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DEVELOPMENT OF A FUNCTIONAL MEAT PRODUCT WITH SEA BUCKTHORN OIL AND ANALYSIS OF ITS SENSORY AND PHYSICOCHEMICAL QUALITY

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Abstract

The present study was carried out to follow the technological manufacturing process of functional meat products - three batches of pork tenderloin injected with sea buckthorn oil in three different proportions of 1, 3, and 5% and to analyze their quality. The products were obtained in the Meat and Meat Products Microproduction Workshop of the University of Life Sciences Iasi. After the experimental batches were made, their sensory and physical-chemical analysis was carried out. The sensory analysis of the three types of muscle injected with sea buckthorn oil involved the application of a CATA questionnaire to a group of evaluators, which showed that these products have good consumer acceptability, especially the 3% and 1% sea buckthorn oil batches. The physicochemical aspects were analyzed in terms of color, pH, and raw chemical composition. The colorimetric analysis showed a decrease in the brightness of the samples with an increase in the amount of sea buckthorn oil in the batch. As for the chemical analysis, the increase in the amount of sea buckthorn oil resulted in very different values between batches.

Key words*: functional food product, meat product, quality parameters, sea buckthorn oil.*

INTRODUCTION

In recent years, as people pay more and more attention to health, the physiological functions of food have received increasing attention (Arihara et al., 2006).
Meat is a good source of dietary protein and has a high biological value (Hathwar et al., 2011). However, consumers often label meat negatively, characterizing it as a high-fat, cancer-promoting food (Valsta et al., 2005). For these reasons, consuming meat and meat products is often avoided to minimize the risk of cancer, obesity, and other diseases. However, such a view ignores the essential importance of meat in maintaining human health. Although the importance of meat and meat products in consumer health has been widely discussed in scientific articles to better educate and inform consumers, data are still lacking in many countries (Arihara et al., 2004; Biesalski et al., 2005; Cassens, 1999; D'Amicis and Turrini, 2002; Desmond and Troy, 2004; Enser, 2000; Ferna´ndez-Gine´s et al., 2005; Garnier et al., 2003; Gregory, 2004; Higgs, 2000; Jime´nez-Colmenero et al., 2001, 2006; Kues and Niemann, 2004; Ovesen, 2004a, 2004b; Tarrant, 1998; Valsta et al., 2005; Verbeke et al., 1999).
One of the most maligned and avoided components of meat and meat products because of the risks it is thought to pose - fat - can be minimized by selecting lean cuts of meat, eliminating the fat, manipulating the diet to alter the fatty acid composition, and controlling portions appropriately to reduce fat intake and calorie intake. In recent years, particular attention has been paid to developing meat products with health benefits by introducing bioactive ingredients (Arihara et al., 2004).
Functional foods are an outstanding and promising category of foods that exhibit beneficial characteristics such as cholesterol-lowering properties, antioxidant, and anti-cancer properties that are considered quite attractive by consumers (Ioannis and Maria, 2005).
Increasing consumer demand for healthy food has initiated extensive research and development of new products in the food

industry. To meet this ever-increasing consumer demand, the food industry is reformulating food products to improve the physiological functionality of inherent nutrients or by adding a bioactive ingredient (Day et al., 2009).

One of the most interesting functional ingredients that can be added to meat products is sea buckthorn fruit oil, which contains high concentrations of vitamin C, carotenoids, tocopherols, and other bioactive compounds with a strong antioxidant role, in addition to the unique profile of beneficial lipids in the pulp and peel of the berries. Sea buckthorn oil contains a multitude of active substances. Scientific studies confirm the content of almost 200 ingredients that ensure the multidirectional effect of this type of vegetable oil (Zielińska and Nowak, 2014; Rajaram, 2014; Ng et al., 2014; Walczak-Zeidler et al., 2012; Kall io et al., 2012). The phenolic fraction is a major component in the bioactive function of sea buckthorn oil and has recently been studied for its possible health effects. According to Ma et al. (2016), one of the main aglycones in sea buckthorn is isorhamnetin. Isohamnetin, which is mainly found in the aqueous fraction of the fruit, has been shown to exhibit high antioxidant activity, even higher than that exerted by ascorbic acid, and this has been confirmed by various chemical tests (FRAP, DPPH), as reported by Pengfei et al. (2009). Nowadays, many food companies are striving for clean-label products, and the phenolic fraction in sea buckthorn is emerging as a possible natural antioxidant that can replace synthetic antioxidants. In addition, the phenolic fraction of sea buckthorn fruit has been shown to significantly decrease hydrogen peroxide-induced plasma peroxidation and increase clotting time in a test tube study, thus demonstrating interesting anticoagulant activity (Olas, 2018).

The trend in global food consumption away from traditional foods towards functional foods with guaranteed health effects will significantly increase the use of foods incorporated in meat products. Developing and marketing these products is a complex, costly, and risky task. The success of a product involves the combined efforts of diverse professional branches, notably nutritionists, epidemiologists, food technologists, natural product chemists, and others. Also, regulatory issues, sensory evaluation, and supermarket simulation are important aspects of the success of a new, functional meat product. Ultimately, the success or failure of functional foods depends on the characteristics of the product, its commercial viability, and, in turn, the nature, extent, and management of collaboration between related fields (Arihara et al., 2006).

The utility and ultimate applicability of functional materials or ingredients depend on four major factors - availability, durability, marketability, and consumer acceptance (Nimish et al., 2011).

The study aimed to manufacture functional meat products (3 batches of pork tenderloin injected with sea buckthorn oil in proportions of 1, 3, and 5%) and to analyze their sensory and physicochemical quality.

MATERIALS AND METHODS

The present study was carried out in the Meat and Meat Products Microproduction Workshop, in the Sensory Analysis Laboratory, and in the Meat and Meat Products Technology Laboratory; all part of the Faculty of Agriculture of the "Ion Ionescu de la Brad" University of Life Sciences Iasi.

The raw meat material used to make the 3 batches of pork tenderloin with sea buckthorn oil and the control batch was purchased from the local food market, as the sea buckthorn oil. The percentage values required to manufacture the batches presented in this paragraph are given in Table 1.

Table 1. Composition of the experimental batches

Batch	Ingredients (%)		
	Pork tenderloin	Seabuckthorn oil	Salt
L1SO1	97	1	2
L2SO3	95	3	2
L3SO5	93	5	2

The experimental protocol consisted of injecting pork muscle with three different concentrations of sea buckthorn oil (1, 3, and 5%), using a manual injection device. Before injection, the muscle was subjected to a dry salting process with a 2% salt concentration, lasting 24 h. The salted and injected tenderloin with sea buckthorn oil was inserted into a textile membrane with pepper, tied at one end, and hung on the raster trolley. After this step, thermal processing of the products followed, which included the steps and parameters shown in Table 2. After completion of the steps shown in Table 2, the products were cooled within 6 hours, packed, labeled, vacuum-packed, and stored at 2-4ºC.

Table 2. Thermal process stages and parameters for the pastrami

Stage	Time (minutes)	The temperature in the heat treatment cell (ºC)	The temperature in the thermal center of the product (ºC)	Humidity (%)
Drying	30	65	55	25
Smoking	30	65	55	25
Boiling	-	72	69	99
Drying	20	80	72	25

After obtaining the three batches of pork tenderloin with sea buckthorn oil, sensory and physicochemical analyses were carried out on them.

The sensory analysis of the three batches was carried out by a group of 39 students of the University of Life Sciences of Iasi in the Sensory Analysis Laboratory of the same University. The students who were part of this analysis were aged between 20-22 years. Four tasting sessions were carried out. At the beginning of these sessions, it was explained to the evaluators the content of the questionnaire, how to fill it in, and the actual tasting procedure. The samples from the three batches were sliced using a slicer to ensure uniformity between them and were coded with three random numbers. The evaluators were asked to tick the characteristics identified in the questionnaire in the samples, namely: crust integrity, noticeable sea buckthorn oil, heavy sea buckthorn oil in the mass of the product, uniform color, acid aroma, pepper aroma, characteristic meat flavor, soft sea buckthorn oil taste, salty taste, tasteless and balanced taste (meat and sea buckthorn oil). The results of the questionnaires were further processed in the XLSTAT software, using the CATA analysis contained therein.

The physical analyses applied to the products studied consisted of instrumental colorimetric analyses and instrumental pH analyses. The color analyses of the studied batches were carried out using the portable Konica Minolta Chroma Meter CR-410. The colorimetric analysis was performed through the CIELAB three-dimensional color system, which measured the quantitative relationship between the color parameters L* (black-white), a* (red-green), and b* (yellow-blue), with the D65 illuminant. The chronometer was calibrated before the analysis on a standard white calibration plate. A total of 5 section readings were taken for each batch.

Hanna Instruments portable pH meter for meat and meat products, model HI99163, was used to measure the pH value. Five measurements were made for each batch, each of which was carried out at a different location of the samples studied.

The determination of the chemical composition of the three batches of pork tenderloin with sea buckthorn oil consisted of measuring their main chemical components, represented by: protein, collagen, lipids, salt, and moisture. In order to carry out this type of analysis, the Food-Check automatic meat analyzer was used, which uses NIR (Near InfraRed) spectroscopy which is the analytical technique of using infrared radiation to determine the organic composition of the samples analyzed.

The physicochemical analyses were subjected to ANOVA and Tukey's test at a 5% level of significance ($p < 0.05$) for comparison of mean values.

RESULTS AND DISCUSSIONS

The results of the sensory analysis, using the CATA questionnaire, were evaluated using multiple factor analysis (MFA), as shown in Figure 1. Factors 1 and 2 show the variation that exists between the studied groups. In order to perform the multiple-factor analysis, an ideal was chosen, which has the following characteristics: crust integrity, uniform color, pepper aroma, characteristic meat flavor, soft sea buckthorn oil taste, noticeable sea buckthorn oil, balanced taste (meat and sea buckthorn oil). The similarity chart, which is divided into four quadrants, shows the attributes of the ideal product, but also those of an undesirable product: heavy sea buckthorn oil and intense sea buckthorn oil taste. Also, three other characteristics that were part of the questionnaire (acid aroma, salty taste, and tasteless) do not appear in the graphic, as they were not identified by the 39 evaluators in the three batches studied. By analyzing Figure 1 it can be noticed that the most desired characteristics are found in the two cadrans on the left side of the graph, and the batch closest to the ideal is L2SO3 (tenderloin injected with 3% sea buckthorn oil), which possesses the most desired sensory characteristics by consumers. Batch L1SO1 is also on the left side of the graph, which means that this batch also has sensory characteristics that are to consumers' liking. The last batch, L3SO5, is located on the right side of the graph, but not far to the left. This batch did not appeal to consumers in the same way as the other two batches, but it does not stray very far from them either. The main negative characteristic identified by a significant number of reviewers was the pronounced taste of sea buckthorn oil, which was not to their liking.

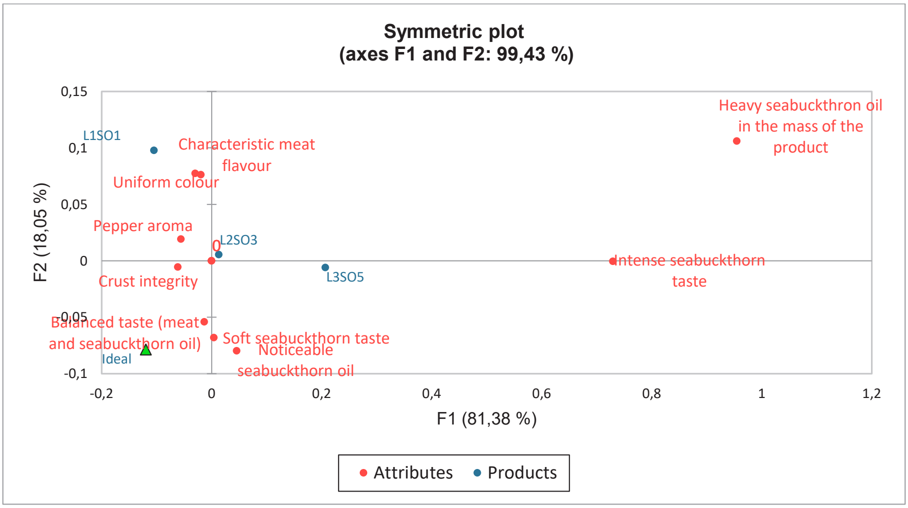

Figure 1. CATA analysis results for the three batches studied, using multiple factor analysis (MFA)

The color parameters (L*, a*, b*) are presented in Table 3 for the 3 batches studied. The L* parameter (0 - darkness; 100 - lightness) recorded the highest value in the L1SO1 batch, with the value of this parameter gradually decreasing with an increasing amount of sea buckthorn oil in the batch. In line with this statement, we can observe the value of L* for the L3SO5 batch (Table 3), which is significantly lower than the value of the L1SO1 batch ($p < 0.0001$). As for the parameter a* (negative - green color; positive - red color) we can observe that its value increases significantly with increasing the amount of sea buckthorn oil ($p < 0$). The highest mean value for the parameter a* is found in the L3SO5 batch, and the lowest in the L1SO1 batch (the batch with the lowest amount of sea buckthorn oil). As with the L* parameter, the L2SO3 batch also ranks with the a* parameter in the middle position between the other two studied batches. For the parameter b* (negative - blue color; positive - yellow color similar path can be observed as for a*, meaning that the mean value for b* increased with the increase in the oil content, but the differences are not significant ($p = 0.217$).

Table 3. Mean (± standard deviation) of colour parameters (L*, a*, b*) for the samples of tenderloins

Parameters	Batches			p-value
	L1SO1	L2SO3	L3SO5	
L*	56.92±0.316	51.16±1.099	50.99±0,647	<0.0001
a*	14.11±0.283	16.82±0.609	18.26±0.569	<0.0001
b*	14.19±0.941	15.16±1.920	18.068±1.563	0.217

ANOVA Tukey test: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1

Table 4 shows the physicochemical composition of the three batches of tenderloin injected with buckthorn oil. All parameters studied showed significant differences between batches (p < 0.0001), except for pH, which showed insignificant differences (p = 0.184). For protein content, the L2SO3 batch recorded the highest value, the second highest value in descending order was identified for the first batch (L1SO1), and the lowest value was found in the L3SO5 batch. After analyzing the mean values for protein content, we can conclude that the addition of sea buckthorn oil does not influence its value. The collagen content shows the same order as the protein in terms of mean values.

Lipid content within the three batches of tenderloin varied significantly (p < 0.0001), with the highest value found in batch three (the batch with the highest content of sea buckthorn oil - 5% and the lowest in batch L2SO3. Batch L2SO3 has a lower amount of fat than batch L1SO1, the reason for this value being the uneven distribution of the sea buckthorn oil throughout the tenderloin mass.

Table 4. Physico-chemical composition of the experimental batches

Studied characteristics	Experimental batches			p-value
	L1SO1	L2SO3	L3SO5	
Protein (%)	21.4±0	21.8±0.02	21.3±0	<0.0001
Collagen (%)	19.78±0.037	20.22±0.02	19.72±0.02	<0.0001
Fat (%)	4.14±0.024	2.38±0.058	4.58±0.02	<0.0001
Moisture (%)	74,08±0.037	75.52±0.058	73.64±0.04	<0.0001
Salt (%)	1.84±0.024	1.92±0.048	2.52±0.02	<0.0001
pH	6.18±0.010	6.19±0.005	6.17±0.007	0.184

ANOVA Tukey test: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < . < 0.1 < ° < 1

The lowest moisture content was identified in batch L3SO5, this result could be due to the higher amount of sea buckthorn oil in this batch. For the L2SO3 batch, the average value of water content is the highest of all three studied batches, even though this batch does not have the lowest amount of sea buckthorn oil. As in the case of lipid content, we can conclude that the cause of this discrepancy is the uneven distribution of sea buckthorn oil in the raw material.

The water content shows, as for the other chemical parameters, a significant difference (p < 0.0001) between batches. The value of this parameter increases concomitantly with the increase in the content of sea buckthorn oil in the batches.

The pH values for the three batches are extremely close, which can be seen by the insignificant p-value (p = 0.184).

CONCLUSIONS

The addition of sea buckthorn oil to meat products and their transformation into functional products is a suitable option to improve their bioactivity and antioxidant capacity, thus responding to market demand for products with improved value and without synthetic additions (synthetic antioxidants). Sensory analysis conducted in this study demonstrated very good consumer acceptability of the sea buckthorn oil injected tenderloin, especially for the 3% and 1% sea buckthorn oil amounts. Injecting the tenderloin with 5% sea buckthorn oil was considered by some evaluators to be too high, but these were in extremely small numbers. Colorimetric analysis showed that increasing the amount of sea buckthorn oil resulted in decreased brightness of the samples and increased red and yellow color. This aspect does not negatively influence the analyzed products, as the presence of a reddish color is expected from meat products, which increases the attractiveness of the products. Chemical analysis revealed a rather high heterogeneity between batches in terms of the macronutrient composition. Significant differences from the other batches were found in the batch with 5% added sea buckthorn oil, with a decrease in moisture content due to a beneficial increase in the lipid profile with the addition of sea buckthorn oil. For the lot with 3% added sea buckthorn oil, lower chemical values were recorded for fat content and higher for moisture content compared to the lot injected with 1% sea buckthorn oil. This is most likely due to the uneven distribution of the sea buckthorn oil in the tenderloin mass, and injection with manual injection devices is not a suitable option for this process.

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