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Some quality parameters of functional fermented, cooked and liver sausages*

Vasilev Dragan[1], Vuković Ilija[1], Saičić Snežana[2]

A b s t r a c t: The most important quality parameters of functional fermented, cooked and liver sausages are presented. Experimental fermented sausages included: a) conventional fermented sausage, b) functional fermented sausage with 2% inulin powder, c) functional fermented sausage with 4% inulin suspension and d) functional fermented sausage with 8% inulin suspension. All fermented sausages contained probiotic strain Lactobacillus casei LC 01. Experimental cooked sausages included: a) conventional cooked sausage, b) functional cooked sausage with inulin suspension, c) functional cooked sausage with flaxseed/rapeseed oil and d) functional cooked sausage with inulin suspension and flaxseed/rapeseed oil. Experimental liver sausages were: a) conventional liver sausage and b) functional liver sausage with inulin suspension. The obtained results show that functional fermented sausages have lower pH (4.77 – 4.93) and a_w (0.89 – 0.90) values then the conventional sausage (pH = 5.18; a_w = 0.93). Functional fermented sausages contain more proteins (24.2–24.5%) and less fat (24.4 – 29.7%) then conventional sausage (proteins = 20.9%; fat = 32.4%). The content of functional ingredients such as inulin and pea fiber (4.1–5.7%), in functional fermented sausages as well as higher number of probiotic strain Lactobacillus casei 01 (8.3–8.5 log cfu/g) than in conventional cooked sausage (8.1 log sfu/g) supports their functional potential. Addition of inulin (both in powder and suspension) and pea fiber improves the appearance, cut surface appearance and texture, but affects the colour of fermented sausages. Addition of 8% inulin suspension affects the odour and taste of fermented sausages. Cooked sausages with inulin suspension contain more water (63%) and less fat (22–23%) than conventional sausage (water – 60%; fat – 25.3%) and sausage containing flaxseed/rapeseed oil (water – 59%; fat – 26%). Protein content is similar in all experimental cooked sausages (10.2 –10.4%). Cooked sausages produced with inulin suspension contain 3.0–3,1% inulin. Sausages produced with flaxseed/rapeseed oil contain more polyunsaturated fatty acids (PUFA), (18.4 – 20.9% of total fatty acid content) and much more favourable omega-6/omega-3 fatty acid ratio (1,6 –2,5) then sausages produced without these oils (PUFA – 11.9–12.1%; omega-6/omega-3 – 22.3 –22.9). Despite the high content of polyunsaturated fatty acids,(TBARS) value in all experimental cooked sausages was 0.00 mg MAL/kg. Addition of flaxseed/rapeseed oil in the amount of 6% affects colour, odour and taste and texture of cooked sausages, but not the appearance and cut surface appearance of the product. Functional liver sausage contains less water (42.5%) and fat (43.6%) than the conventional cooked sausage (water = 44.3%; fat = 44.0%), but protein content is similar in both products (9.0–9.1%). Functional liver sausage contains 3.1% dietary fibre (inulin and pea fiber) which supports its functional potential. Sensory properties of functional liver sausage are rated excellent at the scale from 1 to 5 (average rating 5.0). On the contrary, some sensory properties of the conventional liver sausage were rated somewhat lower (odour and taste 4.8 and texture/juiciness 4.6).

Key words: *functional food, quality, fermented sausages, cooked sausages, liver sausages.*

Introduction

The term functional food refers to food that, in addition to basic nutritional components, contains ingredients which is positively impact on human's health (*Nitsch,* 2006/a). Meat industry and other branches of food industry, in accordance with contemporary scientific knowledge and the market re-

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[1]*Faculty of Veterinary Medicine, Bulevar Oslobođenja 18, 11 000 Belgrade, Republic of Serbia;*
[2]*Institute of Meat Hygiene and Technology, Kaćanskog 13, 11 000 Belgrade, Republic of Serbia;*
[3]*Company „Big Bull", Sremska 36, 22 225 Bačinci, Republic of Serbia.*

Corresponding author: Vasilev Dragan, vasilevd@vet.bg.ac.rs

quirements, begin to manufacture products with properties of functional food. Creating a meat product as functional food is based on knowledge of its nutritional and other characteristics, and includes enrichment of the product with ingredients that have positive effect on human's health and reduction the content of potentially harmful ingredients. The most important ingredients which are added to functional food are probiotics, prebiotics, antioxidants, omega-3 fatty acids, vegetable oils and fats, dietary fibre, micronutrients, vitamins and other (*Jimenez-Colmenero et al.,* 2001*; Arihara,* 2006; *Nitsch,* 2006/a). Because of its technological characteristics, fermented, cooked and liver sausages have a certain potential to be produced as functional food.

The major part in fermented sausage composition is meat (70–80%), which is well known as a source of nutritionally high valuable proteins, B group vitamins, minerals and bioactive substances that are very important in human's diet. Since the fermented sausages are not heat treated during production, these valuable nutrients remain essentially unchanged. In addition, among bacteria of the genus *Lactobacillus* which are involved in fermentation there is the greatest number of strains with probiotic properties, so the use of probiotics as functional ingredients in fermented sausages is of particular importance. Other functional ingredients such as prebiotics (dietary fibre, inulin and oligofructose) and omega-3 fatty acids could be added to fermented sausages too (*Müller,* 2006; *Vuković et al.,* 2007; *Vasilev,* 2010). In this way the functional fermented sausages could be produced and compared to conventional products, have not only greater nutritional value, but also significant potential to have a positive influence on human's health.

Cooked sausages are meat products that in stuffing contain meat batter and are conserved by heat treatment at temperatures of pasteurization. Stuffing of cooked sausages is a complex system made up of true and colloidal solution, swollen protein gels, emulsions, foams and suspensions (*Vuković,* 2006). By production of cooked sausages as functional food, a certain problem could be a reduction of fat, as well as enrichment of products with omega-3 fatty acids, which are mostly found in fish oil and some vegetable oils, such as rapeseed and linseed oil. The use of these oils could influence the aroma, colour and texture of cooked sausages (*Nitsch,* 2006/a) and in addition, polyunsaturated fatty acids easily oxidize, which leads to chemical spoilage of products (*Valencia et al.,* 2007). Functional cooked sausages can be produced by replacing a part of fat tissue with the prebiotic inulin in the form of suspension. Inulin suspension up to 5% of the stuffing has no negative influence on sensory properties of the products (*Nitsch,* 2006/b).

Liver sausages are produced from liver, cooked or boiled meat, fat and connective tissue, salt, spices and additives. Technological base of the stuffing consists of liver, fat and broth. The central role in the sausage stuffing stability belongs to liver protein gelation during heat treatment, which implies pasteurization, cooking or sterilization (*Vuković,* 2006). Liver sausages also have the potential to be a functional food. These products contain at least 10% liver, and it is known that the liver is an important source of vitamin A, B complex vitamins, iron and microelements, whose content in the liver is several times higher than in pork and beef meat (*Vuković,* 2006). In liver sausages, a certain problem could be a reduction of fat tissue content and the addition of oils rich in polyunsaturated fatty acids, due to adverse effects on sensory properties as well as increased susceptibility to oxidation (*Valencia et al.,* 2007). In liver sausages fat tissue can be substituted with up to 20% inulin suspension, without any adverse influence on sensory properties of the products (*Nitsch*, 2006/b).

In this paper some important quality parameters of functional fermented, cooked and liver sausages, which would possess, on the one hand appropriate functional properties and on the other hand acceptable sensory properties are studied.

Material and methods

In this paper were functional fermented, cooked and liver sausages produced and tested.

Functional fermented sausages

a) Conventional fermented sausage – 75% lean beef and pork meat and 25% pork back fat.
b) Functional fermented sausage with 2% inulin powder – 75% lean beef and pork meat, 22% pork back fat, 2% inulin powder (Fibruline instant, Cosucra S.A., Belgium), 1% pea fiber (Swelite, Cosucra S.A., Belgium).
c) Functional fermented sausage with 4% inulin suspension – 75% lean beef and pork meat, 20% pork back fat, 4% inulin suspension (Fibruline XL, Cosucra S.A., Belgium, inulin and water ration 1:1), 1% pea fiber (Swelite, Cosucra S.A., Belgium).
d) Functional fermented sausage with 8% inulin suspension–75% lean beef and pork meat, 16% pork back fat, 8% inulin suspension (Fibruline XL, Cosucra S.A., Bel-

gium, inulin and water ratio 1:1), 1% pea fibre (Swelite, Cosucra S.A., Belgium).

Additions to 1 kg stuffing: 28.0 g curing salt with nitrite, 0.625 g preparation *Lactobaciluus casei* LC 01 strain (Chr. Hansen, Denmark), 1.5 g dextrose, 4.0 g sucrose and 4.0 g mixture of spices.

Inulin suspension was prepared by homogenization of inulin and water (75° C) in a cutter in 1:1 ratio, followed by cooling and freezing.

The stuffing for fermented sausages was prepared by coarse chopping of frozen lean pork meat and pork back fat (including frozen inulin suspension under „c" and „d" in aforementioned products) at the beginning, followed by probiotic starter culture addition. After that, the chilled beef meat, sugars (including inulin powder in „b" sausages), pea fibre and spices were added. The stuffing was comminuted to 2 mm particle size, and at the and of the process the ungrounded pepper and curing salt were added.

The stuffing was filled in the collagen casings 60 mm in diameter, and submitted to fermentation and smoking at a temperature which was decreasing from 26 to 22° C, and then drying and ripening at the temperature which decreased to 15° C. Relative humidity gradually decreased from 91% at the beginning of ripening, to 85% at the end. The total production process lasted 21 days.

Functional cooked sausages:

a) Conventional cooked sausage: 25% pork meat II, 27.5% beef meat II, 22.5% water/ice, 25% pork back fat
b) Functional cooked sausage with inulin suspension: 25% pork meat II, 27.5% beef meat II, 22.5% water/ice, 17% pork back fat, 8% inulin suspension (Fibruline XL, Cosucra S.A., Belgium, inulin and water ratio 1:3),
c) Functional cooked sausage with flax seed/rapeseed oil: 25% pork meat II, 27,5% beef meat II, 22.5% water/ice, 19% pork back fat, 6% flax seed/rapeseed oil (1:1 ratio)
d) Functional cooked sausage with inulin suspension and flax seed/rapeseed oil: 25% pork meat II, 27.5% beef meat II, 22.5% water/ice, 11% pork back fat, 8% inulin suspension (Fibruline XL, Cosucra S.A., Belgium, inulin and water ratio 1:3), 6% flax seed/rapeseed oil (1:1 ratio).

Additions to 1 kg stuffing: 16 g curing salt with nitrite, 3 g phosphate, 4 g spices, 0.3 g ascorbate.

Inulin suspension was prepared by homogenization of inulin and water (75° C) in a cutter in a 1:3 ratio, followed by chilling to +2° C.

The batter was prepared in the usual way for fine grounded cooked sausages and stuffed into polyamide casings 60 mm diameter. Sausages were heat treated at a temperature of 80 ° C, until reaching 72° C in the thermal centre of the sausage, and then chilled to a temperature of +4 ° C.

Functional liver sausages:

a) Conventional liver sausage – 22.5% pork liver, 50% pork fat, 20% pork head meat, 12.5% broth.
b) Functional liver sausage with inulin suspension: 22.5% pork liver, 45% pork fat, 20% pork head meat, 12,5% broth, 4% inulin suspension (Fibruline XL, Cosucra S.A., Belgium, inulin and water ratio 1:3), 1% pea fibre (Swelite, Cosucra S.A., Belgium).

Additions to 1 kg stuffing: 14 g curing salt with nitrite, 3 g phosphate, 4 g spices, 0,3 g ascorbate.

Inulin suspension was prepared by homogenization of inulin and water (75° C) in a cutter in a 1:3 ratio, followed by chilling to + 2°C.

The batter was prepared in the usual way for liver sausages and stuffed into polyamide casings 40 mm diameter. Sausages were heat treated at a temperature of 85°C, until reaching 80°C in the thermal centre of the sausage, and then chilled to a temperature of +4°C.

Experimental sausages were examined using standard physico-chemical, chemical, bacteriological and sensory methods.

pH value was measured by means of digital pH-meter WTW, model 521, with combined electrode (WTW-Wissenschaftlich-Technische Werkstäten GmbH, Weilheim, Germany). Water activity (a_w) was measured by means of a_w-meter (a_w-Wert-Messer) brand Lufft (Durotherm, Stuttgart).

For chemical analysis of experimental sausages the following standard methods were applied: 1) protein was determinated content by method SRPS ISO 937 (1992); 2) relative collagen content in meat proteins was calculated by dividing collagen content and meat protein content. Collagen content was calculated by multiplying hydroxyproline content (%) with factor 8 (hydroxyproline content was determined by method SRPS ISO 3496, 2002); 3) total fat content was determinated by method SRPS ISO 1443 (1992); 4) Acid value by lipid extraction from the sample and further determination by method SRPS ISO 660 (2000); 5) TBARS value (Thiobarbituric Acid Reactive Substances) – according to *Tarladgis et al. (1964) and Holland (1971);* 6) moisture content – by method SRPS ISO 1442 (1998); 7) Sodium chloride content – by method

according to *Volhard* SRPS ISO 1841–1 (1999); 8) Nitrite content – by method SRPS ISO 2918 (1999); 9) Ash content by method SRPS ISO 936 (1999). Total lipids for determination of fatty acids were extracted by Accelerated solvent extraction method with solvents (ASE 200, Dionex, Germany). Fatty acid methyl esters were prepared by transesterification with trimethylsulfonium - hydroxide, according to the method SRPS EN ISO 5509:2007. Methyl esters were determined by capillary gas chromatography with flame-ionizing detector on the device Shimadzu 2010 (Kyoto, Japan) and identified by comparing relative retention times with relative retention times of individual methyl esters in standard Supelco 37 Component FAME Mix.

The number of probiotic strain *Lb. casei* LC 01 in fermented sausages was examined on MRS agar (Merck) supplemented with moxalactam (Sigma M-8158) in the amount of 112 mg / L, at 37°C/72 hrs in anaerobic environment (*Kröckel,* 2006). Confirmation of *Lb. casei* was performed by examining of biochemical characteristics of grown colonies using API 50 CH system (bioMérieux).

Overall sensory quality was investigated by the method of adjusted five-point scale system. Sensory characteristics of fermented sausages were evaluated by scores from 5 (excellent) to 1 (unacceptable), and the obtained scores are multiplied with corresponding coefficients of importance. For fermented sausages the following coefficients are used: appearance 2, cut surface appearance 4, colour and sustainability of colour 4, odour and taste 6 and texture 4. For cooked sausages following coefficients were used: appearance 3, cut surface appearance 3, colour and sustainability of colour 4, odour and taste 6 and texture/juiciness 4. For liver sausage the following coefficients were used: appearance 2, cut surface appearance 3, colour and sustainability of colour 3, odour and taste 7 and texture/juiciness 5. The final rating was given by values from 1 to 5, and the adjusted rating by values from 10 to 100. In order to determine the difference between the sensory properties of the experimental products the triangle test was applied (*Radovanović and Popov-Raljić,* 2001).

The results were statistically analyzed by determining the average value, measure of variation and statistical significance.

Results and discussion

Fermented sausages

The most important functional ingredients, when it comes to fermented sausages, are probiotics and prebiotics. As a probiotic in our experiments was used *Lactobacillus casei* LC 01 strain, which according to the literature data, survives well in fermented sausages and shows no negative influence on sensory properties of these products (*Bactoferm Bulletin,* 2003*; Vasilev,* 2010). The results show that the number of probiotic strain *Lb. casei* LC 01 in functional fermented sausages is from 8.3 to 8.5 log cfu/g, whereas in conventional sausage is 8.1 log cfu / g. This difference was not statistically significant (p-value ranged from 0.07 to 0.15) due to the variations of results. Significantly higher numbers of probiotic bacteria *Lactobacillus casei* LC 01 in functional fermented sausages than in conventional ($p < 0.05$) was determined after 7th and 14th day of production, as shown in Figure 1. The higher number of probiotic bacteria in functional fermented sausages is in accordance with results of *Pennacchia et al.* (2006) and *Vasilev* (2010), by which probiotic bacteria grow better in the fermented sausage containing fructooligosaccharides and inulin. In addition, it should be noted that in all experimental fermented sausages the number of probiotic strain *Lactobacillus casei* LC 01 is more than 2 logarithmic units higher than 6 log cfu/g, which, based on the data from the literature, is defined as the minimum number of probiotic bacteria in the product to be characterized as probiotic food (*Kröckel,* 2006).

As prebiotics in the production of functional fermented sausages were used inulin (soluble fibre) and dietary pea fibre (insoluble fibre). Inulin is indigestible oligosaccharide composed of β-D--fructofuranoses connected with β-(2-1) bonds that are resistant to digestive enzymes (*Nitsch,* 2006/ b). Inulin has the technological characteristics that make it suitable as a replacement for fat in meat products. In water systems inulin forms gel that has a structure similar to fat, has a neutral taste and odour, so in limited quantities does not affect adversely the sensory properties of products (*Janvary,* 2005). The results of our study indicate that the addition of prebiotics such as inulin and pea fibre have some influence on physicochemical properties (pH and a_w) of fermented sausages, chemical composition and on some sensory properties, depending primarily on the amount and form in which inulin was applied.

Functional fermented sausages have significantly lower pH value ($p < 0.001$) than conventional fermented sausages, as shown in Figure 2. Lower pH values in fermented sausages containing oligofructose are found according to *Vasilev et al.* (2009 and 2010) too. Our results show that the pH value of fermented sausages is affected by whether the inulin is added to the stuffing in the form of powder or suspension. pH value at the end of ripening is

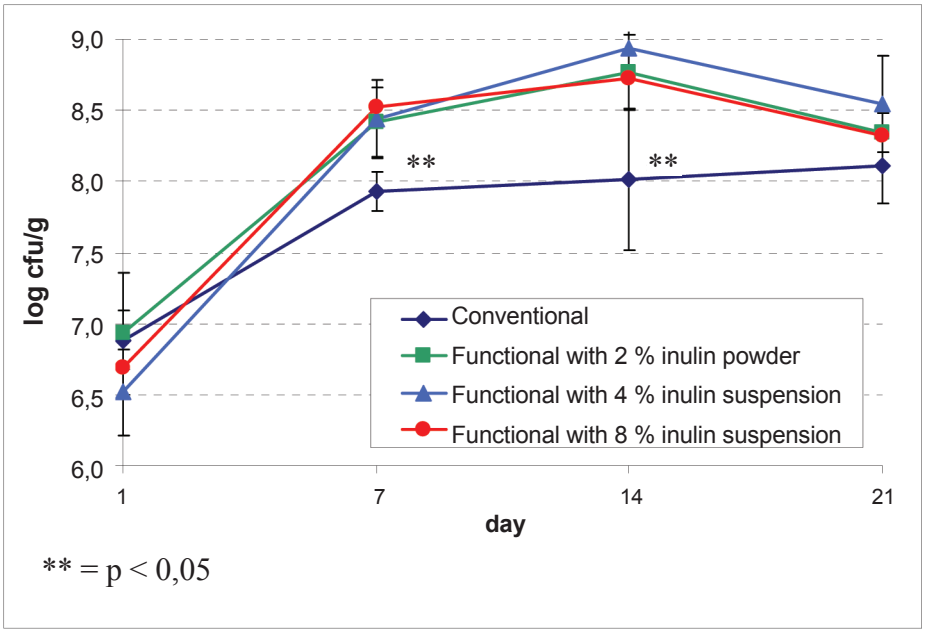

Figure 1. Number of probiotic strain *Lactobacillus casei* LC 01 in fermented sausages
Slika 1. Broj probiotičke bakterije *Lactobacillus casei* LC 01 u fermentisanim kobasicama

the lowest in functional fermented sausage with 2% inulin powder (4.77). In functional fermented sausage with inulin suspension (4 and 8%) pH value was 0.1 and 0.16 units, respectively higher than in sausages in which inulin was added in powder form, and this difference was statistically significant ($p < 0.001$). The reason is probably that the inulin powder, which is thoroughly mixed with the stuffing during preparation, could be more accessible to lactobacilli which ferment inulin (*Pennachia et al.,* 2006) then the inulin which is present in stuffing in the form of peaces of inulin suspension. Although there are differences in pH values of experimental fermented sausages, the measured pH values are typical for this type of meat product and are similar to the values reported by other authors (*Garcia et al.,* 2002; *Muguerza et al.,* 2004).

Water activity at the end of functional sausages ripening in our experiments was lower for about 0.03 a_w-units than in conventional sausage (Figure

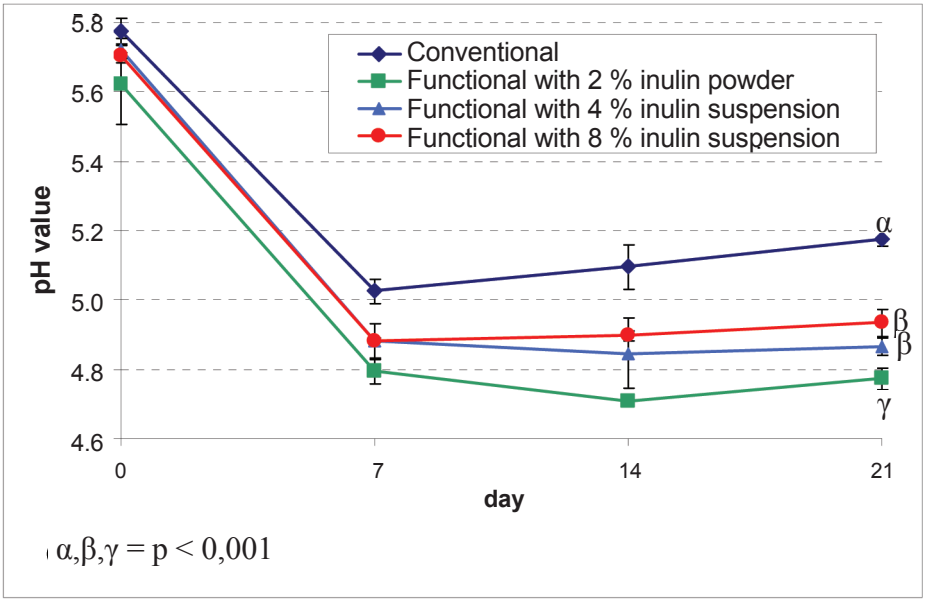

Figure 2. Variations of pH-value in fermented sausages during ripening
Slika 2. Promena pH vrednosti fermentisanih kobasica za vreme zrenja

3), and this difference was statistically confirmed ($p < 0.05$). Other author's reports show that the addition of various dietary fibre decreases water activity of fermented sausages, which at the end of ripening is 0.84 to 0.88 (*Mendoza et al..,* 2001; *Garcia et al.,* 2002; *Sieg,* 2005*; Eim et al.,* 2008; *Vasilev,* 2010). The explanation is in the fact that dietary fibre support drying of fermented sausages by the formation of three-dimensional net, which contributes to more balanced distribution of moisture in the stuffing and its diffusion from the sausage centre to the surface (*Sieg,* 2005).

31.15% (*Saičić et al.,* 2006). Functional fermented sausages from our experiments contain less fat than conventional sausages, in proportion to the amount of fatty tissue that is replaced by prebiotics. Fermented sausage with 8% inulin suspension contains about 8% less fat, fermented sausage with 4% inulin suspension contains 3.86% less fat and fermented sausage with 2% inulin powder contains 2.71% less fat than the conventional sausages (Figure 4). Lower fat content in fermented sausages in which the fatty tissue was replaced with prebiotics were reported by other authors too (*Valencia et al.,* 2007*, Vasilev,*

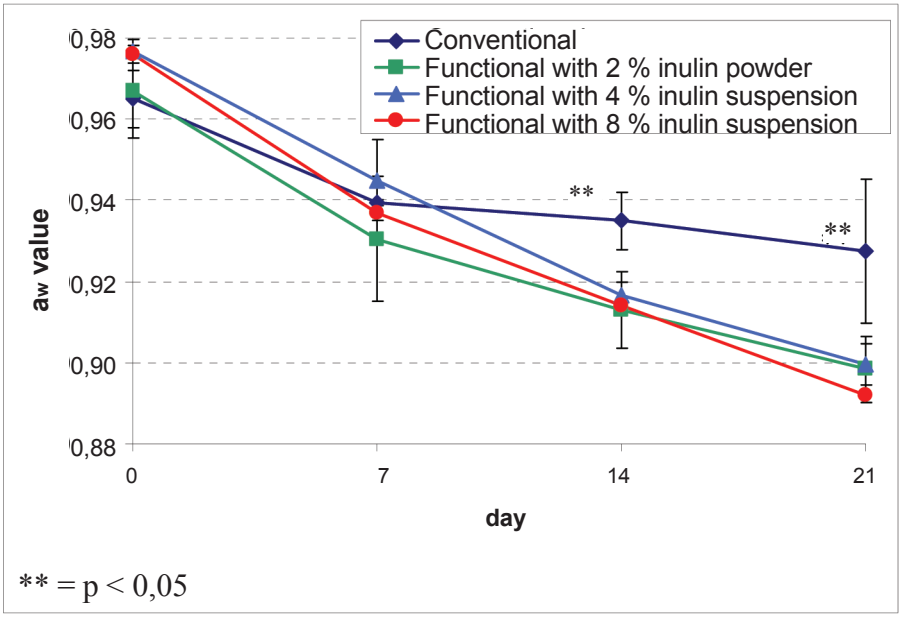

Figure 3. Variations of a_w value in fermented sausages during ripening
Slika 3. Promena a_w vrednosti fermentisanih kobasica za vreme zrenja

Beside the addition of functional ingredients, the concept of functional meat product's manufacture creation includes fat reduction and a higher biological value in terms higher meat protein content, lower connective tissue protein content (*Trumbo et al.,* 2002) and higher content of bioactive substances originating from meat (*Schmid,* 2009). Functional fermented sausages from our experiments contain about 3.3 to 3.6% more meat proteins than conventional fermented sausage (Figure 4). The relative collagen content in meat proteins is similar in all experimental products, ranging from 4.63 to 6.11%, which is significantly less than the norms prescribed by the *Regulation on quality and other requirements for meat products* (2004), in which the relative collagen content in meat proteins in semi-dry fermented sausages can not be higher than 20%. Fermented sausages from domestic market contain 17.52 to 32.96% meat proteins, and the relative collagen content in meat proteins is 6.22 up to

2010). Functional fermented sausage with 8% inulin suspension contains more moisture than the other functional fermented sausages (Figure 4), which can be explained by the fact that the moisture content in the product increases with the amount of added emulsion containing a certain amount of water, which is described by *Muguerza et al.,* (2001) and *Yuldiz-Turp et al.,* (2008). Carbohydrate rest in experimental fermented sausages that represents added prebiotics - inulin and pea fibre, is proportional to the amount of added prebiotics. The highest carbohydrate content was calculated in functional fermented sausage with 8% inulin suspension (5.7%). In the sausage with 2% inulin powder and sausage with 4% inulin suspension (the ratio of inulin and water in the suspension was 1:1) the carbohydrate content is very similar, is 4.07 and 4.10% respectively, which is understandable because in these products the same amount of prebiotics was added.

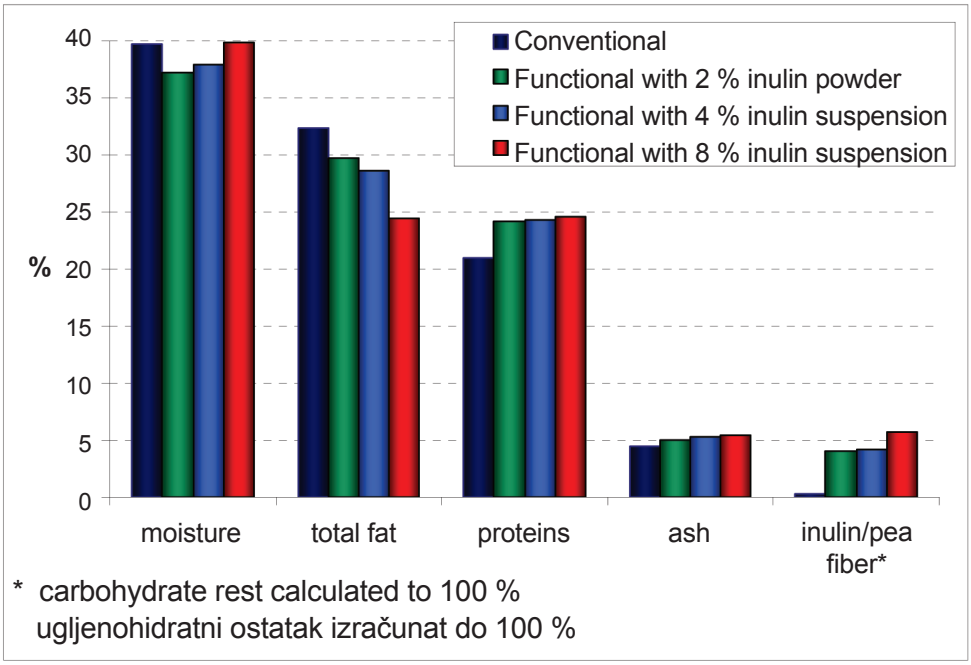

Figure 4. Chemical composition of fermented sausages
Slika 4. Hemijski sastav fermentisanih kobasica

The results of sensory properties examination of the experimental fermented sausages showed that all products are highly evaluated (Figure 5). Functional fermented sausage with 2% inulin powder and functional fermented sausage with 4% inulin suspension were given the best scores for the analyzed sensory properties. The average score for overall sensory quality of both products was 4.80. When taking into account the adjusted ratings, functional fermented sausage with 4% inulin suspension was slightly better rated (96.5) than functional fermented sausage with 2% inulin powder (95.7) because of better aroma and taste, properties which have the highest coefficient of importance for fermented sausages (coefficient 6). Conventional fermented sausage received a score for overall sensory quality of 4.63 (adjusted rating 93.4), because of lower scores for appearance (slightly wrinkled), cut surface appearance and texture. Fermented sausage with 8% inulin suspension got the lowest score for the overall sensory quality, which was 4.58 (adjusted rating 91.0) because of lower scores for odour and taste, which was somewhat different from the typical odour and taste of fermented sausages. Despite the existing differences in individual sensory properties of experimental fermented sausages, the triangle test showed no statistically significant differences between these products, because in 10 repetitions there were between 2 and 4 correct answers obtained. For the statistical significance level of $p < 0.05$ there should be at least 7 correct answers (*Radovanović and Popov-Raljić,* 2001).

Cooked sausages

Results of experimental sausage's chemical composition examination (Figure 6) showed that cooked sausages with inulin suspension contained 2.6 to 3.7% less fat than conventional one, which corresponds to the amount of pork back fat replaced with inulin suspension. Sausages with linseed / rapeseed oil contained about 1% more fat than conventional sausages. The reason for this lies in the fact that the vegetable oil contains almost 100% of total fat (*Swern,* 1972) and adipose tissue of pigs up to 95% total fat (*Vuković,* 2006). Because of that, by the replacement of 6% pork back fat with the same amount of vegetable oil, a slightly higher amount of fat was added in the product. Cooked sausages with inulin suspension contained about 3% more moisture than conventional sausages and sausages with linseed/rapeseed oil, because inulin suspension added into these sausages contained 75% water. The protein content in experimental sausages was similar and ranged from 10.2 to 10.4%, which corresponds to the norms for fine grounded cooked sausages prescribed by *Regulation on quality and other requirements for meat products* (2004). However, collagen content in meat proteins was 13.3 to 16.1% which is significantly less than the norms prescribed by the *Regulation* (25%), so the proteins from the experimental products have a high biological value. Fine grounded cooked sausages from the domestic market contain from 10.06 to 14.85% meat proteins and 8.90 to 14.28% total proteins. The relative

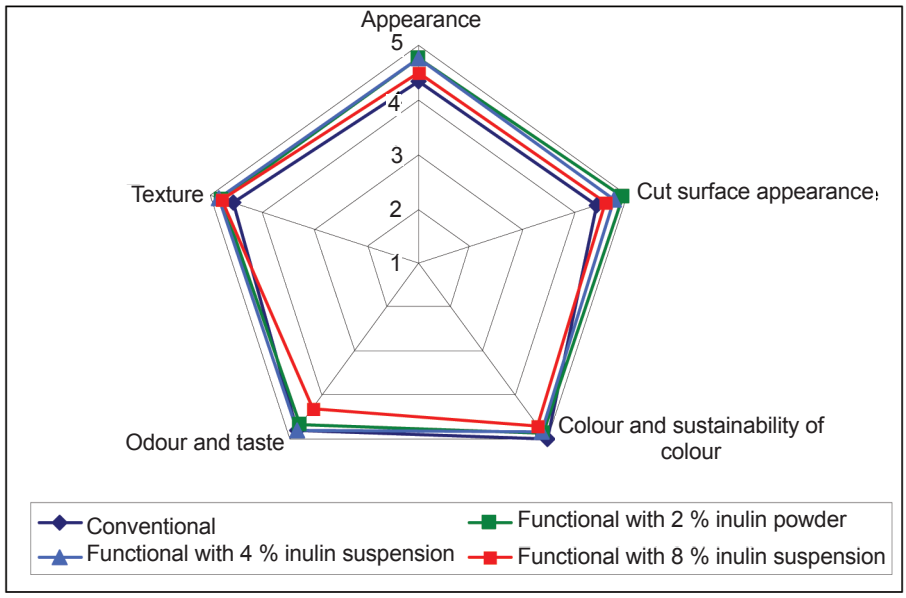

Figure 5. Scores of some sensory properties of fermented sausages
Slika 5. Ocene senzorskih karakterisitka fermentisanih kobasica

content of collagen in meat proteins is between 5.42 and 19.28%, and in total proteins content from 12.18 up to 38.91% (*Saičić et al.,* 2006). Carbohydrate rest in cooked sausages with inulin suspension is 3.0 to 3.1%, corresponding to the amount of inulin added in these products.

Despite the fact that cooked sausages with linseed/rapeseed oil contain more fat, these products have higher nutritional value than the sausages without these oils, because they have a more favourable fatty acid composition, as shown in Table 1. These sausages contain more polyunsaturated fatty acids (18.36 to 20.87%) and more favourable omega-6/omega-3 fatty acids ratio (1.75 to 2.50) than conventional sausage and sausage with inulin, in which the content of polyunsaturated fatty acids was 12.07 and 11.88%, respectively. The N-6/N-3 ratio ranged from 22.29 to 22.94. According to *Jimenez-Colmenero* (2007) the omega-6/omega-3 fatty acids ratio in the diet of man should not be greater than 4.

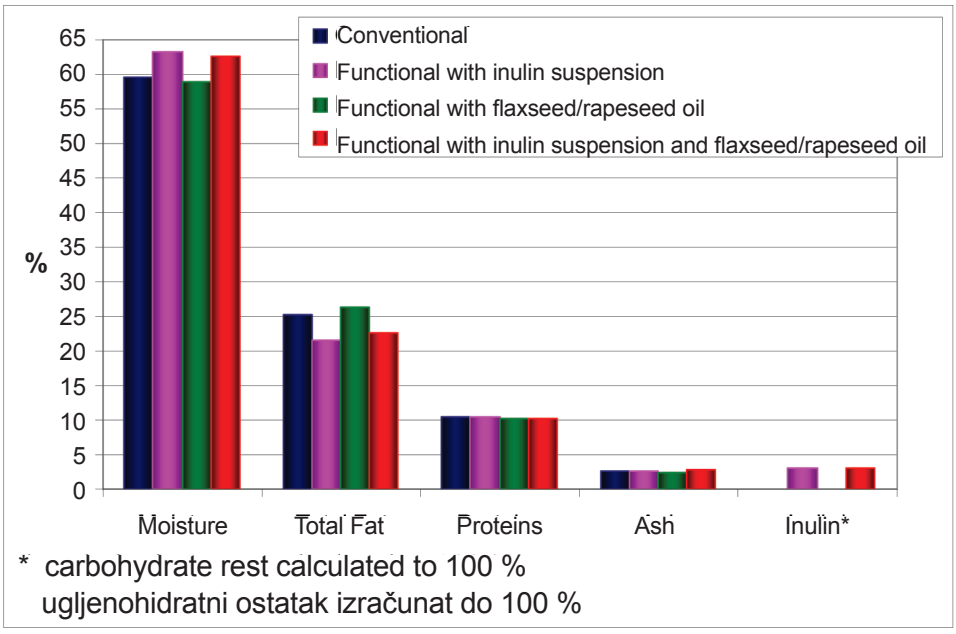

Figure 6. Chemical composition of cooked sausages
Slika 6. Hemijski sastav barenih kobasica

Table 1. Fatty acid composition of cooked sausages (% of total fatty acids content)
Tabela 1. Masnokiselinski sastav barenih kobasica (% od ukupnog sadržaja masnih kiselina)

Fatty acids/ Masne kiseline	Conventional/ Konvencionalna	Functional I/ Funkcionalna I	Functional II/ Funkcionalna II	Functional III/ Funkcionalna III
C14	1,35	1,4	1,12	1,10
C16	25,28	25,53	21,74	20,47
C16:1	2,36	2,42	1,89	1,84
C17	0,35	0,36	0,33	0,33
C18	12,71	12,75	11,38	10,65
C18:1cis-9	42,08	41,80	41,38	41,09
C18:1cis-11	2,98	3,06	2,84	2,73
C18:2n-6	10,40	10,17	11,95	12,11
C18:3n-3	0,43	0,42	5,11	7,46
C20	0,17	0,16	0,20	0,21
C20:1	0,65	0,62	0,70	0,70
C20:2n-6	0,55	0,58	0,56	0,53
C20:3n-6	0,42	0,49	0,48	0,54
C20:3n-3	0,08	0,07	0,08	0,06
C22:1+20:4	0,19	0,15	0,18	0,17
SFA	**39,86**	**40,20**	**34,77**	**32,76**
MUFA	**48,07**	**47,90**	**46,86**	**46,36**
PUFA	**12,07**	**11,88**	**18,36**	**20,87**
N-6	**11,37**	**11,24**	**12,99**	**13,18**
N-3	**0,51**	**0,49**	**5,19**	**7,52**
N6/N3	**22,29**	**22,94**	**2,50**	**1,75**

Since polyunsaturated fatty acids easily oxidize, which can lead to chemical spoilage of sausages (*Valencia et al.,* 2007), the parameters that indicate the degree of fat hydrolysis and rancidity in experimental cooked sausages were investigated. The acid number of sausages that contain linseed/ rapeseed oil is slightly higher (0.91 to 0.93 mg KOH / g) than in conventional (0.72 mg KOH / g) and functional cooked sausage with inulin suspension (0.65 mg KOH / g). However, TBARS-value, which shows the degree of rancidity of fat, in all experimental sausages, was 0.00 mg MAL / kg.

The results of sensory properties investigation of experimental cooked sausages show that functional cooked sausages have poorer sensory quality than conventional sausage which got a total score of 4.90 (Figure 7). The lowest rating for overall sensory quality have cooked sausages with linseed/rapeseed oil (overall rating of 4.36. adjusted rating 84.6. and 85.2) due to the adverse effect of these oils on the colour. texture. odour and taste of these products. The colour was paler than usual for this type of sausage. the texture was softer. and vegetable oil aroma dominated in odour and taste. The adverse effects of vegetable oils on the texture and colour of cooked sausages were determined by *Youssef* and *Barbut* too (2011). Functional cooked sausage with the suspension of inulin is much better rated (overall rating 4.82. adjusted rating 95.9) than functional cooked sausages containing linseed/ rapeseed oil. Literature data also show that functional cooked sausages can be produced with the addition of inulin suspension with no adverse influence on sensory properties of products (*Nitsch,* 2006).

Liver sausages

Results of chemical composition investigation of the experimental liver sausages (Figure 8) show that functional liver sausage contains slightly less moisture but much higher carbohydrate content (3.1%) derived from inulin and dietary pea fibre which represent a functional component of the product. The protein content is very similar and counts 9.0 and 9.1%, which corresponds to norms for liver sausage prescribed by *Regulation on quality and other requirements for meat products* (2004). However, it should be noted that the relative content of collagen in meat proteins in experimental liver sausages (conventional 16.2% and functional 16.6%) is significantly lower than the limits prescribed by *Regulation* (25%). This data support the high

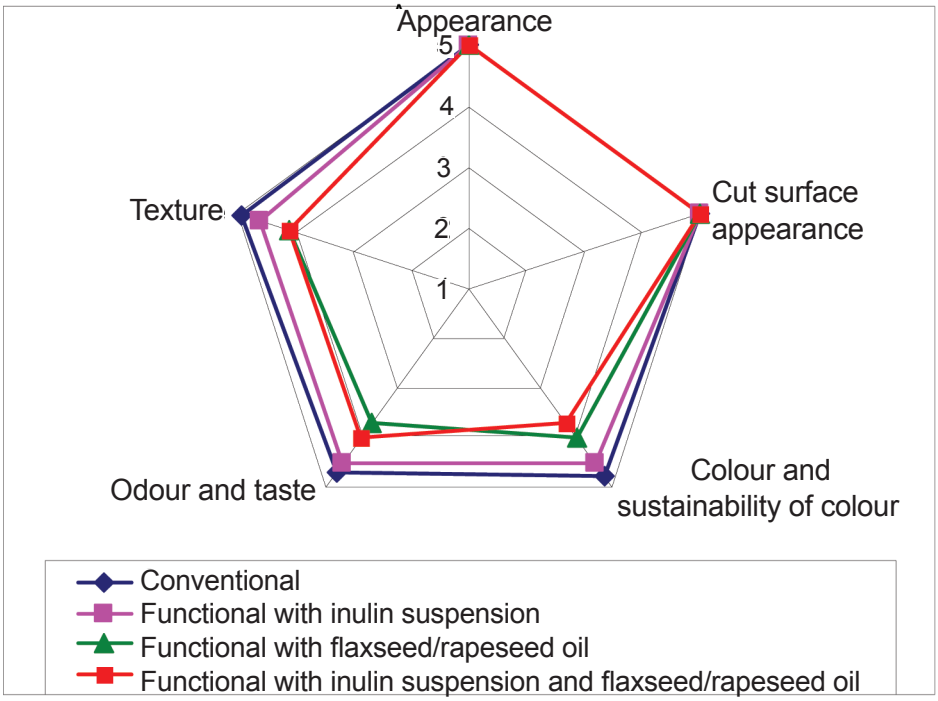

Figure 7. Scores of some sensory properties of cooked sausages
Slika 7. Ocene senzorskih karakterisitka barenih kobasica

biological value of experimental liver sausages. as it is known that proteins of connective tissue contain nearly twice less essential amino acids than muscle tissue proteins (*Prändl,* 1988). Cooked sausages, which include liver sausages too, from the domestic market contain between 8.19 and 12.22% meat proteins and 6.79 to 9.18% total proteins, while the relative collagen content in meat proteins is between 10.78 and 23.26% and in total proteins from 19.87 up to 30.00% (*Saičić et al.,* 2006).

Functional liver sausages have an excellent sensory quality, which is supported by the results of the sensory analysis shown in Figure 9. All sensory properties of functional liver sausage were

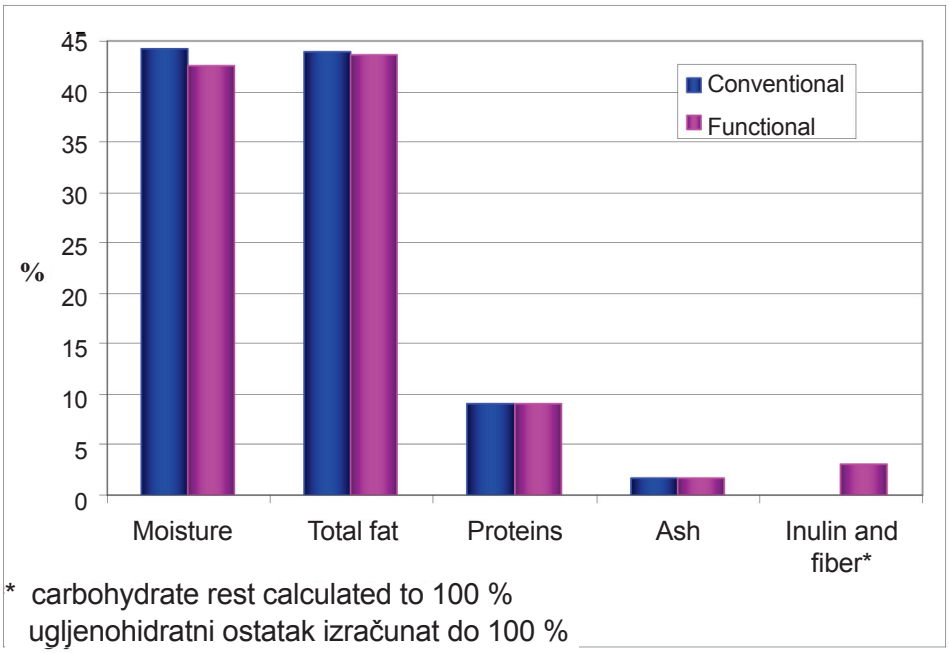

Figure 8. Chemical composition of liver sausages
Slika 8. Hemijski sastav jetrenih kobascia

estimated by a maximum score (overall rating 5.0, adjusted rating 100). On the contrary, odour and taste, and texture and juiciness of conventional liver sausage were slightly lower rated (4.8 and 4.6). The overall rating of sensory properties of conventional liver sausage was 4.88, and adjusted rating 96.6. Literature data show that changing the composition of liver sausage to gain characteristics of functional food by adding vegetable oil emulsions in order to increase content of polyunsaturated fatty acids, adversely affect the colour and texture of these products (*Delgado-Pando,* 2011). On the contrary, functional liver sausages can be produced with the addition of prebiotics in the form of inulin suspension without adverse influence on sensory properties of the products (*Nitsch,* 2006). Results of sensory examination of liver sausage from our experiments show that the addition of 4% inulin suspension and 1% of dietary pea fibre have a positive influence on the colour and texture of liver sausage.

as higher number of probiotic strain *Lactobacillus casei* 01 (8.3–8.5 log cfu/g) than in conventional sausage (8.1 log sfu/g) supports their functional potential. Addition of inulin (both in powder and suspension) and pea fibre improves the appearance, cut surface appearance and texture but affects the colour of fermented sausages. Addition of 8% inulin suspension affects the odour and taste of fermented sausages.

Cooked sausages with inulin suspension contain more water (63%) and less fat (22–23%) than conventional sausage (water – 60%; fat –25.3%) and sausage containing flaxseed/rapeseed oil (water = 59%; fat = 26%). Protein content is similar by all experimental cooked sausages (10.2 – 10.4%). Cooked sausages produced with inulin suspension contain 3.0–3.1% inulin. Sausages produced with flaxseed/rapeseed oil contain more polyunsaturated fatty acids (PUFA) (18.4–20.9% of total fatty acid content) and much more favourable omega-6/omega-

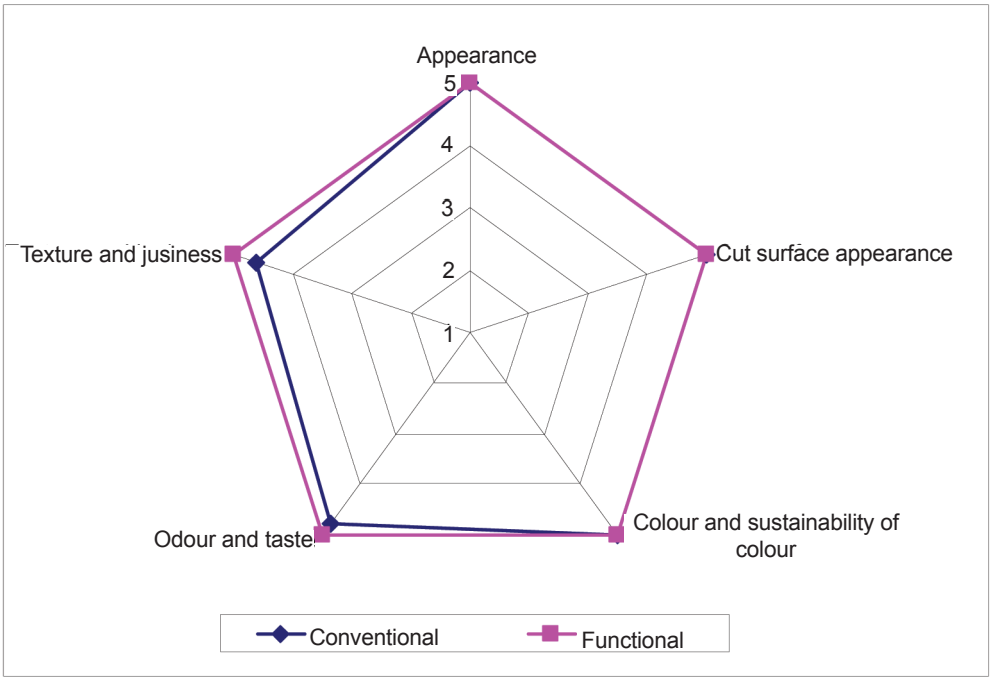

Figure 9. Scores of some sensory properties of liver sausages
Slika 9. Ocene senzoskih karakterisitka jetrenih kobasica

Conclusions

Functional fermented sausages have lower pH (4.77–4.93) and a_w (0.89–0.90) values then the conventional sausage (pH = 5,18; a_w = 0,93). Functional fermented sausages contain more proteins (24.2–24.5%) and less fat (24.4–29.7%) then conventional sausage (proteins = 20.9%; fat = 32.4%). The content of functional ingredients such as inulin and pea fibre (4.1– 5.7%) in functional fermented sausages as well

3 fatty acid ratio (1.6–2.5) then sausages produced without these oils (PUFA –11.9–12.1%; omega-6/omega-3 = 22.3–22.9). Despite the high content of polyunsaturated fatty acids, TBARS value by all experimental cooked sausages was 0,00 mg MAL/kg. Addition of flaxseed/rapeseed oil in the amount of 6% affects the colour, odour and taste and texture of cooked sausages, but not the appearance and cut surface appearance of the product.

Functional liver sausage contains less water (42.5%) and fat (43.6%) than the conventional sausage (water 44.3%; fat 44.0%) but the protein content is similar in both products (9.0–9.1%). Functional liver sausage contains 3.1% dietary fibre (inulin and pea fibre) which supports its functional potential. Sensory properties of functional liver sausage are rated excellent at the scale from 1 to 5 (average rating 5.0). On the contrary, some sensory properties of the conventional liver sausage were rated somewhat lower (odour and taste 4.8 and texture/juiciness 4.6).

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Važniji parametri kvaliteta funkcionalnih fermentisanih, barenih i jetrenih kobasica

Vasilev Dragan, Vuković Ilija, Saičić Snežana

R e z i m e: U radu su prikazani važniji parametri kvaliteta funkcionalnih fermentisanih, kuvanih i jetrenih kobasica. Proizvedene su sledeće eksperimentalne fermentisane kobasice: a) konvencionalna fermentisana kobasica, b) funkcionalna fermentisana kobasica sa 2% inulina u prahu, c) funkcionalna fermentisana kobasica sa 4% suspenzije inulina i d) funkcionalna fermentisana kobasica sa 8% suspenzije inulina. Sve fermentisane kobasice sadržale su probiotski soj bakterije Lactobacillus casei LC 01. Eksperimentalne barene kobasice uključivale su sledeće proizvode: a) konvencionalna barena kobasica, b) funkcionalna barena kobasica sa suspenzijom inulina, c) funkcionalna barena kobasica sa lanenim/repičinim uljem i d) funkcionalna barena kobasica sa suspenzijom inulina i lanenim/repičinim uljem. Iz grupe jetrenih kobasica proizvedene su: a) konvencionalna jetrena kobasica i b) jetrena kobasica sa suspenzijom inulina. Rezultati pokazuju da funkcionalne fermentisane kobasice imaju nižu pH (4,77–4,93) i a_w (0,89–0,90) vrednost nego konvencionalna kobasica (pH = 5,18; a_w = 0,93). Funkcionalne fermentisane kobasice sadrže više proteina (24,2–24,5%) i manje ukupne masti (24,4– 29,7%) nego konvencionalna kobasica (proteini = 20,9%; ukupna mast = 32,4%). Sadržaj funkcionalnih sastojaka kao što su inulin i vlakna graška u količini 4,1–5,7% u funkcionalnim fermentisanim kobasicama kao i veći broj probiotske bakterije Lactobacillus casei 01 (8,3–8,5 log cfu/g) nego u konvencionalnoj kobasici (8,1 log sfu/g) ide u prilog njihovom funkcionalnom potencijalu. Dodatak inulina (kako u obliku praška tako i u obliku suspenzije) i vlakana graška utiče pozitivno na spoljašnji izgled, izgled preseka i teksturu ali nepovoljno utiče na boju fermentisanih kobasica. Dodatak suspenzije inulina u količini od 8% nepovoljno utiče na miris i ukus fermentisanih kobasica. Barene kobasice sa suspenzijom inulina sadrže više vode (63%) i manje ukupne masti (22–23%) nego konvencionalna barena kobasica (voda = 60%; ukupna mast = 25,3%) i kobasice koja sadrži laneno/repičino ulje (voda = 59%; ukupna mast = 26%). Sadržaj proteina je sličan kod svih eksperimentalnih barenih kobasica i iznosi od 10,2 do 10,4%. Barene kobasice proizvedene sa suspenzijom inulina sadrže 3,0 – 3,1% inulina. Kobasice koje su proizvedene sa lanenim/repičinim uljem sadrže više polinezasićenih masnih kiselina (PUFA) (18,4 – 20,9% od ukupnog sadržaja masnih kiselina) i znatno povoljniji odnos omega-6 i omega-3 masnih kiselina (1,6–2,5) nego kobasice koje su proizvedene bez dodatka ovih ulja (PUFA = 11,9 – 12,1%; omega-6/omega-3 = 22,3 – 22,9). Uprkos visokom sadržaju polinezasićenih masnih kiselina, TBARS-vrednost kod svih eksperimentalnih barenih kobasica iznosi 0,00 mg MAL/kg. Dodatak lanenog/repičinog ulja u količini od 6% nepovoljno utiče na boju, aromu i teksturu barenih kobasica, ali ne i na spoljašnji izgled i izgled preseka proizvoda. Funkcionalne jetrene kobasice sadrže manje vode (42,5%) i ukupne masti (43,6%) nego konvencionalna barena kobasica (voda = 44,3%; ukupna mast = 44,0%) ali je sadržaj proteina sličan kod oba proizvoda (9,0–9,1%). Funkcionalne jetrene kobasice sadrže 3,1% dijetnih vlakana (inulin i vlakna graška) što ide u prilog njihovom funkcionalnom potencijalu. Senzorna svojstva funkcionalnih jetrenih kobasica su ocenjena maksimalnom ocenom na skali od 1 do 5 (prosečna ocena 5,00). Na suprot tome, neka senzorna svojstva konvencionalne jetrene kobasice su nešto lošija (miris i ukus 4,8 i tekstura/sočnost 4,6).

Ključne reči: *funkcionalna hrana, kvalitet, fermentisane kobasice, barene kobasice, jetrene kobasice.*

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