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Original Scientific Paper

Development and characterization of dry beef jerky products

Tatjana Peulić[1], Marija Jokanović[2], Jovana Delić[3], Slađana Rakita[1], Miloš Županjac[1], Snežana Škaljac[2] and Predrag Ikonić[1]*

[1] *Institute of Food Technology, University of Novi Sad, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia*
[2] *University of Novi Sad, Faculty of Technology Novi Sad, Bulevar Cara Lazara 1, 21000 Novi Sad, Serbia*
[3] *Institute for Information Technologies Kragujevac, University of Kragujevac, Jovana Cvijića bb, 34000 Kragujevac, Serbia*

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ABSTRACT

In response to growing consumer demand for convenient, high-protein snacks with improved nutritional profiles, three types of beef jerky products were developed and evaluated: basic, sweet and hot. The products were prepared from beef cuts (*M. semimembranosus* and *M. semitendinosus*), marinated with different spice and sauce combinations, and dried under controlled conditions. Microbiological safety and nutritional quality parameters were determined. All products were microbiologically safe for consumption, with no detection of pathogenic microorganisms. Regarding nutritional quality, all products were characterised by a notably high protein content, ranging from 47.61% in the sweet jerky to 49.96% in the hot jerky. Fat content differed slightly between the products, ranging from 5.67% in the basic jerky to 6.29% in the hot jerky, indicating that all products were generally low in fat. Fatty acid profiles indicated a desirable ratio of saturated (SFA), monounsaturated (MUFA), and polyunsaturated fatty acids (PUFA), with SFA being the most dominant group. The sweet jerky contained significantly higher levels of carbohydrates (8.79%) and sugars (8.13%), which can be attributed to the marinade composition. Although salt levels were relatively high across all variants, they remained within expected ranges for jerky products. These findings suggest that beef jerky can be a nutritious meat-based snack, with potential for further improvement—especially in developing a sweet-flavoured variant with reduced sugar content to meet both sensory and health expectations.

1. Introduction

The modern consumer is increasingly aware of the connection between diet and overall psychophysical well-being. A nutritionally balanced diet—providing all essential macro- and micronutrients while ensuring food safety—is a key foundation for maintaining good health. Proper nutrition positively affects health and quality of life, helps prevent non-communicable diseases, improves immunity, physical fitness, and work capacity, and supports the adoption of a healthy lifestyle (*Chang et al.*, 2024; *Vorster*, 2009). Due to the modern lifestyle, traditional dietary patterns based on three main meals a day consumed at specific times and locations are becoming less common (*Jastran et al.*, 2009). Eating outside the home is becoming increasingly prevalent (*Orfanos et al.*, 2007; *Ribas-Barba et al.*,

***Corresponding author:** Tatjana Peulić, *tatjana.peulic@fins.uns.ac.rs*

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2007), as is the frequency of snacking (*Vandevijvere et al.*, 2009). Snack products have been an integral part of daily diets for many years (*Riaz*, 2004). In fact, two-thirds of respondents in the United States (US) reported regularly consuming snack products between meals (*Sanz et al*., 2017). *Kant and Graubard* (2015) reported a decline in calorie intake from main meals (breakfast, lunch, and dinner) over the past 40 years, with a simultaneous increase in calorie intake through snacking, which some researchers have shown to contribute up to 40% of total daily energy intake (*Rangan et al*., 2008; *Rangan et al*., 2009). In Serbia, the percentage of the population consuming three regular meals a day dropped from 71.9% in 2000 to only 56.6% in 2006. A study conducted among young adults aged 18 to 24 in Australia found that, after taste, the most influential factor in food choice was the convenience of the food product (*Hebden et al*., 2015).

Therefore, the food industry is striving to develop food products that are nutritionally rich, while requiring no preparation or only minimal culinary skills and time. In other words, today's consumer needs food that is both easily accessible and nutritionally valuable. This technical solution describes the development of such a product—a jerky-type product characterized by high nutritional value and ease of access.

Most commercial snack products are characterised by low nutritional quality. Typically, these products are high in carbohydrates and fats, and low in dietary fibre, often falling into the category of high glycaemic index foods. In an effort to develop snacks with improved nutritional profiles, there has been increasing interest in the use of unconventional raw materials rich in proteins, dietary fibre, vitamins, polyphenols, and other valuable components. (*Jozinović et al*., 2021; *Raleng et al*., 2022; *Grasso*, 2020; *Delić et al*., 2020).

To improve the nutritional quality of snack products, some authors have investigated the potential of using animal-based ingredients, which contain all essential amino acids. The most commonly studied animal raw materials include mechanically separated meat, milk and whey proteins, meat from spent laying hens, partially defatted beef, and others (*Cakmak et al*., 2016; *Cho & Rizvi*, 2010; *Delić et al*., 2023; *Lee et al*., 2003; *Rhee et al*., 1999; *Verma et al.*, 2014). In the US, meat-based snack products, such as beef jerky, meat sticks, and meat or meat protein bars, are highly popular. According to a 2014 study, meat snacks were the third most commonly consumed salty snack category in the US. Moreover, these products are gaining popularity in Africa and the Middle East, where their consumption has increased by 25% (*Sanz et al*., 2017). In contrast, Europeans are still more inclined toward traditional meat products, with meat snacks and products containing meat or meat proteins only recently starting to enter the European market.

The aim of this study was to develop and evaluate three types of beef jerky—basic, sweet, and hot—as high-protein, ready-to-eat meat snacks with improved nutritional profiles. The products were assessed for microbiological safety, nutritional quality, and fatty acid composition to determine their potential as healthier snack alternatives.

2. Materials and methods

2.1. Preparation of beef jerky

For preparation of jerky, beef *M. Semimembranosus* (SM) and *M. Semitendinosus* (ST) were purchased in local meat facility. All visible fat and connective tissue from fresh muscles were removed and meat was frozen at -18 °C. Thereafter, the thawed muscles were sliced into pieces 10.0 ×4.0 × 0.5 cm, normal to the direction of the muscle fibre.

Prepared beef slices were marinated for 24 hours in the refrigerator using three different marinades M1 (basic), M2 (sweet) and M3 (hot), consisting of liquid (soy sauce, Worcestershire sauce, etc.) and solids (salt and different spices) in different proportions.

Further, marinated beef slices were uniformly distributed on the chamber shelves and processed to drying in a constant climate chamber (Binder KBF 115, Germany). The drying process lasted for 6.5 h, divided into two phases. During the first, the so-called cooking phase, the chamber was set to 70 °C for 2.25 hours, and relative humidity during this period ranged from 80 to ≥90%. In the second phase, the drying temperature ranged from 65 °C to 60 °C, while the relative humidity was gradually reduced from 70 to 35% over 4.25 hours (*Ikonić et al*., 2022).

2.2. Microbiological safety determination

Microbiological safety was determined by enumeration of the total count of bacteria (*ISO*, 2013), yeasts and moulds (*SRPS ISO*, 2011), *Salmonella* spp. (*ISO*, 2017a), *Enterobacteriaceae* (*ISO*, 2017b), and *Escherichia coli* (*ISO*, 2001).

2.3. Nutritional quality determination

Protein content (*ISO*, 2023a), moisture content (*ISO*, 2023b), ash content (*ISO*, 1998), fat content (*ISO*, 1973) and sodium content (*ISO*, 6869:2000) were determined according to ISO methods. The carbohydrate content was determined using the formula provided by *Omole et al*. (2021), and sugar content was determined using the Luff-Schoorl method (*Serbia, 1983*). The sodium chloride content was calculated from the content of sodium according to the Serbian regulations (*Serbia, 2017 and 2018*). Energy value was calculated according to the EU regulations (*European Union, 2011*).

2.4. Fatty acid determination

Fatty acid methyl esters were prepared from the extracted lipids using boron trifluoride/methanol solution and were analyzed by a GC Agilent 7890A system with FID, autoinjection module for liquid, equipped with fused silica capillary column (*Vidosavljević et al.*, 2025).

3. Results and discussion

Safety parameters and nutritional quality of the three developed types of jerky products, basic, sweet, and hot, were analyzed and the results are presented in Tables 1 and 2.

As shown in Table 1, all developed products were microbiologically safe for consumption, as no pathogenic bacteria were detected (including *Salmonella* spp., *Enterobacteriaceae*, and *E. coli*), nor were any yeasts or moulds present (*Županjac et al.*, 2022).

Regarding nutritional quality (Table 2), all beef jerkies were characterized by a notably high protein content, ranging from 47.61% in the sweet jerky to 49.96% in the hot jerky (*Županjac et al.*, 2022). Moisture content differed slightly between the products, with the basic jerky containing the highest moisture content (32.94%) and the hot jerky containing the lowest (30.50%). Moisture content across the beef jerkies was within acceptable limits for dried meat products, indicating effective dehydration. The slight differences could be attributed to variations in formulation or seasoning blends that influence water retention. Ash content was highest in the basic jerky (7.48%) and lowest in the sweet jerky (6.70%). The

Table 1. Indicators of microbiological safety in developed jerky-type products

Microbiological safety parameters	Basic	Sweet	Hot
Total number of bacteria (cfu/g)	390000	64000	140000
Yeasts and moulds (cfu/g)	<100	<100	<100
Salmonella spp. (not detected in 25 g)	not detected	not detected	not detected
Enterobacteriaceae (cfu/g)	<10	<10	<10
E. coli (cfu/g)	<10	<10	<10

Table 2. Indicators of nutritional quality in developed jerky-type products

Nutritional quality parameters	Basic	Sweet	Hot
Protein content (%)	49.61	47.61	49.96
Moisture content (%)	32.94	31.21	30.5
Ash content (%)	7.48	6.7	7.28
Total carbohydrates (%)	4.3	8.79	5.97
of which sugars (%)	2.39	8.13	3.71
Fat content (%)	5.67	5.69	6.29
Saturated fatty acids (in fat %)	46.8	45.4	45.7
Monounsaturated fatty acids (in fat %)	41.3	46.2	45.6
Polyunsaturated fatty acids (in fat %)	11.9	8.4	8.7
Salt content (%)	4.80	4.36	4.52

content of carbohydrates and sugars was, as expected, the highest in the sweet jerky, given that the sweet marinade formulation included the addition of honey and sugar.

Fat content differed slightly among the meat products, ranging from 5.67% in the basic jerky to 6.29% in the hot jerky, indicating that all products were generally low in fat. Regarding the fatty acid profile, the basic jerky contained the highest proportion of saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA) with 46.8% and 11.9%, respectively, while the sweet jerky had the highest proportion of monounsaturated fatty acids (MUFA) with 46.2%.

Salt content was the highest in the basic jerky (4.80%), followed by the hot (4.52%) and sweet (4.36%) jerky. The salt content, although relatively high, was typical for jerky products, due to its role in preservation and flavour enhancement.

4. Conclusion

The analysis of three beef jerky snack types confirmed that all products were high in protein, and low in carbohydrates and fat, making them nutritionally suitable as meat-based snack options. The basic jerky was characterised by the most balanced nutritional profile, while the sweet jerky had elevated sugar and carbohydrate levels. Future improvements should aim to reduce sugar and salt content while maintaining sensory quality.

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Authors info

Tatjana Peulić, https://orcid.org/0000-0002-7074-4633
Marija Jokanović, https://orcid.org/0000-0002-1282-175X
Jovana Delić, https://orcid.org/0000-0002-8764-4110
Slađana Rakita, https://orcid.org/0000-0002-5968-9493
Miloš Županjac, https://orcid.org/0000-0002-8310-4213
Snežana Škaljac, https://orcid.org/0000-0002-9102-8417
Predrag Ikonić, https://orcid.org/0000-0002-4882-8048