apricot, peach, and cherry, which form a significant part of wild boars' diets.

Chemical composition of meat

Moisture content was determined by *ISO 1442* (1998), fat content by *ISO 1443* (1992) and ash content by *ISO 936* (1999). The protein content was calculated by multiplying the nitrogen content by 6.25 using *ISO 937* (1992), and pH, at 45 min post-mortem, was measured by *ISO 2917* (2004).

Fatty acids in meat

The *AOAC* (2001) method was applied for lipid extraction from the tissue. After lipid hydrolysis, the fatty acids were esterified to methyl esters, evaporated to dryness in a stream of nitrogen and stored at –18°C. Analysis of fatty acid methyl esters (FAMEs) was performed by an internal standard method using a gas chromatograph (GC6890N, Agilent Tech., USA) with column DB-23 (60 m × 0.25 mm ID, 0.15 μm) and comparing peak areas and retention times with a standard mix of FAMEs 37 (Supelco, USA). Conditions of analyses: detector temperature = 250°C; injector temperature = 225°C; column temperature = 200°C; carrier gas = helium; carrier gas flow rate = 50 mL/min. Data obtained for fatty acid composition were expressed as a percentage by weight of the identified total fatty acids.

Volatile compounds in meat

Volatile compound analysis was conducted using the Likens-Nickerson extraction procedure (*Likens and Nickerson*, 1964) and *ISO 15303* (2001) using a GCMS-QP2010 Ultra (EIMS, electron energy = 70 eV, scan range = 30–350 amu, and scan rate = 3.99 scans/s) with a SUPELCOWAX® 10 capillary GC column (30 m × 0.25 mm ID, particle size 0.25 μm). The carrier gas was helium with a flow rate of 1 mL/min, and the injection temperature was 200°C. The oven temperature was programmed to initially hold for 10 min at 40°C, and subsequently programmed from 40 ºC to 120 ºC at a rate of 3 ºC/min and at a rate of 10 ºC/min from 120 ºC to 250 ºC where it was held for another 5 min. Identification of the peaks was based on comparison of their mass spectra with the spectra of the WILEY library and in addition, in some cases, by comparison of their retention times with those of standard compounds.

Meat color

Meat color was measured on *m. longissimus dorsi* at 45 min post-mortem. CIE L*a*b* (*CIE Colorimetry*, 1986) color coordinates were determined using a Minolta Chromameter CR 400 (Minolta Co. Ltd., Osaka, Japan) in D-65 lighting, with standard angle of 2 degrees of shelter and 8 mm aperture of the measuring head. CIE L*a*b* color coordinates were given as mean values: L* (lightness), a* (redness) and b* (yellowness).

Sensory analysis

Sensory analyses were carried out in a sensory testing laboratory equipped with individual booths. Each booth was walled on three sides in order to prevent panelists influencing each other. All booths were provided with florescent lights to mask color differences between samples. Sensory tests were performed at room temperature (22–24°C). After a cooling period (4°C for 24 h), meat samples were cut to approximately 2.5×2.5×2.5 cm and labelled with random three-digit numbers. Meat samples were served in plastic bowls, in separate randomized order and individually to each of the 20 trained panelists. Panelists were selected according to ISO standard (*ISO 8586,* 2012, 2015).

Overall acceptability was evaluated based on appearance, texture and aroma. For evaluation, a scoring range from one to five was used, with half and quarter points available. For each selected quality property, the coefficient of importance was determined in order to correct evaluations obtained by multiplication of means. The coefficients of importance were chosen according to the influence of specific properties on the overall quality (surface color — 4, visually evaluated structure — 3, palpatory evaluated firmness — 3, and olfactory evaluated odor — 10), and their sum was 20. By combining individual scores, a complex indicator was obtained that represented the overall sensory quality and was expressed as "percentage of the maximum possible quality" (maximum possible quality was 100%). By dividing this value with a set of coefficients of importance, a weighted average score was obtained, which also represented the total sensory quality of the meat from the three pig breeds. Total sensory quality scores were: 1.00 = very pronounced errors; 2.00 = clearly expressed mistakes; 3.00 = noticeable deviations; 4.00 = minor deviations and; 5.00 = fully meets the quality requirements.

Statistical analysis

Data were analyzed by descriptive and analytical statistical parameters, mean (M) and standard deviation (SD), using Graph Pad Prism 6.0. software (Graph Pad Software Inc., San Diego, CA, USA) and one-way analysis of variance (one-way ANOVA). The differences between means were compared by Tukey's post-hoc test. Levels of $p<0.05$ and $p<0.01$ were considered as significant and highly significant, respectively. The D'Agostino-Pearson normality test was used to verify the normal distribution of data. $p>0.05$ was considered as normal data distribution.

Results

Live weights and carcass weights after evisceration of wild boar, Landrace and Yorkshire pigs are presented in Table 2. There were significant differences among weights of the different pig breeds ($p<0.05$).

Chemical composition and pH of meat from wild boar, Landrace and Yorkshire pigs are presented in Table 3. Water content did not significantly

Table 2. Live weight and hot carcasse weight of wild boar, Landrace and Yorkshire pigs

	No of animals	Live weight	P value (D'Agostino--Pearson test)	Hot carcass weight	P value (D'Agostino--Pearson test)
Wild Boar	10	130.50±1.871^{a}	P = 0.93	87.00 ±1.449^{a}	P = 0.85
Landrace	10	90.50±1.871^{b}	P = 0.89	60.33±1.633^{b}	P = 0.79
Yorkshire	10	92.30±2.160^{b}	P = 0.87	61.53±1.237^{b}	P = 0.88

Legend: ^{a,b} Means within the same column with different superscripts differ significantly ($p<0.05$)

Table 3. Chemical composition and pH of *m. longissimus dorsi* of wild boar, Landrace, and Yorkshire pigs

	Wild boar	P value (D'Agostino--Pearson test)	Landrace	P value (D'Agostino--Pearson test)	Yorksire	P value (D'Agostino--Pearson test)
Moisture,%	73.56±3.500^{ns}	p = 0.83	73.51±3.004^{ns}	p = 0.97	74.31±2.393^{ns}	p = 0.75
Crude fat,%	1.76±0.216^{a}	p = 0.69	3.83±0.224^{b}	p = 0.99	2.53±0.230^{a}	p = 0.77
Crude protein,%	23.30±1.167^{A}	p = 0.91	21.20±1.402^{B}	p = 0.71	21.80±1.437^{A,B}	p = 0.93
Crude ash,%	0.86±0.052^{a}	p = 0.90	1.17±0.019^{b,A}	p = 0.70	1.09±0.076^{B}	p = 0.86
pH	6.06±0.055^{a}	p = 0.84	6.36±0.217^{b}	p = 0.92	6.43±0.074^{b}	p = 0.80

Legend: ^{a,b,c,d} Means within the same row with different superscripts differ significantly ($p<0.05$); ^{A,B} Means within the same row with different superscripts differ significantly ($p<0.01$); ns - non significant

differ among the pig breeds (p>0.05). The contents of crude fat, crude ash and the pH differed significantly among the three pig breeds (p<0.05 and p<0.001), while protein content differed in Landrace and Yorkshire meat (p<0.01), but not compared to that of wild boar. The fat content was the lowest for wild boar and the highest for Landrace meat. The protein content of wild boar meat was significantly higher than that of Landrace meat (p<0.05), but did not differ from that of Yorkshire meat (p>0.05). The pH of Landrace and Yorkshire meat did not differ significantly, but was different to that of wild boar meat (p<0.05).

The fatty acid composition of wild boar, Landrace, and Yorkshire meat is presented in Table 4. There were some differences in fatty acid composition between the three pig breeds (p<0.05). In Yorkshire meat, only caprylic acid (C8:0) was not detected. In Landrace meat, caprylic (C8:0), margaric (C17:0), heptadecenic (C17:1), elaidic (C18:1n9t),

Table 4. Fatty acid composition (%) of *m. longissimus dorsi* from wild boar, Landrace, and Yorkshire pigs

Fatty acid	Wild boar	P value (D'Agostino--Pearson test)	Landrace	P value (D'Agostino--Pearson test)	Yorkshire	P value (D'Agostino--Pearson test)
C8:0 Caprylic acid	0.78±0.004	p = 0.49	nd	-	nd	-
C14:0 Myristic acid	0.99±0.007^{a}	p = 0.37	1.27±0.006^{b}	p = 0.51	0.96±0.005^{c}	p = 0.32
C15:0 Pentadecanoic acid	1.38±0.009^{a}	p = 0.39	1.74±0.009^{b}	p = 0.42	1.27±0.008^{c}	p = 0.38
C16:0 Palmitic acid	22.45±0.040^{a}	p = 0.34	21.09±0.040^{b}	p = 0.69	19.53±0.028^{c}	p = 0.47
C16:1 Palmitoleic acid	2.97±0.011^{a}	p = 0.51	2.61±0.010^{b}	p = 0.57	3.17±0.012^{c}	p = 0.44
C17:0 Margaric acid	0.70±0.003^{a}	p = 0.43	nd	-	0.81±0.004^{b}	p = 0.39
C17:1 Heptadecenic acid	0.44±0.003^{a}	p = 0.48	nd	-	0.75±0.005^{b}	p = 0.32
C18:0 Stearic acid	16.04±0.016^{a}	p = 0.36	11.94±0.012^{b}	p = 0.50	10.22±0.014^{c}	p = 0.51
C18:1n9t Elaidic acid	Nd	-	nd	-	0.45±0.003	p = 0.36
C18:1n9c Oleic acid	40.78±0.070^{a}	p = 0.37	33.41±0.075^{b}	p = 0.73	41.28±0.088^{c}	p = 0.88
C18:2n6t Linolelaidic acid	Nd	-	nd	-	5.40±0.006	p = 0.59
C18:2n6c Linoleic acid	8.30±0.018^{a}	p = 0.47	18.63±0.023^{b}	0.70	10.81±0.019^{c}	p = 0.80
C20:0 Arachidic acid	0.46±0.003^{a}	p = 0.49	4.45±0.012^{b}	p = 0.39	0.46±0.004^{c}	p = 0.45
C20:1n9 Eicosenoic acid	0.68±0.004^{a}	p = 0.46	nd	-	0.46±0.004^{b}	p = 0.39
C18:3n3 Linolenic acid	1.36±0.008^{a}	p = 0.32	nd	-	1.23±0.005^{b}	p = 0.43
C20:2 Eicosadienoic acid	0.58±0.005^{a}	p = 0.33	nd	-	0.66±0.004^{b}	p = 0.41
C20:3n3 Eicosatrienoic	2.09±0.008^{a}	p = 0.52	4.85±0.012^{b}	p = 0.40	2.52±0.008^{c}	p = 0.50

Legend: ^{a,b,c} Means within the same row with different superscripts differ significantly (p<0.05); ns - non significant; nd — not detected

Table 5. Nutritional values and indicators of health benefits according to fatty acid profiles of pig meat

Indicator	Wild boar	Landrace	Yorkshire
ΣSFA	42.80	40.49	33.26
ΣUFA	57.20	59.51	66.74
ΣMUFA	44.87	36.03	46.11
ΣPUFA	12.33	23.48	20.63
UFA/SFA	1.34	1.47	2.01
MUFA/SFA	1.05	0.89	1.39
PUFA/SFA	0.29	0.58	0.62
DFA	73.24	71.45	76.96
OFA	26.76	28.55	23.04
EFA	9.66	18.63	17.44
Nutritional value*	2.52	2.15	2.66

Legend: SFA — saturated fatty acids, UFA — unsaturated fatty acids, MFA — monounsaturated fatty acids, PUFA — polyunsaturated fatty acids, DFA- hypocholesterolemic fatty acids (UFAs + C18:0); OFA — hypercholesterolemic fatty acids (SFAs — C18:0); EFA - essential fatty acids (C18:2 + C18:3); *Nutritional value was calculated according to the equation (C18:0 + C18:1) /C16:0

linolelaidic (C18:2n6t), eicosenoic (C20:1n9), linolenic (C18:3n3) and eicosadienoic (C20:2) acids were not detected. In wild boar meat, elaidic (C18:1n9t) and linolelaidic (C18:2n6t) acids were not detected. Myristic acid occurred only in very small amounts in the pig meat (0.99, 1.27 and 0.96%, for wild boar, Landrace and Yorkshire, respectively). The most abundant saturated fatty acid was stearic acid.

Regarding overall fatty acid contents, wild boar meat had the highest total saturated fatty acid content (Table 5).

The volatile compounds in wild boar, Landrace and Yorkshire meat are presented in Table 6. There were significant differences among all determined volatile substances in meat from the three pig breeds ($p<0.05$). From the group of aldehydes, furfural and

Table 6. Volatile compounds (VOC) in *m. longissimus dorsi* from wild boar, Landrace, and Yorkshire pigs

VOC, µg/kg	Wild boar	P value (D'Agostino--Pearson test)	Landrace	P value (D'Agostino--Pearson test)	Yorkshire	P value (D'Agostino--Pearson test)
Aldehydes						
Hexanal	1.00±0.030^{a}	p = 0.34	nd	-	0.70±0.050^{b}	p = 0.41
Furfural	nd		nd	-	nd	-
Heptanal	0.31±0.010^{a}	p = 0.27	0.01±0.001^{b}	p = 0.29	0.01±0.001^{b}	p = 0.39
Octanal	0.32±0.030^{a}	p = 0.25	nd	-	0.5±0.020^{b}	p = 0.51
Phenylacetaldehyde	0.30±0.020^{a}	p = 0.33	0.10±0.030^{b}	p = 0.40	0.20±0.010^{c}	p = 0.48
Benzaldehyde	nd	-	nd	-	nd	-
Ketones						
2-Butanone	0.39±0.040^{a}		0.19±0.030^{b}	p = 0.43	0.19±0.030^{b}	p = 0.44
2,3-Butanedione	0.73±0.090^{a}	p = 0.61	nd	-	0.05±0.010^{b}	p = 0.47
2-Heptanone	0.20±0.030^{a}	p = 0.49	0.10±0.010^{b}	p = 0.33	nd	-
3-Methyl-2(5H)-furanone	0.85±0.070^{a}	p = 0.71	1.20±0.110^{b}	p = 0.80	2.60±0.140^{c}	p = 0.81
Heterocyclic compounds						
Furan	0.62±0.040^{a}	p = 0.77	1.18±0.080^{b}	p = 0.59	1.09±0.070^{c}	p = 0.59
β-Butyrolactone	0.01±0.003	p = 0.39	nd	-	nd	-
2-Pentylfuran	0.31±0.040	p = 0.47	nd	-	nd	-

VOC, µg/kg	Wild boar	P value (D'Agostino--Pearson test)	Landrace	P value (D'Agostino--Pearson test)	Yorkshire	P value (D'Agostino--Pearson test)
2-Methyl pyrazine	0.20±0.040[a]	p = 0.60	0.50±0.060[b]	p = 0.81	0.80±0.110[c]	p = 0.79
2,5-Dimethyl pyrazin	0.01±0.001[ns]	p = 0.28	0.01±0.001[ns]	p = 0.36	nd	-
2,6-Dimethyl pyrazin	0.10±0.020[a]	p = 0.33	0.11±0.020[b]	p = 0.44	0.12±0.030[c]	p = 0.50
Thiophene	nd	-	nd	-	0.13±0.010	p = 0.59
Phenolic compounds						
Guaiacol	0.02±0.003[a]	p = 0.25	0.02±0.001[b]	p = 0.29	0.01±0.001[b]	p = 0.23
Aromatic hydrocarbons						
1,2-Dimethoxybenzene	0.04±0.002[a]	p = 0.31	0.01±0.001[b]	p = 0.30	0.01±0.001[b]	p = 0.34
Sulfuric compounds						
2,5-Dimethyl thiophene	0.10±0.020	p = 0.28	nd	-	nd	-
2-Methyl thiophene	nd	-	0.20±0.010[ns]	p = 0.46	0.20±0.020[ns]	p = 0.34
2-Buthanethiol	0.01±0.001[a]	p = 0.43	0.01±0.001[a]	p = 0.45	0.02±0.003[b]	p = 0.35
2-Methyl-3-furanthiol	nd	-	nd	-	nd	-
Alcohols						
2-butanol	0.04±0.003[a]	p = 0.27	0.16±0.020[b]	p = 0.39	0.01±0.002[c]	p = 0.28
2-pentanol	nd	-	nd	-	0.14±0.020	p = 0.47
3-methyl –1-butanol	0.31±0.040	p = 0.22	nd	-	nd	-
2,3-Butanediol	0.10±0.010	p = 0.25	nd	-	nd	-
1-Octen-3-ol	1.33±0.110[a]	p = 0.65	0.10±0.030[b]	p = 0.25	nd	-
Organic acids						
Propionic acid	nd	-	0.21±0.030	p = 0.35	nd	-
3-Methylbutanoic acid	0.01±0.001[ns]	p = 0.30	nd	-	0.01±0.001[ns]	p = 0.26
Hexanoic acid	0.04±0.004[a]	p = 0.24	0.03±0.003[b]	p = 0.31	nd	-
Nonanoic acid	0.17±0.020[a]	p = 0.51	0.07±0.010[b]	p = 0.42	0.15±0.030[a]	p = 0.50
Esters						
Isopropenyl acetate	nd	-	0.04±0.002	p = 0.38	nd	-
Ethyl acetate	nd	-	nd	-	nd	-
Isobutyl acetate	0.10±0.020	p = 0.41	nd	-	nd	-
Butyl acetate	nd	-	nd	-	0.21±0.030	p = 0.53
2-methylbutyl acetate	0.45±0.040[a]	p = 0.26	0.02±0.003[b]	p = 0.27	0.05±0.010[c]	p = 0.29
3-methylbutyl acetate	0.20±0.03[a]	p = 0.33	0.10±0.02[b]	p = 0.42	nd	-
Hexyl acetate	0.03±0.002[a]	p = 0.27	0.01±0.001[b]	p = 0.28	0.02±0.002[c]	p = 0.38
Ethyl butanoate	nd	-	nd	-	nd	-
Ethyl isovalerate	nd	-	nd	-	nd	-
Ethyl 2-methylbutanoate	nd	-	nd	-	nd	-
Ethyl octanoate	nd	-	nd	-	nd	-
Alkanes						
Heptane	0.09±0.010[a]	p = 0.29	0.10±0.020[b]	p = 0.39	nd	-

Legend: [a,b,c] Means within the same row with different superscripts differ significantly ($p<0.05$); nd - not detected; ns — non significant

benzaldehyde were not detected in any analyzed sample, and from the group of phenolic compounds 2-Methyl-3-furanthiol was not detected. From the group of esters, ethyl acetate, butyl acetate, ethyl butanoate, ethyl isovalerate, ethyl 2-methylbutanoate and ethyl octanoate were not detected. The most abundant group of volatile compounds was heterocyclic compounds in Landrace meat, with furan being the predominant compound. In wild boar and Yorkshire meat, the predominant volatiles were ketones, and within this group, 3-Methyl-2(5H)-furanone had the highest content in all three pig breeds. The relative amounts of volatile compounds in wild boar meat were 25.86%, 23%, 21.22%, 18.64% and 14.89% of ketones, aldehydes, alcohols and heterocyclic compounds, respectively. In Landrace meat, heterocyclic compounds, ketones, organic acids, alcohols and aldehydes constituted 40.18%, 33.26%, 6.92%, 5.80% and 2.45% of the volatiles, respectively. In Yorkshire meat, ketones predominated (39.33%) among the volatiles, followed by heterocyclic compounds (29.64%) and aldehydes (19.53%).

Color parameters (L* a* b*) of wild boar, Landrace and Yorkshire pig meat are presented in Table 7. There were significant differences among all examined parameters in the CIE L*a*b* system that defined color.

In Table 8, sensory evaluation of individual sensory attributes, the percentage of the maximum score for all evaluated characteristics, and the weighted mean values of ratings are shown. The quality of wild boar, Landrace, and Yorkshire meat did not significantly differ in the main sensory characteristics (surface color, visually evaluated structure, palpatory evaluated firmness, and olfactory evaluated odor). Landrace meat achieved the highest numeric color score, followed by Yorkshire meat, which was slightly darker, and wild boar meat. The visually evaluated structure and palpatory evaluated firmness of Yorkshire meat (13.90 and 15.5, respectively), were the highest among the three pig breeds. Visual evaluations of Landrace (12.50) and wild boar meat (13.00) produced similar scores. The olfactory evaluated odor of meat from the three pig breeds showed that wild boar meat had the highest odor score (Table 8), followed by Landrace and Yorkshire meat. Overall sensory quality followed the order: Yorkshire (95.50%/ weighted average 4.77), Landrace (L) (92.00/4.60) and wild boar (90.50/4.52).

Table 7. Color of *m. longissimus dorsi* from wild boar, Landrace and Yorkshire pigs

	Wild boar	P value (D'Agostino--Pearson test)	Landrace	P value (D'Agostino--Pearson test)	Yorkshire	P value (D'Agostino--Pearson test)
L*	38.79±0.767^{a}	p = 0.90	51.67±0.711^{b}	p = 0.98	39.07±1.150^{a}	p = 0.94
a*	15.32±0.73^{0a}	p = 0.88	11.9±0.258^{b}	p = 0.91	12.82±0.44^{4b}	p = 0.89
b*	7.89±0.282^{a}	p = 0.82	7.67±0.308^{b}	p = 0.87	4.66±0.186^{c}	p = 0.86

Legend: ^{a,b,c,d} Means within the same row with different superscripts differ significantly (P<0.05)

Table 8. Sensory evaluation of *m. longissimus dorsi* from wild boar, Landrace, and Yorkshire pigs

	Attributes				Percentage of maximal possible quality	Weighted average
	Appearance	Texture		Flavor		
	Color Surface	Visually evaluated structure	Palpatory evaluated firmness	Olfactory evaluated odor		
	Coefficient of importance					
	4	3	3	10	100	100/20
Wild boar	18.00±0.28	13.00±0.16	11.00±0.39	48.50±0.20	90.50	4.52
Landrace	20.00±0.25	12.50±0.18	12.00±0.18	47.50±0.13	92.00	4.60
Yorkshire	19.10±0.28	13.90±0.25	15.50±0.23	47.00±0.32	95.50	4.77

Discussion

The pigs' live weights were in line with breed characteristics (*Furman et al*., 2010), and the chemical composition of the meats were in line with our previous findings. In a study of meat quality characteristics of Duroc x Yorkshire, Duroc x Yorkshire x wild boar and wild boar meat, significant differences in meat chemical composition between breeds were observed (*Ivanović et al*., 2013). *Václavková* and *Bečková* (2007) examined the impact of different feed additives on chemical composition of *M. longissimus dorsi* in (Czech Large White x Czech Landrace) x (Hampshire x Pietrain). The fat content (2.1%) in the control pigs fed a basal diet was similar to our results for Yorkshire meat. However, the fat contents determined in the current study were not in line with the results of *Šimek et al.* (2004), who reported their pigs had 1.6% intramuscular fat. Choi *et al.* (2016) reported *m. longissimus dorsi* from Yorkshire pigs had a higher fat content than that from Landrace, which could be a consequence of differences in final weight and nutrition. In our study, proximate meat composition and pH varied significantly among the compared breeds. Similar results have been reported by other authors (*Kosovac et al*., 2009; *Kasprzyk et al*., 2015).

The ideal intramuscular fat content of fresh meat is between 2 and 3%, whereas meat with a fat content >3.5% can be rejected by consumers (*Fernandez et al*., 1999; *Kasprzyk et al*., 2015). In the current study, the fat content of Yorkshire meat was acceptable. However, Landrace meat had a higher fat content (3.83%) and wild boar meat had a lower fat content (1.76%), which could indicate the meat from these pigs was of low quality (*Tyra and Zak*, 2010; *Kasprzyk et al*., 2015). In spite of that, consumers nowadays prefer low fat and low cholesterol levels in food, and therefore, wild boar meat could be considered as favorable food for human consumption. *Postolache et al*. (2011) examined the chemical composition of *m. longissimus dorsi* from three- to four-year-old wild boar hunted in Romania. The proximate composition (water content of 75.36%, protein content of 21.81%, and fat content of 2.58%) and ultimate pH (5.56) of their boar meat differ from our current results. Those discrepancies could be a consequence of different ages and nutrition of the examined animals.

The most prevalent fatty acid was oleic acid in all examined breeds, followed by palmitic and stearic acid. The highest oleic acid content was determined in Yorkshire meat, followed by wild boar and Landrace meat. Regarding palmitic and stearic acid, wild boar meat contained the most, followed by Landrace and Yorkshire meat. The linoleic acid content was the highest in Landrace meat, and lowest in wild boar meat. Furthermore, there were significant differences between all determined fatty acids, which highlighted the impact of breed on fatty acid profile of meat, as others have said. Wood *et al.* (2004) examined intramuscular fat content and fatty acid composition of M. *longissimus dorsi* from Berkshire and Tamworth, a Large White line and a Duroc line, and found breed significantly impacted the examined parameters. *Furman et al.* (2010) studied hybrid Large White × Slovenian Landrace mated with Pietrain, Duroc or Piertain × Slovenian Landrace and came to a similar conclusion.

Furthermore, animals' diet can affect chemical composition, fatty acid profile and volatile compound content in meat (*Wood et al*., 2008; *Čítek et al*., 2015). The complete feed mixtures used in this study were the same for the two commercial breeds (Landrace and Yorkshire). Differences in fatty acid content between Landrace and Yorkshire meat occurred, regardless of the same diet being used. However, fatty acid content also differed between the pure breeds and wild boar meat. It should be noted that diet has an impact on meat quality, in conjunction with several different factors. Thus, diet (feed additives) can affect the fatty acid profile of meat, but does not have a crucial effect on intramuscular fat content (*Čítek et al.*, 2015) ; *Kouba et al.*, 2003; *Okrouhla et al.*, 2013).

Among the saturated fatty acids, not all have the same effect on human health. It is considered that lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids can increase the concentration of cholesterol in plasma. Myristic acid had the most adverse effect, four times more pronounced than the effects of lauric and palmitic acids, on the cardiovascular system (*Hegsted et al.*, 1959). Our pig meat contained only small amounts of myristic acid. Stearic acid, which was the most abundant saturated fatty acid in our study, is considered as neutral (*Webb and O'Neill* 2008; *Kasprzyk et al.,* 2015).

Indicators of the nutritional value and health benefits of fat depend on the amounts of particular fatty acid groups. Regarding overall fatty acid contents, wild boar meat had the highest total saturated fatty acid content. The ratio of polyunsaturated to saturated fatty acids should be higher than 0.4 (*Wood et al., 2008*), and in our study, only wild boar meat did not fulfill this human health indicator.

Aldehydes are commonly found in the pig meat, as high as 50% (*Xie et al.,* 2008; Lorenzo *et al.*, 2013), or even 75% (*Hou et al*., 2018) of total volatile compounds. In contrast, in our study, aldehydes

were not the most abundant volatiles, particularly in Landrace meat that contained just 2.45% aldehydes. Within the group, linear aldehydes are products of fat oxidative degradation, with the exception of phenylacetaldehyde, which is a product of amino acid degradation (*Belitz and Grosch*, 1987; *Xie et al.*, 2008). Aldehydes, regardless of their amount, have a low aroma threshold and intensive and specific aroma, which can make them important contributors to meat's aromatic profile. Aldehydes, especially hexanal that is the most abundant and derived from linoleic and arachidonic acid, have grease, green grass, and apple flavors, (*Yang et al*., 2017; *Hou et al*., 2018). In our study, among the aldehydes, hexanal predominated in wild boar and Yorkshire meat, but it was not detected in Landrace meat. Aldehyde content is determined by fatty acid and protein content, and furthermore, is affected by several factors: chilling conditions, storage time, heat treatment of meat etc. Thus, the aldehyde content can vary significantly along with conditions of meat manipulation.

Ketones are considered to have a significant impact on meat aroma, especially when they occur in large amounts. Ketones have a specific aroma that is described as ether-like, buttery, spicy notes or blue cheese notes (*Creuly et al*., 1992; *Lecanu et al*., 2002). Furthermore, methyl ketones, and among them 3-Methyl-2(5H)-furanone that was the most abundant in our study, has buttery and creamy notes (*Xie et al*., 2008). Ketones can be produced by lipid oxidation as a consequence of autoxidation (*Beliz and Grosch*, 1987; *Flores et al*., 1997) or microbiological activity (*Sunesen and Stahnke*, 2003). For example, the β-oxidation activity of molds growing on the surface of dry-cured products results in 2-pentanone production. Ketones have high odor thresholds, and so we presume their contribution to the meats' total aroma profiles was significant, considering the large amount of ketones in the meats.

Heterocyclic compounds are significant odorants, and among them furan compounds, due to their low thresholds, might be major contributors to pig meat odor. Furan is derived from n-6 fatty acids, particularly linoleic acid (*Elmore et al.*, 1999; *Yang et al*., 2017). These compounds were detected in various pig meat breeds (*Zhao et al*., 2017; *Hou et al*., 2018), and furan is described as having vegetable, green, earthy, and beany notes (*Stetzer et al*., 2008). In the current study, Yorkshire and Landrace meat contained more furan than did wild boar meat. Commercial breeds in our study received in their diets linoleic acid that is precursor for furan synthesis. Linoleic acid from pig diets will accumulate in muscles (*Ramsay et al.*, 2001; *Čítek et al.*, 2015; *Pinelli-Saavedra et al*., 2019), and thus affects the fatty acid and volatile profiles of meat.

On the contrary, 1-octen-3-ol that is generated from oxidative breakdown of linoleic acid was the highest in wild boar meat, despite this meat having the lowest content of linoleic acid. Considering that meat's volatile profile is multifactorial, we conclude that differences in nutrition have significant, but not decisive impacts. 1-octen-3-ol is considered to have sweet, earthy odor (*Hong et al.*, 1988). Furthermore, alcohols are products of lipid oxidation or reduction of aldehydes to alcohols (*Lorenzo et al.*, 2013). They have herbaceous, woody and fatty perception and contribute to flavor and odor meat profile due to their low thresholds (*Lorenzo et al.*, 2013).

Meat's volatile compounds and flavor profile are affected by numerous factors. Volatiles can be derived thermally from fatty and amino acid degradation, so the volatile profile depends on the thermal processes applied (cooking, smoking, roasting). In our study, spices that can significantly contribute to meat flavor development, were not used, which could explain disagreements with other studies (*Xie et al*., 2008; *Lorenzo et al*., 2013).

Meat color correlates with myoglobin content, but also is closely related to intramuscular fat content and pH (*Lee and Joo*, 1999; *Mancini and Hunt*, 2005; *Choi et al*., 2016). In our study, Landrace meat had the fat highest content, which logically explains Landrace meat's lightness values. However, wild boar meat had the lowest pH, which could be expected to result in high lightness values, but this was not the case in our study. Wild boar meat had higher a* and b* values than did Landrace and Yorkshire meat, which could be a consequence of the higher myoglobin content in game meat.

Marchiori and de Felício (2003) instrumentally measured pig meat color (at 24 h post-slaughter in *m. longissimus dorsi*). Their L* and b* values were higher than ours, but their a* values were lower than ours. Meat color, measured after seven days in *m. longissimus lumbrorum* from Large White Landrace (Lebret and Guillard**,** 2005), was darker than our Yorkshire meat but lighter than our Landrace meat. *Marchiori* and de Felício (2003) also measured the color of wild boar meat (48 h post-slaughter in *m. longissimus dorsi*); their L* and b* values were higher than ours.

The visually evaluated structure of Yorkshire meat indicated this meat had uniform distribution of muscle fibers at the intersection. It is difficult to compare the results of sensory analysis between different authors and between different techniques. *Kasprzyk et*

al., (2010) evaluated Pulawska meat, wild boar and Pulawska x (Hampshire x Wild boar). In that study, wild boar meat received the lowest rating, while cross-breed meat achieved a perfect score. *Morrison et al.* (2007) investigated the effect of different housing methods on sensory qualities. The scores varied slightly, but did not differ in tenderness, juiciness, pork flavor or overall desirability of pork produced from the two housing treatments. These results (*Morrison et al.*, 2007) are similar to ours. Although we did find slight differences in the sensory evaluation of meat appearance, they did not affect the acceptability of meat.

Conclusions

Unsaturated fatty acids accounted for 57.20% of total fatty acids in wild boar meat, 59.51% in Landrace meat and 66.74% in Yorkshire meat. Yorkshire meat had the most favorable unsaturated to saturated fatty acid ratio and the highest nutritional value. On the other hand, wild boar meat had the lowest intramuscular fat content. Regarding overall sensory acceptability, Yorkshire meat achieved the highest score, followed by Landrace and wild boar meat. In conclusion, sensory evaluation and indicators of the nutritional value showed that meat from pure breeds, in particularly Yorkshire, has benefits for consumers, but wild boar meat will satisfy consumers' expectations for lean meat.

The present study is not without limitations. Indeed, some fatty acids and volatile compounds were not identified, indicating that further research is required. Furthermore, evaluation of pork meat quality was conducted, but the study did not include the quality of meat products. Finally, other pig breeds are likely to have other characteristics, so they deserve study.

Parametri kvaliteta mesa divljih svinja i komercijalnih rasa svinja

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A p s t r a k t: Poslednjih decenija u Srbiji se povećala proizvodnja svinjskog mesa, a svinjsko meso je meso koje se najviše konzumira. Na kvalitet svinjskog mesa utiče nekoliko faktora: rasa, pol, proizvodni rezultati, prilagođavanje stresu i faktori koji se odnose na upravljanje životinjama. Cilj ovog istraživanja bio je da se uporede osobina kvaliteta mesa divljih svinja i rasa svinja poboljšanih selekcijom. Uzorci m. longissimus dorsi su uzeti od tri različite rase - jorkšir, landras i divlje svinje. Određeni su hemijski sastav, pH, profil masnih kiselina, isparljiva jedinjenja, boja i ukupan senzorni kvalitet mesa. Hemijski sastav, pH, profil masnih kiselina i isparljiva jedinjenja značajno su se razlikovali (p <0,05) između rasa svinja. Meso svinja rase jorkšir je imalo najpovoljniji odnos nezasićenih i zasićenih masnih kiselina i najveću hranljivu vrednost. S druge strane, meso divlje svinje imalo je najmanji sadržaj intramuskularne masti. Utvrđene razlike između različitih rasa svinja ukazuju na uticaj rase na kvalitet svinjskog mesa. Dobijeni rezultati mogu se koristiti u svrhu zadovoljavanja potreba potrošača u pogledu sastava masnih kiselina i senzornih svojstava mesa.

Ključne reči: *kvalitet mesa, jorkšir, landras, divlja svinja.*

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Original scientific paper

Rheological, sensorial, and textural properties of ingredient-mix based dried beef product (*Kilishi*)

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A b s t r a c t: As a ready-to-eat (RTE) meat product, Kilishi is gaining increasing popularity within Africa. Only experienced persons make Kilishi products, and improving the production process using comminuted meat production/technology can enhance the products' quality and uniformity. In line with this, the rheological (elastic modulus, viscosity, and rupture strength), textural (hardness, springiness, cohesiveness, and chewiness), and sensorial (taste, color, texture, aroma, and overall acceptability) properties of ingredient-mix based Kilishi sausage were measured. Traditional Kilishi as a control was compared with seven other comminuted Kilishi products (CK1-7) of different ingredient-mix ratios. Comminuted Kilishi products obtained higher values for textural characteristics compared to the traditional Kilishi. Results indicated that CK7 had the highest elastic modulus (E_o, E_1, and E_2) and rupture strength (18.95 N), while CK2 had the lowest of these values amongst the comminuted Kilishi products. However, TK was more viscous (2.09×10^6 Pas), yet had the lowest rupture strength (6.85 N). Sensorially, the panel rating for overall acceptability showed CK2 achieved the highest score (7.02) which is indicative of its degree of preference. Both rheology and texture strongly correlated ($p<0.05$) with one or more sensorial attributes. The ingredient-mix ratios and degree of exposure to heat treatment significantly influenced the rheological, textural, and sensorial properties of Kilishi. Compared to traditional Kilishi, CK2 appears very promising as it was more preferred by panelists, and among the comminuted Kilishi, CK2 had the most favorable textural and rheological attributes, and had the lowest ingredient-mix ratio, which is indicative of lower production costs than the other comminuted Kilishi products. The comminution technique and use of precise ingredient-mix ratios can provide added value in the Kilishi processing industry.

Keywords: *beef meat; ingredient-mix; rheology; comminuted meat; sensory; texture*

Introduction

Consumer demand and increasing competition are making meat product manufacturers around the globe embrace new processing methods and ingredient systems (*Weiss et al*., 2010). Across the West Africa sub-region for example, ready-to-eat (RTE) meat products such as roasted and fried beef, or chicken meat, are increasingly popular, largely prepared and sold for consumption either immediately or at a later time, without needing further processing (*Roger et al.,* 2015). A typical example of a RTE meat product is *Kilishi*, which *Olagunju and Taiwo* (2020) considered an increasingly popular street food, with its consumption extending to other parts of Africa. *Seini et al.* (2018) reported that *Kilishi* is not only of artisanal activity and traditionally manufactured, but is typically made from beef meat, dried and grilled into strips, and seasoned with spicy peanut paste. *Seydou et al.* (2019) reported *Kilishi* as either coated or uncoated. The coating involves trimming meat, cut into a parallel pipe shape prior to it being sliced into flat thin sheets, then sun-drying and marinating in complex blended spiced sauce, followed by a second sun-drying, and grilling. The uncoated *Kilishi* is sun-dried meat, slightly seasoned and grilled. Additionally, *Kilishi* is usually prepared and packaged at the point of consumer purchase.

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Specifically, *Kilishi* processing by percentage has slightly less of the meat, but more of the non-meat ingredients (i.e., condiments, spices, etc.). Notwithstanding, the methods of *Kilishi* production (*Badau et al.,* 1997; *Igene et al.,* 1990; *Igene et al.,* 1993; *Yaou et al.*, 1986) and the condiments and spices used (*Nkama et al.,* 1994) appear well established. However, *Kilishi* quality can still vary, even from the same producer (*Igene*, 1988). It was to standardize the non-meat ingredient portion that *Badau et al.* (1997) developed an instant standard ingredient, a groundnut-cake powder, which at that time, improved the overall acceptability/yield and simplified *Kilishi* production. On the other hand, the development of meat processing technology has advanced, particularly over recent years. Through a wide range of methods/procedures, the *Kilishi* processing technology has adopted modifications that help the attainment of desirable properties (*Hidayat et al*., 2017; *Savic*, 1985). Neither the meat or spice formula, however, can serve as a means to classify this type of product. This is because the many formulations can include (similar) combinations of diverse meat and seasoning types. Seasonality in raw material supply, therefore, can bring about periodic differences in the proportions of various meat types and spices employed (*Savic*, 1985). In addition, despite the complex interactions/matrix, comminuted meat systems can provide an environment where the constituent chemical and physical properties would determine the ultimate stability of the product (*Acton et al.*, 1983). Comminution refers to a procedure of reducing a material, to achieve a fine particulate state. The ultimate purpose is to realize a stable comminuted meat matrix (*Acton et al.,* 1983).

Rheological, sensorial, and textural considerations can help establish consumer acceptability of meat products. For example, when a slice of meat or meat product is subjected to heat treatment, the muscle protein obviously denatures. This result is the situation where the myosin converts from its soluble into the gel state. Such (above-mentioned) texture-related contexts (specific to heated-impacted meat muscles) are equated by consumers with cooked meat. Equally, rheological, sensorial, and textural considerations can help in defining the eating quality of meat/comminuted meat (*Hui*, 2012). In the mouth specifically, the texture feel of meat products can be represented by such descriptors as adhesion, mealiness, hardness, rubberiness, etc. (*Hui*, 2012). The hardness, for example, can help to determine not only the commercial value but also consumer acceptance of a meat product (*Caine et al.*, 2003; *Girard et al.*, 2012). Rheological behavior of meat products can be studied through mechanical methods like compression, shear, tension, and torsion. Texture profile analysis (TPA) (compression) and *Warner Bratzler* (shear) tests are two instrumental approaches most commonly used (*Romero de Ávila, et al.*, 2014). The relationship(s) between textural and structural changes in food products, especially those that take place during processing, are unraveled through analyzing the deformation and flow of matter, which has always been underscored by rheological principles (*Gao et al.,* 2003*; Sun,* 2006*; Janmey and Schliwa,* 2008).

Specific to the *Kilishi* product, however, the process of making it still remains rather complicated and time-consuming. Deemed artisanal, experienced persons are necessary to perform the intricacies involved in the making of *Kilishi*, especially when it comes to both the curing and slicing steps. Most likely, improving the production process should help to enhance both the quality and uniformity of the *Kilishi*. The use of ground meat, which resembles those employed in comminuted meat production/technology, could serve as a promising start/pathway. Therefore, the specific objective of the current study was to investigate the rheological, textural, and sensorial properties of ingredient-mix based comminuted *Kilishi* product.

Materials and methods

Schematic overview of study

The schematic overview of the experimental program, showing the major stages from the procurement of meat to laboratory analyses, is presented in Figure 1. Traditional *Kilishi* (TK) served as a control and was compared with seven other comminuted *Kilishi* products (CK1-7) that were composed of different ingredient-mix ratios. Rheological measurements determined the elastic modulus, viscosity, and rupture strength. Textural measurements determined hardness, springiness, cohesiveness, and chewiness. Sensorial measurements determined taste, color, texture, aroma, and overall acceptability. Triplicate measurements were performed for all analyses *via* simple random sampling of the *Kilishi*. All laboratory experiments had institutional approval and followed standard procedures/protocols, which were made up of relevant guidelines and regulations, as found in published references.

Procurement of raw materials

Fresh beef muscles were procured from the central abattoir, Owerri, Imo State, Nigeria. The components used to make the ingredient-mix (spices, groundnut paste, onion, garlic, sugar, salt, and bullion cubes) were procured from the Owerri market, Imo State, Nigeria. These above-mentioned procurements are consistent with those previously described by *Iheagwara and Okonkwo* (2016).

Sample preparation and processing

Meat preparation

The beef meat for the evaluative study had its excess fat, bones, and connective tissue removed and thereafter was washed thoroughly in salted water. The bulk was cut into eight portions, each of which was evenly milled and/or sliced into thin strips of 1 mm thickness. The sliced portion was used for the TK, which served as the control, while the remaining seven portions were used to produce the comminuted *Kilishi* (CK1-7).

Preparation of infused ingredients

The infused ingredients were ginger, alligator/black/red/sweet peppers, onion, garlic, African nutmeg, groundnut paste, Magi seasoning, salt, sugar, and water, as presented in Table 1. These ingredients are well known to be used by the artisans who make *Kilishi* across Nigeria. Preparation of TK followed the exact measurements obtained from an artisanal producer. The purpose of the different ingredient-mix ratios was to reflect the variants practically in use by various *Kilishi* artisans in Nigeria. That is based on the practical assumption that the *Kilishi* of

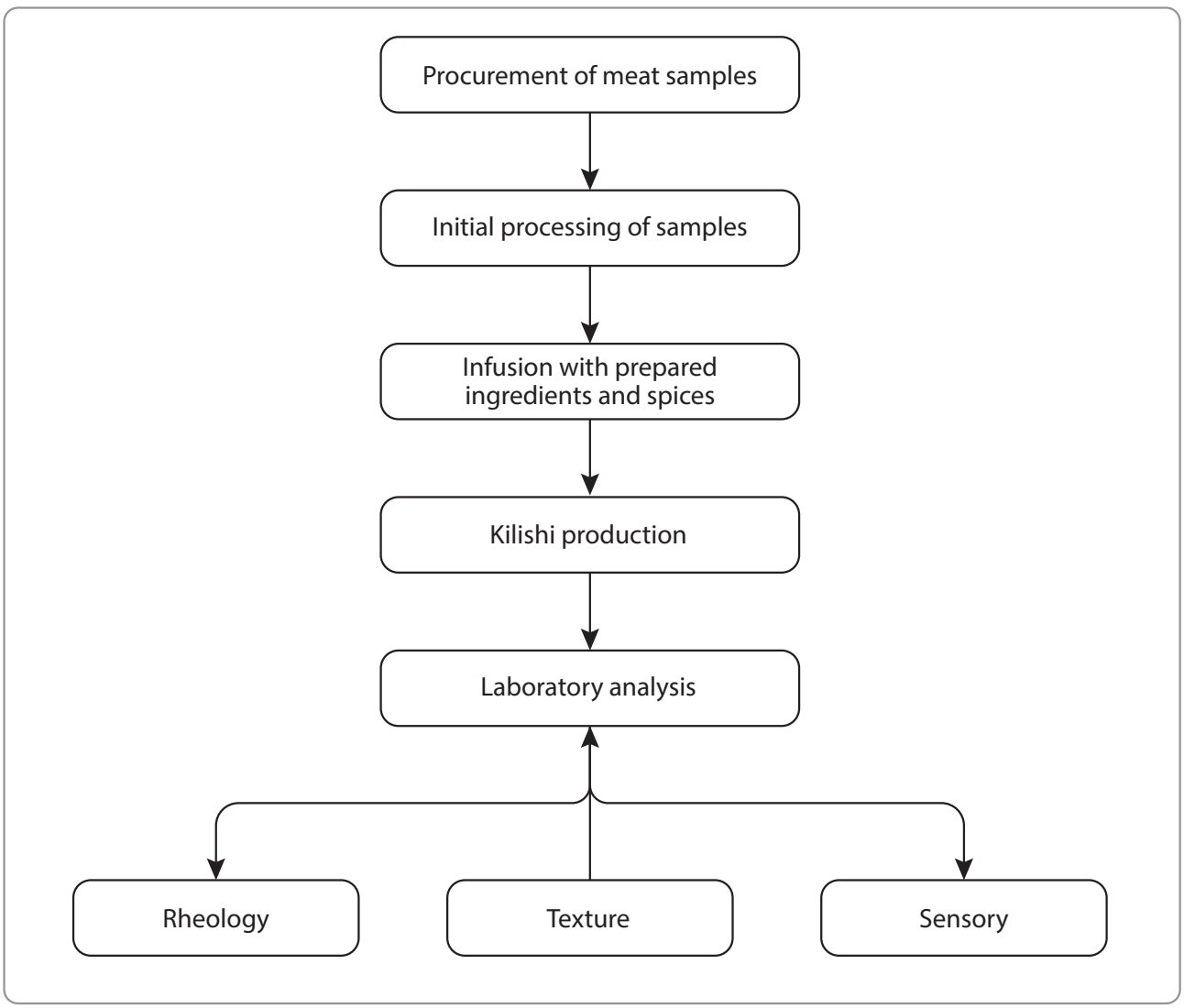

Figure 1. Schematic overview of the experimental program, showing the major stages, from meat procurement to laboratory analyses

an artisan A will not be exactly the same as B, even if they produce side-by-side in the same location.

Preparation of *Kilishi*

TK was prepared by subjecting the thin meat in strips of 1 mm thickness to pre-drying treatment in a hot air oven (Genlab, England, Model M 30 C, S/N 92B060) at 60°C for 3 h. The dried thin meat strips were infused in the ingredient-mix that was previously made to a slurry with water (*Igene*, 1988), as presented in Table 1, and allowed to soak for 30 min. Subsequently, the TK were dried at 60°C for 5 h.

To prepare the comminuted *Kilishi* products, the raw meat was milled together with the infusion ingredient-mixes with different ingredient ratios as presented in Table 1, and molded into flat sheets of 1 mm thickness to generate various comminuted *Kilishi* (CK1-7) (*Iheagwara and Okonkwo*, 2016). Subsequently, the *Kilishi* were dried at 60°C for 5 h.

Following the drying treatment, all *Kilishi* were roasted in a smoking kiln at 100°C for 5 min, to impart aromatic flavor and phenolic compounds with preservative effect. This was then followed by cooling at ambient temperature (28±2°C), and subsequent storage until required for analytical (rheological, textural, and sensorial) measurements.

Determination of rheological, textural, and sensorial properties of Kilishi

The determinations of the studied rheological, textural, and sensorial properties of *Kilishi* were carried out at the Meat Science Laboratory, Department of Animal Science, University of Ibadan, Nigeria. The rheological properties studied were elastic modulus, viscosity, and rupture strength, the textural properties were hardness, springiness, cohesiveness, and chewiness, and the sensorial properties were taste, color, texture, aroma, and overall acceptability.

Determination of rheological properties

Stress relaxation measurement was carried out on the *Kilishi* using a texture analyzer (TMS-PRO Texture Analyzer, Food Technology Corporation, USA) at room temperature. Stress is the deformation force per unit area of the body or material, whereas strain with no dimensions, is expressed as relative change in shape or size of an object due to externally

Table 1. Composition of ingredient-mixes used in *Kilishi* preparation (g/100g)

Ingredients	TK	CK1	CK2	CK3	CK4	CK5	CK6	CK7
Ginger (*Zingiber officinale*)	3.30	3.30	2.81	2.97	3.14	3.47	3.63	3.80
Alligator pepper (*Afromomum meleguata*)	1.20	1.20	1.02	1.08	1.14	1.26	1.32	1.38
Black pepper (*Piper guineense*)	3.00	3.00	2.55	2.70	2.85	3.15	3.30	3.45
Red pepper (*Capsicum frutescens*)	2.00	2.00	1.70	1.80	1.90	2.10	2.20	2.30
Sweet pepper (*Capsicum annum*)	2.00	2.00	1.70	1.80	1.90	2.10	2.20	2.30
Onion (*Allium cepa*)	12.00	12.00	10.20	10.80	11.40	12.60	13.20	13.80
Garlic (*Allium sativum*)	0.50	0.50	0.43	0.45	0.48	0.53	0.55	0.58
African nutmeg (*Monodora myristica*)	1.00	1.00	0.85	0.90	0.95	1.05	1.10	1.15
Groundnut paste (*Arachis hypogea*)	31.50	31.50	26.78	28.35	29.93	33.08	34.65	36.23
Magi seasoning	1.50	1.50	1.28	1.35	1.43	1.56	1.65	1.73
Salt	3.00	3.00	2.55	2.70	2.85	3.15	3.30	3.45
Sugar	3.00	3.00	2.55	2.70	2.85	3.15	3.30	3.45
Water	36.00	36.00	30.60	32.40	34.20	37.80	39.60	41.40

Legend: TK – Traditional *Kilishi* (100% ingredients); CK1 – Comminuted *Kilishi* (100% ingirents); CK2 – Comminuted *Kilishi* (85% ingredients);CK3 – Comminuted *Kilishi* (90% ingredients); CK4 – Comminuted *Kilishi* (95% ingredients); CK5 – Comminuted *Kilishi* (105% ingredients); CK6 – Comminuted *Kilishi* (110% ingredients); CK7 – Comminuted *Kilishi* (115% ingredients) Source: *Iheagwara and Okonkwo* (2016)

applied forces (*Hui*, 2012). At a constant strain of 0.02, *Kilishi* samples were compressed using a cylindrical probe (4.0 mm internal diameter) and when compression reached the maximum, the instantaneous modulus (E_0) was calculated from the load. The progressive approximate method described by *Saito et al*. (2002) was used to analyze the stress relaxation curve. The stress-relaxation approximate equation was expressed as follows:

$$\sigma(t) = e_0 \sum_{i=1}^{n} E_i \, exp\left(-T/T_i\right) \quad \text{Eq. 1}$$

Where is the stress at relaxation time, is the constant strain, T is the time, is the elastic modulus of the i-th element, and is the stress-relaxation time per *Kilishi* sample of the i-th element shown in Table 2. n_i which is related to the viscosity of the i-th element, n, and E is as shown in equation (2).

$$T_i = n_i/E_i \ldots\ldots\ldots\ldots\ldots (2) \quad \text{Eq. 2}$$

E_0 is defined as follows:

$$E_0 = E_1 + E_2 + \cdots \ldots + E_n \ldots\ldots\ldots\ldots (3) \quad \text{Eq. 3}$$

Table 2. Stress-relaxation time (seconds) of different processed *Kilishi*

Kilishi	T_1 (s)	T_2 (s)
TK	15.80	1.96
CK1	38.67	2.43
CK2	36.08	2.84
CK3	37.10	2.88
CK4	38.16	2.93
CK5	42.28	3.26
CK6	43.60	3.49
CK7	45.87	3.65

Legend: T_1 – Stress relaxation time of the first element; T_2 – Stress relaxation time of the second element

The rupture strength of the *Kilishi* was measured by the same texture analyzer at room temperature. *Kilishi* were compressed at the rate of 2.0 mm/s using a cylindrical probe (2 mm internal diameter), and the peak of the force-time curve was regarded as the rupture strength value.

Determination of sensorial properties

The sensorial properties of the *Kilishi* were determined by 30 trained panelists using the appropriate descriptors, consistent with the method previously described by *Carbonell et al., (2002)*. Importantly, informed consent was obtained from all panelists prior to their participation in the sensory analysis. Briefly, the sensory evaluation procedure started with the sensory descriptors of taste, color, texture, and aroma, which were provided to the trained panelists. The sensory descriptors were designated with a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely), which would help the panelists to identify the characteristic changes in the taste, color, texture, and aroma of the studied *Kilishi*. The overall acceptability, computed as the average score of the sum of taste, color, texture, and aroma, was also determined.

Determination of textural properties

The texture profile analysis (TPA) of the *Kilishi* was carried out using the same texture analyzer (above). Specifically, the double compression cycle test was carried out according to the following procedure: a) cylindrical probe = 4 mm internal diameter; b) final strain = 0.05 time interval between the first and second compression at 5 s. The pre-speed, test-speed and post-speed were 0.5 mm/s, 1.0 mm/s and 5.0 mm/s, respectively. The following measurements were elucidated through the TPA parameters: a) Hardness (N) refers to the peak force in the first compression cycle; b) Springiness (dimensionless) refers to the ratio of the length duration of the force input during the second compression to that during the first compression; c) Cohesiveness refers to the ratio of the positive force area during the second compression to that during the first compression; and d) Chewiness (N) refers to the product of hardness, springiness, and cohesiveness (*Caine et al.*, 2003; *Duan et al*., 2010).

Statistical analysis

Using boxplots, as well as Levene's, and Shapiro-Wilk tests, the analysis of variance (ANOVA) assumptions considered outliers, homogeneity of variances, and normality (*Ofoedu et al.*, 2020). One-way ANOVA was applied to data obtained from triplicate measurements, with results expressed as mean ± standard deviation (SD). Fisher's least significant difference (LSD) was used to resolve mean differences. Whether positive (directly related) or negative

(indirectly related), and by a coefficient (r) and probability (p) value (*Okpala and Bono*, 2016), correlation tests aim to establish how strong one variable moves in relation to another (*Mat Roni et al.*, 2020). When correlation was examined, Pearson's test was applied to see how the tested parameters moved with each other, regardless of different ingredient-mix ratios. Probability level of statistical significance was set at $p<0.05$. IBM SPSS software version 20 (IBM Corporation, New York, USA) was used to do the analysis.

Results and discussion

Rheological properties

The rheological properties (i.e., elastic modulus, viscosity, and rupture strength) of the different *Kilishi* are depicted in Table 3. The elastic modulus, viscosity, and rupture strength of TK significantly differed ($p<0.05$) compared to CK1-7. The E_0, E_1, and E_2 values for all *Kilishi* were within the ranges of 2.02–3.86 × 10^5 Pa, 0.96–1.82 × 10^5 Pa, and 1.18–1.69 × 10^5 Pa, respectively. Specifically, the elastic modulus (E_0, E_1, and E_2) values of TK were less than those of CK1-7. However, there was a somewhat increasing trend in the elastic modulus across CK 1-7, although with somewhat decreasing trends across E_0, E_1, and E_2 values. Specifically, the elastic modulus (E_0, E_1, and E_2) was highest in CK7 compared to the other *Kilishi*, while CK2 had the lowest elastic modulus amongst the comminuted *Kilishi*. In this context, the elastic modulus is the amount of resistance to deformation given by the dried meat products to an applied stress. The lower elastic modulus in TK could be as a result of its structural arrangement in fibrous protein strands (*Arfat and Benjakul*, 2012; *Cobos and Di*az, 2014), unlike CK1-7 with their micro-particulate aggregate structural network. The low elastic modulus in TK could indicate stiffening when exposed to small stresses and softening when exposed to larger stresses. In the same vein, the network configuration of the comminuted *Kilishi* could be such that they are soft (compliant) under small stresses but much stiffer under larger stresses (*Hanmey and Schliwa*, 2008).

The viscosities η_1 and η_2 of all the *Kilishi* ranged between 0.56 and 2.09 × 10^6 Pa, and between 0.50 and 0.97 × 10^6 Pa, respectively. Principally (and *vice versa*), the elastic modulus should increase with a decrease in the elastic force (*Matumoto and Yamano*, 1987). As widely understood, an increase in viscosity (η) would occur with decrease in viscous force. This suggests the TK in the current study to be more viscous than the other *Kilishi* (CK1-7). Severe changes in texture are caused by loss of water-holding capacity and shrinkage of meat fiber, which leads to toughening of muscle tissue. The initial pre-drying (heat) treatment during the processing of TK likely caused denaturation and aggregation of proteins which resulted in low viscous flow, and hence, the high viscosity of TK. This corroborates the report of *Fellows* (2017) that solid food becomes more viscous during drying and can pass through series of rubbery and leathery states. The elastic modulus and viscosity

Table 3. Rheological properties of different processed *Kilishi*

Kilishi	E_o(x10^5Pa)	E_1(x10^5Pa)	E_2(x10^5Pa)	η_1(x10^6Pas)	η_2(x10^6Pas)	Rupture strength (N)
TK	2.02±0.01^{h}	0.96±0.01^{f}	1.18±0.01^{g}	2.09±0.01^{a}	0.67±0.01^{a}	6.85±0.01^{h}
CK1	3.63±0.01^{d}	1.68±0.01^{c}	1.50±0.01^{d}	0.83±0.01^{c}	0.75±0.01^{bc}	14.08±0.01^{d}
CK2	3.01±0.01^{g}	1.40±0.01^{d}	1.38±0.01^{f}	0.56±0.01^{h}	0.50±0.01^{c}	10.32±0.01^{g}
CK3	3.36±0.01^{f}	1.51±0.01^{e}	1.40±0.01^{f}	0.68±0.01^{g}	0.53±0.01^{e}	12.42±0.01^{f}
CK4	3.48±0.01^{c}	1.58±0.01^{e}	1.45±0.01^{e}	0.75±0.01^{f}	0.61±0.01^{d}	13.68±0.01^{e}
CK5	3.70±0.01^{c}	1.72±0.01^{b}	1.60±0.01^{c}	0.89±0.01^{d}	0.72±0.01^{c}	16.27±0.01^{c}
CK6	3.78±0.01^{b}	1.79±0.01^{ab}	1.63±0.01^{b}	0.94±0.01^{c}	0.79±0.01^{b}	18.08±0.01^{b}
CK7	3.86±0.01^{a}	1.82±0.01^{a}	1.69±0.01^{a}	0.98±0.01^{b}	0.83±0.01^{b}	18.95±0.01^{a}
LSD	**0.036**	**0.081**	**0.024**	**0.033**	**0.060**	**0.026**

Legend: $^{a-h}$ Means with different superscripts in a column differ significantly at $p<0.05$; E_0 – Instantaneous modulus when compression reached maximum; E_1 – Elastic modulus of first element; E_2 – Elastic modulus of second element; η_1 – Viscosity of the first element; η_2 – Viscosity of the second element

attributes of *Kilishi* demonstrate elastic component/solid-like behavior and viscous component/fluid-like behavior, respectively. Interestingly, elastic moduli and viscosities are not constants but are functions of force, time, and direction of application of force (*Hanmey and Schl*iwa, 2008). Additionally, both elastic modulus and viscosity, as reported by *Sato et al.* (1995) and *Funami et al.* (1998), could closely associate with the texture.

The rupture strength of all the *Kilishi* ranged between 6.85–18.95 N, with CK7 having the highest (18.95N), and TK having the lowest (6.85N), but CK2 had the lowest rupture strength amongst the comminuted *Kilishi*. The rupture strength of *Kilishi*, specific to the context of this meat product, resembled that of heated sea cucumber meat (Liu et al., 2012). Generally, the higher rupture strength in CK1-7 compared to that of TK demonstrated the impact of the increased elastic component (elastic modulus) of the comminuted products. Possibly, the meat comminution into a matrix of micro-particulate aggregate (*Verdier,* 2003) and heating might have caused strong gel matrices by cross-linking of either protein-protein molecules, protein-lipid-protein molecules or even formation of protein bonds mainly due to hydrophilic interactions and covalent disulfide bonds (*Hashemi and Jafarpour*, 2016). The high rupture strength of CK7 (18.95 N) could suggest the muscle protein had aggregated and denatured, and subsequently dehydrated and shrunk (*Chen et al*., 2011). Besides the degree of cooking/heat application affecting meat toughness, it can markedly vary from muscle to muscle within an animal, as well as from point to point within the same muscle (*Bourne*, 2002). Additionally, the combined action of heating and variations in ingredient-mix ratios, especially in the salt content, could greatly influence the rupture strength of the *Kilishi* products. According to *Barbut and Mittal* (1990), salt reduction and increased heating rates enhances reduction in elastic modulus, resulting in lower rupture strength.

Sensorial properties

The sensory properties (i.e., taste, color, texture, and aroma) of the different processed *Kilishi* are shown in Table 5. The mean taste scores of all the *Kilishi* ranged between 6.82–7.30. CK2 obtained the highest taste score (7.30), whereas CK7 obtained the lowest taste score (6.82). The decrease in the taste mean scores from CK2 to CK7 might be attributed to the differences in the proportions of spices and other ingredients used. The color descriptions and preferences, according to the sensory panel, were significantly different ($p<0.05$) across the *Kilishi*. The color range was considered neither bright nor dark and was liked moderately. Specifically, the (mean) color score was highest for TK (7.00) and lowest for CK7 (6.13). The color differences among the *Kilishi* could be attributed to the milling technology adopted to produce the comminuted *Kilishi*. Color differences could also be attributed to various complex chemical reactions as a result of interactions of the ingredient-mix in the different ratios with the large surface area of comminuted meat (*Ogunsola and Omojola*, 2008). Interestingly, the nature and texture of the meat products significantly influenced *Kilishi* color, as colored compounds were trapped on the surface or enmeshed in the comminuted *Kilishi* of TK and CK1-7, respectively. For TK, with the highest colour score, it is possible that the infusion of thin meat strips in the slurry of ingredient-mix, over time, caused adsorption of colored components onto the meat surfaces. Subsequently, these compounds could be oxidized to produce a brown coloration, in addition to the formation of melanoidin compounds (*Osuji et al.*, 2019; *Iwouno et al.*, 2019a; *Osuji et al.*, 2020; *Ofoedu et al.*, 2021) by the action of heat in the presence of sugar and protein. This could thereby impart a desirable brown coloration (*Okafor et al.*, 2018; *Iwouno et al.*, 2019b) compared to that of the comminuted *Kilishi*.

The sensorial texture of *Kilishi* depicts the mouthfeel during mastication, which might corroborate either the tenderness or toughness of the studied meat product. The sensorial texture of all the *Kilishi* differed significantly ($p<0.05$), which can be considered somewhat dependent on the differences in the ingredient-mix used as well as the size of the comminuted/sliced meat. Regarding the aroma score, CK2 had the highest (7.52) whereas CK7 had the lowest (6.53). This suggested that, as adjudged by the panelists, the 85% ingredient-mix utilization for CK2 was moderately liked compared with the less liked hot pungent aroma resulting from the ingredient-mix used for CK7. This aroma result agrees with some previously published data (*Jones et al.*, 2001). Furthermore, the highest overall sensory acceptability was achieved by CK2 (7.02), which was deemed completely acceptable. However, the lowest overall acceptability was given to CK7 (6.02), which indicates this *Kilishi* was the least liked. This could be attributed to its higher percentage of ingredient-mix (115%) which gave rise to higher contents of salt, sugar, seasoning, etc., thus making this *Kilishi* somewhat harsh for the panelists. Somewhat consistent with the argument of *Isah and Okubanjo*

(2012), the sensorial preferences for taste, colour, aroma, and texture of *Kilishi* in the current study would potentially influence consumers' overall acceptability. Based on the sensory evaluation, there is a high chance that both the ingredient-mix variation and the comminution of the beef meat influenced the rheological and textural characteristics of the various comminuted *Kilishi*. Increasing the percentage of ingredient-mix to 115% significantly influenced the rheological and textural characteristics of the comminuted *Kilishi*, which would also affect their sensory properties.

Textural properties

The textural properties (i.e., hardness, springiness, cohesiveness, and chewiness) of different processed *Kilishi* were examined, as shown in Table 4. There were significant differences ($p<0.05$) in the studied textural properties. Specifically, the

Table 4. Textural property analysis of different processed *Kilishi*

Kilishi	Texture parameters			
	Hardness (N)	**Springiness**	**Cohesiveness**	**Chewiness (N)**
TK	10.97±0.01^{h}	0.38±0.01^{d}	0.37±0.01^{d}	10.50±0.01^{h}
CK1	29.36±0.02^{d}	0.50±0.01^{e}	0.58±0.01^{c}	19.00±0.01^{d}
CK2	25.58±0.02^{g}	0.40±0.01^{d}	0.53±0.01^{c}	15.13±0.01^{g}
CK3	26.40±0.01^{f}	0.42±0.01^{cd}	0.55±0.01^{c}	16.30±0.01^{f}
CK4	28.64±0.02^{e}	0.48±0.01^{ce}	0.57±0.01^{c}	17.97±0.01^{e}
CK5	32.56±0.01^{c}	0.58±0.01^{b}	0.65±0.01^{b}	22.14±0.01^{c}
CK6	33.92±0.01^{b}	0.67±0.01^{a}	0.70±0.01^{b}	23.18±0.01^{b}
CK7	34.94±0.02^{a}	0.72±0.01^{a}	0.78±0.01^{a}	25.04±0.01^{a}
LSD	0.035	0.078	0.053	0.042

Legend: $^{a-h}$ Means with different superscripts in a column differ significantly at $p<0.05$

Table 5. Mean sensory scores of different processed *Kilishi*

Kilishi	Sensory parameters				
	Taste	**Colour**	**Texture**	**Aroma**	**Overall acceptability**
TK	6.80±0.41^{f}	6.13±0.30^{e}	6.15±0.40^{b}	6.05±0.42^{f}	6.53±0.37^{f}
CK1	7.05±0.33^{d}	6.58±0.41^{d}	6.13±0.24^{c}	6.15±0.33^{e}	6.67±0.40^{d}
CK2	7.30±0.52^{a}	6.53±0.43^{d}	6.15±0.30^{bc}	6.53 ±0.43^{a}	7.02±0.39^{a}
CK3	7.18±0.43^{b}	6.78±0'31^{c}	6.25±0.42^{a}	6.42±0.35^{b}	6.83±0.32^{b}
CK4	7.10±0.42^{c}	6.84±0.40^{b}	6.12±0.33^{c}	6.31±0.44^{c}	6.78±0.41^{c}
CK5	7.03±0.30^{d}	6.83±0.37^{b}	6.08±0.28^{d}	6.16±0.32^{e}	6.58±0.38^{e}
CK6	7.00±0.33^{e}	6.98±0.46^{a}	6.00±0.26^{e}	6.23±0.38^{d}	6.40±0.28^{g}
CK7	6.82±0.41^{f}	7.00±0.47^{a}	5.58±0.41^{f}	5.82±0.41^{g}	6.02±0.36^{h}
LSD	**0.027**	**0.055**	**0.039**	**0.052**	**0.048**

Legend: $^{a-h}$ Means with different superscripts in a column differ significantly at $p<0.05$

hardness values of all the *Kilishi* ranged between 10.97 N and 34.94 N. The hardness was highest for CK7 (34.94 N) but lowest for TK (10.97 N). Furthermore, the high hardness of CK7 suggests the occurrence of structural changes as the muscle protein denatured (*Gao et al.,* 2002). However, the lower hardness of TK compared to comminuted *Kilishi* (CK1-7) could be a result of the greater exposure of TK to heat treatment, thereby causing more denaturation in its protein network. During drying (heat treatment) of the *Kilishi*, the myofibrillar proteins tend to coagulate, resulting in different degrees of structure rigidity and denaturation points. This corroborates the report of *Barbut and Mitta*l (1990) that slower or minimal heating produces more rigid myosin gels than does intense heat treatment. This implies that the highest hardness, measured in CK7, could be due to the combined effect of minimal heat treatment and high salt concentration in its ingredient-mix. In addition, the hardness range herein corroborates the hardness data reported by *Liu et al.* (2012), which ranged between 8.86 N and 32.58 N.

The springiness of all the *Kilishi* ranged between 0.38 and 0.72. Specifically, springiness was highest for CK7 (0.72), and lowest for TK (0.38). The springiness range of *Kilishi* herein also corroborates the data of *Liu et al*. (2012), who reported a springiness range of between 0.27 and 1.03 in sea cucumber meat heated at different temperatures. The cohesiveness of the *Kilishi* ranged between 0.37 and 0.78. Clearly, the most cohesive (0.78) was CK7 whereas the least cohesive (0.37) was TK, but CK2 had the least cohesiveness amongst the comminuted *Kilishi*. In addition, the cohesiveness of TK was significantly lower ($p<0.05$) than that of CK1-7. However, no significant differences between cohesiveness of CK5 and CK6 ($p>0.05$) were found, but CK7 was noticeably more cohesive ($p<0.05$) than CK1-6 (Table 4). It could be that the minimal heat treatment and high amount of salt in its ingredient-mix contributed to the more cohesive nature of CK7. Under slower or minimal heat treatment, proteins have enough time to unfold and interact with each other, thus enabling formation of a stronger gel matrix, which would result in higher cohesiveness. Previous studies have also recorded larger cohesiveness at lower treatment temperature or with minimal heat treatment and high salt content in meat batter (*Barbut and Mittal*, 1990).

Chewiness, well known as the net energy required to chew solid food to the point required for swallowing it, significantly differed ($p<0.05$) across all the *Kilishi*, with a range between 10.50 N and 25.04 N (Table 2). Specifically, the chewiness was highest in CK7 (25.04 N) and lowest in TK (10.50 N). The chewiness differences in the *Kilishi* could be attributed to the size of the comminuted/sliced particulates/meat pieces, heat treatment, and protein-water and protein-protein interactions that most likely occurred during drying given the high moisture and protein contents in the meat muscle (*Boggs et al.,* 1998). The comminuted *Kilishi* that were exposed to minimal heat treatment had significantly higher chewiness compared to TK. Similar to hardness, chewiness is also influenced by the mode/nature of heat treatment and salt concentration as reported by *Barbut and Mittal* (1990). Thermal processing should aim to ensure a desirable texture in a given food product. This is because during thermal processing, textural changes in food products do occur, where tissues might soften and render it (the food product) unacceptable to consumers (*Sun*, 2006).

Correlation outcomes

Correlation tests established how the rheological, textural, and sensorial properties of *Kilishi* moved together, regardless of the different ingredient-mix ratios (Table 6). The results showed a wide range of statistically significant ($p<0.05$) correlations, a lot more of which were positive than were negative. Furthermore, the rheological properties (elastic modulus, viscosity, and rupture strength) correlated the most with the textural and sensorial data, and were largely with positive coefficients, except for $\eta_1 \times$ Hardness, $\eta_2 \times$ Taste, $\eta_2 \times$ Texture, $\eta_2 \times$ Aroma, and $\eta_2 \times$ Overall acceptability. A closer look at Table 6 shows all the rheological and textural properties correlated with either one or more of the sensorial properties. *Bourne* (2002) asserted that none of the correlations between the (single) instrumental measurement derived from force-deformation curves and sensory data significantly improved on those already reported data. Despite this, and based on the correlation outcomes herein, there is a high chance that both the size of the meat resulting from comminution/slicing and the ingredient-mix variation in the current study might have influenced the rheological, textural, and sensorial characteristics of the *Kilishi*. As heat is applied to the meat product, the muscle protein denatures, and myosin changes from the soluble to the gel state. From this gel state perspective, the rheological parameters could, even at the point of fracture, be associated with the sensory outcomes of the meat products (*Hui*, 2012), which is very much applicable to the *Kilishi* products of the current study.

Table 6. Correlation analysis of rheological properties, textural properties and sensory properties of *Kilishi*

		E_0	E_1	E_2	η_1	η_2	Rupture strength	Hardness	Springiness	Cohesiveness	Chewiness	Taste	Colour	Texture	Aroma	Overall acceptability
Eo	Pearson Correlation	1	.994**	.934**	–.726*	.437	.930**	.985**	.754*	.910**	.918**	.155	.922**	–.443	–.113	–.306
	Sig. (2-tailed)		.000	.001	.042	.279	.001	.000	.031	.002	.001	.714	.001	.271	.790	.461
E1	Pearson Correlation	.994**	1	.963**	–.676	.510	.957**	.990**	.811*	.939**	.950**	.090	.917**	–.506	–.175	–.377
	Sig. (2-tailed)	.000		.000	.065	.197	.000	.000	.015	.001	.000	.832	.001	.201	.678	.358
E2	Pearson Correlation	.934**	.963**	1	–.513	.647	.989**	.959**	.925**	.985**	.997**	–.105	.895**	–.674	–.355	–.565
	Sig. (2-tailed)	.001	.000		.194	.083	.000	.000	.001	.000	.000	.805	.003	.067	.389	.145
η_1	Pearson Correlation	–.726*	–.676	–.513	1	.267	–.466	–.729*	–.177	–.514	–.458	–.769*	–.649	–.028	–.525	–.360
	Sig. (2-tailed)	.042	.065	.194		.523	.244	.040	.676	.192	.254	.026	.081	.948	.181	.381
η_2	Pearson Correlation	.437	.510	.647	.267	1	.673	.433	.830*	.607	.685	–.756*	.362	–.712*	–.847**	–.887**
	Sig. (2-tailed)	.279	.197	.083	.523		.067	.284	.011	.110	.061	.030	.378	.048	.008	.003
Rupture strength	Pearson Correlation	.930**	.957**	.989**	–.466	.673	1	.942**	.939**	.978**	.994**	–.161	.920**	–.669	–.381	–.605
	Sig. (2-tailed)	.001	.000	.000	.244	.067		.000	.001	.000	.000	.704	.001	.070	.352	.112
Hardness	Pearson Correlation	.985**	.990**	.959**	–.729*	.433	.942**	1	.792*	.944**	.941**	.164	.932**	–.505	–.104	–.326
	Sig. (2-tailed)	.000	.000	.000	.040	.284	.000		.019	.000	.000	.698	.001	.201	.806	.431
Springiness	Pearson Correlation	.754*	.811*	.925**	–.177	.830*	.939**	.792*	1	.928**	.946**	–.435	.781*	–.825*	–.603	–.814*
	Sig. (2-tailed)	.031	.015	.001	.676	.011	.001	.019		.001	.000	.282	.022	.012	.114	.014
Cohesiveness	Pearson Correlation	.910**	.939**	.985**	–.514	.607	.978**	.944**	.928**	1	.984**	–.113	.914**	–.743*	–.362	–.598
	Sig. (2-tailed)	.002	.001	.000	.192	.110	.000	.000	.001		.000	.789	.001	.035	.379	.117
Chewiness	Pearson Correlation	.918**	.950**	.997**	–.458	.685	.994**	.941**	.946**	.984**	1	–.169	.893**	–.699	–.406	–.615
	Sig. (2-tailed)	.001	.000	.000	.254	.061	.000	.000	.000	.000		.689	.003	.054	.319	.105
Taste	Pearson Correlation	.155	.090	–.105	–.769*	–.756*	–.161	.164	–.435	–.113	–.169	1	.097	.580	.930**	.852**
	Sig. (2-tailed)	.714	.832	.805	.026	.030	.704	.698	.282	.789	.689		.819	.132	.001	.007
Colour	Pearson Correlation	.922**	.917**	.895**	–.649	.362	.920**	.932**	.781*	.914**	.893**	.097	1	–.507	–.097	–.374
	Sig. (2-tailed)	.001	.001	.003	.081	.378	.001	.001	.022	.001	.003	.819		.200	.820	.361
Texture	Pearson Correlation	–.443	–.506	–.674	–.028	–.712*	–.669	–.505	–.825*	–.743*	–.699	.580	–.507	1	.760*	.871**
	Sig. (2-tailed)	.271	.201	.067	.948	.048	.070	.201	.012	.035	.054	.132	.200		.029	.005
Aroma	Pearson Correlation	–.113	–.175	–.355	–.525	–.847**	–.381	–.104	–.603	–.362	–.406	.930**	–.097	.760*	1	.917**
	Sig. (2-tailed)	.790	.678	.389	.181	.008	.352	.806	.114	.379	.319	.001	.820	.029		.001
Overall acceptability	Pearson Correlation	–.306	–.377	–.565	–.360	–.887**	–.605	–.326	–.814*	–.598	–.615	.852**	–.374	.871**	.917**	1
	Sig. (2-tailed)	.461	.358	.145	.381	.003	.112	.431	.014	.117	.105	.007	.361	.005	.001	

Legend: **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

Conclusion

The rheological, sensorial, and textural properties of traditional and comminuted *Kilishi*, formulated using different ingredient-mix ratios were examined. The comminuted *Kilishi* exhibited higher values for those rheological properties evaluated compared to the TK. Texturally, the comminuted *Kilishi* had significantly higher characteristics of hardness, springiness, cohesiveness, and chewiness compared to the TK. Specifically, CK7 obtained the highest textural properties, elastic modulus, and rupture strength, whereas the TK was more viscous, yet with the lowest rupture strength. Moreover, CK2 obtained the lowest rheological and textural values compared to the other comminuted *Kilishi* samples. Furthermore, sensory panel assessment showed that CK2 was the most preferred *Kilishi* product. The ingredient-mix ratios and processing method (degree of exposure to heat treatment) significantly influenced the rheological, textural, and sensorial properties of *Kilishi*. The strong correlation between rheological, textural, and sensorial properties supports this proposition.

Overall, based on the rheological, textural, and sensorial outcomes of this current *Kilishi* study, the CK2 appears very promising compared to the traditional *Kilishi* and the other comminuted ones. The CK2 has greater added-value potential over TK in terms of its rheological and textural characteristics. In terms of sensorial properties, the CK2 appears the more acceptable product than the others. Additionally, the CK2 is formulated with the lowest ingredient-mix ratio, which has a cost saving implication. This study has revealed the integral role the comminuted meat technique and the ingredient-mix ratio can play in the *Kilishi* processing industry. The direction of future studies should focus on optimizing the ingredient-mix used in the production of comminuted *Kilishi* products, especially those ingredients that greatly influenced the rheological, textural, and sensorial properties such as salt, sugar, and seasoning, so as to deduce the best combination that would give optimized output.

Reološka, senzorna i teksturna svojstva sušenog goveđeg proizvoda („Kilishi“) na bazi mešavine sastojaka

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A p s t r a k t: Kao gotov mesni proizvod (RTE- ready-to-eat), „Kilishi“ stiče sve veću popularnost u Africi. Proizvodnjom „Kilishi“ proizvoda bave se samo iskusne osobe, a poboljšanje proizvodnog procesa primenom proizvodnje/tehnologije usitnjenog mesa, može poboljšati kvalitet i uniformnost proizvoda. U skladu s tim, ispitivana su reološka (modul elastičnosti, viskoznost i čvrstoća na pucanje), teksturna (tvrdoća, elastičnost, kohezivnost i žvakaća tekstura) i senzorna (ukus, boja, tekstura, aroma i ukupna prihvatljivost) svojstva mešavine sastojaka kobasice „Kilishi“ . Tradicionalni „Kilishi“ kao kontrola upoređen je sa sedam drugih usitnjenih „Kilishi“ proizvoda (CK1-7) različitih odnosa sastojaka i mešavine. Usitnjeni proizvodi „Kilishi“ postigli su veće vrednosti za svojstva teksture u poređenju sa tradicionalnim „Kilishi“ proizvodom. Rezultati su pokazali da je CK7 imao najveći modul elastičnosti (Eo, E1 i E2) i čvrstoću pucanja (18,95 N), dok je CK2 imao najmanju od ovih vrednosti među usitnjenim „Kilishi“ proizvodima. Međutim, TK je bio viskozniji (2,09 × 106 Pas), ali je imao najmanju jačinu pucanja (6,85 N). Senzorno, ocena panela za opštu prihvatljivost pokazala je da je CK2 postigao najviši rezultat (7,02), što ukazuje na stepen njegove preferencije. I reološka svojstva i tekstura su u snažnoj korelaciji ($p < 0,05$) sa jednim ili više senzornih atributa. Odnosi sastojaka i mešavine i stepen izloženosti toplotnoj obradi značajno su uticali na reološka, teksturna i senzorna svojstva „Kilishi“ proizvoda. U poređenju sa tradicionalnim „Kilishi“ proizvodom, CK2 deluje vrlo obećavajuće jer su ga panelisti preferirali, a među usitnjenim „Kilishi“ proizvodima, CK2 je imao najpovoljnije teksturna i reološka svojstva i imao je najniži odnos mešavine sastojaka, što ukazuje na niže proizvodne troškove od drugi usitnjeni proizvoda „Kilishi“. Tehnika usitnjavanja i upotreba preciznih odnosa mešavine sastojaka mogu pružiti dodatnu vrednost u prerađivačkoj industriji za dobijanje proizvoda „Kilishi“.

Ključne reči: *goveđe meso; mešavina sastojaka; reologija; usitnjeno meso; senzorna svojstva; tekstura.*

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Original scientific paper

Estimation of fat content in fermented sausages by means of Computer Vision System (CVS)

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A b s t r a c t: The aim of this study was to investigate the possibility of computer vision system (CVS) application in fat content estimation for different types of fermented sausages. Four different types of local fermented sausages with different fat contents were studied: Njeguška, Kulen, Pirotska and tea sausage. Results obtained for CVS-estimated fat content were compared to the results of traditional chemical analysis. Relative errors of fat content estimation in Njeguška, Kulen, Pirotska and tea sausage were 1.47%, 0.46%, 20.84% and 11.19%, respectively. Results of t-test showed a significant ($p<0.01$) difference between mean fat contents obtained by CVS and chemical analysis in the case of Pirotska sausage. On the other hand, there was no significant ($p<0.01$) difference between mean fat contents obtained by the two methods for the rest of the analysed sausages. The results indicate CVS has potential for application in the analysis of fat content of fermented sausages.

Keywords: *computer vision, fat content, fat estimation, fermented sausages, dry sausages.*

Introduction

Dry fermented sausages are an important part of European consumer diet (*Simunovic et al.*, 2020). Average annual consumption of dry and processed meat in Serbia in 2017 was 14.41 kg per capita (*Statistical Office of the Republic of Serbia*, 2018). Generally, fermented sausages are produced using two main ingredients, meat and pork back fat. Characteristics of the final product depend on the type and quality of the ingredients, processing conditions and microbial ecology (*Prado et al.*, 2019). However, fermented sausages are acidified, either by undergoing relatively extensive fermentation processes as a result of the activity of lactic acid bacteria or by addition of acidifiers like glucono-delta-lactone. During fermentation, lactic acid bacteria generate lactic acid which decreases the sausage pH and plays an important role in flavour formation in the final product. In addition, use of different spices like paprika, which is used in production of Chorizo and Kulen, contributes to the development of specific flavour characteristics of sausages (*Salgado et al.*, 2005; *Ikonić et al.*, 2013). Geographic origin, tradition and natural resources have influenced the development of the variety of these meat products around the world.

In recent years, there has been increasing consumption of low-fat products, which led to a number of attempts to reduce fat content in fermented sausages (*Olivares et al.*, 2010; *Stajic et al*., 2018; *Pintado and Cofrades*, 2020). In most cases, addition of fat replacers like olive and linseed oil failed to meet consumer demands in terms of colour, texture and flavour (*Stajic et al*., 2018; *Pintado and Cofrades*, 2020). Fats are important from the physiological point of view because they contain a number of vitamins and essential fatty acids and are an important source of energy. In addition, fat contributes to the different sensory characteristics of flavour, juiciness, appearance and hardness. According to *Olivares et al.* (2010), low-fat fermented sausages were less appreciated by consumers compared to those with higher fat content. On the other hand, fat content is an important economics parameter for dry sausages. Commercial fermented sausages usually

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contain around 32% fat after stuffing and around 40–50% in the end product (*Wirth*, 1988). A higher fat content in sausage formulation reduces the production price due to the lower price of back fat compared to meat. As a consequence of high fat content, the quality of these products can be deteriorated, so fat content is also considered as a quality parameter.

According to Serbian Regulation (*Official Gazette RS*, 2019), the free fat content in fermented sausages should be determined using SRPS ISO 1444:1998, which is identical to ISO 1444:1996 (*ISO*, 1996; *SRPS ISO*, 1998). Apart from being time-consuming and laborious, the method involves the use of organic solvents which are not considered environmentally friendly. More precisely, the method is based on the Soxhlet extraction using n-hexane or petroleum ether. In recent years, an increased interest in the field of green chemistry has been reported (*Doble and Kruthiventi*, 2007). Development of automated, accurate and precise methods that do not require use of organic solvents would be of interest not only for producers and laboratories but for the environment.

In recent years, there has been a number of studies regarding implementation of computer vision system (CVS) into different food industries. In the studies of *Milovanović et al.* (2020) and *Tomasevic et al*. (2019), colour measurements of fresh meat and various processed meats by means of CVS were more accurate and precise than measurements obtained by the traditional method. This was even more obvious for bi-coloured products like fermented sausages. The main advantage of CVS is the possibility of image processing using a number of available software products on the market that provide many different options for the image analysis. A recent study by *Djekic et al.* (2021) demonstrated the possibility of calculating the particle size distribution of boluses obtained from pork ham samples processed by three different culinary methods. Furthermore, the intramuscular fat content of *M. longissimus dorsi* was estimated using a computer vision based method with an accuracy of 82.63% (*Du et al.*, 2008). These results were in accordance with those reported by *Faucitano et al.* (2005), who determined a strong correlation between estimated fat content by CVS and fat content obtained by chemical analysis of pork. The authors identified a knowledge gap in CVS application in the analysis of the fat content of dry sausages. Therefore, the aim of this study was to investigate the possibility of CVS application in fat content estimation for different types of local fermented sausages.

Materials and Methods

Fermented sausages

Four types of fermented sausages with different fat contents were obtained from local manufacturers. Two of the sausages were commercial fermented sausages (Kulen and tea sausage), while the other two were produced by traditional means (Njeguška and Pirot ironed sausage). All the sausages were vacuum packed and transferred to the laboratory in refrigerated boxes.

Determination of fat content

Collagen casings of Kulen and tea sausage were removed prior to homogenisation in a bowl chopper (Blixer 2, Robot Coupe, France). On the other hand, Njeguška and Pirot ironed sausage were homogenised with their edible natural casings. Free fat content was determined according to SRPS ISO 1444:1998 (*SRPS ISO*, 1998). Briefly, homogenised sausages were dried according to ISO 1442:1997 (*ISO,* 1997) until they reached constant mass. Afterwards, dried homogenates were subjected to Soxhlet extraction using n-hexane. Extracted components in n-hexane were dried and measured, based on which, the free fat contents were calculated.

CVS analysis

The CVS system consisted of one closed cubical wooden box illuminated with four fluorescent lamps (Philips, Eindhoven, the Netherlands). The interior of the box was coated with black opaque photographic cloth, as described by *Tomašević et al*. (2019b). Sausages were cut into 10 mm thick slices and placed on a white board. The board with a sausage slice was placed on the bottom of the box and photographed with a Sony Alpha DSLR-A200 digital camera, as previously explained by *Tomašević et al*. (2019b). The procedure was repeated for each type of analysed sausage. Images were imported into Adobe Photoshop 2020 (Adobe Inc., San Jose, CA, USA), where the white background colour was replaced with green in order to avoid interferences during colour segmentation. Processed images were converted into PNG format and imported into ImageJ (National Institutes of Health, Version 1.45 K) software in order to perform colour segmentation. For each picture containing a sausage slice, three clusters were identified using Color Segmentation plugin. The first cluster represented the colour of fatty tissue, the second corresponded to the colour of meat, while the third

Figure 1. Results of colour segmentation analysis of Kulen sausage: original image (left), background colour adjustments (middle) and colour segmentation (right).

referred to the green background colour (Figure 1). The third cluster was only used to calculate percentages for the first two clusters.

Statistical analysis

Mean values and standard deviations were obtained using SPSS package (SPSS 23.0, Chicago, IL, USA). In order to compare results obtained by the two methods, the paired-sample T-test was used, with statistical significance being set at $p<0.01$. MS Excel (Microsoft, Redmond, WA, USA) was used to calculate the percentages of meat and fat areas on the face of the sausage slices.

Results and Discussion

The fat content of Njeguška sausage was the highest among all the analysed sausages. The results are in accordance with the study of *Simunović et al*. (2020), who found high fat content in Njeguška sausage. The estimated fat content of Njeguška sausage by means of CVS was 43.66% while the chemically determined fat content was 44.31% (Table 1). The measurement values obtained by the two methods used were extremely close. The relative error for fat content estimation of Njeguška sausage by CVS was 1.47%. Despite the relatively low relative error of the CVS method, results showed a higher standard deviation (SD) compared to traditional chemical analysis, which indicates that the data were more spread out from the mean. The reasons for this could be in the coarsely ground meat batter and uneven distribution of meat and fat in the sausage. Njeguška is a traditional dry sausage with pieces having a unique cross section, usually formed by mincing the meat and fat through a plate with 13 mm diameter holes (*Simunović et al*. 2020). In addition, production of dry sausages by traditional means usually involves mixing of the batter by hand, which could be the reason for uneven distribution of meat and fat. However, there was no significant ($p<0.01$) difference between mean values obtained by CVS and traditional chemical analysis.

On the other hand, the mean fat content determined by the two methods significantly ($p<0.01$) differed in the case of Pirot ironed sausage. According to *Simunović et al.* (2019), the sausage is traditionally made from a combination of beef, chevon and mutton which are trimmed off visible fat.

Table 1. Estimated fat content (mean±standard deviation) in different types of fermented sausages and comparison of fat contents from CVS and traditional chemical analyses

Type of fermented sausage	Estimated fat content by CVS (%)	Chemically determined fat content (%)	Result comparison (%)
Njeguška	43.66±4.14[a]	44.31±0.19[a]	98.53
Kulen	32.75±4.21[a]	32.60±1.42[a]	100.46
Tea	36.16±1.47[a]	32.52±0.21[a]	111.19
Pirotska	11.25±0.71[a]	9.31±0.04[b]	120.84

Legend: [a, b] Values in the same row followed by different letters are significantly different ($p<0.01$)

However, the final product always contains a low level of fat, partially as a result of the presence of intramuscular fat in meat cuts. The relative error of fat content estimation by CVS in Pirot ironed sausage was 20.84% and was the highest among all analysed sausages. During ripening of Pirot ironed sausage, the natural casing (beef small intestine) into which the meat batter is stuffed becomes covered with white moulds. As mentioned above, a white background colour can interfere with fat colour during colour segmentation. This resulted in the white sausage casing clustering with the fatty tissue, which consequently affected segmentation results. However, the edible casing is considered as part of the product and is homogenised with the sausage prior to chemical analyses. From this, it can be concluded the proposed CVS method needs to be modified in the case of sausages covered with white moulds.

The chemically determined fat content of tea sausage analysed in this study was 32.60%, which is lower than that reported by *Dzinić et al.* (2015). *Dzinić et al.* (2015) analysed tea sausages from six different manufacturers and found that free fat content in analysed sausages varied from 36.43% to 59.80%. The estimated mean fat content of tea sausage by means of CVS was numerically higher than that obtained by chemical analysis (Table 1). However, t-test results showed no significant ($p<0.01$) difference between mean fat contents obtained by the two methods. The relative error of the estimated fat content by means of CVS was 11.19%. This high relative error could indicate that the proposed CVS method has difficulties in colour segmentation of finely chopped fermented sausages. In addition, in the study of *Du et al.* (2008) it was showed that CVS has difficulties in distinguishing between fat and connective tissue due to their similar colours, which could be one of the reasons for our high relative error. Tea sausage is characterised by finely comminuted meat batter that is formed by mincing meat through a plate with 4 mm diameter holes and comminution in a bowl cutter. Fine comminution of meat batter allows producers to use meat with a high content of connective tissue. According to *Official Gazette RS* (2019), the collagen content in total meat proteins must not exceed 15%. However, *Dzinić et al*. (2016) reported the collagen content in total meat proteins of six tea sausages obtained from different producers ranged from 10.09% to 18.11%. The high content of connective tissue could be one of the reasons for the lower accuracy of CVS in estimating the fat content of tea sausage.

In the present study, the chemically determined free fat content of Kulen was 32.60%, which was higher than that reported by *Parunović et al*. (2013) but lower than those reported by *Ikonić et al*. (2010) and *Branković Lazic et al.* (2019). The relative error of the estimated fat content by means of CVS was 0.46%, which was the lowest error among all the sausages analysed. In addition, there was no significant ($p<0.01$) difference between mean fat contents obtained by the two applied methods, which indicates CVS could potentially be applied in the analysis of Kulen's fat content. However, the standard deviation of the CVS method was higher than that of chemical analysis. Because of that, it is important to include an appropriately high number of slices in CVS analysis of Kulen fat content.

The proposed method is based on cluster identification depending on defined R (red), G (green), B (blue) values. Each pixel of an image displays colours by the combination of red, green and blue. Image segmentation is performed by assigning specific RGB colour to a cluster. K-means or hidden Markov model algorithms are then used to calculate the percentage of each defined cluster in the image. More precisely, algorithms process every pixel of an image and match each with just one of the clusters, i.e., with the most closely approximate defined colour. As a result of this process, every pixel of the image is assigned to one of the clusters, and the results are expressed as a percentage for each cluster in the image. Because of this, it is important that background colour of the image is different from the colour of the sample (*Du et al.*, 2008). However, in cases where the white background colour interferes with the colour of fatty tissue, it is advisable to change background colour to produce a clear boundary between background and the sausage slice.

Conclusion

In this study, a novel method for estimation of fat content in fermented sausages was proposed. Fat content estimation showed high accuracy in the case of Kulen, Njeguška and tea sausage. However, high SDs for CVS-estimated fat content indicate that the number of tested sausage slices should be as high as possible in order to obtain more accurate results. Application of the proposed method would reduce time and cost of the analysis compared to traditional chemical measurements. In addition, the method is environmentally friendly because it does not involve use of organic solvents. The proposed CVS method showed difficulties in distinguishing between the colour of fatty tissue and connective tissue.

Procena sadržaja masti u fermentisanim kobasicama primenom kompjuterskog vizuelnog sistema

Stefan Simunović, Sara Rajić, Vesna Đorđević, Vladimir Tomović, Dragan Vujadinović, Ilija Đekić, Igor Tomašević

A p s t r a k t: Cilj ovog rada bio je da se ispita mogućnost primene kompjuterskog vizuelnog sistema u proceni sadržaja masti u različitim tipovima fermentisanih kobasica. Četiri različita tipa fermentisanih kobasica su izabrana: Njeguška, Kulen, Pirotska i Čajna kobasica. Rezultati dobijeni primenom kompjuterskog vizuelnog sistema upoređeni su sa rezultatima sadržaja masti dobijenih pomoću konvencionalne hemijske analize. Relativne greške kompjuterskog vizuelnog sistema u proceni sadržaja masti za Njegušku, Kulen, Pirotsku i Čajnu kobasicu bile su 1.47%, 0.46%, 20.84% i 11.19%, respektivno. Rezultati t-testa pokazali su statistički značajnu ($p<0.01$) razliku između srednjih vrednosti dobijenih pomoću kompjuterskog vizuelnog sistema i hemijske analize u slučaju Pirotske kobasice. Sa druge strane, rezultati nisu pokazali značajne razlike između srednjih vrednosti dobijenih primenom dve metode u slučaju ostalih ispitivanih kobasica. Dobijeni rezultati ukazuju na mogućnost primene komjuterskog vizuelnog sitema u analizi sadržaja masti fermentisanih kobasica.

Ključne reči: *kompjuterski vizuelni sistem, sadržaj masti, fermentisane kobasice, suve kobasice.*

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Brief of preliminary paper

Dietary salt/sodium intake through consumption of animal origin foodstuffs available on the Serbian market

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A b s t r a c t: Salt (sodium chloride) was the first and the best recognised food preservative, particularly for meat. The World Health Organization strongly recommends a reduction in sodium intake in adults to less than 2 g/day sodium (5 g/day salt) to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease, as well a reduction in sodium intake in children to control blood pressure. The goal of this paper was to investigate the salt content as labelled on foods of animal origin from the Serbian retail market. The study reviewed a total of 395 foods, of which 16 were meat preparations, 13 were fresh sausages, 31 were finely minced cooked sausages, 16 were coarsely minced cooked sausages, 39 were patés, 21 were canned meats (luncheon meat type), 10 were pasteurised ham, 26 were pasteurised smoked meat products, 20 were bacon, 8 were semi-dry fermented sausages, 57 were dry fermented sausages, 28 were dry meat, 15 were prepared meat meals, 18 were soft cheese, 36 were semi-hard cheese, 6 were meat soups, 17 were smoked salmon and 18 were sandwiches. The highest declared salt contents are labelled on thermally untreated meat products, i.e. dry meat, bacon, dry and semi-dry fermented sausages and smoked salmon. Pasteurised and sterilised meat products have lower salt contents declared on labels. It was concluded that meat products examined in this study are important sources of dietary salt, and that consumption of 100 g of these products can largely meet daily dietary requirements for salt/sodium. Due to that, it is necessary to reduce salt/sodium content in these foods by decreasing amounts of salt used during production and by using salt substitutes, such as salt with potassium.

Keywords: *salt, sodium, meat products, daily requirements.*

Introduction

Salt's history is important to the history of the human population. Salt (sodium chloride) was the first and the best recognised food preservative, particularly for meat. The discovery of salt had great importance and its use in food was very practical due to it making food more shelf stable and available independently of annual season. Also, it ensured food could be transported for long distances. Salt was one of the first categories of trade and was the subject of taxes, salaries and colonial power. One kilogram of salt was sometimes equal to one kilogram of gold, especially in sub-Saharan Africa. Salt consumption achieved a maximum level during the first years of the 20th century, but salt use has continued to grow along with industrial food production.

Salt is the prototypical stimulus for salty taste (*Dotsch et al*., 2009) and it improves the sensory properties of food by increasing saltiness, decreasing bitterness and increasing sweetness and other congruent flavour effects (*Keast and Breslin*, 2003). However, nowadays, excessive dietary sodium intake from salt is recognised as a main cause of essential hypertension. Besides that, excessive sodium intake can lead to: direct risk of heart attack (*Perry and Beevers*, 1992), hypertrophy of the left heart chamber (*Schmieder and Messerli*, 2000), sodium retention in extracellular fluid (*MacGregor and de Wardener*, 1997), greater possibility of infection by *Helicobacter pylori* and risk of gastric cancer (*Tsugane et al.*, 2004), increase of urinary excretion of calcium and risk of forming of kidney calculi (*Cappuccio et al.*, 2000), risk of reduced bone density (*Devine et al.*, 1995), exacerbations of asthmatic seizures (*Mickleborough et al.*, 2005) and increase of HOMA (homeostasis model assessment) insulin resistance in patients with essential hypertension (*Kuroda et al.*, 1999).

The World Health Organization (WHO) strongly recommends sodium intake in adults is reduced to less than 2 g/day sodium (5 g/day salt) to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease, and sodium

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intake in children is reduced to control blood pressure. The recommended level is based on the energy requirements of children relative to those of adults. There is high-quality evidence that decreasing sodium is beneficial for blood pressure in adults and children, while it has no harmful effect on blood lipids, catecholamine levels, renal function or any minor side effects (e.g. headache and dizziness) in adults or children. Moderate-quality evidence is that reduced sodium is consistent with a benefit to renal function in adults; that reduced sodium is beneficial for reducing risk of cardiovascular disease, stroke and coronary heart disease, because of the well-established relationship between blood pressure and cardiovascular disease outcomes, and; that reduced sodium is beneficial for controlling blood pressure in children (*WHO Guideline*, 2012).

According to European Commission data (*European Commission*, 2013), the highest daily salt intake is in Czech Republic (13.6 g) and similar levels are consumed in Slovenia, Hungary and Portugal (12.7, 12.5 and 12.3 g, respectively). Lower daily consumption levels were established in Poland, Romania, Belgium, Estonia, Norway and Spain (11.5, 11.1, 10.5, 10.0, 10.0 and 10.0 g, respectively). Under 10.0 g/day salt is consumed in Italy, Lithuania, Switzerland, the Netherlands, Denmark, France, Austria, Finland, UK, Sweden, Slovakia, Latvia, Bulgaria, Cyprus and Germany (9.6, 9.0, 9.0, 8.7, 8.6, 8.6, 8.5, 8.1, 8.1, 8.0, 7.6, 7.3, 7.1, 6.5 and 6.3 g/day, respectively) (*European Commission*, 2013).

In most European countries, the greatest salt intake originates from bread, cereals, and bakery products, followed by meat products, cheese and dairy products (*Anderson et al.*, 2010*; Guallar-Castillón et al.*, 2013). There is no adopted international standard for sodium versus salt labelling. The term salt is more common in the European Union, and because of that term, salt instead of sodium should be used on food labels to ensure consumer understanding, according to Regulation (EU) No 1169/2011 (*European Commission*, 2011). Front-of-package labelling used in Serbia provides information about the energy value of food, and fat, saturated fat, carbohydrate, sugar, protein and salt contents in 100 g or 100 ml of food. This information can also be presented as the percentage of an adult's guideline daily amount met by one serving or 100 g or 100 ml of food.

The goal of this paper was to investigate the salt content as labelled on foods of animal origin from the Serbian retail market.

Materials and Methods

The study involved checking the labelled sodium chloride content on the nutrition declarations of a total of 395 foods, of which 16 were meat preparations, 13 were fresh sausages, 31 were finely minced cooked sausages, 16 were coarsely minced cooked sausages, 39 were patés, 21 were canned meats (luncheon meat type), 10 were pasteurised ham, 26 were pasteurised smoked meat products, 20 were bacon, 8 were semi-dry fermented sausages, 57 were dry fermented sausages, 28 were dry meat, 15 were prepared meals were meat, 18 were soft cheese, 36 were semi-hard cheese, 6 were meat soups, 17 were smoked salmon and 18 were sandwiches. Sodium content was calculated by dividing the salt content by 2.5.

The results obtained were statistically evaluated using Microsoft Excel 2010 and are presented as mean ± SD.

Results and discussion

The declared salt content of the foods is presented in Figures 1–6. The highest labelled salt content in this study (Figure 1) was in the range from 2.60 to 6.40 g/100 g (average 4.10 ± 1.21 g/100 g), as labelled on dry meat, then dry fermented sausages in the range from 3.10–4.50 g/100 g (average 3.80 ± 0.36 g/100 g). Lower salt content (Figure 2) was declared on semi-dry fermented sausages, bacon, smoked salmon and pasteurised smoked meat products (3.10–4.50 g/100 g, average 2.80 ± 0.51; 2.00–5.10 g/100 g, average 2.80 ± 0.81; 1.20–3.50 g/100 g, average 2.50 ± 0.61 g/100 g and 1.70–3.30 g/100 g, average 2.70 ± 0.56 g/100 g, respectively. Salt content in food depends on many factors such as type of food, consumer habits and geographical area, but primarily on the production process. A high salt content in these products is expected because they are not produced under high temperature treatments, their production cycle lasts a long time, and salt and low temperature are the main hygienic factors. In thermally untreated food, smoking can also be an important preservation technique. The salt content is very variable, depending primarily on the amount of salt used at the start of production, then on the size of meat (ham, smaller pieces of meat) and consumer consumption habits.

Foods with a salt content around 2 g/100 g were mostly meat products and products using meat as an ingredient. Meat preparations had a declared on-label salt content of 1.40–2.50 g/100, average 1.88 ± 0.41, fresh

sausages 1.65–2.50 g/100 g, average 2.10 ± 0.37 g/100 g, finely minced cooked sausages 1.40–2.50 g/100 g, average 1.80 ± 033 g/100 g, coarsely minced cooked sausages 1.70–2.90 g /100 g, average 2.23 ± 0.33 g/100 g, pasteurised ham 1.60–2.50 g/100 g, average 2.00 ± 0.31 g/100 g, sandwiches 1.70–2.20 g/100 g, average 1.97 ± 0.21 g/100 g, prepared meals of meat 1.10–1.80 g/100 g, average 1.52 ± 0.18 g/100 g (Figure 3 and 4), canned meats (luncheon meat type) 1.40–1.80 g/100 g, average 1.64 ± 0.11 g/100 g, meat soup 1.30–1.60, average 1.43 ± 0.09 and paté 1.10–1.30 g/100 g, average 1.20 ± 0.06 g/100 g (Figure 5). This salt content is primarily the result of the nature of these products, and each product's expected saltiness characteristics, as well as of salt's technological aspects, such as its contribution to consistency and textural characteristics of the products.

Soft cheese had a slightly lower salt content (1.35–2.00 g/100 g, average 1.61 ± 0.22 g/100 g). Although semi-hard cheese had a lower average salt content (1.10 ± 0.83 g/100 g), individual cheeses in this group sometimes had significantly higher salt contents, 0.50–4.00 g/100 g (Figure 6).

Data on the declared sodium contents in the foods are presented in Table 1, and they were in direct correlation with declared salt contents. From the human health aspect, the most interesting data are the percentages of the daily recommended intake of salt/sodium that consumption of 100 g of food meets (Table 2). Up to 100% and sometimes more of daily sodium requirements can be met by consumption of 100 g of some foods: dry meat (52–128%), bacon (40–102%), dry and semi-dry fermented sausages (62–90%), semi-hard cheese (10–80%) and smoked salmon (24–70%). About

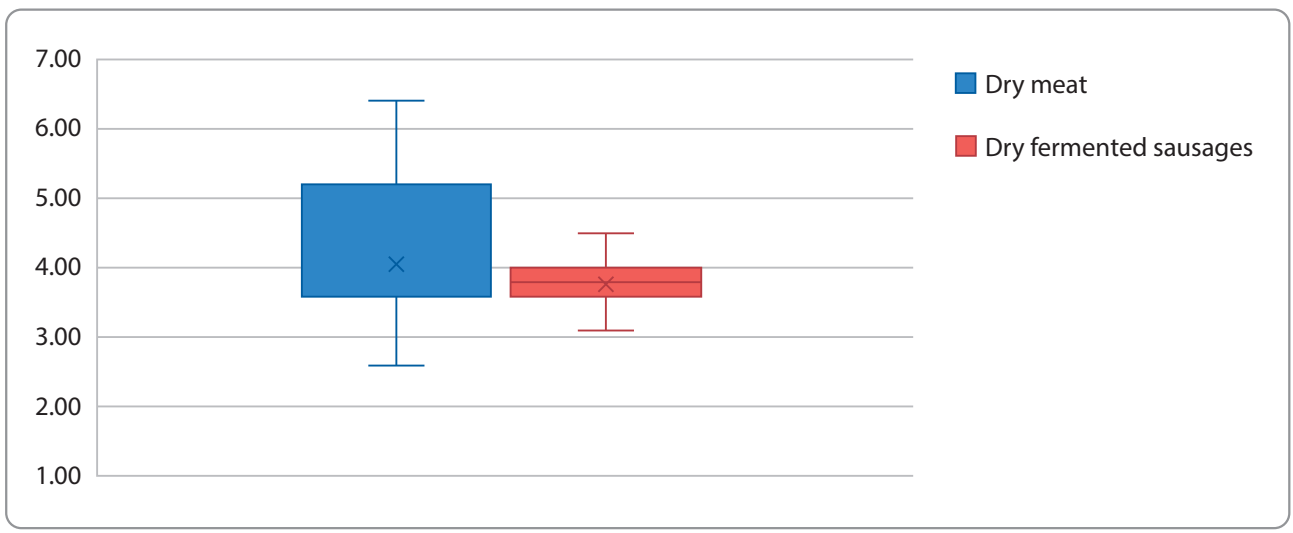

Figure 1. Salt content in dry meat and dry fermented sausages, g/100 g

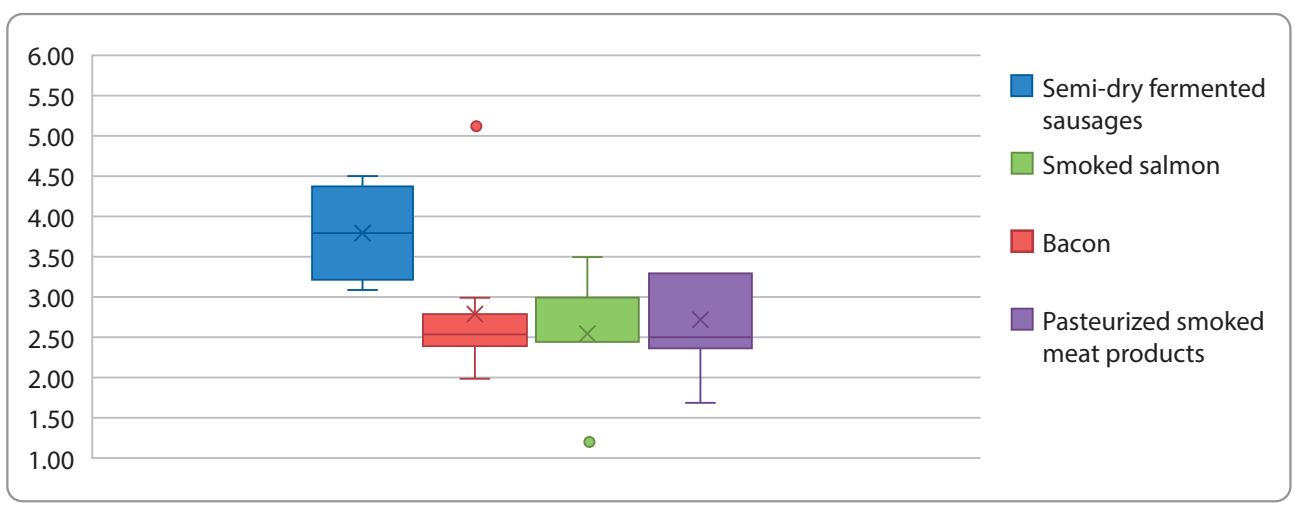

Figure 2. Salt content in semi-dry fermented sausages, bacon, pasteurised smoked meat products and smoked salmon, g/100 g

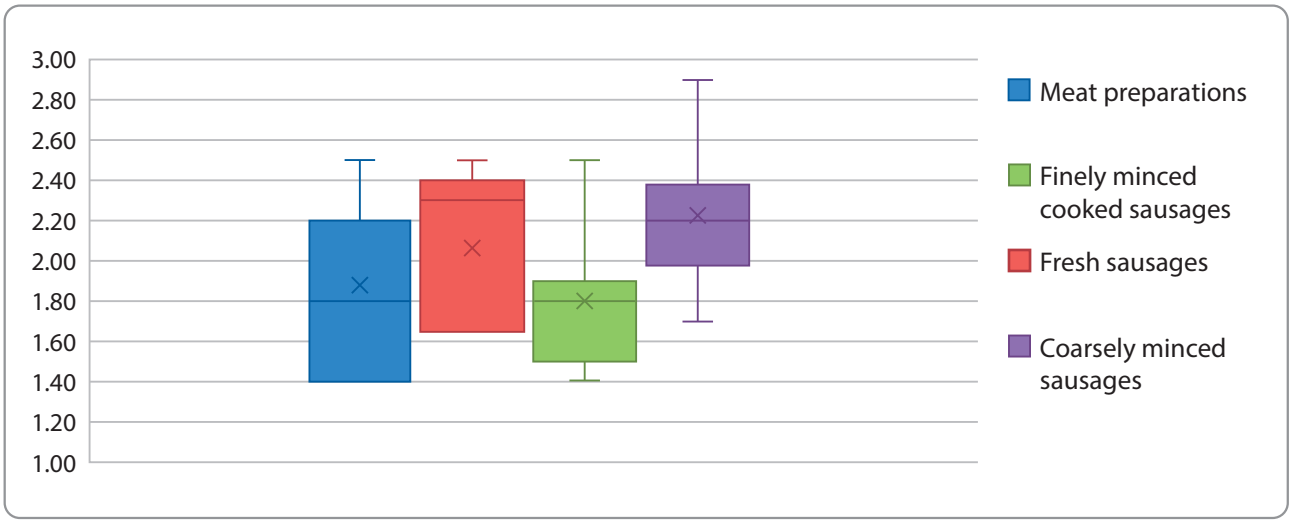

Figure 3. Salt content in meat preparations, fresh sausages, finely and coarsely minces sausages, g/100 g

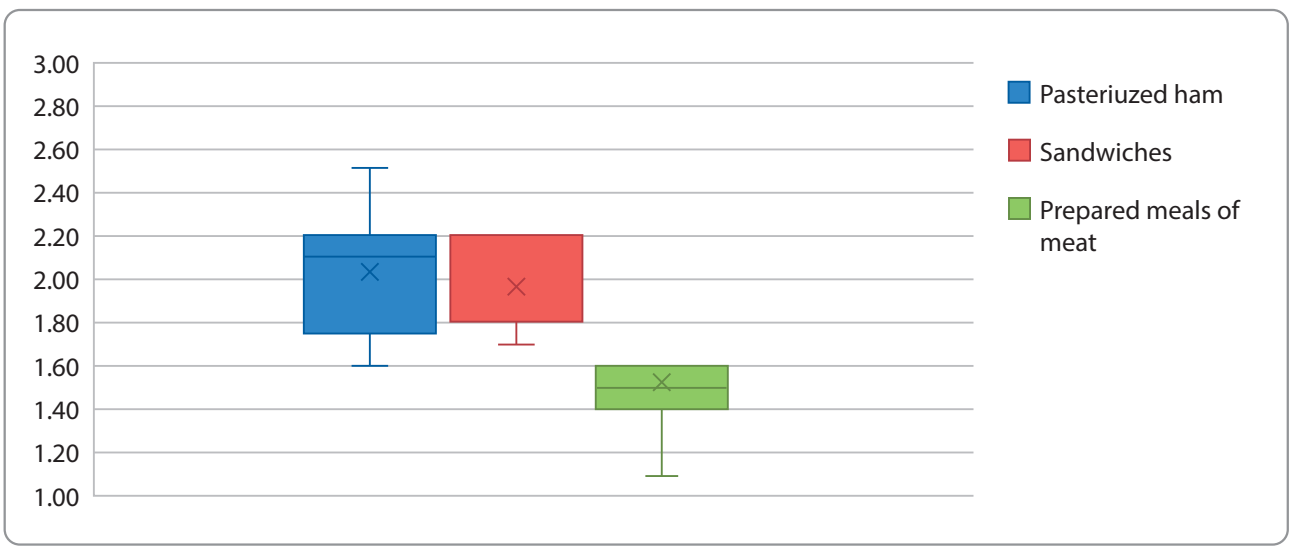

Figure 4. Salt content in pasteurised ham, sandwiches and prepared meals of meat, g/100 g

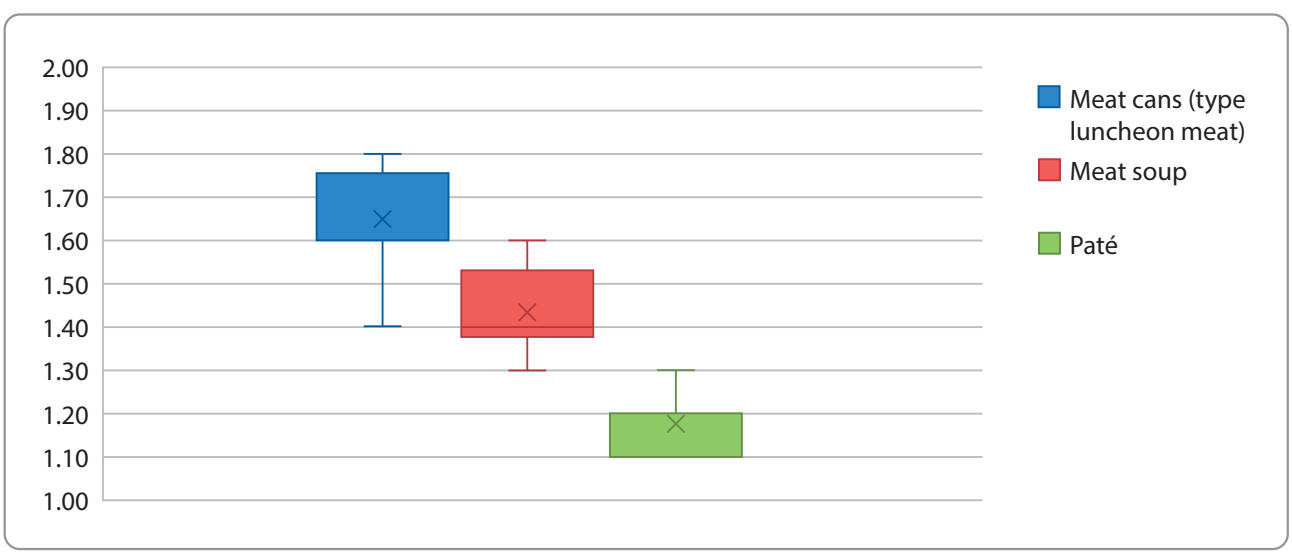

Figure 5. Salt content in canned meats (luncheon meat type), meat soup and paté, g/100 g

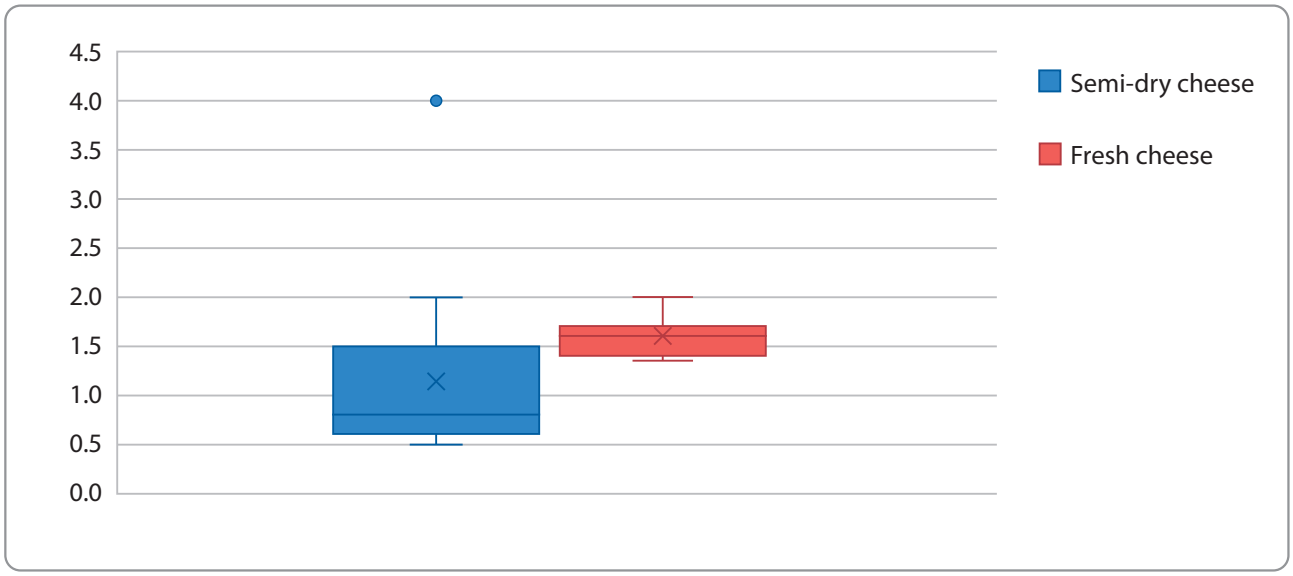

Figure 6. Salt content in semi-dry and fresh cheese, g/100 g

half of daily sodium requirements can be met by consumption of 100 g of some foods: meat preparations (28–50%), fresh sausages (33–50%), finely and coarsely minced cooked sausages (28–50% and 34–58%, respectively), pasteurised smoked meat products (34–66%), pasteurised ham (32–50%) and sandwiches (34–44%).

It can be concluded that meat products, especially thermally untreated meat products, are one of the main dietary sources of sodium. Although other meat products are preserved with high temperature (pasteurisation or sterilisation), they are also important sources of sodium due to salt imparting a desirable taste, and to consumer consumption habits.

Table 1. Sodium content (mean values and ranges) declared on food labels, mg/100 g

	n	Sodium (mean ± SD)	Range
Meat preparations	16	752.50 ± 162.62	560–1000
Fresh sausages	13	826.15 ± 149.33	660–1000
Cooked sausages, finely minced	31	720.00 ± 130.11	560–1000
Cooked sausages, coarsely minced	16	890.00 ± 132.29	680–1160
Paté	39	468.72 ± 25.54	440–520
Canned meat (luncheon meat type)	21	657.14 ± 45.48	560–720
Pasteurised ham	10	808.00 ± 122.38	640–1000
Pasteurised, smoked meat products	26	1086.15 ± 224.55	680–1320
Bacon	20	1120.00 ± 324.47	800–2040
Semi-dry fermented sausages	8	1520.00 ± 205.91	1240–1800
Dry fermented sausages	57	1504.56 ± 144.47	1240–1800
Dry meat	28	1620.00 ± 483.62	1040–2560
Prepared meat meals	15	608.00 ± 73.32	440–720
Soft cheese	18	643.33 ± 88.25	540–800
Semi-hard cheese	36	453.33 ± 330.12	200–1600
Meat soup	6	573.33 ± 37.71	520–640
Smoked salmon	17	1023.53 ± 242.82	480–1400
Sandwiches	18	786.67 ± 84.33	680–880

Table 2. Percentage of sodium chloride (NaCl) and sodium (Na) (mean values and ranges) in recommended daily requirements (*WHO Guideline, 2012*) met by consumption of 100 g of food

	n	NaCl (mean)	NaCl (range)	Na (mean)	Na (range)
Meat preparations	16	31.33	23.33–41.67	37.63	28.00–50.00
Fresh sausages	13	35.00	27.50–41.67	41.30	33.00–50.00
Cooked sausages, finely minced	31	30.00	23.33–41.66	36.00	28.00–50.00
Cooked sausages, coarsely minced	16	37.17	28.33–48.33	44.50	34.00–58.00
Paté	39	20.00	18.33–21.67	23.44	22.00–26.00
Canned meat (luncheon meat type)	21	27.33	23.33–30.00	32.86	28.00–36.00
Pasteurised ham	10	33.33	26.67–41.67	40.40	32.00–50.00
Pasteurised, smoked meat products	26	45.00	28.33–55.00	54.31	34.00–66.00
Bacon	20	46.67	33.33–85.00	56.00	40.00–102.00
Semi-dry fermented sausages	8	46.67	51.67–75.00	76.00	62.00–90.00
Dry fermented sausages	57	63.33	51.67–74.00	75.23	62.00–90.00
Dry meat	28	68.33	43.33–106.67	81.00	52.00–128.00
Prepared meals of meat	15	25.33	18.33–30.00	30.40	22.00–36.00
Soft cheese	18	26.83	22.50–23.33	32.17	27.00–40.00
Semi-hard cheese	36	18.33	8.33–66.67	22.67	10.00–80.00
Meat soup	6	23.83	21.67–26.67	28.67	26.00–32.00
Smoked salmon	17	41.67	20.00–58.33	51.18	24.00–70.00
Sandwiches	18	32.83	28.33–36.67	39.33	34.00–44.00

Conclusion

The main retail food products with high salt/sodium contents declared on labels are thermally untreated meat products, i.e. dry meat, bacon, smoked salmon and dry and semi-dry fermented sausages. Lower amounts of salt are declared on other meat products. In general, 100 g of the examined foods mostly met half or 100% of the daily recommended requirements for salt and sodium. Due to that, it is necessary to reduce the salt/sodium content in these foods by decreasing the amount of salt used during production and by using salt substitutes, such as salt with potassium. Also, foods with large amounts of salt should be combined with other kinds of foods, such as vegetable and fruit rich in potassium, to achieve WHO recommendations for salt intake.

Unos soli/natrijuma hranom animalnog porekla sa tržišta Srbije

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A p s t r a k t: So (natrijum hlorid) je prvi konzervans za hranu, posebno za meso. Svetska zdravstvena organizacija donela je stroge preporuke za smanjenje unosa natrijuma u cilju snižavanja krvnog pritiska i rizika od pojave kardiovaskularnih oboljenja, moždanog i srčanog udara, na manje od 2 g natrijuma dnevno (5 g soli dnevno), kako kod odraslih, tako i kod dece. Cilj rada bio je da se istraži sadržaj soli deklarisan na proizvodima animalnog porekla sa tržišta Srbije. Ogled je obuhvatio pregled deklaracija ukupno 395 uzoraka hrane, od toga 16 uzoraka poluproizvoda od mesa, 13 uzoraka svežih kobasica, 31 uzorak fino usitnjenih barenih kobasica, 16 uzoraka grubo usitnjenih barenih kobasica, 39 uzoraka pašteta, 21 uzorak konzervi od usitnjenog mesa, 10 uzoraka pasterizovane šunke, 26 uzoraka dimljenih proizvoda od mesa, 20 uzoraka slanine, 8 uzoraka fermentisanih polusuvih kobasica, 57 uzoraka fermentisanih suvih kobasica, 28 uzoraka suvog mesa, 15 uzoraka pripremljenih jela od mesa, 18 uzoraka mekog sira, 36 uzoraka polutvrdog sira, 6 uzoraka mesnih supa, 17 uzoraka dimljenog lososa i 18 uzoraka sendviča. Najveći sadržaj soli deklarisan je na termički netretiranim proizvodima od mesa, kao što su suvo meso, slanina, fermentisane polusuve i suve kobasice i dimljenom lososu. Nešto manji sadržaj soli deklarisan je na pasterizovanim i sterilizovanim proizvodima od mesa. Može da se zaključi da proizvodi od mesa predstavljaju značajn izvor soli i, da se konzumiranjem 100 g ovih proizvoda, može da se zadovolji celokupna dnevna potreba u soli, odnosno natrijumu. Zbog toga, neophodno je smanjiti sadržaj soli, odnosno natrijuma u hrani, smanjivanjem dodate soli u proizvodnji, kao i korišćenjem supstituenata soli, u prvom redu solima kalijuma.

Ključne reči: *so, natrijum, proizvodi od mesa, dnevne potrebe.*

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Towards delineating butchers' knowledge base, challenges encountered, and enhancement prospects of meat inspection processes: A cattle slaughterhouse case analysis

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A b s t r a c t: There is a paucity of relevant literature about what Nigerian butchers know and challenges encountered, especially during cattle meat inspection processes. Butchers, if encouraged to put forward their suggestions so as to improve the meat inspection process, together with their advice to the veterinarians, can serve as (future) enhancement prospects. This study aimed towards delineating the butchers' knowledge base, challenges encountered, and enhancement prospects of meat inspection processes via case analysis of a cattle slaughterhouse at Nsukka urban, considered representative of many others in Nigeria. A semi-structure questionnaire via interview was administered to 54 butchers, with interview time dependent on their availability and convenience. The butchers, all male (Freq.=100.0%, n=54), largely secondary school educated, most with >5 years of work experience and delivering ≥5 days/week work patterns, were very familiar with slaughterhouse components, clearly understood what meat inspection is and appeared always prepared for the worst outcomes. Butchers (Freq.=98.15%, n=53) considered meat inspection important ($p<0.0001$, H-adj.=99.22) to increasingly prioritise beef meat and consumer safety. Butchers' challenges in the meat inspection process include the fear of losing the beef meat, or entire cattle carcass and the financial implications of any loss. Despite some positively ($p<0.05$) correlated variables, the latter obtained similar odds ratios trends based on the butchers' years of work experience. The butchers' acceptance of negative meat inspection outcomes can improve if veterinarians engage more effectively.

Keywords: *meat handlers; challenges; meat hygiene; veterinarian; correlation; logistic regression.*

Introduction

Globally, the demand for livestock products increases with changing consumer landscape/preferences, economic improvement/progress, as well as population growth and urbanization (*Agus and Widi*, 2018). In Nigeria, cattle have long served as an important meat source, largely under the care of nomadic rearers (*Kabir, Umoh and Umoh*, 2002). Despite being considered the most important source of animal protein, beef meat increasingly occupies a very important consumer space across various communities (*Udoh and Akintola*, 2003). As meat processing large depends on livestock production (*Tambi and Maina*, 2003; *Tambi, Maina, and Bessin*, 2003), the beef (meat) market value continually provides employment to the butchers (*Lawal-Adebowale*, 2012). The cattle used for the beef meat in Nigeria are predominantly Zebu species. Typically, the edible (meat with offals and bones) portions constitute over 70% of a slaughtered cattle carcass (*Omole and Ogbiye*, 2013). Besides the slaughterhouse serving as the control authority with approved/registered premises for slaughtering and dressing animals such as cattle (*CAC*, 1993; *Bello et al.,* 2015), the direct purpose remains to produce beef (meat), not only through hygienic slaughtering and dressing technique(s) but importantly, through proper, humane handling of the cattle (*Bello et al.,* 2015; *Okpala and Korzeniowska*, 2021; *Veall,* 1992). In addition, slaughterhouse and its regulations are a vital aspect of the control of livestock production chain (*Raji et al.,* 2010). Despite the butchers' capacity to purchase, slaughter, and dress slaughtered (cattle) individually, the design of slaughterhouses should be such to provide the adequate facilities that sustain high-quality hygienic conditions. In many parts of Africa, slaughterhouses function largely under the administrative authority of the districts/local governments/states (*Adeyemo et al.,* 2009; *Aftab et al.,* 2012).

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As a well-established aspect of veterinary public health, meat inspection started with a visual and risk-based focus on contemporary disease panorama. Its epidemiological picture has evolved, such that current (meat) inspection techniques do not easily detect the causative agents of zoonotic diseases like salmonellosis, campylobacteriosis, and yersiniosis. Together with other classical zoonoses, these abovementioned zoonotic diseases appear no longer a significant issue in most developed industrialized countries (*EFSA*, 2011; *Alvseike et al.,* 2018). Among the food safety function of veterinarians, the meat inspection process involves looking closely at the slaughterhouse's live animals (antemortem) and carcasses (postmortem) (*Raheem and Ameen*, 2008). Specific to beef processing, veterinarians usually examine the: head, oesophagus and spleen, lungs and heart, bile duct and liver, and other accessible carcass lymph nodes, diaphragm and kidneys, carcass internal and external surfaces (*The Meat Inspection Process*, 1990). To reiterate, the primary objective of the meat inspection process is to protect the consumer and enhance good animal health/welfare. This usually involves a wide range of measures, not only within the slaughterhouses but also, throughout the meat value chain. The key focus is to reduce

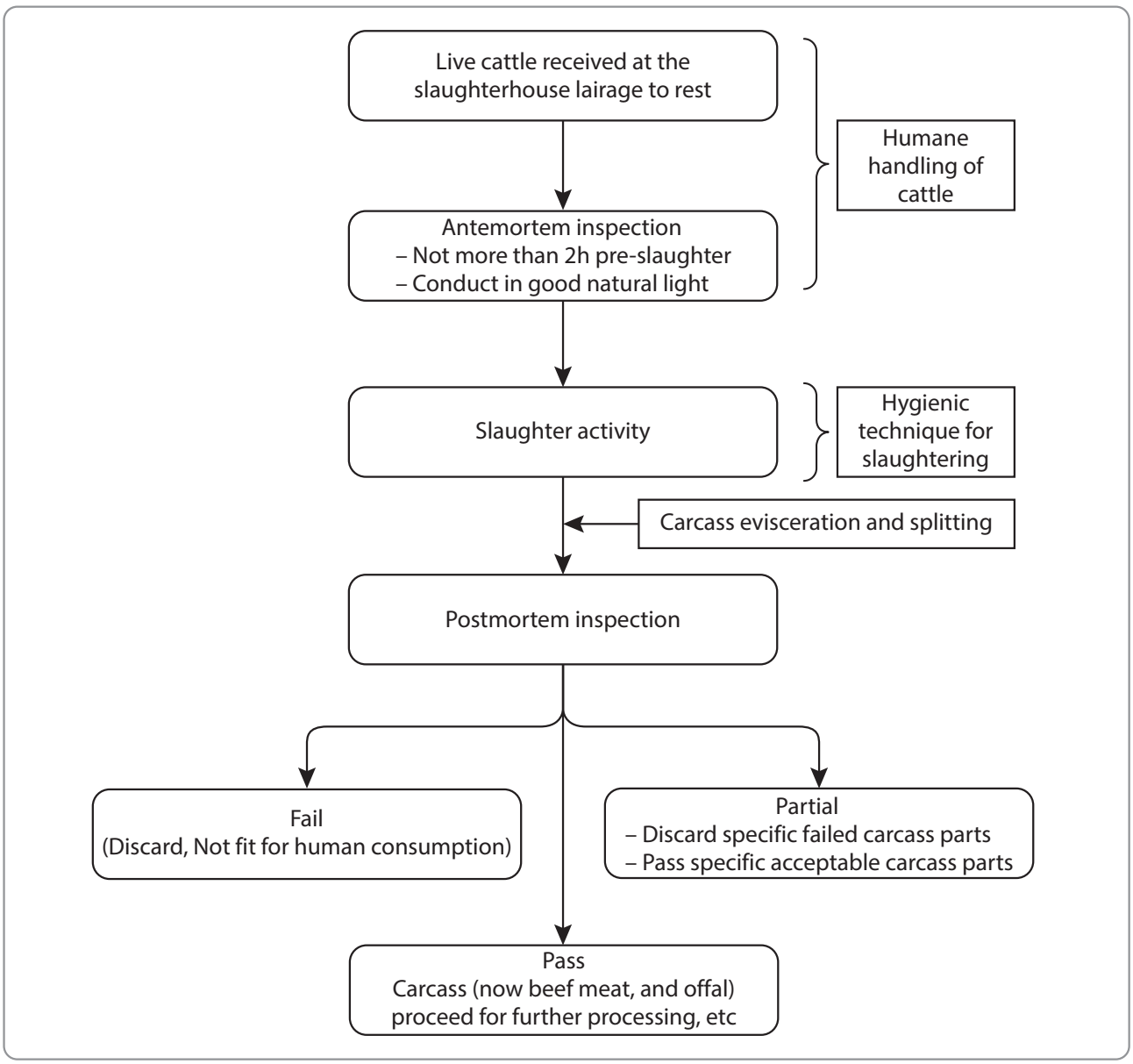

Figure 1. A schematic representation of the basic meat inspection activities involving cattle slaughter in a typical slaughterhouse in Nigeria. Before and after antemortem inspection, the stages involving humane handling of cattle and hygienic techniques for slaughter are shown. Usually, the postmortem inspection would result in three major outcomes to the eviscerated/split cattle carcass/beef meat, which are either fail, partial, or pass.

the foodborne risks to consumers, with great emphasis on the prevention and control of contamination throughout the slaughtering and dressing processes (*Alvseike et al.,* 2018). A schematic representation of the basic meat inspection activities involving cattle slaughter in a typical slaughterhouse in Nigeria is shown in Figure 1. As can be deciphered, the butcher has a number of functions within the slaughter process. Some functions include assembling the live cattle into the slaughterhouse lairage, conducting the slaughter process, carcass evisceration, carcass split into desirable portions, and ensuring the latter are well prepared for sale/storage. The core of (bovine) meat inspection involves two major well-known facets, antemortem and postmortem inspection. The slaughter of cattle, regardless of any slight variations, must involve optimal hygienic techniques. In addition, the postmortem inspection outputs three major judgments: pass, partial, or fail. The importance of the butcher is best appreciated when witnessing the slaughtering activity/process. The differences in butchery practice remain fundamental to dismemberment of the carcass and its surrounding issues (*Seetah*, 2002). Besides acting as buyer to marketing the cattle, the butchers in the various slaughterhouses link both meat production and processing chain (*Musemwa et al.,* 2008; *Prabhakar et al.*, 2017).

Butchers in a typical Nigerian slaughterhouse witness the entire meat inspection process, similar to other cattle-rich nations. In addition, butchers are poised to meet the occupational health and hygiene and infrastructural requirements, in order to comply with the prerequisite food safety standards. Despite this, the meat inspection process can, at times and inevitably, get complicated. Whether the meat inspection procedures were impromptu or prearranged, such complicated meat inspection process situations could pose a wide range of challenges. In such contexts, the considerations of *Prinsen et al*. (2020) would indeed be useful, because when such butcher-meat inspection challenges emerge, there is the need to resolve them very quickly, which could be through either some form of negotiation and diplomacy, or some kind of self-regulation. Therefore, the degree/level of butchers' knowledge and understanding of the meat inspection processes is crucial, if problem-solving approaches were to be established, especially for meat inspection controversies and considering the sensitive nature of the butchers' work. Nonetheless, there is a paucity of relevant literature about what Nigerian butchers know and challenges encountered, especially during cattle meat inspection processes. Besides, there are a wide range of challenges/problems that butchers and their slaughterhouses encounter. For example, *Adeyemo et al.* (2009) reported the cruel handling of cattle at slaughterhouses in Oyo, Nigeria. Poor sanitation practices in cattle slaughterhouses is not new, and has been reported even in Tanzania (*Komba et al.*, 2012; *Ndalama et al.* 2013). Elsewhere, *Afnabi et al*. (2014) reported on the typology of slaughterhouses in Northern Cameroon, and observed the hygiene practices of butchers, especially during production, involve poor personnel management/treatment processes of carcass.

Besides the challenges/problems butchers confront in their slaughterhouses in many parts of Nigeria, understanding the problems, as well as getting them involved in the problem-solving strategies should be useful. Butchers if encouraged to put forward their suggestions so as to improve the meat inspection process, together with their advice to the veterinarians, can serve as (future) enhancement prospects. Considering all above-mentioned, the authors herein decided to conduct a case analysis of a slaughterhouse in Nigeria, which would help establish what butchers know and understand regarding the challenges encountered during the meat inspection processes. To supplement existing information, this study aimed towards delineating the butchers' knowledge base, challenges encountered, and enhancement prospects for meat inspection processes *via* case analysis of a cattle slaughterhouse at Nsukka urban, considered representative of many others typical in other local governments/states around Nigeria. We hypothesised that the butchers' responses would generate useful information, to help make meat inspection processes less complicated and conflict-free.

Materials and Methods

Schematic overview of case study

A schematic overview of the current study, indicating the development of research instruments, study design, conducted interviews, informal discussions, data analysis, delineating results, and conducting discussions using the available relevant literature synthesis, is shown in Figure 2. Essentially, this specific slaughterhouse was selected because of the important role it plays, from receiving the cattle, slaughter, processing, and packaging, to the eventual beef meat supply to the increasingly thriving Nsukka market situated in Enugu State, Nigeria.

Ethical approval

Ethical approval was not required for the study. Moreover, this study was carried out in adherence to the code of ethics of the World Medical Association Declaration of Helsinki (WMA, 2013). Specifically, informed consent was orally obtained from all butchers who participated in this study. Also, participation was voluntary.

Study area and target population

Well-known as a university town, Nsukka urban in Enugu State, Nigeria is situated at latitude 6° 45' and 7° N and longitude 7° 12.5' and 7° 36' E with an estimated population of about 1.26 million (Nwanta, *Onunkwo, and Ezenduka*, 2010). The butchers at the Nsukka slaughterhouse were the target population, who by experience, expertise, and delivery of services, are typically representative of others situated in various communities across their respective local government areas (LGAs) around the country.

Development of research instrument

The research instrument employed for the data collection took the form of a semi-structured questionnaire administered through an interview approach. Specifically, the interview approach was adopted to save time and enabled the butchers to have more time to attempt more, if not all questions, given the nature of their work. The questionnaire

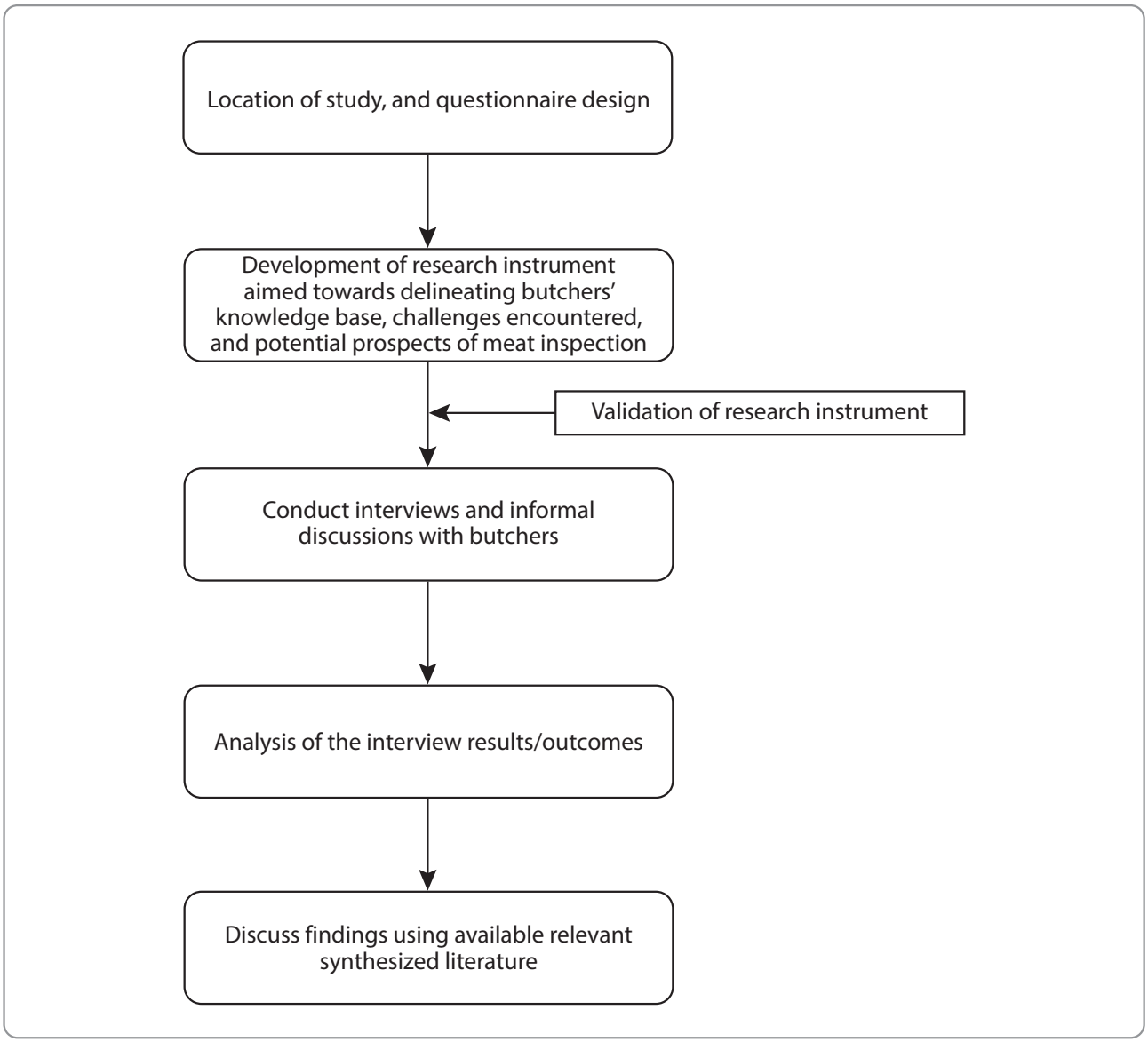

Figure 2. The schematic overview of the current study, from the design of questionnaire, conducted interviews and informal discussions, data analysis, to discussing findings using the relevant synthesized literature.

was developed *via* a combination of synthesized relevant literature and authors' experience/expertise. Content validation was conducted by a specialist veterinarian together with a lead butcher, both with substantial years of cattle slaughter and slaughterhouse experience, when combined. Specifically, content validation, as highly recommended by *Taherdoost* (2016), helps to amend the research instrument questions, with the primary purpose of strengthening their relevance and representation to the target (research) construct as well as the context of the investigated study. During the content validation process, the questions in the research instrument were critically examined based on contents and contexts, and amended where necessary, which altogether strengthened its relevance and representation to the targeted research construct/context of this current case study. Before the research instrument could be administered, it had to be approved by the lead butcher, who represented the Nsukka butchers association.

Questionnaire content and interview process

The questionnaire of this current study can be defined as a semi-structured type. Specifically, the questionnaire content comprised more open-ended rather than closed-structured items. The entire questionnaire presented the following five sections: i) Section A focused on the demographic and work experience/pattern of butchers; ii) Section B focused on the butchers' familiarity with slaughterhouse facilities; iii) Section C focused on the butchers' knowledge base regards the meat inspection process; iv) Section D focused on the butchers' challenges encountered during the meat inspection process, and v) Section E focused on the butchers' suggestions to improve the meat inspection process and engaging with the veterinarians. There were 39 items in total, which were distributed as follows: Section A = 6 items (6 structured questions); Section B = 6 items (4 open-ended and 2 structured questions); Section C = 7 items (6 open-ended and 1 structured questions), Section D = 16 items (8 open-ended and 8 structured questions), and Section E = 4 items (2 open-ended and 2 structured questions).

The entire interview activities were carried out in June 2020. During the slaughterhouse visits, face-to-face interviews were conducted, along with some informal discussions. A total of 54 butchers were interviewed. Each interview started with a brief relay of the study's objective to the butcher before the items in the questionnaire were presented. The interview was carried out at the convenience of interviewees (butchers) and specifically, in such a way that it assured their anonymity, and encouraged their pro-active participation and willingness to provide information in a non-biased/objective fashion. To ease the interviewee's understanding of questions when difficulties arose, the use of vernacular was applied without any change of both content(s) and context(s) of the specific questionnaire item. This was carried out to enhance the butchers' understanding of the questions, and to prevent the butcher feeling any form/kind of stress, which ensured they were comfortable/relaxed throughout the interview. In addition, the interview process was such that the questions were posed to the butchers, and their responses were simultaneously written down by the interviewer (veterinarian). With this approach, the interview time would be maximized as well as optimized, to note down as much information possible. The interview time was dependent on the availability and convenience of the interviewees (butchers). In the situation where the interviews could not be accomplished/performed on the day, another time was scheduled to the agreement of both parties.

Statistical analysis

All data were subject to the Anderson-Darling normality test, which showed it as non-parametric. The Kruskal-Wallis analysis of variance (ANOVA) test was, therefore, applied to establish whether any statistical difference existed between the response variables. Analysed data were presented in terms of frequencies, percentages, and H-adjusted (H-adj) values. Where correlation was required, Spearman's test was applied and its coefficient (r) was reported. Minitab Express software (version 1.5.3, Minitab Ltd., Coventry, UK) was used to run the statistical analysis. In addition, the open-ended responses were analysed using the word-based technique described by *Ryan and Bernard* (2003). Texts, based on the butchers' responses, were sorted to develop specific statements. The frequency of occurrence was tallied, ranked and reported as percentage. Simple binomial logistic regression was used for some studied variables, to examine whether any relationships existed between any dependent and independent variables. In order to understand the outcomes, the odds ratios and Akaike Information Criteria (AIC) were determined. Specifically, the simple binomial logistic regression of data was run using the R statistical software (RStudio, PBC, Boston USA). The probability of alpha error was accepted at 0.05.

Results and Discussion

Demographics and work experience/pattern

The demographic and work experience/pattern of butchers of the current study is shown in Table 1. The butchers were all ($p<0.0001$, H-adj.=107.00) male (Freq.=100.0%, n=54). Male-dominated slaughterhouses are not a new phenomenon, as has been reported by other researchers (*Adzitey et al.,* 2018; *Asuming-Bediako et al.*, 2018; *Simpson et al.,* 2011; Simpson *et al.*, 2014; *Voracek et al.*, 2010). Furthermore, significantly more butchers ($p<0.0001$, H-adj.=28.66) had secondary level education (Freq.=55.56%, n=30), over primary (Freq.=20.37%, n=11) and tertiary (Freq.=11.11%, n=6) education levels. In their study conducted at another location, *Otupiri et al*. (2000) reported butchers had no formal training but acquired their trade exclusively from older colleagues. Previously, *Afnabi et al*. (2014) associated butchers that had primary education with the Knowledge-Attitude-Practice model, which considers the behaviour and practice dependent on the individual's knowledge, together with the new information being acquired. This specific form of knowledge acquisition can directly result in a change of attitude, and consequently, the individual's behaviour. Besides, the current study showed butchers with >5 years' experience (Freq.=66.67%, n=36) were significantly more numerous ($p<0.0001$, H-adj.=51.56) than those with 1–5 years' (Freq.=29.63%, n=16) work experience. Additionally, butchers mostly (Freq.=66.67%, n=36) ($p<0.0001$, H-adj.=17.86) indicated the studied slaughterhouse was their first workplace. From these specific butchers (n=36), those with >5 years' work experience (Freq.=48.15%, n=26) were more common ($p<0.0001$, H-adj.=37.89) than butchers with 1–5 years' (Freq.=16.67%, n=9) work experience. Finally, almost all butchers (Freq.=98.15%, n=53) ($p<0.0001$, H-adj.=103.11) delivered ≥ 5 days/week work patterns.

Butchers' familiarity with slaughterhouse components

When asked what a slaughterhouse was, almost all the butchers (Freq.=94.44%, n=51) openly responded 'a place where cattle beast brought in for slaughter, and its beef meat subsequently made available for public consumption as well as purchase'. When asked the purpose of slaughterhouse, butchers' (n=53) open responses ranked: to kill/slaughter cattle (Freq.=62.96%, n=34) > to enhance

Table 1. The demographics and work experience/patterns of butchers in the current study

Item	Category	% (n)	H-adj.	P-value
Sex	Male	100.00%(n=54)	107.00	<0.0001
	Female	0% (n=0)		
Educational status	Primary	20.37%(n=11)	28.66	<0.0001
	Secondary	55.56%(n=30)		
	Tertiary	11.11%(n=6)		
Years of work experience as a butcher	<1 year	1.85% (n=1)	51.56	<0.0001
	1–5 years	29.63%(n=16)		
	>5years	66.67% (n=36)		
Is this slaughterhouse your first workplace?	Yes	66.67% (n=36)	17.86	<0.0001
	No	25.93% (n=14)		
If yes, how long have you been here?	<1 year	0% (n=0)	37.89	<0.0001
	1–5 years	16.67% (n=9)		
	>5years	48.15% (n=26)		
Work pattern	<5 days/week	0% (n=0)	103.11	<0.0001
	≥5 days/week	98.15% (n=53)		

Legend: % = Frequency; n=Number of respondents; H-adj.= Kruskal-Walis H-value; p-value = Statistically significant at $p<0.05$

slaughtered cattle hygiene/safety, make it free from contamination (Freq.=24.07%, n=13) > to prepare slaughtered cattle and transport to places of consumption/sale (Freq.=11.11%, n=6).

The numbers of butchers familiar (Freq.=48.15%, n=26) or not familiar (Freq.=51.85%, n=28) with slaughterhouse components were not significantly different ($p>0.05$, H-adj.=0.15). Those familiar with the slaughterhouse components openly responded with examples (where n=number of occurrences of the examples), which ranked: water source (Freq.=20.54%, n=23) > slab (Freq.=16.96%, n=19) > lairage (Freq.=9.82%, n=11) ≈ cold room (Freq.=9.82%, n=11) > drainage system (Freq.=8.93%, n=10) > veterinary office (Freq.=8.04%, n=9) > knives (Freq.=7.14%, n=8) ≈ security office (Freq.=7.14%, n=8) > light (Freq.=4.46%, n=5) > sanitation materials (Freq.=3.57%, n=4) ≈ fireplace (Freq.=3.57%, n=4). Despite their formal educational level/limitations, the knowledge butchers showed about the various components of the slaughterhouse appears very reasonable. Nonetheless, most slaughterhouses in Nigeria are guided by regulatory frameworks of local/state government, with prerequisite standards regarding construction/location, ancillary facilities, procedures for humane slaughter (of cattle), and involvement of personnel, including post-slaughter handling of the beef carcass/meat (*Annan-Prah et al.*, 2012).

Out of those familiar (Freq.=48.15%, n=26) with the slaughterhouse components, almost all (Freq.= 96.15%, n=25) markedly ($p<0.0001$, H-adj.=43.46) explained the use of either one or more components (where n=number of occurrence of the examples explained) and open-responses ranked: water source (water supply for washing meat, and for cleaning equipment/slaughterhouse environment) (Freq.=24.14%, n=21) > slab (where beef meat is placed, cut/dressed as well as displayed) (Freq.=19.54%, n=17) > drainage system (to ease the discharge/passage/removal of slaughterhouse fluid waste) (Freq.=11.49%, n=10) ≈ lairage: for keeping the live cattle (Freq.=11.49%, n=10) > knives (for cutting (beef meat) and slaughtering {cattle}) (Freq.=8.05%, n=7) > veterinary office (where veterinarians and officials stay) (Freq.=5.75%, n=5) ≈ security office/post (keeping the slaughterhouse safe) (Freq.=5.75%, n=5) > cold room (beef meat storage) (Freq.=4.60%, n=4) > light (to help see properly) (Freq.=3.45%, n=3) ≈ sanitization materials (used in cleaning the slaughterhouse and its environment) (Freq.=3.45%, n=3) > fireplace (for burning debris removed from slaughterhouse, as well as roasting beef meat) (Freq.=2.30%, n=2). Take for instance, the cutting implements, which are considered very essential in the butchery practice, since their nature and shape determine the technique applied to dismember the cattle (*Seetah*, 2002). On the other hand, given that disease can occur and potentially spread in the slaughterhouse, Raji, Salami, and *Ameh* (2010) emphasized the proper burning of diseased meat as a mandatory as well as recommended practice. The availability of the fireplace in the studied slaughterhouse should, therefore, be a good plus. Additionally, improved slaughterhouses in Nigeria with modern laboratory and cold room facilities would help achieve as well as sustain the wholesomeness of beef meat, which makes it fit for human consumption. The hygiene situation of a slaughterhouse would provide a useful signal about the health status of slaughtered animals. Certainly, sustaining the hygiene situation of slaughterhouses at the optimal level will help reduce the incidence of foodborne disease spread and meat contamination.

Butchers' knowledge base about the meat inspection process

When asked 'what do you understand about meat inspection', butchers' (n=40) responses ranked: when veterinarians check the health status (i.e., any challenging problems in the liver, lungs, etc.) of cattle to be killed/slaughtered (Freq.=31.48%, n=17) ≈ the process to carefully examine the beef meat after slaughter (Freq.=31.48%, n=17) > the process veterinarian employs to check the killed cattle so as to obtain wholesome meat, very safe for consumption, and if bad, to condemn it (Freq.=22.22%, n=12) > when veterinarian checks if the cattle being slaughtered has any infection, sickness or, is just healthy enough for the public consumption (Freq.=11.11%, n=6). Almost all butchers significantly ($p<0.0001$, H-adj.=99.22) considered the meat inspection 'important' (Freq.=98.15%, n=53). When asked why, butchers' (n=49) open-responses ranked: to check and ensure the beef meat is safe before it is sold to the consumer (Freq.=22.45%, n=11) > to stop the distribution and remove bad (contaminated/diseased/infected) beef meat that should not be consumed (Freq.=20.41%, n=10) > to make sure only quality safe meats of good health status are sold (Freq.=18.37%, n=9) > to detect/identify the foodborne disease and prevent its spread/transmission from cattle to consumer public (Freq.=16.33%, n=8) > if beef meat is not properly checked, the public will consume contaminated beef meat (Freq.=14.29%, n=7) > help to separate off sick cattle that may not be with good/healthy beef meat (Freq.=8.16%, n=4).

When asked which area(s) of meat inspection was/were most important, butchers' (n=25) open-responses ranked: all aspects of meat inspection are important (Freq.=60.0%, n=15) > checking the dead/killed cattle first before the live ones (Freq.=20.0%, n=5) ≈ checking head, liver, muscle, and intestines of slaughtered cattle (Freq.=20.0%, n=5).

Generally, the Nigerian populace believes that butchers know their duties and responsibilities. Butchers, therefore, have to make the best effort to grow their expected and prerequisite knowledge and skills in meat inspection procedures and processes, which they acquire through their routine exposures to pre-slaughter, slaughter, and post-slaughter (cattle) activities. Whereas some earlier slaughterhouse surveys have focused on the entire organs of the animal body, some others have done so only on one or two organs. The incidences of abnormalities obtained in such surveys, even across different geographical locations, have widely varied. Factors like the degree of veterinary inspection/supervision, and the critical appraisal of the identified abnormalities by the person conducting the survey, have affected the findings of such surveys (*Raji et al.*, 2010; *Al-Dahash and David*, 1977; *Okoli*, 2001). In this current study, when asked specifically whether inspecting the cattle either 'before' or 'after' slaughter was more important, the butchers' (n=50) open-responses ranked: 'after' slaughter (Freq.=72.0%, n=36) > 'before' slaughter (Freq.=20.0%, n=10) > both (Freq.=8.0%, n=4). When asked what meat inspection 'before' and 'after' slaughter was called, one butcher came close to calling 'before' a 'physical examination' whereas another was correct to call 'after' as 'postmortem'. However, almost all butchers were unable to name 'antemortem', and 'postmortem' inspection, which should not be surprising. This is because there is published evidence of butchers unable to identify/name essential aspects closely related to the meat inspection process. For example, *Otupiri et al*. (2000) reported that butchers in a Kumasi slaughterhouse in Ghana were unaware of common/frequent foodborne diseases, such as salmonellosis and or anthrax. A way out of this challenge could follow *Raji et al.* (2010), who proffered the need for a committed effort to educate butchers (and cattle traders) thoroughly about meat inspection of cattle. This would help the butchers appreciate the meat inspection process much more. In addition, as butchers have close contact with cattle destined to be slaughtered (*Otupiri et al.*, 2000), their capacity to acquire additional meat inspection knowledge should not be underestimated.

Delineating butchers' challenges encountered during the meat inspection process

An attempt to delineate butchers' challenges encountered during the meat inspection process is shown in Table 2. When asked if they were 'comfortable' with any aspect of meat inspection, the number of butchers who indicated 'yes' (Freq.=46.30%, n=25) did not significantly differ ($p>0.05$) from those who indicated 'no' (Freq.=46.30%, n=25). The butchers (n=25) who indicated 'yes' to 'comfortable' openly shared their thoughts, which ranked: inspection considered important parts like head, lungs, liver and intestine (Freq.= 56.0%, n=14) > comfortable at all aspects of the meat inspection process (Freq.= 36.0%, n=9) > veterinarians empower the butchers with calmness, confidence, and trust during the meat inspection process (Freq.=8.0%, n=2). When asked if they were 'uncomfortable' with any aspect of meat inspection, butchers who indicated 'no' (Freq.=81.48%, n=44) were significantly more numerous ($p<0.0001$, H-adj.=42.42) than those who indicated 'yes' (Freq.=18.52%, n=10). The butchers (n=10) who indicated 'yes' to 'uncomfortable', openly shared their thoughts, which ranked: liver if bad signals a big problem because of the anticipated loss (Freq.= 60.0%, n=6) > the manner in which veterinarians speak about the condemned meat oftentimes is not pleasant (Freq.=10.0%, n=1) > there are situations when butchers did not believe the veterinarians (Freq.=10.0%, n=1). Although a significant ($p<0.0001$, H-adj.=77.64) majority of butchers agreed the inspectors were well engaged during the meat inspection (Freq.=92.59%, n=50) (Table 4), the few who indicated 'no' (Freq.=7.41%, n=4) openly shared their thoughts, which ranked: the veterinarians sometimes make it so difficult to be well engaged with (Freq.= 5.6%, n=3) > veterinarians sometimes do not elaborate on why the meat being condemned is bad (Freq.=1.8%, n=1).

The financial implications of condemned beef meat for the butchers have been well reported (*Antia and Alonge*, 1982; *Halle,* 1998; *Raji et al.*, 2010). A significant ($p<0.0001$, H-adj.=99.22) majority of butchers (Freq.=98.15%, n=53) agreed that the meat inspection process added value to their profession (Table 4). One butcher (Freq.=1.89%, n=1), who indicated the meat inspection process did not add value, openly shared that the process sometimes confuses them (butchers). Clearly, the butchers greatly depend on the veterinarians, who provide quality checks for the beef meat product and for cattle health status. In this context, butchers (and cattle traders) should be encouraged to seek the assistance of

veterinarians, particularly for their sick cattle, in order to reduce meat contamination (*Raji et al*., 2010). Besides strengthening how the meat inspection process adds value, butchers of this current study called for a greater well-engaged (meat inspection) process, which would allow veterinarian's decision making to be further explained, considering that the butchers' professional existence equally depends on it. Despite this, the butchers recognize the meat inspection process, either directly or indirectly, provides (some) inspiration and protects their profession.

Significantly ($p<0.0001$, H-adj=24.81), many butchers appeared not worried about the final outcome of the meat inspection process (Freq.=74.07%, n=40) (Table 4). On the other hand, those who indicated they were worried (Freq.=25.93%, n=14) shared their thoughts, which ranked: destruction of condemned meat (Freq.=7.41%, n=4) > loss of money from condemned meat portions (Freq.=5.56%, n=3) > personal feeling about (sick) cattle's health when it is condemned (Freq.=3.70%, n=2) ≈ loss of borrowed/loaned funds used to purchase cattle, now condemned, so it is double loss (Freq.=3.70%, n=2). Clearly, the butchers invest a lot into achieving a strong health status for the cattle especially pre-slaughter. It is, therefore, not a good situation when either an animal and/or its beef meat is condemned, based on the inspection verdict of a severe nature infection, which renders the beef meat unfit for human consumption. Such meat inspection outcomes, if not upheld, would definitely lead to public health implications and when upheld, on the other hand, poses immense financial implications for the butchers. A previous report about beef retail in Zaria, Nigeria, indicated the cost of 1 kg of cattle liver, lung, and heart as of 2010 to be around $1. So, if an animal had been struck by disease, and beef meat were to be condemned, one could only but imagine the significant

Table 2. An attempt to delineate butchers' challenges encountered during meat inspection process

Item	Category	% (n)	H-adj.	P-value
Any aspect of meat inspection 'comfortable'?	Yes	46.30% (n=25)	0.00	>0.05
	No	46.30% (n=25)		
Any aspect of meat inspection 'uncomfortable'?	Yes	18.52% (n=10)	42.42	<0.0001
	No	81.48% (n=44)		
Well engaged with vet. officers at meat inspection process?	Yes	92.59% (n=50)	77.64	<0.0001
	No	7.41% (n=4)		
Do vet. officers and meat inspection process add-value?	Yes	98.15% (n=53)	99.22	<0.0001
	No	1.85% (n=1)		
You worry about meat inspection process outcome?	Yes	25.93% (n=14)	24.81	<0.0001
	No	74.07% (n=40)		
Do you see the meat inspection process as time-consuming?	Yes	7.41% (n=4)	77.64	<0.0001
	No	92.59% (n=50)		
Do you have a voice during the meat inspection process?	Yes	83.33% (n=45)	47.56	<0.0001
	No	16.67% (n=9)		
Any other meat inspection process challenges to share?	Yes	9.26% (n=5)	71.04	<0.0001
	No	90.74% (n=49)		

Legend: % = Frequency; n=Number of respondents; H-adj.= Kruskal-Walis H-value; p-value = Statistically significant at $p<0.05$

financial loss such would bring to the livestock industry (*Raji et al.*, 2010). Besides the clear financial and public health implications, there is also the quality management implication for the beef meat product. If the meat inspection is not thorough enough, the quality management output will be compromised. In the current work, almost all the butchers (Freq.=92.59%, n=50) significantly ($p<0.0001$,H-adj.=77.64) considered the meat inspection not time-consuming. However, those who indicated the meat inspection was time consuming (Freq.=7.41%, n=4) (Table 4), openly responded that more hands were needed to make the process faster, especially in the situations when increased quantities of cattle were being slaughtered. To reiterate, the meat inspection process requires veterinarians' objectivity, consistency, and thoroughness to assure consumer protection and safety.

Many butchers (Freq.=83.33%, n=45) significantly ($p<0.0001$, H-adj.= 47.56) indicated they have a voice during the meat inspection process (Table 4). On the other hand, those who believed they have no voice during the meat inspection process (Freq.=16.67%, n=9) openly shared their thoughts, which ranked: veterinarians know better, so we have to adhere to what they say (Freq.=7.41%, n=4) > veterinarians cannot be questioned because they follow well established regulatory framework/guidelines (Freq.=3.70%, n=2) ≈ one cannot do anything about bad/condemned meat, but to discard it (Freq.=3.70%, n=2) > sometimes, the meat inspection process brings fear, and the butcher is unable to do or say anything (Freq.=1.85%, n=1). From these open responses, the butchers believe the veterinarians have a role to play in empowering them to have a voice, especially in the meat inspection process. When asked if there were any other challenges encountered during the meat inspection process, butchers who indicated 'yes' (Freq.=9.26%, n=5) were significantly fewer in number ($p<0.00001$, H-adj.=71.04) than those who indicated 'no' (Freq.=90.74%, n=49). The few who indicated 'yes' to any other challenges encountered during the meat inspection openly shared their thoughts, which ranked: at times, some beef meat, not entirely bad in our opinion and that ought not to be condemned, is condemned (Freq.=7.41%, n=4) > sometimes, the veterinarian makes the meat inspection procedure very complicated for the butchers to follow/understand (Freq.=1.85%, n=1). Indeed, we can deduce the butchers are strongly attached to both the cattle and emergent beef meat. By streamlining the meat inspection process, the butchers could become more persuaded to accept the eventual decision/outcome reached by the veterinarian(s).

Enhancement prospects for the meat inspection process

When asked if there were suggestions to improve the meat inspection processes, butchers who indicated 'yes' (Freq.=42.59%, n=23) appeared not significantly different in number ($p>0.05$, H-adj.=1.80) from those who indicated 'no' (Freq.=57.41%, n=31). Some of those who indicated 'yes' openly shared their suggestions, which ranked: the meat inspection process should be a source of encouraging the veterinary officials despite the challenges (Freq.=16.67%, n=9) > the meat inspection process should not only focus on beef meat and cattle but also, the slaughterhouse, its environment, hygiene as well as sanitation (Freq.=7.41%, n=4) ≈ the meat inspection should remain a detailed process especially when there are many (cattle) being slaughtered (Freq.=7.41%, n=4) > the meat inspection process should be consistent throughout, especially in adherence to the established regulatory guidelines/framework (Freq.=3.70%, n=2) > the meat inspection process should enable the veterinary officials to make themselves more accessible and available (Freq.=1.85%, n=1). Clearly, it can be deduced that the butchers herein strongly believe in the meat inspection process, and equally understand that it can be very challenging. Despite this, butchers still desire more from (and beyond) the meat inspection process.

When asked if they had any general advice to the veterinarians, the number of butchers who indicated 'yes' (Freq.=57.41%, n=31) appeared not significantly more ($p>0.05$, H-adj.=2.35) than those who indicated 'no' (Freq.=42.59%, n=23). Some of those who indicated 'yes', openly shared their advice, which ranked: veterinarians should increase their consistency, diligence and objectivity, with no favouritism during the meat inspection process, for the public good (Freq.=25.93%, n=14) > veterinarians should not be aggressive, but should treat the owner of cattle/beef meat with some regard/respect (Freq.=7.41%, n=4) ≈ veterinarians should find a way to compensate/placate the butchers whose meat has (now) been condemned (Freq.=7.41%, n=4) > veterinarians should see the (meat) inspection process as a means to further educate/equip the butchers (Freq.=3.70%, n=2) ≈ veterinarians should show empathy, especially for the loss borne by the butcher of a condemned cattle/beef meat, and discuss amicably, and calmly (Freq.=3.70%, n=2) ≈ veterinarians should help add to the voice of butchers, especially in seeking the assistance of local/state government towards improving the meat inspection process/slaughterhouse facilities (Freq.=3.70%, n=2). In offering

their advice, butchers herein seem critical and at the same time somewhat objective, yet, cognisant of the importance of the meat inspection process, and desirous to learn more. Indeed, the butchers demand increased empathy from the veterinarians. Essentially, the butchers also believe veterinarians have a crucial role to play, not only in the meat inspection process, but also, in the progress of the slaughterhouse.

Correlation and logistic regression outcomes

The correlation tests can reveal how strongly one variable brings about some change in and or movement of another (*Mat Roni et al.,* 2020). Whether such change in, and/or movement of, is negative (inversely related) or positive (directly related), the correlation tests remain depicted by way of coefficient (r) and probability (p) values (*Okpala and Bono*, 2016). In an attempt to deduce whether butchers' knowledge base is associated with any potential challenges, correlation tests were performed. The correlation coefficients obtained between significant elements of frequent responses from butchers' knowledge base and challenges encountered of meat inspection processes is shown in Table 3. A total of five positive significant correlations were found. Butchers who indicated 'yes' that veterinarians engaged well, strongly correlated with the meat inspection process (and veterinarians) adding value (r=0.485643, p=0.0002). Interestingly, butchers familiar with and able to explain the slaughterhouse components strongly associated with those who did not worry about the final outcome of the meat inspection process (r=0.316736, p=0.0196). The butchers who indicated 'no' to any aspects of the meat inspection process considered 'uncomfortable', strongly associated with the meat inspection process 'not' being time-consuming (r=0.411262, p=0.0020). The butchers who did not worry about the final outcome strongly associated with the meat inspection process 'not' being time-consuming (r=0.316736, p=0.0196). Unsurprisingly, butchers who indicated the meat inspection process/veterinarians add value to their profession strongly associated with not having any other (meat inspection) challenges to share (r=0.430007, p=0.0012). Moreover, butchers should be considered as full-fledged professionals in their right, despite the rather repetitive and routine nature of their activities in the slaughterhouse.

Table 3. Correlation coefficients obtained between significant elements of frequent responses from butchers' knowledge base and challenges encountered in meat inspection processes.

	A1	B1	C1	C2	C3	C4	C5	C6
B1	–0.038851 [1] 0.7803 [2]							
C1	0.047194 0.7347	–0.065484 0.6380						
C2	–0.080000 0.5653	–0.038851 0.7803	–0.134840 0.3310					
C3	–0.038851 0.7803	–0.018868 0.8923	–0.065484 0.6380	*0.485643* *0.0002**				
C4	*0.316736* *0.0196**	–0.081264 0.5591	0.153106 0.2690	–0.167332 0.2265	–0.081264 0.5591			
C5	–0.080000 0.5653	–0.038851 0.7803	*0.411262* *0.0020**	–0.080000 0.5653	–0.038851 0.7803	*0.316736* *0.0196**		
C6	0.063246 0.6496	–0.061430 0.6590	0.042640 0.7597	0.063246 0.6496	–0.061430 0.6590	0.188982 0.1711	–0.126491 0.3621	
C7	–0.090351 0.5159	–0.043878 0.7527	–0.152286 0.2716	0.153596 0.2675	0.430007 0.0012*	0.102590 0.4604	–0.090351 0.5159	0.028571 0.8375

Legend: [1]Correlation coefficient, [2]Probability Level; *Correlation data (also presented in italics) significantly different at p<0.05; A1 = Butchers familiar with slaughterhouse components and able to explain it; B1 = Butchers who indicated 'yes' to meat inspection as important; C1 = Butchers who indicated 'no' to finding aspects of meat inspection 'uncomfortable'; C2 = Butchers who indicated 'yes' that they were well engaged with veterinarians during the meat inspection process; C3 = Butchers who indicated 'yes' that meat inspection process+veterinarians added value to their profession; C4 = Butchers who indicated 'no' to worrying about the final outcome of the meat inspection process; C5 = Butchers who indicated 'no' to meat inspection process being time-consuming; C6 = Butchers who indicated they have a 'voice' during the meat inspection process; C7 = Butchers who had no other challenges concerning the meat inspection process.

To interpret logistic regression outcomes, and less depend on the probability levels, the use of odds ratios can help to measure the unique effect of predictor on outcome, given its ability to be scaled-up without confrontation of boundary points of between 0 and 1 (Gelman and Hill, 2007). Excluding sex and work pattern, the butchers' years of work experience (<1 year, 1–5 years, and or >5 years) by obtaining a reasonable H-adj value of 51.56, was deemed suitable as the predictor in the logistic regression test. The influence of butchers' years of work experience on the studied meat inspection slaughterhouse variables using simple logistic regression analysis is shown in Table 4. Despite the obtained non-significant (p>0.05) probability results, the butchers' years of work experience produced three odds ratios trends on the meat inspection slaughterhouse (output) variables. Firstly, those who indicated 'yes' to being familiar with slaughterhouse components, are comfortable with aspects of meat inspection, and worry about the final outcome of the meat inspection process obtained similar odds ratios trend (<1 year: odds ratios=1; 1–5 years: odds ratios= >1; >5 years: odds ratios= >1). Secondly, those who indicated 'yes' to considering meat inspection important, and that veterinarians and the meat inspection process add value, obtained similar odds

Table 4. Influence of butchers' years of work experience on the studied meat inspection slaughterhouse variables using simple logistic regression analysis

Variables	Years of work experience	Odds Ratio	Level of Probability*	AIC
Indicated 'yes' to familiar with slaughterhouse components	<1 1–5 >5	1 >1 >1	p>0.05	79.73
Indicated 'yes' to consider 'meat inspection' important	<1 1–5 >5	1 1 <1	p>0.05	17.14
Indicated 'yes' to comfortable with aspects of meat inspection	<1 1–5 >5	1 >1 >1	p>0.05	76.97
Indicated 'yes' to uncomfortable with aspects of meat inspection	<1 1–5 >5	1 >1 >1	p>0.05	58.91
Indicated 'yes' to well engaged with veterinarians at meat inspection process	<1 1–5 >5	>1 >1 >1	p>0.05	28.65
Indicated 'yes' that veterinarians and meat inspection process add value	<1 1–5 >5	1 1 <1	p>0.05	17.14
Indicated 'yes' to worry about final outcome of meat inspection process	<1 1–5 >5	1 >1 >1	p>0.05	68.54
Indicated 'yes' the meat inspection process as time consuming	<1 1–5 >5	1 1 >1	p>0.05	33.12
Indicated 'yes' to have a voice during the meat inspection process	<1 1–5 >5	1 1 >1	p>0.05	55.88
Indicated 'yes' to other meat inspection challenges to share	<1 1–5 >5	1 1 >1	p>0.05	37.01

Legend: Key: AIC = Akaike Information Criterion; *Level of significance set at <0.05

ratios trend (<1 year: odds ratios=1; 1–5 years: odds ratios= 1; >5 years: odds ratios= <1). Thirdly, those who indicated 'yes' to meat inspection process being time consuming, who have a voice during the meat inspection process, and who had other meat inspection challenges to share, obtained similar odds ratio trend (<1 year: odds ratios=1; 1–5 years: odds ratios= 1; >5years: odds ratios= >1).

Moreover, AIC has been deemed useful to determine the authenticity, and validity of regression (models) outcomes, even when the sample size of a given study is small (*Hurvich and Tsai*, 1989). Table 7 shows the AIC value was least (AIC=17.14) for those butchers who indicated 'yes' that veterinarians and the meat inspection process add value, and greatest (AIC=79.73) for those butchers who indicated 'yes' that they were familiar with slaughterhouse components. Through their years of work experience, butchers could develop a better appreciation and understanding about how veterinarians and meat inspection process could add value to their profession. Deducing from *Tyre et al*. (2003), the AIC would be the estimate of constant with the relative distance between the unknown true likelihood function of data, and fitted likelihood function of model, wherein the lower AIC depicted the model considered as closer to the truth.

Limitations of study

In the implementation process of this current work, a number of limitations, in our opinion, were delineated. Firstly, the small sample size of the current study, that is, 54 butchers, as well as that it focused on one slaughterhouse, might be considered a limitation to this study. The small sample size might also limit the detectability of years of work experience predictor to logistically regress any influence on the studied meat inspection slaughterhouse variables. Moreover, there is a possibility that a study investigating the same specific objective, but capturing more butchers, and to a large extent, more slaughterhouses, could provide a different outcome. Secondly, even though the slaughterhouse in the current study resembles others in various LGAs in Nigeria, the discussion herein might not be adequately/fully representative of Nigeria's butchers'/slaughterhouses' circumstances. Nigeria being a multicultural and multi-ethnic nation, both butchers' work terrain and slaughterhouse circumstances in the various local governments would differ. Thirdly, although any conducted meat inspection procedure/process largely coordinated by any veterinarian in Nigeria would typically adhere to and be consistent with the prescribed format learned through Doctor of Veterinary Medicine (DVM) training as delivered across the veterinary schools, how the butchers associate and connect with one (or more) veterinarian(s) has a fair chance to differ within and across slaughterhouses. Fourthly, there were some questions posed to the butchers that required either 'yes' or 'no'. The butchers providing such answers could be perceived as a limitation. According to *Okpala, Nwobi and Korzeniowska* (2021), such responses might not necessarily reveal the truth. Additionally, the various attributes of knowledge base, challenges encountered, and enhancement prospects of meat inspection process studied herein might be perceived to appear rather preliminary. Howbeit, we hold the opinion that this current work lays a robust foundation for future studies. Considering all the above-mentioned limitations, nonetheless, the database the current study has created serves great benefit to all the involved parties, that is, from butchers, slaughterhouse management, consumers, government/policy makers, to researchers.

Conclusions

Through this current slaughterhouse case analysis, a strong attempt has been made towards delineating the butchers' knowledge base, challenges encountered, and enhancement prospects for meat inspection processes. The butchers, male-dominated, largely secondary level educated with over five years of work experience, delivered mostly ≥5 days/week work patterns. Besides their great familiarity with the slaughterhouse components, butchers undoubtedly know what the meat inspection process entails and appear always prepared for the worst of the outcomes.

Almost all butchers considered the meat inspection important, greatly prioritizing checking and ensuring the beef meat is safe before it is sold to the consumer. Besides some positively correlated variables, the latter obtained resembling odds ratios trends in butchers' years of work experience. Butchers' greatest challenge in the meat inspection process is the fear of losing their beef meat. The meat inspection process requires veterinarians' objectivity, consistency, and thoroughness to assure consumer protection and safety. It is clear the butchers need more help in the meat inspection process so as to become more persuaded to accept the eventual decision/outcome reached by the veterinarians. Despite this, the butchers still believe in the meat inspection process, with the understanding that it is equally very challenging.

The butchers' acceptance of negative meat inspection outcomes could improve if veterinarians engage more effectively. Nonetheless, the butchers desire more from the veterinarians, and beyond the meat inspection process. For instance, they demand empathy from the veterinarians, and to enable butchers to add a voice in order to help improve the slaughterhouse's progress for the public good. Clearly, the repetitive nature of the butchers' daily routines is reflected in their capacity to develop and grow in their profession through years of work experience. The butchers yearn for both local and state governments of Nigeria to fund the improvement of their knowledge base. Additionally, butchers yearn for more cooperation and understanding from veterinarians, especially during the meat inspection processes, so that it becomes less complicated, more motivating, and conflict-free. Future work should be directed on the financial and public health implications of meat inspection outcomes, and this can be achieved through more robust case studies.

Razgraničenje baze znanja mesara, izazovi i perspektive za poboljšanje postupka inspekcije mesa: primer klanice goveda

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A p s t r a k t: Postoji relevantna literatura o onome što nigerijski mesari znaju i izazovima sa kojima se susreću, posebno tokom procesa inspekcije mesa goveda. Mesari, podstaknuti da iznesu svoje predloge za poboljšanje procesa inspekcije mesa, zajedno sa savetima veterinara, mogu poslužiti kao (budući) faktori poboljšanja. Ova studija imala je za cilj da razgraniči bazu znanja mesara, izazove sa kojima se susreću i perspektive za poboljšanje postupka inspekcije mesa, kroz analizu slučaja/primera klanice goveda u Nsukka urbanu, koja se smatra predstavnicom mnogih drugih u Nigeriji. Polustrukturalni upitnik je distrivuiran putem intervjua mesarima, ukupno 54 osobe, a vreme intervjua zavisilo je od njihove dostupnosti i pogodnosti. Mesari, muškarci (frekv. = 100 %, n = 54), uglavnom srednješkolsko obrazovani, većina sa> 5 godina radnog iskustva i radnom nedeljom od ≥ 5 dana, bili su vrlo dobro upoznati sa komponentama klanica, jasno su razumeli šta je inspekcija mesa i činilo se da su uvek bili pripremljeni za najgore ishode. Mesari (frekv. = 98,15%, n = 53) su bili mišljenja da je inspekcija mesa važna (p <0,0001, H-adj. = 99,22) kako bi se prioritet dao govođem mesu i bezbednosti potrošača. Izazovi mesara u postupku inspekcije mesa uključuju strah od gubitka govođeg mesa ili celog trupa stoke, kao i finansijske implikacije bilo kakvog gubitka. Uprkos nekim pozitivnim (p <0,05) promenljivim vrednostima u korelaciji, kasnije dobijeni slični trendovi odnosa kvota na osnovu radnog iskustva mesara. Prihvatanje negativnih rezultata inspekcije mesa od strane mesara može se poboljšati ako se veterinari efikasnije angažuju.

Ključne reči: *rukovaoci mesom; izazovi; higijena mesa; veterinar; korelacija; logistička regresija.*

Authors contributions: CORO conceptualized the study, prepared the research instrument, conducted literature synthesis, supervised the research survey, drafted the initial draft, and developed the intellectual content of the manuscript. OCN participated to validate the research instrument, implemented the research survey, and contributed to the intellectual content of the manuscript. MK supervised the validation of the research instrument and contributed to the intellectual content of the manuscript. All authors approved the final manuscript draft/version for publication.

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Original scientific paper

The capacities of laboratories in Serbia for testing meat quality and safety

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A b s t r a c t: Thanks to its content, and primarily due to that of nutrient materials, meat can be found nearly daily in the diet of humans. Predictions indicate that the upcoming period expects to see a rise in both the production and consumption of meat worldwide. However, in addition to satisfying the needs of the consumers in terms of the quantity of meat, it is also important to satisfy their needs when it comes to quality, meat safety, and the reliability of the information provided. Furthermore, it is in the interest of the consumer that the testing of the meat be carried out in accredited laboratories in line with SRPS ISO/IEC 17025:2017. Bearing in mind the great number of parameters which are tested with the aim of determining quality, safety, and meat authenticity, it is the goal of this paper to analyse the capacities of the accredited laboratories for carrying out such tests. By applying the methodology (the Accreditation Body of Serbia's website was searched), it was determined that 58 laboratories in Serbia have at least one, but more commonly multiple accredited methods which each laboratory can use in order to examine several of the parameters for safety and/or meat quality. It was determined that the capacities of the laboratories, in both the private and the public sectors, for testing the parameters of meat quality and safety in Serbia were sufficient, particularly for the parameters of meat safety which, according to research, is the area which worries consumers the most. What should definitely be a joint task for testing laboratories and the state competent authorities is the development of methods through which meat fraud could be detected.

Keywords: *meat, safety, quality, fraud, laboratory testing, accreditation.*

Introduction

Thanks to its nutritional content, meat is one of the most valuable foods in existence and is present in the diet of most people on a near-daily basis (*Baltic & Boskovic*, 2015). Animal-based proteins are also known as complete proteins, given that they contain all essential amino acids (*Zhubi-Bakija et al.,* 2021). In addition to essential amino acids, meat is a significant source of micronutrients, particularly Fe, Zn, Se, Cu, Mg, Co, Pb, Cr, and Ni. Furthermore, it is important to highlight that these elements are far more efficiently absorbed compared with those of plant-based origin. Meat, alongside other animal-based food, is an important source of vitamin B12, which vegetarians and vegans tend to have a deficit of (*Stanisic et al.,* 2018).

Bearing in mind the importance of animal-based protein for the human diet, the need for animal-based protein is reflected in the ever-growing production of meat worldwide. Despite the fall of meat production globally as a consequence of 2019's African Swine Fever outbreak, the predictions for production and consumption of meat look different for the upcoming period. According to data (*OECD/FAO,* 2020), it is believed that the consumption of meat will increase by 12% by the year 2029. The prediction is that nearly the entirety of this rise will be the consequence of consuming poultry meat, as its price is lower, making this type of meat more accessible to citizens of developing nations.

It is believed that the rise in meat consumption will become typical for developing countries, which are known for their high population levels and growth rates. The expectation is particularly high for Africa and Asia where, despite low per-capita incomes, meat consumption will be greater due to the liberalization of the market, which leads to lower costs of meat. Developed countries are expected to see a fall in the consumption of meat per person in comparison with the previous decade (*OECD/FAO,* 2020). The reason for this is that the developed nation consumer has a choice when it comes to food, prefers options when it comes to quality, and takes into account factors such as nutrition, well-being, and health, thereby enabling them to be choosy and place high demands (*Sarcevic et al.,* 2011). Simultaneously, the eating habits of those individuals living

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in countries with high incomes are changing and, rather than purchasing fresh produce and preparing it in their own homes, they opt to dine at restaurants with more frequency. Furthermore, the number of households consisting of the elderly or singles is on the rise, for whom eating outside the home has become the norm (*OECD/FAO,* 2020).

According to the *Statistical Office of the Republic of Serbia* (2020a), the sum of consumed quantities of meat per household in Serbia amounted to 123.3 kg in 2019. The breakdown of meat consumption according to type is as follows: beef (fresh and frozen) 16.8 kg/household, pork (fresh and frozen) 49.6 kg/household, poultry and other (fresh and frozen) 50.2 kg/household, and other kinds of meat (fresh and frozen) 6.7 kg/household. Statistics on the amount of meat produced in 2019 show total meat amounted to 548,000 tons, wherein the production of beef amounted to 71,000 t, pork 298,000 t, mutton 34,000 t, poultry 114,000 t, and edible offal 31,000 t (*Statistical Office of the Republic of Serbia*, 2020b). This reflects a mild growth in the total production of meat compared with the previous two years.

It is a recognized fact that the modern-day consumer is far pickier when it comes to meat quality and safety and product labelling, as well as the producers being determined to implement standards in food production, etc. (*Sarcevic et al.*, 2011). Consequently, in addition to handling the growth in production, the meat industry is also responsible for satisfying all the needs of consumers in terms of availability of their desired amounts. Although the importance of meat in the human diet cannot be neglected, given its favourable composition of nutrient-rich materials, primarily protein, vitamins, and minerals, but also desired sensory characteristics, what cannot be ignored is the truth that meat has the potential to be a significant source of biological, chemical, and physical hazards. Consuming unsafe meat can lead to meat-borne illnesses, namely, infection, toxification, or intoxication (*Kilibarda,* 2019).

Meat production assumes the raising of the animal, the transport of the animal, slaughter, processing the carcass, freezing, packing, and storing. It also includes the distribution, selling, preparation, and serving of the meat when consumed in individual households (*Das et al.,* 2019). It is important to highlight that meat can become contaminated by any number of hazardous substances at every given phase in its production chain. Chemical hazards, such as the residues of veterinary medications, which can sometimes be found in the meat of the animal at slaughter during primary production are, above all, the effect of unconscionable and inexpert usage of veterinary drugs. The presence of pesticides and heavy metals in meat and other edible parts of the animal is the consequence of the animal's exposure to those contaminants found in the environment in which they live (*Viegas et al.,* 2012; *Smith & Kim,* 2017). Potentially harmful pollutants in the environment and toxins as a result of human activity can also be found in the meat of animals, including inorganic elements such as As, Cd, Hg, Pb, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, and others. Inadequate transportation of animals (unhygienic conditions or a large number of head per unit of transport area) is a significant risk for the presence of cross-contamination by bacterial pathogens. Furthermore, the inhumane treatment of animals prior to their slaughter, exposing them to stress, has an additional negative influence on the quality and safety of meat. The slaughter line has numerous points during which contamination by potentially pathogenic microorganisms is possible, and the causes of contamination are numerous (the workers' hands, the equipment, the carcasses themselves) (*Karabasil et al.,* 2008). During the final stage of the food chain, the quality and safety of meat is influenced by a great number of factors, including the packing, storing, transport, and sale, as well as the treatment of meat in the actual households. Meat is, given its physico-chemical characteristics and the content of nutrient materials, a substrate which favours the growth of microorganisms. As such, it is considered an easily perishable food, so maintaining the cold chain throughout the distribution of meat is imperative. Because of that, the cold chain must not be stopped, and it is particularly important to prevent the arrival of cross-contamination throughout this stage (*Das et al.,* 2019). As the main biological meat-borne hazards, *Buncic* (2015) lists pathogenic microorganisms, *Campylobacter, Salmonella*, *Yersinia*, verocytotoxigenic *Escherichia coli*, *Listeria monocytogenes*, *Trichinella*, *Toxoplasma gondii*, norovirus, hepatitis A virus, hepatitis E virus, and prions that cause transmissible spongiform encephalopathies (TSEs) in humans. The WHO estimates that *Salmonella* spp., *Campylobacter* spp., norovirus and hepatitis A virus are important, common foodborne hazards that lead to illness in humans, and are transmitted through food of animal origin (*WHO;* 2017). Eating food of animal origin was associated with most strong-evidence foodborne outbreaks (*EFSA & ECDC*, 2021). However, regardless of the fact that the data indicates that biological hazards most commonly lead to illnesses in humans,

research on consumers in the European Union (*Sofos,* 2008; *Viegas et al.,* 2011) indicates that, when it comes to food-borne risks, what concerns consumers the most is their exposure to veterinary drug residues inside the meat (*Verbeke et al.,* 2007; *European Commission*; 2019; *Rembischevski & Caldas*, 2020). This would appear to be contradictory, given that the use of substances with hormonal action on animal farms is prohibited within EU borders by Council Directives No. 96/22/EC (*EC,* 1996) and 2003/74/EC *(EC,* 2003a). Also, according to Regulation (EC) No. 1831/2003 (*EC*, 2003b), the use of antibiotic growth promoting substances as additives for use in animal nutrition is forbidden (*Andree et al.,* 2011). Despite that, the latest research on Danish consumers indicates that up to two thirds of consumers are willing to pay higher prices for pork if they were able to know that the pigs had been raised in a manner which reduces the need for antibiotic usage over the course of their lifetime (*Denver et al.,* 2021). A reason listed as to why veterinary drug residues in meat are perceived by consumers as presenting the highest risk is because these hazards are invisible to the consumers, having long-term effects and serious health consequences (*Ha et al.,* 2019). In general, chemical hazards to the consumers are something unknown and unnatural, and as such, are assumed to be a greater risk. Consumers are much more familiar with and have far more knowledge about biological hazards, which is a likely consequence of consuming unsafe food containing biological hazards, which cause momentary and acute impacts. Furthermore, the consumers of biological hazards experience such events as something which they can influence and control, unlike chemical hazards, over which they have no possibility of controlling (*Kher et al.,* 2013).

Moreover, what has been leading to rising doubt and concern among the consumer today is, in fact, food fraud (*Das et al.,* 2019). Food authenticity and meat authenticity pose questions of the highest concern in modern-day society (*Premanandh*, 2013). The demand for meat from specific geographic regions continues to grow, as does that for meat products produced in a traditional manner, which consumers believe to be high-quality food, and which adds to its value (*Montowska & Pospiech*, 2012). In addition, the Muslim community has demonstrated an ever-growing interest in confirming the status of Halal meat which they consume in order to ensure that it does not contain additions that are not in line with their religion and traditions. All this justifies the global need for the consumer worldwide to have access to information, which is accessible, clear, correct, and reliable. As such, several peer-reviewed papers were published recently which dealt with this very question (*Ali et al.,* 2012; *Farouk,* 2013; *Nakyinsige et al.,* 2012). When it comes to meat fraud, these economically-motivated and illegal actions can be divided into three categories: 1) concealing the origin of the meat and the animal's diet (incorrect, or rather, false information concerning its origins, for example, when it comes to meat with geographic indication); 2) replacing the ingredients of one type of meat with those of a different type of animal; and 3) adding non-meat components, such as water or additives, into the meat (*Ballin,* 2010). For these reasons, it is the duty of the government to ensure all necessary resources (both material and human) that will allow for the constant development of methodologies with which it will ensure the establishment of potentially illegal activities whose ultimate goal is to economic benefit, yet which lead to consumer confusion and harm the quality of the meat (*Spink & Moier,* 2011; *Sentandreu & Sentandreu* 2014).

The issue of food safety and quality, as well as meat fraud, is a complex concept which depends upon many factors, given the greater number of hazards and paths leading to meat contamination. It also depends on illegal practices through which meat can end up adulterated, or which could lower its quality (*Sofos,* 2008; *Viegas et al.,* 2012). For these reasons, meat, and the food which we consume in general, are tested in laboratories more so than ever before. They are tested through the application of various methods and by using high-performance equipment, thereby determining both the quality and the safety of meat with a high degree of reliability. Due to the globalization of the food market, the issue of food safety requires a global approach. This is why it is of utmost importance for food inspection to be carried out in a way that is internationally recognized by laboratories, with the aim of establishing the presence of hazards within the food, as well as confirming additional quality, regardless of whether it be through official or internal controls.

According to the law on food safety (*Serbia*, 2009, *Serbia*, 2019), it is a requirement for laboratories that perform laboratory testing in the process of official controls in the fields of food safety and fodder safety to be accredited in line with the demands of the SRPS ISO/IEC 17025:2017 standard (*SRPS*, 2017) – General requirements for the competence of testing and calibration laboratories. The process of accreditation, which is an independent and impartial grade of competency of the body that carries out the tasks of testing, is the best path towards

determining a laboratory's performance. Receiving a certificate for accreditation of the laboratory determines its superior positioning in the market, and allows for international recognition for technical competency, that is, internationally recognized results for the testing which it carries out. This way, by obtaining a certification of accreditation, the laboratory is able to provide its clients with objective proof that the research it carries out is done so competently, and that the results of the tests are reliable, valid, and in line with the prescribed requirements, specifications, standards, and rules (*Rajković et al.,* 2019). This also demonstrates that its work has been verified by an independent institution, that is, within Serbia, the Accreditation Body of Serbia. The accreditation of a laboratory for testing food supports a global approach in ensuring the safety and quality of food, given that the signing of The European co-operation for Accreditation Multilateral Agreement (EA MLA) (an agreement of international recognition of accreditation) recognizes the equivalence and reliability of reports published by foreign bodies for grading compatibility throughout Europe. The Accreditation Body of Serbia has been a signatory to this agreement since 2012.

Given the large number of parameters which must be examined in the process of grading meat in terms of quality, safety, and authenticity, the aim of this study was to analyse the capacities of laboratories to carry out such tests. Because of the very global approach to this problem, only laboratories with accredited methods testing parameters of interest were taken into consideration for this analysis in order to gauge their current capacities, competitiveness, and the international recognition of testing laboratories in Serbia.

Materials and methods

With the aim of gathering data on accredited laboratories in Serbia with the capacity to examine the parameters indicating quality, safety, and meat fraud, the Accreditation Body of Serbia's website was searched in the period between May 2nd, 2021 to May 9th, 2021. The key word "meat" was used during the web searches in order to discover, from among all the testing laboratories accredited by SRPS ISO/IEC 17025:2017 (*SRPS*, 2017), those with meat as a subject of inspection. However, upon additional inspection, it was determined that the site's search function was created in a way as to take into account smaller content descriptions of accredited laboratories, which often included food as a wider concept, but not specifically meat, meaning a new approach to the search had to be taken on. For more reliable searches and, as such, results, the key word used was "food". The selection of the laboratory was then conducted by insight and analysis, providing a valid range of selected, accredited laboratories. For the purposes of further analysis, only those laboratories with the goal of testing through the application of various methods and techniques encompassing meat were included. After that, a database was created using Microsoft Office Excel 365 in which the extracted parameters were analysed. Descriptive statistics, percentages, and graphic representation of the results were also processed using Microsoft Office Excel 365. The safety and meat quality parameters, in relation to the research techniques, were sorted after analysis in the following way. The meat safety parameters singled out pathogenic microorganisms, the presence of which is tested by applying the standard methods or the polymerase chain reaction (PCR) method. The presence of the *Trichinella* parasite in pork is determined using the method of artificial digestion. Tests for the presence of metals, metalloids, and other chemical components, pesticide residues, veterinary drug residues (confirmative and screening methods), PCBs, PAHs, and radionuclides follow different procedures. As parameters for the basis upon which the quality of meat is graded more narrowly, physico-chemical and sensory testing capacities were extracted. The parameter for uncovering meat fraud included methods for determining the presence of species-specific animal-origin DNA (using the PCR method or an ELISA test).

Results and Discussion

By applying the methodology, it was determined that 58 laboratories in Serbia have at least one, but more commonly multiple accredited methods which each laboratory can use in order to examine several of the parameters for safety and/or meat quality. The geographical distribution of the laboratories is indicated in Figure 1, whereby noticeably, an equal number of laboratories (n=18; 31%) can be found in Belgrade and in the Autonomous Province of Vojvodina. Out of the total number of laboratories, 38% (n=22) were distributed throughout the rest of the territory of Serbia. Privately owned laboratories constituted only 22% of the total laboratories (n=13), while 78% of the laboratories were state-owned, with the structure visible in Figure 2. The greatest percentage of laboratories for testing several of the meat hygiene parameters were represented precisely by the Public Health Institute (hereinafter, public health

laboratory), which carries out tasks in the fields of health activities, and which the Government founded (47%, n=21). Next up were the laboratories within the research institutes or scientific or educational institutions, namely faculties (22%, n=10) (hereinafter scientific laboratories). The veterinary institute, which carries out these activities in the field of veterinary sciences (hereinafter veterinary laboratories), made up 22% (n=10) of the total number of laboratories in the government sector, while the smallest percentage was found within state property (9%, n=4) (hereinafter public laboratories).

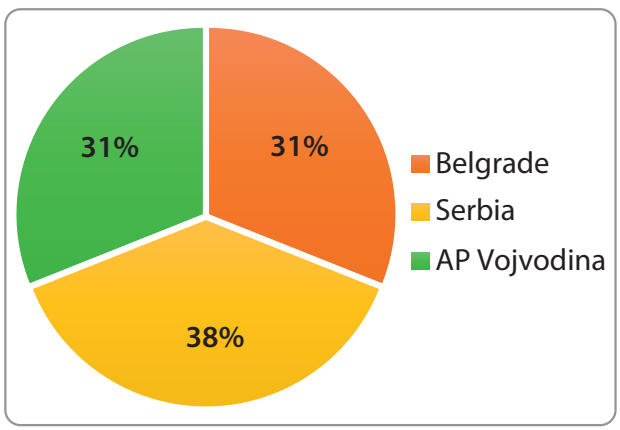

Figure 1. Geographic distribution of the laboratories in Serbia

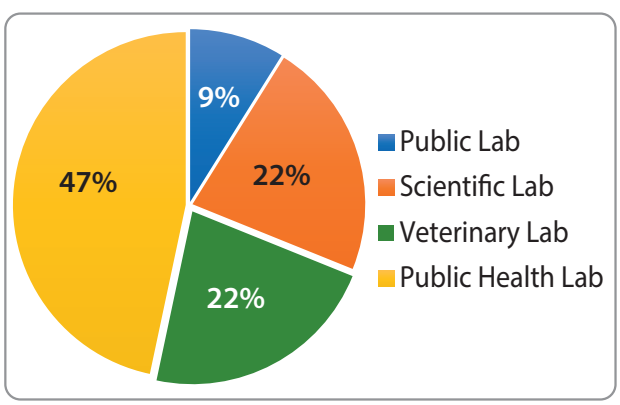

Figure 2. Structure of the state-owned laboratories

The geographic distribution of these laboratories according to sector (private, public) can be viewed in Figure 3. Noticeably, over half of the privately-owned laboratories were located in Belgrade – 7 out of a total of 13 – and the Public Health Institutes are found distributed around all of Serbia. An interesting fact is that the accredited laboratories found within the frameworks of institutes and/or faculties were found exclusively in Belgrade (n=6) and Vojvodina (n=4). This is unusual, given that the university centres of Serbia include the cities of Niš and Kragujevac. The conclusion is drawn that it is precisely the differences in development and the per capita income between Belgrade, Vojvodina, and the rest of Serbia that reflect the weaker amount of investment into science and technologies in Niš and Kragujevac. The territorial distribution of all ten veterinary institutes is in line with the epizootiology territories of Serbia.

Given the parameters which were examined with the aim of grading meat quality and safety, and which can be found stated in the assigned space concerning the accreditation of laboratories, the capacities of accredited laboratories for this type of research compliance were analysed (Figure 4).

It can generally be stated that the majority (88%) of the analysed laboratories had the capacity to test for the presence of microorganisms in meat. The microbiological parameters of meat safety were generally researched using standard methods, while the average number of accredited methods was 12, bearing in mind that one of those laboratories (a scientific laboratory) had 31 accredited microbiological methods. A smaller number of laboratories had the capacity to validate the number/presence of pathogenic bacteria (such as *Salmonella* spp.) in meat through rapid tests. When it comes to researching the microbiological parameters, it is interesting to mention that all private, veterinary, and public health laboratories had the capacity to examine these meat safety parameters using accredited methods. The situation was somewhat different in the scientific laboratories, given that (only) half of these laboratories have opted for accreditation of their microbiological methods, while some of them only performed one type of testing, which was most often testing for the presence of radionuclides through gamma spectrometry. Based on the analysed data, the significant laboratory capacities for testing the presence of biological hazards in food using standard microbiological methods can be explained by the fact that investment into microbiological research does not require extensive financial resources, nor long-term absence of the staff due to training or specialization. Such is not the case with methods in the fields of researching chemical hazards, such as veterinary drug residues, pesticides, the presence of heavy metals and similar, which require high-performance equipment and highly trained staff.

The situation was somewhat different when it comes to testing for the presence of pathogenic microorganisms by applying PCR methodology, which only five laboratories (9%) had accredited; of those, three were private, one was veterinary, and one was a

public health laboratory. This is to be expected, given that the legal regulation itself prescribes standard microbiological methods for testing for the presence of biological hazards. The equipment, the training of the staff, and the activities associated with the fields of ensuring trust in the quality of the testing require significant material investment, which is why laboratories more rarely opt for this type of testing.

Testing for the presence of the *Trichinella spiralis* parasite, which induces human trichinellosis by the consumption of undercooked domestic pork and meat products (especially sausages), and today, more often by the consumption of raw or undercooked wild and home-raised game meats (*Diaz et al.,* 2020), is carried out by the reference method of artificial digestion. Out of the total number of analysed laboratories, 24% of laboratories, of which were nine out of the ten veterinary, three scientific, and two private laboratories, had accredited this method of testing. The presence of this method of testing compared with the laboratory structure is to be expected, given that this method should be carried out by graduate veterinarians who are employed in veterinary organizations.

When it comes to meat quality parameters, which are determined by testing the physico-chemical properties of meat, it was established that, alongside microbiological testing, this type of testing is the one most commonly found in accredited laboratories, that is, these tests were carried out by over half of the analysed laboratories (53%). The physico-chemical parameter tests were accredited in 77% (n=10) of private laboratories, 62% (n=13) of public health laboratories, and 50% (n=5) of scientific laboratories, while only

Figure 3. Geographic distribution of laboratories according to sector (private, public)

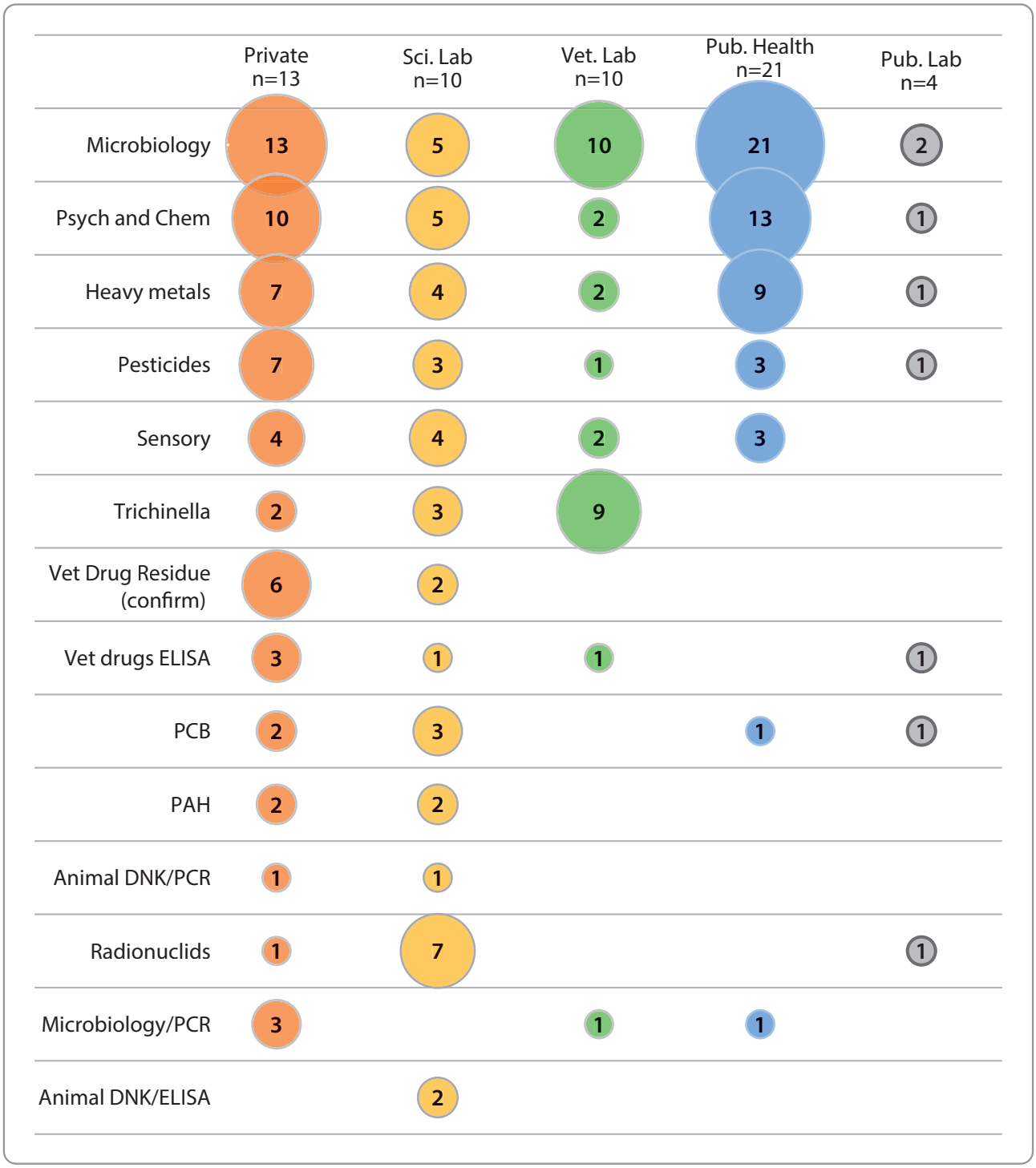

Figure 4. The capacities of accredited laboratories in Serbia

two (20%) veterinary laboratories had this capacity, as did two out of four public laboratories. The sensory testing is interesting in that it determines the parameters of meat quality, which is an area not covered by our own laboratories. Out of 58 laboratories, only 22% (n=13) carried out sensory testing using accredited methods. Sensory testing does not require any specific equipment nor great investment. However, the belief may be that performing sensory testing requires a well-trained staff in order for the subjectivity of this testing to be reduced to a minimum. Likely, it is a lack of trained human resources that leads to laboratories not opting for accreditation of this method. It is also very important to mention that, when it comes to parameters of quality, only one private laboratory in Serbia has the capacity to apply high performance liquid chromatography (HPLC) technique to determine amino acid compositions of meat, as well as the presence

of vitamins B1, B2, B6, A, C, and D using accredited methods. Moreover, only one public health laboratory has the capacity to determine the presence of vitamins B1, B2, and B6.

Heavy metals, such as Pb, Fe, Cd, Hg, Cr, Cu, As, and Ni, are rooted in natural, but also artificial sources, the latter of which is the direct consequence of human activity, that is, industrial production, which ends up in landfills and water sources. By way of food and water, animals consume these metals which then accumulate in their tissues and organs, and in this way, the hazards enter the food chain. If consumers are exposed to unsuitably large amounts of these chemical hazards through meat and edible animal parts, this could lead to serious health consequences (*Andree et al.,* 2011; *Mahmutovic et al.,* 2018). This is why it is of exceptional importance that laboratory capacities exist for the purposes of testing for the presence of such hazards in food. This research determined that the presence can be determined of metals and metalloids and other chemical elements of interest in meat by accredited methods in 40% of all analysed laboratories, those being: 54% (n=7) of private laboratories, 40% (n=4) of scientific laboratories, 20% (n=2) of veterinary laboratories, 43 % (n=9) public health laboratories, and one public laboratory. These food safety parameters are overwhelmingly tested by using the atomic absorption spectroscopy (AAS) technique. However, the inductively coupled plasma-optical emission spectroscopy (ICP-OES) technique for determining chemical elements was carried out by six laboratories, of which three were public health laboratories, two were private laboratories, and one was a public laboratory. Furthermore, five laboratories had the capacity to use the inductively coupled plasma mass spectrometry (ICP-MS) testing technique to determine the presence of the elements of interest in meat (three private laboratories, and two scientific laboratories). It is very important to emphasize that, through the application of both techniques − ICP-OES and ICP-MS − a more sensitive analysis of a great number of chemical elements can be carried out simultaneously, up to the milligram and nanogram levels. The conclusion can be drawn that Serbia has significant laboratory capacities for testing for the presence of chemical elements in meat and edible parts, given that a full half of the laboratories have the capacity to carry out more sensitive techniques, such as ICP-OES and ICP-MS.

Veterinary drugs are used as therapeutic measures for controlling various animal diseases, for prophylactic measures, and for controlling parasite infections (*Das et al.,* 2019). When they are applied recklessly and inexpertly, the remains of veterinary drugs can enter the food chain, after which consumers can be exposed to these chemical hazards which, as mentioned previously, is of the most critical importance when it comes to the consumer. The residues of veterinary drugs in meat are determined through the application of the HPLC technique, which is a confirmative method when compared with the screening methods which are carried out by, for example, ELISA techniques (*Andree et al.,* 2011). By use of confirmative methods, the presence of veterinary drug residues was able to be established in seven private and two public laboratories (14% of the total accredited laboratories). The laboratories usually have the capacity to test for the presence of residues of those drugs which are most frequently used in practice, which are the residues of sulphonamides and tetracycline. However, one of the scientific laboratories has the capacity to apply liquid chromatography–mass spectrometry (LC-MS), through which it can examine for a great number of veterinary drug residues: anti-inflammatory drugs, steroids, thyrostatics, anthelmintic, coccidiostats, natamycin, metabolites of a quinoxaline, macrocyclic lactones, bacitracin, chloramphenicol, thiamphenicol, fluorphenicol, quinolone, metabolites of nitrofuran, tetracycline, nitroimidazole, β-lactam antibiotic, sulphonamide, and aminoglycoside. One private laboratory had the capacity to determine the presence of residues of coccidiostats, natamycin sulphonamides, and tetracyclines and chloramphenicol. When it comes to applying the screening methods, such as the ELISA technique, the capacity to test for veterinary drug residues was found in six laboratories (10%), while one of them, a scientific laboratory, had the capacity to test for a great number of veterinary drug residues; the other laboratories generally tested for the presence of antimicrobial drug residues.

The capacity to test for pesticide residues in meat by application of the gas chromatography method and/or chromatography with various detectors was found in 14 laboratories (26%), of which seven were private, two were scientific, three were public health laboratories, and one was a veterinary, or rather, public laboratory. The laboratories had the capacity to determine the presence of levels of 10 pa, and over 40 types of pesticides in meat. It is clear that the number and types of pesticides which can be determined by the accredited methods are, overwhelmingly, dictated by the market, but it is important to emphasize that laboratories in Serbia have all the capacities necessary to, in accordance with the needs and demands of the consumers, test an even

greater number of pesticides in meat. In that sense, laboratories could be reviewed for receiving accreditation for a flexible scope that would enable them the assigned responsibility for managing the extent of the accreditation and the possibility of carrying out changes in the acquired scope of the accreditation, without previously receiving appraisement from the Accreditation Body of Serbia.

When discussing the presence of other environmental contaminants, the presence of PCBs was tested through the use of gas chromatography in seven laboratories (12%), three of which were scientific, one was public, two were private, and one was a public health laboratory. The presence of PAHs in meat was tested through the application of the gas and/or liquid chromatography methods using various detectors by only 7% of the total number of analysed laboratories (two private and two scientific).

Determining the presence of radionuclides by testing with gamma spectrometry was possible in nine laboratories (16%), of which one was private, one was public, and seven were scientific laboratories. Of these seven scientific laboratories, four of them performed only gamma spectrometry testing of meat, that is, they have only one accredited method for testing the parameters, in this case, for meat safety. This situation is truly understandable, given that this is a very specific type of test which requires, primarily, particular infrastructure solutions.

As far as methods for determining meat adulteration go, as mentioned above, some laboratories determined the presence of chemical elements by using the ICP-MS technique. However, the application of this technique is made possible through isotopic analysis. The measurement of stable isotope ratios and trace elements is the method with which it is possible to determine meat origins and the animal's feeding regime, and to confirm or refute information concerning its origin, that is, to detect potential meat fraud. The conclusion can be drawn that these laboratories, although not located within the assigned scope of accreditation, could have the capacity and opportunity to confirm meat origin or uncover meat fraud. Among the methods that use that non-targeted approaches when uncovering meat fraud was nuclear magnetic resonance (NMR) to detect the fraudulent addition of water, so this technique analyses water distribution in fresh meat in relation to meat quality parameters, such as water holding capacity, tenderness, and juiciness (*Bertram & Andersen*, 2007; *Pearce et al.,* 2011). Another method used was histology and image analysis, based on light or electron microscopy in combination with digital analysis of images. Metabolites in meat have been analysed by the use of either liquid (LC) or gas (GC) chromatography coupled to different detectors. When it comes to methods which have targeted approaches with the aim of uncovering meat fraud, the ELISA technique is likely the most commonly used one for determining the presence of animal-origin DNA in meat (*Asensio et al.*, 2008). In spite of its many advantages, this technique is not highly specific, and often produces false positive results due to cross-reactions between the antibodies used. Serbia has two scientific laboratories which have accredited methods for determining the presence of animal-origin DNA in meat using the ELISA technique. Methods based on DNA analysis, and particularly those based on PCR, are very sensitive and reliable, and hence have a high level of sensitivity, reflected in the fact that it is possible to uncover as little as 0.1% of added meat protein from different kinds of animal *(Natonek-Wisniewska et al.,* 2013). However, this high level of sensitivity, or rather, ability to detect very small amounts of fraudulent material, is not needed to determine meat fraud, given that fraud takes place in order to increase economic benefit, which is why prohibited ingredients are added at amounts of greater than 10%. Still, this specific case of meat fraud could be of great importance for the Muslim population, for whom the presence of any amount of pork (even 0.1%) would render the meat unacceptable for this community (*Mohamad et al.,* 2013; *Sentandreu & Sentandreu,* 2014). The detection of animal protein by use of PCR was available through only two laboratories, one scientific, and one private.

Finally, it is important to highlight why the goal of this paper was to provide a broad picture and analysis of the capacities of accredited laboratories for the purposes of testing the parameters of meat safety and quality, as well as the option of uncovering meat fraud. Reviewing detailed analyses of the appraised scope of specific laboratories goes beyond this study. What can generally be said is that laboratories from the private sector, although constituting a smaller percentage (22%) of the laboratories analysed, had significant capacities and potential to test a large number of specific meat hygiene parameters. Roughly divided, half of the accredited scientific laboratories, and one of them in particular, had the potential to test a large number of parameters, while the other half has opted for just one type of testing, primarily using gamma spectrometry to establish the presence of radionuclides. As far as public health laboratories go, even though they are the most numerous of the laboratories studied, it is important to mention that

their capacities for testing meat were often limited to microbiological testing, which is understandable given that the scope of their work is usually focused on testing water, dietary substances, and supplements. Veterinary laboratories stood out for carrying out practically all of their testing using the artificial digestion method for *Trichinella*, which is also to be expected, but only a small number of these laboratories had the capacity to test a greater number of parameters of meat hygiene.

Conclusion

Alongside demands for food to be safe and of high-quality, consumers today request ever more clear and reliable information about the food they consume. In order to ensure the safety and quality of meat, an honest market and the freedom of choice for each individual, it is the task of the government to guarantee that information concerning food found on the market be correct. This is why accredited laboratories with the capacity to test and confirm food quality and safety play a supporting role, as it is of exceptional importance today due to market liberalization and the increase in international trade and the global approach to food safety. The product of each laboratory is precisely its report on the results of the research, and the granted accreditation for the job of testing provides confirmation that those results are correct, reliable, and internationally recognized. This can, to a great extent, influence directly and indirectly the reputation and position of a country on the international market. Even so, it is important to keep in mind that the methods for testing are not perfect analytical tools, despite the high sensitivity, specificity, reliability and robustness, which is why various approaches to insuring safe, high-quality food must be applied, from the provider to the consumer. For these reasons, in the production of safe and high-quality food, the scientific laboratories and internal laboratories of the meat industry provide a significant contribution, as it is their business goal to be focused on competitiveness in the market and, as such, these types of tests are not accredited in accordance with the SRPS ISO/IEC 17025:2017 standard. In conclusion, the capacities of laboratories from both the public and the private sectors in Serbia for testing the parameters of meat quality and safety are sufficient. This is especially the case for testing for veterinary drug residues in meat which, according to research, are the chemical hazards of most concern to consumers. The capacity of one laboratory in particular stands out for that, in which it is possible through the use of accredited methods, to establish the presence of a significant number of various groups of veterinary drugs. What should definitely be a joint task for testing laboratories and the competent state authorities is the development of methods through which meat fraud could be detected.

Kapacitet laboratorija u Srbiji za ispitivanje bezbednosti i kvaliteta mesa

Nataša Kilibarda

A p s t r a k t: Zahvaljujući svom sastavu, a pre svega sadržaju hranljivih materija, meso je gotovo svakodnevno zastupljeno u ishrani ljudi. Prognoze su takve da se u narednom periodu očekuje kako porast proizvodnje, tako i porast potrošnje mesa na globalnom nivou. Međutim, pored potrebe da se zadovolje zahtevi potrošača u pogledu količine mesa, veoma je važno da se zadovolje zahtevi u pogledu kvaliteta, bezbednosti mesa i pouzdanosti pruženih informacija. Takođe, u interesu potrošača je da se ispitivanje mesa obavlja u laboratorijama akreditovanim u skladu sa SRPS ISO/IEC 17025:2017. Imajući u vidu veliki broj parametara se ispituju u cilju procene kvaliteta, bezbednosti i autentičnosti mesa, cilj ovog rada je da se analiziraju kapaciteti akreditovanih laboratorija za izvođenje tih ispitivanja. Analizom dostupnih informacija na zvaničnom sajtu Akreditacionog tela Srbije, utvrđeno je da 58 laboratorija u Srbiji ima najmanje jednu, ali najčešće više akreditovanih metoda kojima je u mogućnosti da ispita neke od parametara bezbednosti i/ili kvaliteta mesa. Zaključeno je da su kapaciteti laboratorija, i privatnog i državnog sektora, za ispitivanje parametara kvaliteta i bezbednosti mesa u Srbiji dovoljni, posebno za parametre bezbednosti, koje po istraživanjima, predstavljaju hemijske opasnosti koje potrošače najviše i zabrinjavaju. Ono što definitivno treba da bude zajednički zadatak kako laboratorija za ispitivanje, ali tako i nadležnih državnih organa, to je razvoj metoda kojim bi se mogle utvrditi prevare u vezi sa mesom.

Ključne reči: *meso, bezbednost, kvalitet, krivotovorenje, laboratorijsko ispitivanje, akreditacija.*

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Original Scientific Paper

The importance of traditional food quality — the viewpoint of the tourism

Miloš Zrnić[1], Ivana Brdar[2], Nataša Kilibarda[2]

A b s t r a c t: This study provides an approach to the relationship between gastronomy and tourism, with a particular focus on the quality of traditional food. In recent years, since the world became a "global village" and people worldwide could access the Internet, it is easy for enthusiastic tourists and business travellers to acquire information about diverse destinations, thus aiding the growth of globalization and the tourism industries. This study explains to what extent gastronomy and traditional food are relevant to development of tourism and why it is crucial to offer visitors and tourists unique, traditional meals of high quality. Larger cities were considered for the case study in Serbia. The study highlights the importance of traditional food in creating overall, memorable tourist experiences, given that tradition, culture and food are strongly imprinted in the identity of each country.

Keywords: *gastronomy, traditional food, tourist experience, cultural identity.*

Introduction

It is in human nature to explore, learn and try new things. This encompasses interesting, enriching experiences, awakening all senses — to taste something new, to see something never seen before, to hear different sounds, to smell extraordinary fragrances or to touch new shapes (*Tikkanen,* 2007). Without such new experiences, the life of many would be less exciting, and these specific needs contribute to people's leisure travel, consequently leading to tourism blossoming and business growing, positively impacting the entire economic sphere and labour market (*Hsu,* 2015). Cultural experience can also be expressed through food (*Long,* 2004). However, a food destination needs to be authentic in order to be recognized by tourists (*Sánchez-Cañizares and López-Guzmán*, 2012).

Food awakens all our senses. It is not just about taste – it is also about the scent that caresses our nostrils while smelling food; it is about the way the food is decorated, to make our eyes shine; it is about the feeling we have on our fingertips when we touch it, and last, but not least – it is about the crunchy sound we hear when we bite or nibble it, followed by the soft and pleasant sound of a favourite food gliding smoothly through the throat. All of these experiences are even more intensive when it comes to traditional food (*Zhang,* 2019). In a way, food always follows us, anywhere we go (*Steinmetz,* 2010). In fact, foods we encounter in the early age of our lives leave a big impact on our memories and digestive systems. The human senses of smell and taste are inseparable, and they both recognize biochemical components when consuming food, which confirms the fact that these two senses function closely together. In order to obtain the sensation of flavour, the senses of smell and taste need to collaborate closely (*Sims,* 2009).

Therefore, some tourists like to bring with them specific spices or drinks, as these help them to bring back pleasant memories and feelings. If it is not possible to bring some ingredients, tourists can decide to eat the food that is mostly similar to their traditional food, regardless of whether their visit to another country is for business or pleasure. Traditional food can be defined in many ways, but the simplest explanation is that it refers to dishes/foods that are passed from one generation to another (*Hotz and Gibson,* 2007). In nearly all countries, this preserves the traditional food heritage, which is the inseparable ingredient of each country's unique tradition. Traditional food is also a major component marking the dietary habits of people (*Alibabic et al.,* 2012).

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Literature review

In a tourism sense, authentic traditional foods help countries to be well-positioned on the global tourist map and recognized among other destinations (*Bertella,* 2011). In today's competitive world, it is of the utmost significance to be distinguishable and memorable, and good traditional food can be a major ally in achieving that goal. Food can boost the status of the destination, because it includes elements of lifestyle, local creation and cultural tradition (*Tsai and Wang,* 2017), but also contributes to the destination's promotion and financial status (*Henderson*, 2009). Tourists can buy food and beverage souvenirs over the Internet, even when they are far from the visited destination (*Hall and Sharples, 2008*).

Together with beverages, traditional foods can be produced as homemade products by restaurants, small catering companies and large but local manufacturers or simply created in-house. Some traditional foods have geographical indications or are traditional specialties in the EU (European Union) designation scheme, which indicates they have protected designation of origin (*Kilibarda et al.,* 2018a).

All these elements help to serve prosperity and maintain a living cultural heritage with local food. Through many different cultural events, traditional food (very often cheeses or wines) as a unique offer from a particular destination is very often provided for both local and foreign visitors. Gastronomy, including traditional food, as a valuable cultural element, can draw tourist attention, additional to other cultural attractions such as museums, festivals and fairs (*Correia et al.,* 2008). Food fairs and wine tours are some of the many ways to help visitors explore tourist destinations, allowing them to discover something specific while visiting food destinations. Authentic traditional foods have their charm as one of the key elements that contribute to development of a tourism industry (*Bessiere and Tibere,* 2013).

On the other hand, if tourist expectations are not met when consuming local dishes, the individual's opinion can negatively affect local tourism (*Sánchez-Cañizares and López-Guzmán,* 2012). Many studies report the importance of food for tourism to progress (*Ivanova et al.* 2014). Food events positively affect local tourism, helping people to maintain jobs in hotel and catering industries (*Richards,* 2014). The concept of unique food makes it easy to present a country, its distinguishable culture and distinct history. Home-made food can be an incredible advantage for tourists exploring the culture of a destination, which means that local dishes are linked to visitor adventure (*Rilakovic,* 2013).

Food is an important part in the tourism industry because traditional food is one of the attributes of a destination that can be used to promote tourism. What is certain is that the sale of traditional food to tourists is very important for the destination. Increasing the supply of traditional food and local food products within catering facilities is very encouraging for sustainable tourism growth, and according to research by Sims (2009), traditional food can play an important role in connecting tourists with local culture.

Kim and Eves (2012) investigated the reasons why tourists tend to experiment with traditional gastronomic specialties and came to the following conclusions:

1. getting acquainted with a new culture and gaining new knowledge and experiences,
2. developing interpersonal relations and creating the opportunity to make new acquaintances,
3. excitement and escape from routine,
4. sensory pleasures: taste and aroma seem attractive to them,
5. health care: whether they avoid or try local food, people who have a developed awareness of and highly value health their are guided by this principle.

Whether tourists accept local food depends on several factors, primarily their culture, nationality and personality. Thus, *Chang et al*. (2010) claimed that tourists show the so-called "culturally-specific core eating behaviour", which largely determines their preferences. Culture is an integral part of the human values system and largely determines our dietary preferences. National cuisine is marked by its composition, meal preparation methods and the culture of enjoyment. In general, tourists find it easier to accept differences in foods that are not crucial in their daily diet. Here, food can be classified as core or peripheral: core foods are closely related to culture and require the greatest effort to change them.

Also, not all nationalities are equally open to trying new specialties. *Torres* (2002) agreed with this, saying the tendency to try traditional food certainly depends on nationality, and he believed that most people do not want to try local specialties. According to *Fields* (2002), in addition to nationality, there are other personal characteristics that influence whether a tourist will try traditional food. Some people are motivated to try local food to complement

their experience of local culture, while others experience the enjoyment of local specialties as prestigious. Middle-class intellectuals seem most likely to try local specialties, as *Heldke* (2003) explains: "This cultivated 'taste' in foreign cuisine can enhance an individual's level of sophistication, which is important for raising stature in future social situations."

Methodology and methods

The research was conducted in the period from October 2019 to March 2020 in six cities (Belgrade (BG), Novi Sad (NS), Nis (NI), Smederevo (SD), Subotica (SU) and Valjevo (VA)) in Serbia. The questionnaire contained 16 questions, 13 statements in the form of a Likert scale (7 point, where 1 stands for strongly disagree and 7 stands for strongly agree) and 3 socio-demographic questions. To better determine the attitudes of the respondents and explain the results, the average scores obtained by the Likert scale were classified into three categories: scores from 1 to 2.5 indicate a negative attitude; from 2.5 to 5 indicate a neutral attitude, while grades from 5 to 7 indicate a positive attitude. The population sample consisted of 94 respondents, aged between 18-60. Male respondents (66%) dominated over females (34%). Work status among respondents: employed (43.21), unemployed (39.9%), students (16.89%). Methods used in this study were: content analysis; data classification; data and information processing; online survey research. Descriptive statistics were obtained using SPSS.

Results and discussion

The survey of consumer opinion on traditional food (Table 1) indicated interesting data/opinions regarding local traditional dishes and their consumption.

After categorising the Likert scale scores, respondents did not express a negative attitude towards any of the statements, which is a good indicator because with adequate measures and activities, neutral attitudes can be turned into positive ones (*Živković and Brdar,* 2018).

An interesting result obtained by the research is that the respondents showed a neutral attitude with regard to the nature of the product – whether traditional food is natural, organic, and whether it is produced in the local area. Bearing in mind that the production of organic food most often requires traditional, conventional production methods (*Thøgersen et al*., 2017), a question that should be further explored in future research is whether, and to what extent, people in Serbia are familiar with the concept of organic food.

Regional and local cuisines are key to differentiating from other cuisines in a highly competitive environment. Tourists have recognized the importance of local and regional gastronomy because this is, above all, a reminder of the history and tradition of the area, and local cuisine helps tourists become acquainted with the destination. This was confirmed by our study, since traditional food provided respondents with a connection with history. For the statement *When consuming traditional food, I contemplate about the history behind each and every dish*, respondents from Smederevo had the most positive attitude (6.91). This result could possibly be due to the fact that, although it is the smallest city included in the research, its rich history (e.g. Smederevo is the former capital of the earlier Serbian state, and it is positioned along the Roman border (Limes)) contributes to the recognisability of this area. Also, this region boasts recognisable traditional dishes — Smederevo perch and grapevine-leaf sarma (a local version of Greek vine dolmades).

Traditional, local food can play a key role in creating the identity and brand of the local community, facilitating the connection of tourists and destinations, enabling the development of agricultural activities, entrepreneurship and job creation, which directly contributes to strengthening the economy of a local community (*Du Rand et al., 2003*). Local food can be an attraction for a destination, and can be used to promote tourism. Therefore, it is not unusual that the respondents from Valjevo had the most positive attitude regarding the recognisability of traditional food (5.89), the connection between taste and climate (5.71), and food production in the local area (5.37). The most famous gastronomic product of Valjevo is, of course, fine pork crackling, reminiscent, in form, of tobacco and locally called *duvan čvarci*, such that this gastronomic product has its own festival, "Days of Valjevo Tobacco-cracklings". Livestock and fruit growing are well-developed here, so the local cuisine is rich in cheese, *kajmak* (a thick, fermented clotted cream), meat and fruit. Plums and raspberries are widely grown, and forest fruits are also harvested, primarily mushrooms. The Valjevo region is also known for pies, cornbread (*proja*) made from millstone-ground flour, Valjevo cheese and *kajmak*, Valjevo meadow cabbage soup, etc., which are prepared from locally produced

Table 1. Consumer perceptions, indicated by average Likert scale scores, related to traditional food products in Belgrade (BG), Novi Sad (NS), Nis (NI), Smederevo (SD), Subotica (SU) and Valjevo (VA).

Statement	BG	NS	NI	SM	SU	VA	*Average across all cities*
When consuming traditional food, I contemplate about the history behind each and every dish	5.83	5.68	5.66	**6.91**	6.12	6.03	*6.04*
Home-made food is well recognized	5.55	5.42	5.55	5.71	5.73	**5.89**	*5.64*
The quality of home-made food depends on the season	5.49	**5.93**	5.69	5.10	5.22	5.66	*5.51*
In my opinion, we can eat traditional food every day	5.22	5.51	5.23	4.99	4.80	**5.54**	*5.21*
Traditional food does not exist without good local recipes	5.06	5.48	5.69	5.22	**5.79**	5.77	*5.50*
Authentic traditional food is related to tastes that are characteristic of a given climate	4.95	5.49	5.61	5.12	5.59	**5.71**	*5.41*
In order to enjoy traditional authentic food, local ingredients are mandatory	4.88	5.39	5.41	5.25	**5.68**	5.30	*5.32*
Nobody knows better to prepare a traditional food than grandma	4.72	5.29	5.16	5.18	**5.88**	5.57	*5.30*
Traditional food has a unique production system	4.61	5.02	5.48	4.99	**5.54**	5.34	*5.16*
To have successful production of traditional food, food must be produced in the local area	4.46	5.20	5.23	4.15	4.92	**5.37**	*4.89*
My first association with traditional food is natural, organic	4.43	4.89	4.42	4.66	4.88	**5.18**	*4.74*
An authentic traditional food should have a story to tell	3.92	4.99	5.49	4.55	**6.18**	5.39	*5.09*
Traditional food is all about special moments and/or events	3.90	4.79	4.90	5.10	**5.35**	4.42	*4.74*
Average by cities	*4.85*	*5.31*	*5.35*	*5.15*	***5.51***	*5.47*	

foods. Additionally, the Valjevo region is known for its development of rural tourism, where learning to prepare traditional food is one of the key tourist activities. As stated by *Baltic et al.* (2018), events that are organized in Serbia, in which various rural associations participate, play a big role in tourism, which is important because in Serbian villages, people still consume a lot of traditional food and nurture the national cuisine in simple and complex ways.

For the statement *The quality of home-made food depends on the season*, respondents in all cities had, on average, a positive attitude, which to some extent could be expected. Having in mind the role of food safety, but also the importance of sensory characteristics of traditional dishes, it is necessary to use fresh foods in order to maintain the quality of food. The reason that speaks in favour of this is that local food can be an obstacle in the development of tourism, since not all tourists appreciate foods that they find new or unusual. Unlike standard activities in destinations where tourists are generally more willing to try and experience things new

and different, consuming new and unfamiliar food causes fear in many (*Perito et al*., 2020). Tourists can perceive new and different food as potentially dangerous for their health. The risk of food poisoning at the destination is one of the biggest problems and fears of tourists. The largest number of cases of foodborne disease among tourists is characteristic of Africa, followed by Central America, South America, the Caribbean, South and East Asia. The most common problems that tourists face are: diarrhoea, stomach complications and diseases, dermatological diseases, respiratory diseases, infectious diseases (*Rosselló et al.,* 2017). The risk for tourists, when it comes to foodborne disease, is often consumption of traditional food, i.e., food with which the tourist has never before come into contact (*Kilibarda*, 2019). Also, it is important to consider the statement *Traditional food has a unique production system,* which showed that only Belgrade residents have a neutral attitude regarding the way food is produced. This could be explained by the lifestyle in big cities and the eating patterns of people who "live fast". The results of the current study indicate special attention should be paid to the application of food safety standards in the production of traditional cuisine, in order to reduce among tourists the perceived risk of consuming traditional food.

When it comes to local cuisine and the claim that "Grandma's kitchen" is the best, the most positive attitudes, on average, were recorded for Subotica (5.79; 5.88) and Valjevo (5.77; 5.57), while Belgraders were neutral on this topic. The recorded results could be due to demographics – household structure, intergenerational connections and cultural characteristics of the place of residence. The data obtained for the statement *Traditional food is all about special moments and/or events*, where similar results were recorded, also support this. Namely, life in big cities is often characterized by greater alienation of people from each other, which is directly reflected in the experiences of tradition, family and traditional, shared meals.

Serbian cuisine is very heterogeneous; dynamic historical events have influenced the nutrition of the people and the formation of diet patterns, so each region has its own specifics and differences (*Gagić et al.,* 2014). Traditional food is one of the most interesting aspects of tourism and often leaves the strongest impression, which is also the reason for the return of many visitors. This speaks in favour of the fact that traditional food, among other things, must tell a story, i.e., contribute to the overall experience of tourists. On this issue and on average, positive attitudes were reported only from Subotica, Valjevo and Nis.

Observing the answers from the different cities, it can be concluded that respondents from all cities had a positive attitude towards traditional food, except Belgrade, where a neutral attitude was recorded (average score 4.85), while the highest score was recorded in Subotica.

Bearing in mind that Belgrade is the capital and the most populous city in Serbia, and taking into account the modern way of life in big cities ("separation" from family, spending most of the day away from home, consuming fast food) and the dominance of global culture, the result is, to some extent, understandable. However, it is important to note in relation to global culture that, although globalization is expected to lead to increased homogenization, this is not the case when it comes to gastronomy and tourism. Globalization and the connection of different national cuisines are causing significant changes in traditional and local gastronomy. Although globalization is often seen as a threat to local gastronomic identity, it can also bring benefits to local gastronomy, because without global connectivity, some authentic dishes in individual countries and destinations would still be completely anonymous. Globalization can also encourage revitalization of some local gastronomic products. Also, globalization has contributed to the creation of so-called "*glocal*" gastronomic products. Glocalization is a combination of globalization and localization, which means that globalization is adapted to local conditions (*Stano,* 2018). This term is used today to denote the application or representation of some global socio-cultural phenomena in specific localities. Glocalization is the result of the relationships between the global and the local, and these relationships allow them to complement each other instead of competing. Examples of such products include pizza, pasta, sushi, curry, ice cream etc. (*Brdar,* 2015). Nonetheless, globalization and internationalization could diminish the authentic food market. Our duty is to keep working, improving, exploring and learning about new food and destinations, but at the same time to maintain the authenticity of traditional dishes and culture whenever possible. This is the only way to stay unique in today's world where it is easy to forget important matters. Also, from the aspect of tourism development, Belgrade is dominated by business rather than leisure tourists. Additionally, nine gastronomic events are held annually in Belgrade, a special statistical region of Serbia that makes up 3.7% of the country's territory (*Kilibarda et al.,* 2018b).

On the other hand, the current results for Subotica are not surprising, taking into account the demographic characteristics of this area, multiculturalism, the fact that in the late 19th and early 20th centuries the meat exporters Hartman & Konen were the first in the country to use refrigerators, and that agriculture is the second-largest employment sector in the area (16.93%) (*Local sustainable development strategy of the city of Subotica 2013 – 2022*, 2013). In addition, a large number of *salaš* farms and households that actively participate in bringing the traditional cuisine closer to tourists can be taken into account. The richness of the cuisine is characterized by the famous "wines from the sand", fruit brandies, from the Bunjevac specialities, the most popular dish is *krompirača* (potatoes baked with fresh and blood sausages), and from Hungarian specialities, the most popular meal is veal perklet. Additionally, based on official data and announced events, a total of 29 events are held in the region of Vojvodina (in the area of Subotica, the most popular are those dedicated to wines and brandies – Palić Wine Festival, Berban Days and Young Brandy Festival) (*Kilibarda et al.,* 2018b), which further contributes to the possibility of connecting tourism and traditional food.

The tourist season in Serbia, in accordance with the circumstances of the coronavirus pandemic, caused a large number of domestic tourists to visit local destinations in 2020. For example, according to the Statistical Office of the Republic of Serbia (2020), compared to August 2019, in August 2020, the number of domestic tourist arrivals increased by 25.3% while the number of foreign tourist arrivals decreased by 87.1%. Forced to spend their summer vacation in their own country, expectations were different, in relation to previously acquired experiences, i.e., requirements. The situation with COVID-19 was unexpected, but not impossible. In rural areas or tourist destinations, those involved in hospitality must always be ready to meet the expectations of demanding tourists. In this regard, traditional food, as part of the tourist offer and consumption, must be of uniform and high quality, and produced respecting and adhering to good hygienic practices that ensure the production of safe products. This can be achieved only through the cooperation of small producers, individual farms and local producers, with support from local government and scientific and professional bodies, and finally central government. Such cooperation should improve gastronomic tourism, due to production of attractive traditional dishes that satisfy even the most demanding tourists in terms of quality in the broadest sense.

Conclusion

The gastronomic offer of a tourist destination is an important element of the tourist experience, because the taste of the food consumed during the trip is remembered for a long time and is something that tourists, if satisfied, will look for again. Traditional food production is a combination of unique elements of the natural environment, knowledge of the local community and historical and cultural resources that are synergistically connected and form the unique food character of the specific place. Traditionally prepared food is an important factor in choosing a destination for some tourists, but special emphasis should be placed on the quality of food, especially taking into account the safety aspects of food preparation and consumption. Despite the current study involving only small-scale research, the results obtained are informative and relevant for employees in tourism and hospitality, as well as for tourists. The characteristics of traditional food that the respondents considered the most important were: history of traditional dishes, that the quality of traditional food depends on the season, and that such food is high quality and safe, healthy and authentic, with specific sensory characteristics. It is recommended the quality and protection of the authenticity of traditional food is improved through the use of safe food ingredients, is produced by local producers, and is prepared in a safe way. In order to maintain cuisine customs along with traditional dishes and promote a destination, those involved in today's competitive tourism market should connect and work closely together. A limitation of this study is the small number of respondents, but this research could be a starting point for researching other factors that could influence the attitudes of tourists when it comes to traditional food in a destination. The obtained results will definitely help create an adequate tourist offer, but they can also help the development of local food production practices.

Značaj tradicionalne kvalitete hrane — gledište turizma

Miloš Zrnić, Ivana Brdar, Nataša Kilibarda

A p s t r a k t: Ovaj članak daje pristup odnosu gastronomije i turizma, sa posebnim naglaskom na kvalitetu tradicionalne hrane. Poslednjih godina, kada je svet postao „globalno selo", a ljudi širom sveta imaju pristup Internetu, oduševljeni turisti i privrednici lako mogu dobiti informacije o različitim destinacijama, pomažući tako rastu globalizacije i turističke industrije. Ovaj članak objašnjava u kojoj su meri gastronomija i tradicionalna hrana relevantni za razvoj turizma i zašto je presudno posetiocima i turistima ponuditi jedinstvena, tradicionalna jela visokog kvaliteta. Za proučavanje slučaja u Republici Srbiji razmatrani su veći gradovi. Dodatno, članak naglašava važnost tradicionalne hrane u stvaranju sveukupnog, nezaboravnog turističkog iskustva, s obzirom na to da su tradicija, kultura i hrana snažno utisnuti u identitet svake zemlje.

Ključne reči: *gastronomija, tradicionalna hrana, turističko iskustvo, kulturni identitet.*

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Original Scientific Paper

Cook slow, eat fine — consumer attitudes on food quality in new gastronomic trends

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A b s t r a c t: The introduction and application of new ideas in business plays a key role in the development of the company and is an important factor for competitiveness in the market. Leading hospitality companies, through the application of different kinds of standards, have introduced numerous innovations that have influenced a number of changes in such businesses. The constant pursuit of innovation has led to the emergence of new directions in gastronomy. Preparing food in the most modern appliances and designing menus in almost laboratory-like conditions have become features of fine-dining and molecular gastronomy restaurants. A return to old, forgotten tastes, often termed hedonism, in turn, characterises slow food gastronomy. However, modern generations' dining wishes are being realised in fast-food restaurants. The aim of this study, based on a sample of 580 people, was to provide insight into how familiar Belgrade residents are with new trends in restaurant food preparation, with special emphasis on the importance of food quality.

Keywords: *gastronomy, food, hospitality, trends, attitudes.*

Introduction

Innovation has a very important role in modern business, and can be defined as the process of applying any new idea to solve a problem, or improve a service process, product or service (*Hjalager*, 2010; *Lee et al*., 2016). Živković *and Brdar* (2018) stated that in modern business, everything can be considered a type of cost, except innovation. Accordingly, profit created is not created by products, services, business, or employees, but by consumers who are willing to pay the right price for a product or service that will satisfy their needs and expectations.

High-quality service is imperative in modern business and is very important for achieving competitiveness in service industries. Quality assurance is the dominant process in all business activities, from industrial to service companies. Careful quality management has become a decisive factor in the success or failure of many organisations. In recent years, increasing attention has been paid to the quality of services. Gaining and retaining customers is a key factor in marketplace survival (*Cho et al*., 2020). Service industries are paying more attention to quality management, while manufacturing companies realise that complementary, additional services, such as ordering, delivery and complaint handling, are very important aspects of their business. A process of continuous innovation helps restaurants make it harder for competitors to imitate potential services and allows such businesses to maintain their uniqueness ahead of others, leading to a long-term competitive advantage (*Lee et al*., 2016). In modern market conditions and strong competition in all aspects of business, it is necessary to have good knowledge of the specifics of service marketing, so that companies and organisations in the field of service activities can survive and develop in the right way (*Veljković*, 2009). Modern service consumers are experienced, aware of their needs, demand value for money and have increasingly complex requirements. The basis for meeting their needs is to provide quality services that are constantly improved and innovated, with an emphasis on the need to apply standards when creating services (external and internal — quality management, food safety, corporate social responsibility, etc.) (*Živković and Brdar*, 2018).

Given that hospitality is a complex service system, innovations in this area can be considered much more complex than in manufacturing sectors (*Kyriakopoulos and Moorman*, 2004). However, although innovations in hospitality do not necessarily involve a classic change or expansion of the product line, they must primarily be profitable for the business (*Čavlek et al*., 2010). Innovations in the hospitality industry are generally characterised by anything

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that differs from ordinary business or that is an innovation of business practice (*Ottenbacher and Gnoth*, 2005; *Hjalager*, 2010; *Trantopoulos et al*., 2017; *Albors-Garrigós et al*., 2018).

Innovations can be divided according to different criteria, but when it comes to innovations in tourism and hospitality, we can use the following divisions: (*Hjalager*, 2002; *Hjalager*, 2010)

- product innovation,
- innovations in business operations,
- innovations in the field of information management,
- innovations in the field of management, and,
- institutional innovation.

The most important factors in hospitality are to create an innovative menu and to implement it in the right way. Hospitality managers need to innovate their offer of gastronomic products in response to modern trends in nutrition and create menus that are in line with the current requirements of consumers (*Cho et al.,* 2020). To ensure success in an organisation, the menu needs to be aligned with market changes. Modern trends in gastronomy tend to emphasise the natural taste, composition, texture and structure of food; this is a response to the increased awareness of guests about what they consume every day (*Gagić et al*., 2014). The main forms of service innovation in the hospitality industry are innovative culinary-scientific techniques (e.g., molecular gastronomy), offering healthy meals, an innovative approach to food presentation, and authenticity as elements of the innovative offer.

Contemporary trends in gastronomy – literature review

Molecular gastronomy (molecular cuisine) is a trend in line with new trends in human nutrition. Molecular gastronomy can be described as a fusion of science and classic cuisine, i.e., the use of certain devices that give food peculiar organoleptic properties (*Vega and Ubbink*, 2008). This (2009) defines it as "a branch of science that studies the physico-chemical transformations of edible materials during cooking and sensory phenomena associated with their consumption". When culinary art merged with science, a completely new, rather revolutionary culinary trend emerged, which lately has become a means of expression for master chefs, but it also entices guests who are ready to try something new and unusual. Kitchens have been turned into laboratories, where the magic happens with the help of liquid nitrogen, deionised water, helium, calcium compounds, homogenisers, lasers and injections, which in short means — chemical construction with the aim of changing the structure of the food (*Rao et al*., 2003; *Ottenbacher and Harrington*, 2009; *Slavich et al*., 2019; *Miličević*, 2020).

Molecular gastronomy has not only produced innovations in the way food is prepared by restaurants. In fact, food preparation under the principles of molecular gastronomy changes the entire restaurant and the hierarchy in the kitchen (*Blanck*, 2007; *Cousins et al*., 2010). Implementation of molecular gastronomy shows the restaurant is actually ready for innovation and specific changes in order to achieve authenticity and competitive advantages (*Blanck*, 2007; *Cousins et al*., 2010). Molecular gastronomy at first glance can be characterised as a relatively expensive endeavour. At restaurant level, it can cost significantly more than traditional cuisine at the same restaurant, for practical reasons of the non-existence of hierarchy in the situation where there are as many chefs as there are dishes. From the restaurant side, it should be pointed out that molecular gastronomy requires some investment in infrastructure, because the dining experience lasts for several hours. Everything is opposed to classic restaurant operation (*Rodgers*, 2011; *Božić and Đurović*, 2019).

A menu based on healthful acceptable meals embraces the "healthy food" concept, i.e., the concept of nutritious meals in which no additives or unwanted supplements are introduced *via* foods of plant or animal origin. In restaurants with this approach, the menu can be based just on the fact that classic white wheat flour is not used. As Gagić (2014) stated, the introduction of whole grains as a raw material for bakery products is seen as an innovative step that will meet the needs of the market segment that sees this type of carbohydrate food as a better choice compared to the previously used refined flour. Today, it is very desirable to have integral flour bakery products on the menu, but the use of white, refined sugar in desserts is also under scrutiny. Simply, the healthy food concept is to avoid excessive use of salt, flour and sugar. Desserts in these restaurants utilise various substitutes for white sugar, such as sweeteners and other more acceptable foods, that give the dish some sweetness (*Gagić*, 2014).

Fine dining restaurants offer very high standards in all aspects of their business. Their products are defined by fresh ingredients of exceptional quality (*Ninemeier*, 2005). Also, chefs with particular culinary skills are necessary, because the dishes are prepared using special devices that allow chefs to prepare them in an experimental way, combining different

flavours and textures of food. A particularly important technique in food preparation is *sous vide*, a technique that focuses on meeting demanding guests' expectations of minimally processed, safe, nutritious food that has a visual appeal, smell, taste, and texture comparable to fresh food (*Kilibarda et al*., 2018). However, in addition to the food itself, great emphasis is placed on the selection of dinnerware and utensils to be used, on the service itself, and on the wines that will be served with a particular dish (*Tsaur et al*., 2015). When it comes to the interior design of this type of restaurant, it is elegant, exclusive, and exudes a refined atmosphere (*Rozekhi et al*., 2016).

Education is considered to influence people's experience and shape their values, beliefs, attitudes, interests, activities and lifestyles. Some research shows that with increasing education level, consumers become better acquainted with food and drink and the level of restaurant service (*Tsaur and Lo*, 2020). Some authors argue that high-income groups are more likely to visit fine dining restaurants because of the quality, comfort, prestige and personalised service observed in full-service restaurants (*Hyun and Kang*, 2014; *Cao et al*., 2019). High-income groups have more disposable income, and probably some amount of their higher disposable income is spent in search of hedonistic pleasure, among which is counted fine dining (*Ali Eliwa*, 2006; *Sahni and Mohsin*, 2017).

Fast-food can be defined as a sector of the food industry that is characterised by fast preparation of food and beverages, and rapid service, for immediate sale to the customer (*Ninemeier*, 2005). Although fast-food restaurants differ from each other in some aspects, they do have something in common — a limited menu and a process focused on one product (pizza, burger, etc.) (*Barjaktarović*, 2015). All aspects of working in fast-food restaurants are highly standardised, which leads to large production volumes. Variable operating costs constitute a large part of the selling price of the product, so must be accurately calculated. This type of restaurant is intended for markets with relatively low average consumption frequencies in restaurants. In a competitive market, fast-food restaurants need to focus on improving the quality of their services in order to compete and survive (*Namin*, 2017).

Slow food is a global organisation officially founded in 1989 in Paris after the signing of the Slow Food Manifesto, although the idea and movement itself emerged in Rome three years earlier after demonstrations against the opening of a McDonald's restaurant on the Spanish Steps, one of the city's landmarks (*Hendrix and Lagendijk*, 2020). The organisation was created to prevent the extinction of local food-related cultures and traditions, to oppose a fast-paced lifestyle and to raise people's awareness of the value of food. This is exactly what the Statute of Slow Food says – slow food acts to protect the right to enjoyment of both humane rhythms of life and a harmonious relationship between people and nature (*Altuna et al*., 2017). It has developed into a global movement in which millions of people are involved, working to provide everyone with access to good, clean and fair food. This concept promotes the idea that food is related to many other aspects of life, including culture, politics and agriculture. Also, the slow food movement believes food choices can collectively influence how food is grown, produced and distributed, and that the world changes as a result (*Siniscalchi*, 2014).

Slow food is an environment in which all people can have access to and enjoy food that is healthy and acceptable for them, for those who produce the food, and that is good for the earth. The approach to this concept is based on three interrelated principles: good, clean and fair (*Slowfood*, 2015). The principle "good" applies to quality, tasty and healthy food. "Clean" refers to production that does not harm the environment, while the principle "fair" refers to affordable prices for consumers and fair conditions for payment to producers (*Simonetti*, 2012; *Siniscalchi*, 2014; *Hendrix and Lagendijk*, 2020). Every member of the slow food organisation around the world spreads the philosophy of this movement through the events and activities they organise in their communities. These events include food tastings, touring local producers and farms, and conferences and festivals (*Andrews*, 2008).

Slow food restaurants have a different concept from other restaurants. The waiter has a menu and introduces the guests to the selection, making it more immediate for them. These types of restaurants can offer all major food groups — meat, fish, fruits, and vegetables, but the food is exclusively local and locally prepared. Specifically, slow food restaurants intend that people have a hedonistic approach to food and simply enjoy it, but the goal is also to raise guests' awareness of food perception and where their food comes from (*Payandeh et al*., 2020).

National cuisine or gastronomy is a branch of general gastronomy and refers to the set of all the characteristics related to nutrition, food culture and food preparation methods in a location, all conditioned by the ethnic being of the people themselves (*Vukić*, 2012). However, *Baltic et al*. (2018) state the term "national cuisine" can only be used conditionally because there is no truly homogeneous national cuisine. National cuisines have developed throughout history and are related to the culture of the people who inhabited

specific territories, and thus, they reflect the material culture of the people. Authenticity, as an element of an innovative offer, affects the overall ambience of the product and can greatly improve the way national cuisine restaurants do business (*Le et al*., 2019).

This study aimed to find out about the attitudes of residents in Belgrade, Serbia, towards modern trends in the restaurant business.

Materials and Methods

The research was conducted using an anonymous survey in the period from January 30, 2020 to March 31, 2020 on a sample of 580 respondents in Belgrade, Serbia. A questionnaire containing 22 questions was developed. The questionnaire consisted of five parts: the first part referred to the socio-demographic characteristics of the respondents and included six questions. The second part included questions related to the habits of the respondents as consumers in relation to restaurants. In this part, four closed-ended questions were asked, with the possibility of choosing one or more answers. The third part of the questionnaire dealt with the attitudes of consumers towards restaurants, i.e., what is of great importance to them when they choose and visit restaurants. This part included five questions in the form of a modified Likert scale (5 points, where 1 stands for I don't care at all and 5 stands for "of crucial importance"). The fourth part of the questionnaire included seven closed-ended questions, with answers limited to only one p er question. This part was based on modern trends in the restaurant industry and included opinions and knowledge questions on some recent trends in the hospitality industry.

Results and Discussion

The first part of the questionnaire dealt with the socio-demographic characteristics of the respondents, and these data are shown in Table 1.

The second part of the questionnaire related to the habits of the respondents as guests in relation to restaurants. Table 2 shows the answers to the questions

Table 1. Socio-demographic characteristics of the respondents

Socio-demographic characteristics		No. of respondents (percentage)
Sex	Male	264 (45.5%)
	Female	316 (54.5%)
Age	18–25	368 (63.5%)
	26–35	132 (22.8%)
	36–45	40 (6.9%)
	46–55	20 (3.45%)
	55+	20 (3.45%)
Education	High school	164 (28.3%)
	Undergraduate degree	312 (53.8%)
	Higher degree	104 (17.9%)
Marital status	Married	80 (13.8%)
	In relationship	260 (44.8%)
	Single	240 (41.4%)
Employment Status	Employed	280 (48.3%)
	Self-employed	64 (11%)
	Student	204 (35.2%)
	Unemployed	32 (5.5%)
Monthly Income	Up to 30,000 RSD	148 (25.5%)
	30,000–50,000 RSD	96 (16.6%)
	50,000–80,000 RSD	168 (29%)
	80,000–120,000 RSD	80 (13.8%)
	Over 120,000 RSD	88 (15.2%)

Table 2. Restaurant visits, type of restaurant and expense per visit

Frequency of visits	*No. of respondents*	*Percentage*
Daily	118	20.35%
Once a week	134	23.10%
Several times a week	**242**	**41.72%**
Once a month	46	7.93%
A couple of times a year	32	5.52%
Once a year / never	8	1.38%
Restaurant type	***No. of respondents***	***Percentage***
Fast-food restaurants	**260**	**44.8%**
International cuisine	136	23.4%
Local cuisine	166	28.6%
Eat exclusively at home	32	5.5%
Canteen	24	4.1%
Fine dining restaurants	**20**	**3.4%**
Amount of money spent per visit	***No. of respondents***	***Percentage***
Up to 1,000 dinars (up to 10 $ or 10 €)	184	31.7%
Between 1,000 and 2,500 dinars (10–25 $ or 10–25 €)	**228**	**39.3%**
Between 2,500 and 5,000 dinars ($ 25–50 or € 25–50)	124	21.4%
Over 5,000 dinars (more than 50 $ or 50 €)	44	7.6%

on how often the respondents visit restaurants, which restaurant types they visit the most frequently, and how much they typically spend during their visit. The most common answers are marked in bold.

The results in Table 2 show the large numbers of respondents visited restaurants several times a week (41.72%), followed by those who go to restaurants once a week (23.10%) or every day (20.35%). The largest number of respondents visited fast-food restaurants (260; 44.8%). *Dave et al*. (2009) suggested that public education on fast-food's unhealthiness may not affect fast-food consumption, while the frequency of fast-food intake is significantly associated with perceptions of fast-food's suitability and the respondent's aversion to cooking, but not with the perceived unhealthiness of fast-food. If consumption is taken into account, these results are confirmed by the current study, having in mind that the largest number of respondents spent between 1000 and 2500 dinars (39.3%), followed by those who spend up to 1000 dinars (31.7%) per restaurant visit. It follows, therefore, that the majority of respondents eat unhealthily at fast-food restaurants, but this could be explained by lifestyles, i.e., the fact that employed people spend most of their time outside their homes and, therefore, look for the simplest ways to consume food. Another reason could be a complicated personal economic situation, impelling our respondents to find cheaper solutions to eating out. Also, *Mill* (2007) stated that people mostly visit fast-food restaurants, where customers order food at the counter, or full-service restaurants that have lower prices. The convenience of fast service and suitable location are the main sales factors for both types of restaurants, which to some extent shows increased consumer concerns about value-for-money in difficult economic times, but also boosts the popularity of this type of business. *Statista* (2020) showed that on average, people visit fast-food restaurants once or several times a week, with the younger population recording more frequent visits, and that full-service restaurants are visited several times per year by people of all generations. According to *Eurostat* (2017), households in the European Union (EU) spend an average of 8.8% of total spending on restaurants and hotels, which is about €1,400 per capita in the EU, which would be about €12 per month. According to *Henderson* (2019), the per capita average expenditure in restaurants in the United States in 2019 was about $128, i.e., about $12 monthly. With this in mind, it can be said that although Serbia lags behind the European Union and the United States in terms of living standards, the pattern of people's behaviour with respect to restaurants is probably quite similar.

Table 3. Crucial factors for restaurant selection

Factors	No of respondents	Percentage
Price	87	15.0%
Food quality	**212**	**36.6%**
Service	43	7.4%
Price-quality ratio	**97**	**16.7%**
Food safety	**112**	**19.3%**
Diversity and innovation of the offer	29	5.0%

Factors of crucial importance to the respondents in order to decide to visit a restaurant were examined, and the results are shown in Table 3.

The largest number of respondents (36.6%) stated the quality of food is of crucial importance to them. Another important factor is food safety (19.3%), followed by the price-quality ratio (16.7%). It was somewhat unexpected that price was not revealed as one of the primary factors in decision making, having in mind the price sensitivity of the Serbian population, but also taking into account respondents' answers related to their expenditure per visit in restaurants. Food quality and safety are certainly important, as the respondents showed. Other studies produced somewhat similar results, but at the same time pointed out price as one of the key factors. For example, *Lee and Cranage* (2007) found taste, price and the provision of nutritional information are key factors for restaurant choice in adolescents. On the other hand, *McCall and Linn* (2008) reported that detailed descriptions of dishes on the menu can increase the perception of food quality and can increase the likelihood of a meal being chosen, and also point out that prices will play a smaller role in quality assessment, but should influence the decision as to whether to visit a restaurant. On the other hand, *Cohen and Avieli* (2004) analysed what is crucial for Chinese and (United States) Americans. Chinese people are driven by an experience in which authenticity is important, especially food quality. In contrast, since Americans strive for freedom, prices, correlated with a lifestyle appeal, are important to them. *Jia* (2020) somewhat confirmed that Americans focus more on why and how they eat, while the Chinese primarily care about what they eat. Certainly, our results indicate the need for restaurants to pay more attention to the selection of quality and safe food, as well as to application of food safety standards to provide greater safety and quality guarantees to their consumers. Also, *Djordjevic et al*. (2019) believed that application of modern sensory analysis methods can ensure food quality and correct food's organoleptic properties in accordance with consumer preferences.

The third part of the current study dealt with the attitudes of consumers to restaurants, i.e., what is of great importance to them when it comes to choosing and visiting restaurants. The answers were ranked on a scale of 1 to 5, where 1 represents the statement "Not relevant" and 5 the statement "Crucial".

Reactions to food allergies in restaurants are attributed to a variety of causes, most commonly when food has accidentally come into contact with the allergens or if the consumer is accidentally exposed to food allergens hidden in mixed foods and/or sauces (*Wen and Lee*, 2020). Since there is no cure for food allergy, the only way to prevent an allergic reaction is to avoid contacting, eating and inhaling allergens (*Kwon et al*., 2020). Therefore, respondents were asked about the importance of allergen labelling in restaurant menus. Nearly half of respondents (47.6%) said allergen labelling in the menu is not important to them at all. It is assumed that people who have a food allergy usually ask restaurant employees about potential allergens in food. Interestingly, *Wen and Lee* (2020) stated that 55% of respondents never or rarely communicated with restaurant employees about their food allergies, while only 11% of respondents did so. Certainly, the communication process can be made much easier if all potential allergens are highlighted in each dish on the restaurant menu.

The next question asked whether the restaurant needs to offer extravagant products (products that are unusual and that you can try only in that place), as well as traditional dishes. The answers showed that opinions are divided and that this exclusivity is not of great importance, so most respondents (64.1%) had a neutral attitude towards extravagant products. The greatest percentage of respondents (37.9%) were also neutral about restaurants offering traditional dishes. On the one hand, fine-dining traditional restaurants have higher prices, which reflected somewhat

by specific dishes of high quality (*Lane*, 2013; *Peters and Remaud*, 2020). On the other hand, the characteristics of traditional food are related to guests' food experience, and research showed the taste, recipes, dietary pattern, use of fresh foods and food presentation contribute to this (*Oh and Kim*, 2020; *Shafieizadeh and Tao*, 2020). Customs, food preparation techniques and the type of food consumed are part of the tradition and heritage of traditional cuisines and dishes (*Baltic et al*., 2018). Because our respondents mostly go to fast-food restaurants, this lack of recognition of the importance of extravagant

Table 4. Importance of individual elements of the modern restaurant offer

The importance of allergen labelling			
Importance	***No. of answers***	***Percentage***	***Mean***
Not relevant	**276**	**47.6%**	2.37
Don't care	103	17.8%	
Neutral	29	5%	
Important	56	9.6%	
Crucial	116	20%	
The importance of extravagant gastronomic products			
Importance	***No. of answers***	***Percentage***	***Mean***
Not relevant	42	7.2%	3.06
Don't care	53	9.1%	
Neutral	**372**	**64.1%**	
Important	53	9.1%	
Crucial	60	10.3%	
The importance of traditional gastronomic products			
Importance	***No. of answers***	***Percentage***	***Mean***
Not relevant	124	21.4%	2.89
Don't care	76	13.1%	
Neutral	**220**	**37.9%**	
Important	56	9.7%	
Crucial	104	17.9%	
The importance of food safety			
Importance	***No. of answers***	***Percentage***	***Mean***
Not relevant	4	0.7%	**4.54**
Don't care	14	2.4%	
Neutral	37	6.4%	
Important	133	22.9%	
Crucial	**392**	**67.6%**	
The importance of balanced nutritional value			
Importance	***No. of answers***	***Percentage***	***Mean***
Not relevant	143	24.7%	2.83
Don't care	39	6.7%	
Neutral	**264**	**45.5%**	
Important	38	6.6%	
Crucial	96	16.5%	

Table 5. The relation between respondents' sex and the importance of balanced nutritional values

	The importance of balanced nutritional value					
Sex:	1	2	3	4	5	Total
Male	18.18%	24.24%	22.73%	21.21%	13.64%	100%
Female	29.11%	12.66%	32.91%	12.66%	12.66%	100%
Total	**24.14%**	**17.93%**	**28.28%**	**16.55%**	**13.10%**	**100%**

and traditional dishes in restaurants is not surprising. By implementing a suitable marketing strategy and an appropriate segmentation-targeting-positioning strategy, restaurants could change the neutral attitude of consumers to a positive one and, thus, bring their offer closer to the target groups.

Food safety a key area in the restaurant business. Given the concerns of consumers on this issue, various studies indicate that cleanliness, employee appearance, inspection reports, visual appearance and temperature of food, and the overall impression of the restaurant are indicators that the restaurant cares about the safety of employees and guests (*Henson et al*., 2006; *Namkung and Jang*, 2007; *Ryu and Jang*, 2008; *Liu and Lee*, 2018). The largest percentage of our respondents consider food safety a crucial factor in deciding which restaurant to visit (67.6%), which concurs with other similar studies (*Lee et al*., 2012; *Bai et al*., 2019; *Levy de Andrade et al*., 2019).

Another question in this part of the research asked how important it is for the respondents if the dishes in the restaurant are of balanced nutritional value. The answers showed a relatively small percentage of respondents (16.5%) think this factor is crucial for choosing a restaurant. The largest number of respondents (45.5%) were neutral on this issue. The results obtained seem unusual, having in mind that due to modern lifestyles, people today pay a lot of attention to a healthy diet. Food in restaurants is often perceived as one of the causes of the increase in obesity rates due to its calorie and fat contents. To avoid health problems, consumers have begun to show greater interest in healthy eating, especially when eating out. It follows that guests will more often choose healthier dishes, will take into account the portion size, and will, therefore, more often go to restaurants that have such an offer (*Kang et al*., 2020).

The results from Table 5 show us it is more important for men that the restaurant has dishes with balanced nutritional values (total for scores 4 and 5–34.85%), while more women do not pay much attention or have no opinion about the importance of this factor for going to the restaurant (total for scores 1 and 2–41.77%). This data is very interesting, since most research has shown the opposite (*Driskell et al*., 2006; *O'Mahony and Hall*, 2007; *Larson et al*., 2018).

To better analyse the importance of some factors of the contemporary restaurant offer, the Likert scale was used, and the obtained grades were summarised as follows: scores 1 and 2 refer to a negative attitude, 2 and 3 to a neutral attitude, and 4 and 5 to a positive attitude. The scores showed that the respondents did not have a negative attitude towards any of the factors, but rather, most had a neutral attitude. The only positive attitude was expressed regarding food safety (mean of 4.54). Although this does not seem optimistic, it is not worrisome, because neutral attitudes, with adequate business decisions and measures, can be easily turned into positive ones (*Živković and Brdar*, 2018).

The fourth part of the study was on contemporary trends in the restaurant business and included gathering respondents' opinions about them as well as specific questions on respondents' knowledge about some of the trends. The most common answers are marked in bold.

Table 6. Desired new restaurants by type

New restaurants by type	No of respondents	Percentage
International cuisine	220	37.9%
Fine dining	184	31.7%
Local cuisine	160	27.6%
Fast-food	16	2.8%

Table 6 shows the respondents' opinions on what type of restaurant should be additionally opened in Belgrade. Respondents believe that it would be good to open new restaurants serving international cuisine (37.9%), while restaurants with a fine dining concept came in second place (31.7%). This indicates that fine dining as one of the modern trends should be recognised as a way to improve the offer of Belgrade restaurants.

Finally, the respondents were asked specific knowledge questions in order to determine to what extent they are familiar with new trends in the hospitality industry. Answers are presented in Table 7. Most of our respondents were of the opinion that the features of tasty, clean, and fair with a hedonistic principle are characteristic of a fine dining restaurant (73.1%). However, these are the characteristics of slow food restaurants, which shows the respondents have not yet fully distinguished the characteristics of these two restaurant business concepts.

The next question (Table 7) shows the three main features of fine dining restaurants according to the respondents. They stated the main features are a higher level of service (89%), exclusive interior (72.4%) and higher food prices (61.4%). This supports the claim that consumers know the characteristics of fine dining restaurants, because our respondents correctly chose three of the six answers offered (fast service, home-made drinks and takeaway food were incorrect). Respondents' knowledge of fine dining may have led them to put this category in second place as the best choice for opening new restaurants in Belgrade.

We also investigated whether the respondents were familiar with the *sous vide* method of cooking, and most of them (77.2%) answered correctly that this technique is attributed to molecular and modernised cuisine restaurants. Also, we can conclude that the respondents are familiar with this trend because the largest number of respondents (84.8%) answered that

Table 7. Respondents' knowledge of modern restaurant trends

Knowledge of the characteristics of analysed restaurant trends	**Correct answer**	**No. of respondents/ percentage**	**Trend knowledge (+), trend ignorance (-)**
Delicious, clean and fair with a hedonistic principle	slow food restaurant	424 / 73.1% for fine dining	–
Mark three main attributes of fine dining restaurants	/	Higher quality service − 89% (516 respondents). Exclusive interior 72.4% (420 respondents) Higher food prices 61.4% (356 respondents).	+
Sous vide cooking method	molecular and modernised cuisine restaurants	448 / 77.2%	+
Molecular and modernised cuisine restaurants use liquid nitrogen for technological food processing	Correct	492 / 84.8%	+
High level services	molecular and modernised cuisine restaurants	477 / 82.1%	+
Charcoal grill is used mostly in fast-food restaurants	Correct	360 / 62.1%	+

molecular and modernised cuisine restaurants use liquid nitrogen for the technological processing of food, which also was a correct answer. Another question referred to molecular and modernised kitchens having service quality of the highest level, which, again, the largest number (82.1%) of respondents knew.

That charcoal grills are used mostly in fast-food restaurants was also answered correctly by the largest number of respondents (62.1%). This answer was also expected because 44.8% of the respondents said they eat in fast-food restaurants, so they would already be familiar with those foods that are typically charcoal grilled; burgers, kebabs and the like.

Overall, the respondents to this survey were well acquainted with innovations and new trends in the hospitality industry.

Conclusion

Innovation plays an important role in the business of all hospitality companies. No company can survive in a changing environment without innovating. For hospitality companies to survive in the market for a longer time, they must first and foremost be able to meet the needs of their current and potential consumers. This can be achieved through implementing innovations that directly affect the quality of services. Nonetheless, quality should not be neglected, regardless of the size and success of any company, as innovation is only one element necessary to achieve competitive advantage and meet the needs of its customers. Our findings indicate that Belgrade residents are well informed about modern hospitality requirements; they know and follow modern trends, they are familiar with the types of food prepared in different types of restaurant, they support the opening and expansion of these restaurants, and visiting these restaurants has built positive attitudes about them, despite limitations in terms of the economic situation in the country and the solvency of the population. However, given today's situation with the coronavirus pandemic, it can be said with certainty that food safety, hygiene, and the safety of employees and guests will influence the emergence of new innovations and solutions that will provide full protection for all. The only question is whether we are ready for that and in what way we will accept all the changes that will occur.

Kuvajte sporo, jedite fino — Stavovi potrošača o kvalitetu hrane u novim gastronomskim trendovima

Ivana Brdar

A p s t r a k t: Uvođenje i primena novih ideja u poslovanju ima ključnu ulogu u razvoju kompanije i predstavlja važan faktor za konkurentnost na tržištu. Vodeće ugostiteljske kompanije su, uz primenu standarda, uvele brojne inovacije u svoje poslovanje što je uticalo na niz promena u poslovanju. Stalna težnja inovacijama dovela je do pojave novih pravaca u gastronomiji. Spremanje hrane u najsavremenijim aparatima i osmišljavanje jelovnika u skoro laboratorijskim uslovima postali su odlika fine dining restorana. Povratak starim, zaboravljenim ukusima, izraženi hedonizam, pak, odlikuju slow food gastronomiju. Nove generacije i njihove želje dobile su realizaciju u fast-food restoranima. Cilj ovog rada je da se, na osnovu istraživanaj koje je sprovedeno na uzorku od 580 ljudi, pruži uvid u to koliko su stanovnici Beograda upoznati sa novim trendovima u pripremi hrane, sa posebnim osvrtom na značaj kvaliteta hrane.

Ključne reči: *gastronomija, hrana, ugostiteljstvo, trendovi, stavovi.*

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