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Original Scientific Paper

Consumer attitudes toward egg consumption, food safety, and animal welfare

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ABSTRACT

Hen eggs are a common component of the human diet, and the egg industry today represents an important branch of animal husbandry. Consumer preferences regarding egg characteristics are evolving, with increasing attention placed on production conditions and laying hen welfare, while issues of food safety are often less clearly understood. In addition, the impact of egg consumption on human health continues to be questioned. The aim of this study was to assess consumer attitudes in the municipality of Zrenjanin, Serbia, with a focus on factors influencing egg purchasing decisions. Respondents emphasized production practices and animal welfare, whereas the physical characteristics of eggs were considered less important. Eggs were generally perceived as healthy food, and most consumers did not associate their consumption with an increased risk of cardiovascular disease. However, many respondents showed limited understanding of the concept of egg safety. These findings underline the importance of strengthening consumer education and awareness regarding both the benefits and potential risks of egg consumption.

1. Introduction

Eggs are a low-cost, nutrient-dense food. Almost all of their nutrients are efficiently utilized by the body, and eggs are recognized as a high-quality protein source alongside breast milk (*Park et al.*, 2018). Due to their rich nutrient content, eggs are susceptible to contamination by various pathogens, making their microbial integrity essential. In Serbia, testing of laying hens for *Salmonella* spp. is mandatory as part of the producer's self-control every four weeks. However, facilities producing table eggs for personal consumption are not subject to this legal requirement (*Vidaković Knežević et al.*, 2017). The Zrenjanin Veterinary Specialist Institute regularly conducts tests for *Salmonella* spp. in eggs and egg products, but the primary responsibility for monitoring and submitting eggs for testing lies with the food business operator.

Animal welfare is the state of an organism, which reflects how well animals adapt to the living conditions provided by humans (*Vučinić*, 2016). *Bonnefous et al.* (2022) note that conventional cages for laying hens were developed after World War II to increase egg production. In 2012, conventional cages were banned in the European Union, leaving only

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enriched cages and aviary system as permitted alternatives. The enriched cage system provides 750 cm² of space per hen. In addition to enriched and conventional cages, there are floor, free-range, and organic systems for raising laying hens (*Nielsen et al.,* 2023).

The aim of the study was to investigate the opinions of residents in Zrenjanin municipality regarding their preferences when purchasing eggs, particularly in relation to organoleptic characteristics and different housing systems for laying hens. Additionally, this study aimed to examine consumers' perceptions of the health effects of egg consumption, with the goal of providing recommendations and guidelines for future research and consumer education.

2. Materials and methods

An anonymous and voluntary online questionnaire was conducted, active for approximately one month, from 31st of July to 4th of September 2024. A total of 69 respondents completed the survey.

2.1. Survey structure

The questionnaire consisted of 63 questions, out of which first four questions were related to sociodemographic information of the respondents, including sex, age, residential location, and professional qualifications.

The remaining 59 questions included 29 multiple-choice questions, each with at least three options and the possibility for additional written comments. These questions adressed consumer preferences when purchasing eggs, perceptions of the health benefits of eggs, potential exposure of humans to veterinary drug residues, and the impact of different laying hen production systems on egg quality and safety. This section also included statements rated on a 5-point Likert scale (1 = do not agree at all; 5 = completely agree), divided into three parts. The first part addressed the organoleptic characteristics of eggs, the second part focused on the consumption of eggs and their impact on human health, and the third part examined the influence on hen housing systems on egg quality and integrity.

The following seven questions asked respondents to rate from 0 (unimportant) to 5 (extremely important) how relevant certain factors are for egg consumption in their daily diet.

The final two open-ended questions allowed respondents to provide comments on egg safety and production processes, including the housing conditions of laying hens.

2.2. Statistical analysis

The data collected through the survey were analyzed using R software (version 4.1.2) (*R Core Team*, 2021). Analysis began with descriptive statistics (*Mutavdžić and Nikolić Đorić*, 2018), followed by non-parametric tests, including the Mann-Whitney U and Kruskal-Wallis tests. When significant differences between groups were found, Dunn's post-hoc test was applied to identify specific group differences.

3. Results

3.1. Sociodemographic profile of respondents

Sociodemographic characteristics are presented in Table 1. Most respondents were female (59.4%), and across all participants, the largest age group was

Table 1. Sociodemographic characteristics of respondents

Variable	Categories	Frequency	Percentage
Gender	Male	28	40.6%
	Female	41	59.4%
Age	≤30	22	31.9%
	31-45	25	36.2%
	46-60	16	23.2%
	>61	6	8.7%
Professional qualification	High school	37	53.6%
	Academic studies	16	23.2%
	Integrated academic studies	5	7.2%
	Master's/PhD	11	15.9%
Place of residence	Urban area	48	69.6%
	Rural area	21	30.4%

between 31 and 45 years (36.2%). Regarding professional qualifications, more than half had completed high school (53.6%). Most respondents lived in urban areas (69.6%).

3.2. Consumer perceptions of egg quality and health

Respondents' perceptions of the organoleptic characteristics of eggs, as well as their perceptions regarding egg consumption and its impact on human health, are summarized in Table 2. Statements were rated on a 5-point Likert scale (1 = do not agree at all; 5 = completely agree).

3.3. Factors influencing egg purchase decisions

Respondents rated the importance of several factors when purchasing eggs on a scale from 0 (not important at all) to 5 (extremely important). The results are summarized in Table 3.

4. Discussion

This study explored consumer perceptions of egg quality, health impacts, and purchasing behavior in Zrenjanin municipality. The findings provide insight into preferences regarding organoleptic properties, health-related beliefs, safety considerations, and factors influencing purchasing decisions.

Table 2. Respondents' agreement with statements about organoleptic characteristics of eggs

Variable	$\bar{X}$	SD
Raw eggs are more nutritionally rich/better for the diet than boiled eggs (V1)	2.710	1.112
Dark-shelled eggs are more nutritionally rich/better to eat (V2)	2.304	1.075
Eggs with darker yolks are more delicious (V3)	3.174	1.392
By washing eggs, there is a risk that harmful pathogens are pushed from the shell into the inside of the egg (V4)	2.667	1.431
By placing the eggs in a container of water, the freshness of the eggs can be checked (V5)	3.565	1.355
The taste of eggs depends on the diet of the laying hen (V6)	4.304	0.928
The taste of eggs depends on the way the laying hen is kept (V7)	3.841	1.195
Daily consumption of eggs is good for human health (V8)	3.464	1.219
Excessive egg consumption increases the risk of heart disease (V9)	2.855	1.364
The use of eggs contributes to an increase in muscle mass (V10)	3.841	1.023
Consuming a large amount of eggs has/would have a negative effect on health (V11)	2.870	1.434
Eggs are an irreplaceable source of nutrients and vitamins (V12)	3.667	1.107
Eating eggs directly affects the increase in blood cholesterol (V13)	2.710	1.261
The way eggs are prepared (boiled, raw, baked) greatly affects human health (V14)	3.377	1.237

Note: V = variable number from the questionnaire.

Table 3. Importance of factors when buying eggs (0-5 scale)

Factor	Mean	Median	Min-Max
Price	2.83	3	0-5
Package	2.87	3	0-5
Supporting the local economy	4.23	5	0-5
Hygiene of workers	4.46	5	2-5
Shell hardness	3.13	3	0-5
Free-range eggs	3.61	3	0-5
Housing systems of hens	3.75	4	0-5

Note: Factors were rated on a 0-5 scale, where 0 = not important at all and 5 = extremely important.

According to the survey results, most respondents purchased eggs once a week and consumed them two or more times per week. Eggs were most commonly bought in supermarkets, and the majority of respondents were female. Consumers generally valued external characteristics of eggs, such as shell cleanliness, quality and color, while internal parameters, such as yolk quality, were less decisive when choosing eggs. Similar findings have been reported by *Mitrović* (2022), highlighting consumer sensitivity to shell color. Moreover, comparable results were observed by *Tolimir et al.* (2017), who reported that consumers in Belgrade placed particuar importance on external egg characteristics, with shell color among the most influential factors in purchasing decisions.

Respondents largely believed that the taste of eggs is influenced by both the hen's diet ($\bar{X}$ = 4.304) and housing system ($\bar{X}$ = 3.841). This corresponds with consumer preferences observed in studies where free-range eggs were rated higher in flavor and acceptability (*Anderson*, 2011). The relatively low agreement ($\bar{X}$ = 2.304) that dark-shelled eggs are nutritionally superior reflects common consumer misconceptions, as a study by *Roberts* (2004) confirmed that shell color does not influence nutritional content and is primarily breed-dependent. Respondents' mixed views ($\bar{X}$ =2.667 ± 1.431) on whether washing eggs could push pathogens inward echo scientific findings that washing can remove the protective cuticle, potentially increasing contamination risk (*Board and Tranter*, 1995; *Hutchison et al*., 2004). Collectively, these results underscore that consumer perceptions align with evidence on sensory qualities and risk factors and highlight the importance of accurate education regarding egg handling and nutrition.

One of the greatest food safety issues related to table eggs is contamination with *Salmonella* spp., which can occur through vertical transmission via the reproductive tract or horizontally through the shell after laying (*Vidaković Knežević et al*., 2017; *Holt*, 2021). In our survey, 36.2% of respondents associated soiling of eggs with pathogen transmission, whereas nearly one-third (30.4%) were unfamiliar with the term "egg safety". Similar knowledge gaps among consumers have been reported elsewhere, highlighting the need for targeted education on microbial hazards (*EFSA*, 2021). Trust in institutional control was relatively high, as 71% of respondents expressed confidence in *Salmonella* monitoring, while 63.8% placed primary responsibility for egg safety on producers.

Animal welfare was also a relevant concern: 52.2% of respondents emphasized the importance of compliance with animal welfare legislation, and 30.4% valued information on housing conditions. Notably, 36.2% believed that animal welfare and egg safety are directly related. This reflects the dual challenge of balancing welfare and biosecurity. Free-range housing is associated with benefits such as improved skeletal health (*Tuyttens et al*., 2008), but also with higher risks of parasitic and bacterial infections (*Fossum et al*., 2009). Consumer preferences for welfare-friendly systems have been documented across Europe, although misconceptions regarding food safety in such systems remain widespread (*Harvey and Hubbard*, 2013).

In terms of nutritional perceptions, 34.8% of respondents agreed that eggs contribute to muscle mass, while 30.4% recognized them as an irreplaceable source of nutrients and vitamins. These beliefs are supported by biochemical evidence showing that eggs contain bioactive components, such as phospholipids, lutein, zeaxanthin, and high-quality proteins, that have roles in immune function and the prevention of chronic disease (*Sanlier and Üstün*, 2021; *Miranda et al.*, 2015). Importantly, the majority of respondents rejected the idea that egg consumption substantially increases cholesterol or cardiovascular risk (23.2%). Current scientific consensus supports this perception: recent meta-analyses indicate that moderate egg consumption does not significantly raise blood cholesterol levels or cardiovascular risk in healthy populations (*Alexander et al*., 2016; *Drouin-Chartier et al*., 2020). This position is reflected in the Dietary Guidelines for Americans, which state that one egg per day can be included in a healthy diet without adverse cardiovascular effects (*Phillips*, 2021).

5. Conclusion

This study showed that consumers in the Zrenjanin municipality placed greater importance on production conditions and animal welfare than on the physical characteristics of eggs. While respondents generally perceive eggs as a healthy and safe food, notable knowledge gaps remain, particularly regarding the concept of egg safety and microbiological risks. Hygiene during handling was recognized as a critical factor influencing consumer trust. Furthermore, free-range systems were perceived as the most

desirable future direction for egg production, reflecting a preference for welfare-friendly farming practices. Overall, these findings highlight the need for continued consumer education and transparent communication in order to align perceptions with scientific evidence and support sustainable egg production.

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