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Research Article

Comparison of Chemical Composition and Fatty Acid Profile of Traditional Meat Products from Croatia and Montenegro

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The aim of this study was to compare chemical composition and fatty acid profile of Croatian and Montenegrin dry-cured meat products and dry-fermented sausages produced using a similar technology. Five types of products ($n = 60$) from both countries, i.e., prosciutto, sausages, pancetta, dry sirloin, and dry rack, were analysed. Basic chemical compositions and fatty acid methyl esters were determined using the accredited ISO methods. The obtained results showed no significant differences between Croatian and Montenegrin meat products in most of their chemical components, except for pancetta, in which significant differences in moisture ($p = 0.007$), fat ($p = 0.016$), and sugar ($p = 0.027$) contents were established. The highest protein share, significantly differing between the countries of origin, was determined in prosciutto ($p = 0.018$) and dry sirloin samples ($p = 0.014$). As for individual fatty acids, the most represented was oleic acid (C18 : 1$n-9c$, OA) in prosciutto (42.29%–42.34%), followed by palmitic (C16 : 0, PA) and stearic acid (C18 : 0, SA) in Croatian dry sirloin (27.60%) and dry rack (16.08%). The obtained monounsaturated fatty acid (MUFA), saturated fatty acid (SFA), and polyunsaturated fatty acid (PUFA) shares are typical of pork meat products and were in the following decreasing order: 41.97–49.75%, 39.96–45.94%, and 7.69–14.96%, respectively. The $n-6/n-3$ ratios, which were five- to eight-fold higher than recommended, ranged from 14.82 (pancetta, Montenegro) to 25.83 (pancetta, Croatia) with differences between the countries of origin seen only in pancetta samples ($p < 0.001$). Lipid quality indices (PUFA/SFA ratios), spanned from 0.17 (dry sirloin, Croatia) to 0.38 (pancetta, Montenegro), were also not in accordance with health recommendations. Since Montenegrin traditional meat products are unexplored yet, the obtained results could facilitate the procedure of their designation of origin and consequently contribute to their valorisation and recognisability in the international market.

1. Introduction

Changes in food consumption habits are numerous and constant; however, meat and meat products stand steadily in many of diets. Various factors, such as tradition, ethical or religious beliefs, socioeconomic factors, marketing-related aspects, and sensory meat properties influence consumers' preferences, behaviour, and perception [1]. Meat and meat products are generally considered to be a part of a well-balanced diet, primarily due to their high protein content and also due to their richness in micronutrients, such as zinc, iron, selenium, and vitamins (A, B1, B2, B6, B12) [2]. Despite their nutritive value, due to the high content of fat, particularly saturated fatty acids (SFAs) and an excessive share of n-6 polyunsaturated fatty acids (PUFAs) over n-3 PUFAs, this food group is often linked to cardiovascular diseases, atherosclerosis, and higher concentration of blood LDL-cholesterol [3]. Given that fat affects the nutritional value of meat and meat products and hence consumer health, producers are trying to keep up with current trends and produce functional meat products with a lower fat content or a modified fatty acid profile [4].

Although all characteristics mentioned above describe most of the meat types, pork meat is somewhat different. Contrary to popular assumption that pork meat contains SFAs in the highest share, it is well known that fatty acids predominating in this type of meat are oleic (C18 : 1$n-9c$, OA), palmitic (C16 : 0, PA), and linoleic acid (C18 : 2$n-6c$, LA) [5]. As for the vitamin content, pork meat and its products are considered to be valuable sources of thiamine [6]. Additionally, pork meat is one of the most consumed types of meat worldwide (average consumption of 15.56 kg/capita/year), with the 2018 global production of 121.0 million tonnes. In the same year, Croatia produced 113,500 tonnes of pork meat, while the neighbouring Montenegro managed to produce only 3,436 tonnes of the same. Interestingly, the consumption per capita in 2018 in these two countries was quite similar (Croatia 52.13 kg/capita/year and Montenegro 45.25 kg/capita/year) [7].

Dry-cured meat products are part of tradition of many European countries. Because of their geographical and climate specificities, rich culture and tradition, Croatia and Montenegro have the potential to produce numerous traditional meat products, which may become recognized outside homelands. Nevertheless, the aforementioned is preconditioned by an increased production accompanied by quality standardization and protected designation of origin. In Croatia, prosciutto is one of the most famous and most commonly produced dry-meat products. Istrian prosciutto is PDO (Protected Designation of Origin) labelled, while prosciutto of Krk, prosciutto of Drniš, and Dalmatian prosciutto carry the Protected Geographical Indication label [8]. By getting these labels, Croatian products are protected at the European Union (EU) level, while Montenegro, as a non-EU member state, can protect its products at the national level only, which is a remarkable effort in the protection of agricultural and food products. Two types of prosciuttos, Njeguš and Prosciutto of Montenegro, are PDO labelled [9]. Due to the scientific research and technology development in the field of traditional meat products' production, Croatia, as a Mediterranean country producing similar types of meat products, can serve as an example to Montenegro.

Several studies dealing with nutritional composition of traditional meat products and their production parameters have been published in Croatia insofar [10–15], while, to the best of the authors' knowledge, data on nutritional value of traditional meat products originating from Montenegro are very scarce [16]. In view of the above, the aim of this study was to compare Croatian and Montenegrin dry-cured meat products and dry-fermented sausages produced using a similar technology, by analysing their chemical composition and their fatty acid profile, to the ultimate goal of facilitating the procedure of allocation of the designation of origin, contributing to the valorisation and better recognisability of these products on international market.

2. Materials and Methods

2.1. Production Technology and Sampling. The study included five types of traditional dry-cured meat products and dry-fermented sausages originating from Croatia and Montenegro and collected during 2018 and 2019 from different family farms located in these two countries. Meat products were produced within the 2017–2018 timeframe and included 30 prosciuttos, pancettas, dry sirloins, dry racks, and domestic sausages from each country. In total, 60 dry-cured meat products and dry-fermented sausages were sampled, each in the amount of 1.5 to 2 kg. Products under study were produced according to traditional recipes and technologies observed by each family farm, all of them from pork meat obtained from pigs of different breeds (unknown) with the addition of salt and different spices. Table 1 displays the main characteristics of the production technology applied with the investigated Croatian and Montenegrin traditional meat products.

Systematization of meat products was done according to the Regulations of Meat Products, since they belong to the group of nonthermally processed meat products [17]. Prosciutto, pancetta, dry sirloin, and dry rack were classified into dry-cured meat products, while domestic sausages were considered to be to a self-contained group.

2.2. Sample Preparation. Dry-cured meat products and dry-fermented sausages were chopped and homogenized for 15 sec using a Grindomix GM 200 (Retsch, Haam, Germany) rotating at the speed of 6,000 rpm. Sample preparation followed the ISO 3100–1:1991 [18]. Chemical composition of all samples was analysed within 48 hours. The extracted fat was stored at −18°C until fatty acid composition analysis was done in the next 48 hours.

2.3. Chemical Analysis. The moisture content was determined using a gravimetric analysis [19] carried out at 103°C in an oven (UF75 Plus, Memmert, Schwabach, Germany). In order to establish the ash content, the samples were mineralized in a LV9/11/P320 furnace (Nabertherm, Lilienthal, Germany) at 550°C [20]. The total protein content was established according to the Kjeldahl method and was calculated by multiplying the determined nitrogen content with the conversion factor of 6.25 [21]; to that end, a Unit 8 Basic digestion block (Foss, Höganäs, Sweden) and an automated distillation and titration device (VAPODEST 50 s, Gerhardt, Munich, Germany) were put in use. The total fat content was ascertained using the Soxhlet method [22]. The samples were first digested in an acidic milieu, upon which the fat ingredient was extracted using petroleum ether and an automated Soxtherm 2000 device (Gerhardt, Munich, Germany). The salt content was determined via the internally validated multiple standard addition potentiometric technique necessitating an ion-selective electrode and a Na EasyPlusTM analyser (Mettler Toledo, Germany), according to the application brochure issued by the manufacturer [23]. Based on the established sodium content, the sodium chloride content was determined stoichiometrically. The

Table 1: Production technology applied with Croatian and Montenegrin traditional dry-cured meat products and dry-fermented sausages.

Meat product	Region of production	Spices	Smoking (days)	Ripening length (months)
Croatian traditional meat products				
Dalmatian prosciutto ($n = 7$)	Southern Croatia	Sea salt	Up to 45	15
Pancetta ($n = 4$)	Southern Croatia	Sea salt and nitrite/nitrate salt	Up to 20	1.5–2
Dry sirloin ($n = 5$)	Southern Croatia	Sea salt and nitrite/nitrate salt	Up to 20	1.5
Dry rack ($n = 7$)	Northern Croatia	Sea salt, laurel, black pepper	14	2–2.5
Domestic sausage ($n = 7$)	Eastern Croatia	Kitchen salt, sweet and hot pepper, garlic	14	1.5–2
Montenegrin traditional meat products				
Njeguš prosciutto ($n = 6$)	South, northern, central Montenegro	Sea salt	Up to 45	≥16
Pancetta ($n = 6$)	South, northern, central Montenegro	Sea salt	Up to 15	1.5
Dry sirloin ($n = 6$)	South, northern, central Montenegro	Sea salt and nitrite/nitrate salt	Up to 20	1.5–2
Dry rack ($n = 6$)	Central, south, northern Montenegro	Kitchen salt, black pepper, nitrite/nitrate salt	10	2
Domestic sausage ($n = 6$)	South, northern, central Montenegro	Sea salt, mix of spices	10	≥1.5

sugar content was established according to the instructions given in "UV method for the determination of sucrose, D-glucose, and D-fructose in foodstuffs and other materials" issued by the kit manufacturer using an enzymatic method that employed a commercial enzyme kite (saccharose/D-glucose/D-fructose, UV-test, R-Biopharm, Germany). The preparation of samples was described earlier [24].

Each sample was analysed in duplicate. The results are given as weight percentages (%), the accuracy thereby being 0.01%. Quality control was carried out using the TET003RM Reference Material (RM) (Fapas, York, England). All chemicals were of an analytical grade.

2.4. Fatty Acid Profile. The preparation of samples intended for fatty acid methyl esters' analytics was described earlier by Pleadin et al. [25]. The method employed was gas chromatography (GC), while the procedure followed the EN ISO 12966–2:2011 [26] and the EN ISO 12966–4:2015 [27]. The device in use was a 7890BA gas chromatographer with flame ionization detector (FID) and a 60 m DB-23 0.25 mm ID, capillary column having the stationary phase thickness of 0.25 μm (Agilent Technologies, Santa Clara, USA). The analytes were FID detected at the temperature of 280°C. During the process, the flow rates of hydrogen, air, and nitrogen were 40 mL/min, 450 mL/min, and 25 mL/min, respectively. The initial column temperature was 130°C; after a minute, it was gradually increased by 6.5°C/min up to 170°C. The temperature was then further increased by 2.75°C/min up to 215°C. The latter was kept for 12 min and then again gradually increased by 40°C/min up to the final column temperature of 230°C, which was maintained for 3 min. One μL of a sample was injected into a split-splitless injector at 270°C, the partition coefficient thereby being 1 : 50. The carrier gas was helium (99.9999%), provided at the steady flow rate of 43 cm/sec. Fatty acid methyl esters were identified by comparing their retention times with those of their counterparts in the standard mixture.

The results are given as a percent-shares (%) of each fatty acid in the total fatty acid content with the accuracy of 0.01%. Each sausage sample was analysed in duplicate. Quality control made use of the BCR 163 CRM (provided by the Institute for Reference Materials and Measurements, Geel, Belgium), in which the content of seven fatty acids was known. All chemicals were of an analytical grade.

2.5. Statistical Data Analyses. Statistical analysis was performed using the SPSS Statistics Software 25.0 (SPSS Statistics, NY IBM, 2015). In order to determine statistical differences between the samples of Croatian and Montenegrin origin, the independent sample t-test was used. The interpretation of results was guided by the significance level of $p \leq 0.05$.

3. Results and Discussion

In this research, nutritional composition and fatty acid profile of traditional meat products originating from Croatia and Montenegro were investigated. Basic chemical composition of the analysed meat products is summarized in Table 2.

The share of moisture in Croatian products ranged from 23.24% (pancetta) to 43.60% (dry sirloin). Meat products from Montenegro generally contained more moisture, although significant differences between products coming from the two countries were established only for pancetta ($p = 0.007$) and dry sirloin ($p = 0.002$), the latter being the product containing the highest amount of moisture of them all (61.62%). Ash content varied, but in a very narrow range,

Table 2: Chemical composition of traditional Croatian and Montenegrin dry-cured meat products and dry-fermented sausages.

Product	Country	Moisture% w/w	Ash% w/w	Fat% w/w	Protein% w/w	Sugars% w/w	Salt% w/w
Prosciutto	CRO	36.73 ± 5.74	9.81 ± 2.31	18.04 ± 8.98	$34.93 \pm 4.80^{*}$	0.47 ± 0.69	7.35 ± 1.92
	MNE	39.48 ± 5.95	7.77 ± 1.76	24.65 ± 5.59	$28.08 \pm 4.11^{*}$	<LOD	6.63 ± 1.76
Pancetta	CRO	$23.24 \pm 8.63^{*}$	5.96 ± 0.79	$47.86 \pm 8.31^{*}$	20.58 ± 2.10	2.36 ± 2.25	4.51 ± 1.13
	MNE	$38.30 \pm 7.73^{*}$	5.17 ± 1.51	$35.42 \pm 7.49^{*}$	21.50 ± 2.47	<LOD	3.58 ± 1.08
Dry sirloin	CRO	$43.60 \pm 2.50^{*}$	5.97 ± 0.92	6.73 ± 3.43	$43.42 \pm 5.29^{*}$	0.28 ± 0.48	4.58 ± 0.70
	MNE	$61.62 \pm 7.88^{*}$	5.51 ± 0.91	4.77 ± 1.94	$28.45 \pm 5.80^{*}$	<LOD	3.71 ± 2.47
Dry rack	CRO	40.56 ± 8.86	8.19 ± 0.77	19.60 ± 7.20	30.88 ± 4.33	0.76 ± 0.86	5.96 ± 0.73
	MNE	54.07 ± 11.26	6.72 ± 2.68	13.98 ± 3.50	25.81 ± 9.24	<LOD	6.29 ± 2.68
Domestic sausage	CRO	27.84 ± 6.53	5.02 ± 0.51	37.26 ± 7.19	27.60 ± 3.42	2.28 ± 2.23	3.54 ± 0.71
	MNE	33.88 ± 5.26	4.79 ± 0.95	36.52 ± 7.09	24.18 ± 3.16	0.64 ± 0.50	4.09 ± 0.55

CRO: Croatia; MNE: Montenegro; LOD (limit of detection): sugars 0.02%. The results are expressed as mean values given in weight percentages ± standard deviation. *Difference between rows within same product type ($p < 0.05$).

with no significant differences between Croatian and Montenegrin products. The highest ash content was determined in prosciutto samples (9.81% in Croatian and 7.77% in Montenegrin). Croatian meat products were proven to be a richer source of proteins in comparison with Montenegrin ones, which goes particularly for dry sirloin ($p = 0.014$) and prosciutto ($p = 0.018$). The highest protein content was determined in dry sirloin from both countries, while the lowest was obtained in pancetta samples. Except for sausages, the share of sugars in Montenegrin samples was below the limit of detection, whereas the highest share of sugars ($p = 0.027$) was found in Croatian pancetta.

Previous research has confirmed that fat content in meat products is highly variable depending on the raw material, part of the meat products are made from, the share of fatty tissue, recipe, and production process [3]. The share of fat established in Croatian products ranged from 6.73% (dry sirloin) to 47.86% (pancetta). Dry sirloin was also proven to have the lowest share of fat as compared to other Montenegrin products under study (4.77%). Significant difference in the share of fat was established between pancetta samples ($p = 0.016$), while domestic sausages from both countries had a relatively high fat content (36.52% in Montenegrin and 37.26% in Croatian sausages). Pancetta fat content in Croatian samples was above the previously reported range [14] (30.66–41.56%), as opposed to Montenegrin samples that were in it. Other authors [28] analysed Drniš pancetta and Dalmatian pancetta and reported the shares of fat of 46.63–46.79% and 55.64–57.26%, respectively. Significant differences between Croatian and Montenegrin samples are likely to be attributed to the differences in muscle tissue content used by various producers. It is also known that the share of fat in a meat product significantly contributes to its taste, texture, shelf-life, and price [28].

Dry-fermented sausages are one of the traditional meat products with well-documented composition variability not just across countries, but within the same country, as well. Their chemical composition is influenced not just by recipes (i.e., the composition of stuffing), but also by technological processes, such as conditioning, fermentation, drying, smoking, and ripening, as well as by parameters such as temperature, relative humidity, and air velocity [29]. Nutritional composition of the analysed sausages is similar to that recently reported for Istrian and Dalmatian sausages [25]. Their composition is also comparable to the composition of traditional dry-fermented sausages from other Mediterranean countries, namely Slovenia (Suha klobasa) [30], Italy [31], Spain [32] or Greece [33].

Prosciutto is a traditional meat product produced across the Mediterranean countries and often protected under the designation of origin. Some of the European most famous prosciuttos are Italian Prosciutto di Parma, Prosciutto di San Danielle, Prosciutto di Modena, and Prosciutto Toscano, but those originating from Spain (Guijuelo, Teruel, and Serrano) and France (Jambon de Bayonne) are hardly less famous [34]. Appellation of origin is the guarantee of standardized technologies and quality, so that the goal of manufacturers in any given country is to protect as many products as possible. The tradition of prosciutto production in Croatia and Montenegro is as long as that in other Mediterranean countries; the protection of origin of these products is addressed above.

For the purpose of this study, we choose to compare Croatian Dalmatian type prosciutto with Njeguš prosciutto from Montenegro because of the similarity of their production technologies. The link between the two is geographical vicinity of the production area, climate similarity (the weather being characterized by a cold and dry wind, which blows from the mountains towards the sea, and similar temperature during summer and winter), and the use of traditional production technology, which contributes to nation-wide reputation of these traditional products.

Dalmatian prosciutto is a preserved dry-cured meat product made from pig leg (bone, skin, and subcutaneous fat). Except for sea salt, no additives (such as nitrites, nitrates, potassium sorbate, ascorbic, or propionic acids) are used with its production. It is smoked using a cold smoke coming from burning hornbeam (*Carpinus* sp.), oak (*Quercus* sp.), or beech (*Fagus* sp.) hardwood or shavings. Drying and maturation last 9 to 12 months. Longer maturation contributes to better sensorial properties. A total production length is at least 12 months. The minimum weight of prosciutto released on the market is 6.5 kg [35, 36].

Njeguš prosciutto is a dry-cured meat product made from pork leg (bones other than pelvic, skin, and subcutaneous fat), which is dry-salted with sea salt, smoked by smoke coming from slow-burning dry beech wood (*Fagus* sp.), and then dried and ripen for at least eight months. The final weight of a Njeguš prosciutto should be more than 6.5 kg, and the production takes 16 months at least in the specific geographical area called Njeguši [36, 37].

The results pertaining to the chemical composition of prosciutto, obtained in this study, revealed a slightly lower moisture content in comparison with the results of other research on the same prosciutto type (44.97%, [12]), but still in range (39.19%–42.8%) obtained by other authors [13]. According to the specification, Njeguš prosciutto should contain 40–60% of moisture [37], but our results are slightly under the lower limit (39.48%). Generally, prosciutto from which skin and subcutaneous fatty tissue were removed is more prone to dehydration and contains less moisture (i.e., Istrian prosciutto in Croatia). Since both Dalmatian and Njeguš prosciutto are not skinned off during production, moisture content in final products remains higher.

The share of ash in prosciutto was similar to that previously reported [13], while the protein content in Croatian samples was higher than previously reported 29.35% [12]. The salt content in Croatian samples was lower than previously reported (9.05–9.07%) [13], but similar to values obtained by other researchers [12] (6.45–7.09%). According to the specification, the salt content in a Njeguš prosciutto should range from 4 to 8%, and the values obtained in this research were in the range. A wide range of acceptable salt content values in a finished prosciutto mirrors an individual affinity towards product saltiness differing among producers and the fact that these products are not skinned off.

Many authors have confirmed that the share of fat in a prosciutto is very important for its sensorial characteristics; however, this component has been proven to be highly variable [11–13]. Prosciutto with a higher share of fat usually has better sensorial properties. Since the share of fat in a prosciutto depends on feeding and keeping of animals and pig breed [11], it can be expected that the fat content of Dalmatian and Njeguš prosciutto shall be more variable than that of, for instance, Croatian Istrian prosciutto. In the production of Istrian prosciutto, which is PDO-labelled, only certain pig breeds can be used, while in the production of Dalmatian and Njeguš prosciutto raw materials can be imported. Consequently, greater raw material variability affects the variability of the composition of the prosciutto itself.

Salt should be the essential ingredient of meat products, since it assures not just microbiological stability, but also helps in boosting the moisture and fat binding capability and enhances colour, taste, and texture [38]. Although there were no significant differences in salt content between Croatian and Montenegrin products, the level of salt decreased in the following order: Dalmatian prosciutto > dry rack > dry sirloin > pancetta > domestic sausages (Croatia) and Njeguš prosciutto > dry rack > domestic sausages > dry sirloin > pancetta (Montenegro). Decrease in salt content is inversely related to the previously discussed increase in moisture content. Decrease in moisture content, which occurred during production (drying and ripening), contributed to the increase in salt content [39], as also confirmed by the results of this study.

Salt content values obtained in the analysed meat products were similar to those previously published [10]. The results of the quoted research, which was focused on prosciutto, dry rack, pancetta, dry sirloin, and domestic sausages, revealed the above meat products to have the salt content of 6.34%, 5.46%, 5.57%, 5.34%, and 4.14%, respectively [10]. The results obtained for dry sirloin from Montenegro were about half the values reported earlier [16] ($6.9 \pm 0.5\%$ for industrially produced dry sirloin and $7.8 \pm 0.7\%$ for traditional home-made dry sirloin). The highest salt content was recorded in prosciutto, which is generally recognized as the meat product with the highest salt content, although the amounts of salt established in previous studies conducted on Croatian prosciuttos varied from 6.45% [40] to 9.18% [41]. As reviewed previously [34], these values, and also the values obtained in this study, are slightly higher in comparison with the results obtained for traditional European hams. In the latter products, the salt content ranged from 6.00% (Parma) to 8.70% (Serrano-type hams). Due to the negative health effects of high salt intake (i.e., increased blood pressure, heart and kidney damages, increased incidences of certain types of cancer, etc.), the World Health Organization recommends the daily salt intake not to exceed 5 grams [42].

The characteristics of meat are also affected by the amount of fat and its composition, or the share of individual fatty acids. Fatty acids are important not only for nutritional value, but also for sensory properties, tenderness, and shelf-life of meat products. Fatty tissue with a higher share of saturated and *trans*-fatty acids is harder and has a higher melting point than that containing more unsaturated and *cis*-fatty acids. The shares of individual fatty acids in pork meat and pork meat products usually follow the order: monounsaturated fatty acids-MUFAs (41–59%) > saturated fatty acids-SFAs (30–45%) > polyunsaturated fatty acids-PUFAs (9–18%). Among MUFAs, the most represented fatty acid is oleic acid ($C18:1n-9c$, OA), while among SFAs, palmitic acid (C16 : 0, PA) (23–26% on average) and stearic acid (C18 : 0, SA) (10–15% on average) usually take the lead. Among PUFAs, the highest share is usually that of linoleic acid ($C18:2n-6c$, LA), with an average share in total fatty acids of 6–10% [11–14]. Linoleic acid ($C18:2\ n-6$, LA) is considered to be an essential fatty acid, which is the precursor of arachidonic acid ($C20:4\ n-6$, AA), while alpha-linolenic acid ($C18:3\ n-3$, ALA) is metabolized to eicosapentaenoic acid ($C20:5\ n-3$, EPA). AA is one of the most abundant $n-6$ LCPUFAs in the brain and has a critical role in brain growth, especially during the first months of life. However, the role of AA in neuroprotection against neurodegenerative pathologies such as Alzheimer's disease and Parkinson´s disease is still controversial [43]. Additionally, increased AA levels are associated with a pro-inflammatory state and an oxidative stress with short- and long-term consequences. It has recently been revealed that high levels of $n-6$ LCPUFAs in maternal circulation found during pregnancy and lactation confer a higher risk of obesity and its complications, neuropsychiatric disorders, asthma, and cancer to the offspring [44]. When LA and ALA dietary contributions are similar, the formation of DHA is privileged over that of AA. Additionally, high $n-6/n-3$ fatty acids' ratio has been implicated into the development of nonalcoholic fatty liver disease (NAFLS) [45]. In light of these facts, special attention shall be paid to *e* $n-6/n-3$ ratio determined in analysed samples.

The shares of individual fatty acids in total fatty acids in meat products from Croatia and Montenegro analysed in this study are summarized in Table 3.

As for individual fatty acids, the highest share of oleic acid (C18 : $1n-9c$, OA) was determined in prosciutto samples from both countries (42.29%–42.34%), while the highest share of palmitic acid (C16 : 0, PA) was recorded in dry sirloin originating from Croatia (27.60%, $p=0.008$). The share of stearic acid (C18 : 0, SA) was highest in dry rack from Croatia (16.08%), although no statistical difference among samples from the two countries was established. The highest share of linoleic acid (C18 : $2n-6c$, LA) was determined in pancetta samples from Montenegro (13.16%).

Although the majority of the obtained values were similar to those obtained by other authors [11–15], an interesting finding of this study is a somewhat lower representation of PUFAs, particularly those of $n-3$ group. Namely, the share of as many as five $n-3$ group fatty acids was under the limit of detection (<0.01%), while only two fatty acids belonging to this group (α-linolenic acid C18 : $3n-3$, ALA and stearidonic acid C18 : $4n-3$, SA) were detected. Nevertheless, when it comes to the studied groups of meat products, lower PUFA content could be beneficial, since a higher amount of the latter could worsen the oxidative stability of the products [12]. Free fatty acids in meat products are formed during the process of lipolysis, in which triacylglycerols and phospholipids decompose due to the activity of the enzyme lipase and phospholipase, respectively. The shares of free fatty acids in meat products are related to the initial composition of the meat (namely, triacylglycerols and phospholipids) and previously mentioned decomposition [46].

For prosciutto, the obtained MUFA, SFA, and PUFA values in samples from both countries were 49.73–49.75%, 40.29–42.56%, and 7.69–9.89%, respectively. The obtained results are similar to those previously reported for Dalmatian prosciutto [28], which were as follows: MUFAs 52.69%, SFAs 40.30%, and PUFAs 6.21%. Similar values were obtained by other authors, for instance, Senčić and Samac (MUFAs 48.26%, SFAs 41.14%, and PUFAs 10.69) [12] and Tomić et al. (MUFAs 51.39%; SFAs 38.13%; PUFAs 10.48%) [13]. Similar shares of SFAs, MUFAs, and PUFAs were published for Bayonne (36.4%, 52.9%, and 10.7%, respectively), Parma (36.4%, 15.2%, and 11.1%, respectively), and Serrano ham (33.4%, 55.6%, and 11.0%, respectively) [47]. During the production of dry-fermented meat products, the share of MUFAs increases, the share of PUFAs decreases, while the share of SFAs remains stable. This effect could be linked to the oxidation of unsaturated fatty acids with double bonds [48].

The comparison of fatty acid profile of sausages under our research with three different types of sausages originating from Istria, Slavonia, and Bosnia and Herzegovina, which had the share of SFAs of 39.56–43.00%, the share of MUFAs of 46.66–47.65%, and the share of PUFAs of 10.26–10.33% [25, 49], revealed that the values obtained in this study are comparable to the above for all fatty acid groups. However, sausages analysed in this research contained less oleic acid (C18 : $1n-9c$, OA) (38.51–41.53%) in comparison with similar products from this region. Pleadin et al. [25, 49] showed that traditional sausages from Croatia and Bosnia and Herzegovina contain oleic acid (C18 : $1n-9c$, OA) in the range of 43.74–44.31%.

In comparison with pancetta from Bosnia and Herzegovina, pancetta samples from Croatia and Montenegro have more SFAs and PUFAs, but a similar amount of MUFAs (more precisely, SFAs 40.01–43.13%; PUFAs 12.14–14.96%, and MUFAs (44.66–44.80%) [10]. However, oleic acid (C18 : $1n-9c$, OA) shares determined in this study (38.30%–38.73%) were lower than those established in the study cited above (43.71%) [10]. Moreover, in the analysed Drniš and Dalmatian pancetta samples, the obtained shares of oleic (C18 : $1n-9c$, OA), palmitic (C16 : 0, PA), stearic (C18 : 0, SA), and linoleic acid (C18 : $2n-6c$, LA) were 44.82–46.66%, 23.91–25.94%, 13.27–19.96%, and 7.97–8.98%, respectively [28].

Nutritional quality of fat is usually evaluated using two indices: $n-6/n-3$ ratio and PUFA/SFA ratio [50]. As previously discussed, samples under this study contained less $n-3$ fatty acids, hence also less favourable $n-6/n-3$ ratios. Although an excessive fat intake is related to many so-called civilization diseases, the absolute fat intake is less important than the type of fat consumed. According to the FAO, there is no rational for specific recommendations for $n-6/n-3$ ratio, provided that $n-6$ and $n-6$ fatty acids' intakes fall within the recommended [51]. However, in modern western diet, the intake of $n-6$ fatty acids has increased, and the intake of $n-3$ fatty acids has decreased, resulting in a large increase in $n-6/n-3$ ratio from 1 : 1 during evolution to 20 : 1 or even higher, seen today. However, an unbalanced $n-6/n-3$ ratio in favour of $n-6$ fatty acids is highly proinflammatory and prothrombotic and contributes to the prevalence of atherosclerosis, obesity, and diabetes [52]. In view of the above, it is recommended to balance the $n-6/n-3$ ratio so as to span from 1–2/1 [53] to 2–3/1 [54].

In previous research on traditional meat products, the n-6/n-3 ratios were as follows: prosciutto 8.38–12.09, sausages 9.22–11.70, and pancetta 10.94 [11–13, 25, 49]. In comparison with the samples from Bosnia and Herzegovina, the average $n-6/n-3$ ratio in Croatian samples was more than double. The obtained values were as follows: prosciutto 21.41–24.22, pancetta 14.82–25.83, and sausages 16.09–16.89. If we compare the $n-6/n-3$ ratio found in our products with the recommendations for healthy diet mentioned above, it is obvious that should the ratio be 1/1, our samples surpass it by 16-25-fold. If the recommended 2/1 $n-6/n-3$ ratio is taken as the rationale, those found in our samples are 8- to 12-fold higher. Provided that the ratio of 3/1 is taken as the criterion, the ratios found in our samples were 5- to 8-fold higher. In any case, $n-6$ over $n-3$ ratio markedly exceeds healthy diet recommendations. In comparison with Montenegrin samples, pancetta samples from

Table 3: Fatty acid composition (% of total fatty acids) of traditional Croatian and Montenegrin dry-cured meat products and dry-fermented sausages.

Fatty acid	Prosciutto% total fatty acids		Pancetta% total fatty acids		Dry sirloin% total fatty acids		Dry rack% total fatty acids		Domestic sausage% total fatty acids	
	CRO	MNE	CRO	MNE	CRO	MNE	CRO	MNE	CRO	MNE
C10 : 0	0.10 ± 0.02	0.10 ± 0.01	0.09 ± 0.01	0.10 ± 0.01	0.13 ± 0.01	0.13 ± 0.02	0.10 ± 0.03	0.12 ± 0.02	0.08 ± 0.02*	0.10 ± 0.01*
C12 : 0	0.09 ± 0.02	0.10 ± 0.02	0.08 ± 0.01	0.15 ± 0.11	0.10 ± 0.01	0.12 ± 0.03	0.09 ± 0.03	0.11 ± 0.02	0.09 ± 0.02	0.12 ± 0.04
C14 : 0	1.29 ± 0.16	1.36 ± 0.16	1.37 ± 0.13	1.46 ± 0.31	1.49 ± 0.07	1.43 ± 0.09	1.32 ± 0.21	1.35 ± 0.05	1.50 ± 0.46	1.44 ± 0.14
C15 : 0	0.03 ± 0.03	0.04 ± 0.04	0.03 ± 0.03	0.05 ± 0.02	0.02 ± 0.03	0.03 ± 0.03	0.05 ± 0.03	0.07 ± 0.05	0.09 ± 0.10	0.07 ± 0.02
C16 : 0	25.65 ± 0.88	25.06 ± 0.88	26.29 ± 1.09*	24.38 ± 0.54*	27.60 ± 0.40*	26.31 ± 0.52*	25.10 ± 0.95	25.35 ± 1.23	24.37 ± 2.07	25.37 ± 1.36
C16 : 1$n-7t$	0.34 ± 0.08	0.38 ± 0.09	0.26 ± 0.05*	0.36 ± 0.05*	0.27 ± 0.03*	0.43 ± 0.07*	0.46 ± 0.17	0.49 ± 0.17	0.41 ± 0.09	0.44 ± 0.07
C16 : 1$n-7c$	2.72 ± 0.59	2.67 ± 0.37	2.24 ± 0.16	2.34 ± 0.40	3.12 ± 0.82	2.70 ± 0.33	1.94 ± 0.37	2.16 ± 0.31	2.72 ± 0.96	2.39 ± 0.11
C17 : 0	0.45 ± 0.19	0.44 ± 0.21	0.40 ± 0.11	0.41 ± 0.10	0.28 ± 0.06*	0.43 ± 0.07*	0.57 ± 0.29	0.54 ± 0.21	0.59 ± 0.24	0.52 ± 0.11
C17 : 1	0.28 ± 0.09	0.26 ± 0.10	0.21 ± 0.06	0.24 ± 0.10	0.17 ± 0.06	0.22 ± 0.04	0.23 ± 0.13	0.19 ± 0.11	0.34 ± 0.12	0.29 ± 0.06
C18 : 0	14.66 ± 1.95	12.90 ± 0.51	14.63 ± 0.63*	13.26 ± 0.61*	15.95 ± 1.89	15.34 ± 0.73	16.08 ± 1.86	15.17 ± 1.42	13.00 ± 1.81	14.53 ± 1.36
C18 : 1$n-9t$	0.19 ± 0.05	0.24 ± 0.07	0.02 ± 0.05*	0.17 ± 0.07*	0.12 ± 0.01*	0.34 ± 0.09*	0.23 ± 0.18	0.29 ± 0.06	0.16 ± 0.14	0.21 ± 0.04
C18 : 1$n-9c$	42.29 ± 1.72	42.34 ± 1.95	38.73 ± 1.59	38.30 ± 2.50	38.52 ± 2.32	38.70 ± 1.25	35.96 ± 2.96	38.01 ± 2.45	41.53 ± 2.85*	38.51 ± 1.16*
C18 : 1$n-7$	3.12 ± 0.62	3.01 ± 0.28	2.42 ± 0.09	2.67 ± 0.39	3.27 ± 0.66	3.09 ± 0.34	2.36 ± 0.13*	2.75 ± 0.21*	2.86 ± 0.29	2.80 ± 0.19
C18 : 2$n-6t$	0.12 ± 0.07	0.14 ± 0.03	0.08 ± 0.04*	0.14 ± 0.03*	0.14 ± 0.04	0.12 ± 0.06	0.09 ± 0.01*	0.11 ± 0.01*	0.14 ± 0.04	0.14 ± 0.02
C18 : 2$n-6c$	6.74 ± 1.36	8.79 ± 1.95	10.95 ± 0.83	13.16 ± 3.56	6.82 ± 2.13	8.63 ± 1.61	12.81 ± 2.35	11.21 ± 4.01	9.45 ± 2.76	10.48 ± 1.91
C18:3$n-3$	0.35 ± 0.05	0.41 ± 0.12	0.45 ± 0.04*	0.93 ± 0.29*	0.34 ± 0.20	0.44 ± 0.15	0.53 ± 0.15	0.62 ± 0.11	0.60 ± 0.32	0.69 ± 0.12
C18:4$n-3$	0.01 ± 0.03	<LOD	0.01 ± 0.02	0.02 ± 0.04	0.02 ± 0.03	<LOD	0.04 ± 0.04	<LOD	0.07 ± 0.06	0.02 ± 0.04
C20 : 0	0.20 ± 0.03	0.20 ± 0.01	0.24 ± 0.03*	0.20 ± 0.01*	0.20 ± 0.02	0.18 ± 0.09	0.20 ± 0.05	0.18 ± 0.02	0.20 ± 0.02	0.20 ± 0.02
C20:1$n-9$	0.81 ± 0.14	0.84 ± 0.10	0.78 ± 0.09	0.73 ± 0.13	0.74 ± 0.13	0.79 ± 0.12	0.78 ± 0.10	0.85 ± 0.06	0.92 ± 0.24	0.80 ± 0.04
C20:2$n-6$	0.33 ± 0.06	0.41 ± 0.09	0.48 ± 0.06	0.54 ± 0.11	0.34 ± 0.11	0.40 ± 0.05	0.56 ± 0.10	<LOD	0.47 ± 0.18	0.46 ± 0.09
C20:4$n-6$	0.15 ± 0.05	0.14 ± 0.03	0.17 ± 0.02	0.18 ± 0.02	0.18 ± 0.05	0.18 ± 0.09	0.26 ± 0.04	0.21 ± 0.05	0.18 ± 0.09	0.19 ± 0.03
C23 : 0	0.10 ± 0.11	0.10 ± 0.05	<LOD	<LOD	0.16 ± 0.19	<LOD	0.05 ± 0.08	<LOD	0.05 ± 0.06	0.04 ± 0.05
SFA	42.56 ± 2.42	40.29 ± 1.17	43.13 ± 1.71*	40.01 ± 1.19*	45.94 ± 2.08	43.95 ± 0.92	43.57 ± 1.87	42.88 ± 2.10	39.96 ± 3.89	42.38 ± 2.79
MUFA	49.75 ± 2.76	49.73 ± 2.22	44.66 ± 1.66	44.80 ± 3.25	46.21 ± 3.76	46.27 ± 1.82	41.97 ± 3.18	44.73 ± 2.68	48.96 ± 2.55*	45.44 ± 1.45*
PUFA	7.69 ± 1.40	9.89 ± 2.13	12.14 ± 0.91	14.96 ± 3.88	7.85 ± 2.43	9.76 ± 1.82	14.30 ± 2.50	12.14 ± 4.14	10.90 ± 3.14	11.98 ± 2.11
Sum $n-3$	0.36 ± 0.07	0.41 ± 0.12	0.46 ± 0.04*	0.95 ± 0.26*	0.36 ± 0.23	0.44 ± 0.15	0.57 ± 0.15	0.62 ± 0.11	0.67 ± 0.30	0.71 ± 0.13
Sum $n-6$	7.33 ± 1.43	9.48 ± 2.03	11.68 ± 0.89	14.01 ± 3.64	7.49 ± 2.24	9.32 ± 1.70	13.72 ± 2.41	11.52 ± 4.06	10.23 ± 2.95	11.27 ± 2.01
$n-6/n-3$	21.41 ± 6.93	24.22 ± 5.00	25.83 ± 2.37*	14.82 ± 1.05*	23.79 ± 7.75	22.14 ± 4.05	24.78 ± 5.51	18.45 ± 4.96	16.89 ± 6.23	16.09 ± 2.64
PUFA/SFA	0.18 ± 0.04*	0.25 ± 0.06*	0.28 ± 0.03*	0.38 ± 0.10*	0.17 ± 0.05	0.22 ± 0.04	0.33 ± 0.06	0.29 ± 0.10	0.28 ± 0.09	0.29 ± 0.07
MUFA/SFA	1.18 ± 0.13	1.24 ± 0.07	1.04 ± 0.08	1.12 ± 0.07	1.01 ± 0.12	1.05 ± 0.05	0.97 ± 0.10	1.04 ± 0.05	1.24 ± 0.17*	1.08 ± 0.11*
MUFA/PUFA	6.72 ± 1.68	5.27 ± 1.34	3.70 ± 0.34	3.32 ± 1.57	6.44 ± 2.75	4.89 ± 1.00	3.05 ± 0.85	4.26 ± 2.07	5.12 ± 2.57	3.88 ± 0.60

CRO: Croatia; MNE: Montenegro; LOD (limit of detection): 0.01%; SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids. *Difference between columns within same product type ($p < 0.05$). The results are expressed as the mean value in % of total fatty acids ± standard deviation.

Croatia had a lower $n-3$ fatty acid content ($p \leq 0.001$), resulting in a higher $n-6/n-3$ ratio ($p < 0.001$).

Another indicator of fatty acid quality is PUFA/SFA ratio. In traditional meat products, the ratio determined previously in our region was the following: prosciutto 0.17–0.30, sausages 0.24–0.32, and pancetta 0.30 [11–13, 25, 49]. Since in samples under this study the shares of SFAs and PUFAs in total fatty acids were similar to those established by the previous research, the similar results for PUFA/SFA ratio could be expected as well, what was confirmed by the data obtained for prosciutto (0.18–0.25), pancetta (0.28–0.38), and domestic sausages (0.28–0.29). The lowest PUFA/SFA was obtained for dry sirloin samples (0.17) from Croatia, since this traditional meat product contained the lowest share of PUFAs (7.85%) and the highest share of SFAs (45.94%). In order to meet health recommendations or reduce the risk of developing cardiovascular and other chronic diseases, the PUFA/SFA ratio should be greater than 0.4 [55]. It is therefore to be concluded that samples under this study are inadequate when it comes to both indicators.

4. Conclusion

Dry-cured meat products and dry-fermented sausages represent a part of the tradition of the Mediterranean region, although scientific interest taken in their investigation differs among countries. This study was an incentive for making a comparison between Croatian and Montenegrin traditional meat products in terms of chemical composition and fatty acid profile. Regarding basic chemical composition, despite minor differences between meat products from Croatia and Montenegro, it can be concluded that (except for pancetta) no statistical differences between the countries of origin were established. As for the fatty acid profile, significant differences in shares of some fatty acids, MUFAs and SFAs, but also $n-3$ group, were determined. The quality indices were not in line with health recommendations; moreover, $n-6/n-3$ ratio was five to eight times higher than recommended ($n-6/n-3=3/1$). Future research should include the analyses of raw meat materials obtained from pigs of different breeds on the composition of final traditional meat products and should seek for final products' quality improvement options. The obtained results could strengthen the efforts of the governments to raise the level of recognisability of these nutritionally highly valuable meat products from both countries, especially Montenegrin products of designated origin, which could significantly contribute to valorisation of traditional meat products on an international market.

Data Availability

The data used to support the findings of this study are available from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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