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The Effect of Sea Buckthorn (*Hippophae rhamnoides* L.) Berries on Some Quality Characteristics of Cooked Pork Sausages

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***Abstract*—**The aim of this study was to analyze selected quality characteristics of cooked pork sausages manufactured with the addition of Sea buckthorn (*Hippophae rhamnoides* L.) berries preparations. Stuffings of model sausages consisted of pork, backfat, water and additives such a curing salt and sodium isoascorbate. Functional additives used in production process were two preparations obtained from dried Sea buckthorn berries in form of powder and brew. Powder of dried berries was added in amount of 1 and 3 g, while water infusion as a replacement of 50 and 100% ice water included in meat products formula. Control samples were produced without functional additives. Experimental stuffings were heat treated in water bath and stored for 4 weeks under cooled conditions (4±1ºC). Physical parameters of colour, texture profile and technological parameters as acidity, weight losses and water activity were estimated. The effect of Sea buckthorn berries preparations on lipid oxidation during storage of final products was determine by TBARS method.

Studies have shown that addition of Sea buckthorn preparations to meat-fatty batters significant ($P \leq 0.05$) reduced the pH values of sausages samples after thermal treatment. Moreover, the addition of berries powder caused significant differences ($P \leq 0.05$) in weight losses after cooking process. Analysis of results of texture profile analysis indicated, that utilization of infusion prepared from Sea buckthorn dried berries caused increase of springiness, gumminess and chewiness of final meat products. At the same time, the highest amount of Sea buckthorn berries powder in recipe caused the decrease of all measured texture parameters. Utilization of experimental preparations significantly decreased ($P \leq 0.05$) lightness (L* parameter of color) of meat products. Simultaneously, introduction of 1 and 3 grams of Sea buckthorn berries powder to meat-fatty batter increased redness (a* parameter) of samples under investigation. Higher content of substances reacting with thiobarbituric acid was observed in meat products produced without functional additives. It was observed that powder of Sea buckthorn berries added to meat-fatty batters caused higher protection against lipid oxidation in cooked sausages.

***Keywords*—**Sea buckthorn, meat products, texture, color parameters, lipid oxidation.

I. Introduction

THE food manufacturers should to provide on market food products that meet consumer expectations and, above all, are safe for the health and life. Unfortunately, during marketing and food turnover in components of food may occur various changes that often had a negative impact on its quality. Therefore, researchers looking for solutions that contributes to reduce or inhibit adverse changes in sensory and functional parameters and thus ensure food safety. The use of natural preservatives to control and restrict lipid oxidation, thereby to increase the shelf life of food products, is a promising technology also in meat industry and so far, its use is the least controversy from the consumer point of view. Plant raw materials are readily available source of natural substances which may exhibit antioxidant and/or antimicrobial properties and the same raise the quality and sustainability of food products [1]-[3]. Berries of Sea buckthorn (*Hippophae rhamnoides* L.) are perfect source of bioactive compounds. Fruits of this shrub are rich in polyphenols and vitamin, also contain large amounts of quercetine and flavonols in various forms [4], [5]. As a nutraceutics are used in the treatment of skin changes subsequent radiation, burns, oral inflammation and gastric ulcers. Positive impact on human health may result by reducing the level of cholesterol in the blood plasma, inhibition of platelets aggregation process and regulation of immune function [6]-[8]. Despite the observed pro-health properties very little data is available concerning the application of Sea buckthorn berries in meat products.

The objective of this study was to evaluate the effect of Sea buckthorn berries on some quality properties of model frankfurters-type meat products. Using the results obtained for the evaluated parameters, we aimed to assess the possibility to replacement chemical food additives by used preparations.

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II. Material and Methods

A. Ingredients

The samples of post-rigor pork meat (*M. semimembranosus*) and skinned backfat were obtained from the Meat Plant "Edward and Grzegorz Dworeccy" (Golejewo, Poland). Raw meat was trimmed of visible fat and connective tissue. Lots of pork and backfat were cut into strips and chopped in grinder (W-82AN Spomasz, Żary, Poland) with 0.3 cm plate diameter. The ingredients used in the production of model frankfurters-type meat products include: curing salt (CS, 99.5% sodium chloride and 0.5% sodium nitrate, Solino S.A., Inowrocław, Poland) and sodium isoascorbinate (SI, ZHU Żuk-Pol, Wrocław, Poland) and ice water (IW). Dried Sea buckthorn berries (96% moisture content) were purchased

in local herbalist's shop grounded to powder (Thermomix TM21, Vorwerk, France) and divided into two parts. One part was vacuum packed and kept in a room temperature until use (SBP preparation). Second part was used to prepare infusion. To obtain brew of Sea buckthorn berries (SBB preparation) 20 g of dried fruits was poured over by boiled water and kept under cover for a period of 15 min. The liquid was then strained, cooled and kept in 4°C until use. Infusion of Sea buckthorn berries was prepared as fresh just before the production and was added instead of 50 and 100% of ice water included in meat products formula.

B. Preparation of Experimental Meat Products

Five different meat batters (F1-5) were formulated (Table I). Raw materials and all ingredients were homogenized (9000 rpm, 3s) on Büchi Mixer B-400 machine (BÜCHI Labortechnik GmbH, Deutschland). The final temperature of batters was below 10°C in all cases. The stuffings (approximately 60g) were packed in polipropylene boxes with the capacity of 50 cm^3 (2.5 cm diameter and 12 cm high), and heat treated in water bath (Julabo TW12, Julabo Inc., Allentown, USA) to a final internal temperature 72°C. Final products were cooled down with ice, vaccum packed in polyethylene bags and stored for 4 weeks at 4 ± 1°C. The experiment was replicated in two independent production series. Analyses stipulated in the experiment were conducted directly after production process and after 14 and 28 days of storage of ready products.

TABLE I
FORMULA OF MEAT BATTERS (G)

	Pork	Backfat	CS	SI	IW	SBP	SBB
F1	50	30	2	0.07	25	0	0
F2	50	30	2	0.07	25	1.5	0
F3	50	30	2	0.07	25	3.0	0
F4	50	30	2	0.07	12.5	0	12.5
F5	50	30	2	0.07	0	0	25

C. Weight losses, Water Activity and pH

Weight losses after thermal treatment were expressed as a percentage of initial sample weight. Acidity of model mat products was measured directly in products by using a pH meter Orion 3-Star pH Benchtop Meter (Thermo Fisher Scientific Inc.). The water activity (aw) measurement was performed by using Novasina IC-500 W-LAB equipment (Axair Ltd., Switzerland). Samples of meat products before testing were manual comminuted. The measurement was carried out two times for each production variant.

D. Color Measurement

The color of model sausages surface was evaluated using a reflectance colorimeter Minolta CR-400 and it was expressed in scale L* (lightness) a* (redness) b* (yellowness) in CIE Lab system. Before each measuring session the instrument was calibrated against a white reference. Data presented are means of six measurements of each variant of meat products. The evaluation was carry out directly after production (Day 0) and repeated after 14 and 28 days of cool storage.

E. Texture Profile Analysis

The texture profile analysis (TPA) of frankfurter-type sausages was conducted by using Zwick/Roell Z010 testing machine (Zwick Testing Machines Ltd., Leominster Herefordshire, UK) and TPA 50 test (50% deformation, head speed 60 mm/min, relaxation time - 30 s). The samples (slices of 15×25 mm) were compressed twice to 50% of their original height. Textural parameters such a hardness, cohesiveness, springiness, chewiness and gumminess were measured. The evaluation was conducted at room temperature (22±1°C), directly after production process and after 4 weeks of storage.

F. Lipid Oxidation

The effect of Sea buckthorn preparations on lipid oxidation of cool storage sausages was evaluated using a spectrophotometric extraction method described by Mei *et al.* [9] with slight modifications. Amount of measured thiobarbituric acid reactive substances (TBARS) was expressed as μg of malondialdehyde (MDA) per g of sample calculated using 1,1,3,3-tetraethoxypropane (Sigma-Aldrich, USA) as the standard. TBARS determinations for each sample were performed after 14 and 28 days of storage.

G. Statistical Analysis

Collected data were analyzed using the Statistica software ver. 8.0. (StatSoft Inc., Poland). Statistically significant effects were identified using Duncan's test at the 95% confidence level ($P \leq 0.05$).

III. Results and Discussion

Addition of Sea buckthorn preparations significant ($P \leq 0.05$) influenced on pH values of sausages samples after thermal treatment (Table II). It was observed that along with growing content of plant additive in recipe to increase the acidity of final products. Meat products manufactured with 3 g of Sea buckthorn berries powder had the lowest pH. Simultaneously with decreasing level of pH decreased the weight losses after thermal treatment of experimental sausages. That is due the fact that high acidity decrease the water binding capacity of meat proteins [10]. The highest weight losses were measured in samples produced with 1 and 3 g of SBP preparation. Replacement of 50% ice water by SBB preparation reduced thermal drip to 4.5% from level of 5.6% measured in control samples. Sausages manufactured with brew of Sea buckthorn berries had slight higher values of water activity than other samples.

TABLE II
WATER LOSSES, WATER ACTIVITY AND PH OF MEAT PRODUCTS AFTER THERMAL TREATMENT

	Water losses (%)	Water activity (aw)	pH [OH^-]
F1	5.6^{b}	0.916^{a}	5.93^{d}
F2	12.2^{d}	0.916^{a}	5.34^{b}
F3	15.7^{e}	0.916^{a}	5.02^{a}
F4	4.5^{a}	0.919^{b}	5.83^{d}
F5	8.3^{c}	0.920^{b}	5.64^{c}

[ab]Different letters in the same column indicate significant differences ($P \leq 0.05$) between values

TABLE III
CIE COLOR VALUES OF MEAT PRODUCTS AT DIFFERENT TIME OF MEASUREMENT

	L*			a*			b*		
	Day 0	Day 14	Day 28	Day 0	Day 14	Day 28	Day 0	Day 14	Day 28
F1	75.53	76.74	76.99	4.42	4.93	5.92	9.09	9.27	7.88
F2	68.92	70.23	69.95	4.93	5.42	5.96	10.08	9.13	8.14
F3	68.57	68.35	68.40	5.40	4.67	4.26	11.31	10.76	10.55
F4	75.07	75.04	74.86	3.93	4.45	6.34	9.10	9.35	8.02
F5	74.73	74.60	75.29	4.03	4.25	5.07	9.08	9.44	8.23

The lightness (L* parameter) was affected by used additive of plant origin as indicated in Table III. Utilization of experimental preparations significantly decreased (P≤0.05) lightness of meat products from 75.53 in control samples to 68.57 in samples with the highest amount of SBP preparation. At the same time, introduction of 1 and 3 grams of Sea buckthorn berries powder to meat-fatty batter increased intensity of red color (a* parameter). The lowest values of a* parameter were measured for internal surface of meat products with added SBB preparation. Storage time caused increase of this color parameter in case of all samples under investigation, excepting samples with the highest amount of SBP preparation. Results obtained in this study for parameter b* measurement shown that increasing amount of powder derived from Sea buckthorn berries significantly increase (P≤0.05) the participation of yellow color in color spaces. Simultaneously, after 28 day of storage was observed the decrease (P≤0.05) of measured values both in control and experimental samples. Decrease of L* color parameter after addition to meat products preparations of plant origin also observed [3], [11] in products manufactured with green tea extract and Yu et al. [12] and Fernandez-Lopez et al. [13] in case of rosemary extract utilization. The same changes in a* parameter as in presented study were shown in results of work Alp and Aksu [14] with *Urtica dioica* L. Addition of 500 ppm of liophilizied water extract of *U. dioica* leaves significantly increased redness of ground beef samples.

Texture profile analysis indicated the influence of used plant additives on some textural parameters (Table IV). Large variability of rheological properties results, inter alia, with the different components of the raw material, the degree of hydration of proteins and addition level of selected functional additives [15]. Addition of Sea buckthorn preparations entailed the increase of hardness of meat products, besides samples manufactured with addition of 3 g of SBP preparation. The highest amount of Sea buckthorn berries powder in recipe caused the decrease of all measured texture parameters. These disadvantageous changes in texture profile may be related to the highest water losses in case of these samples after thermal treatment. However utilization of infusion prepared from Sea buckthorn dried berries caused increase of springiness, gumminess and chewiness of final meat products. Results of presented study were in disagreement with Estavez et al. [16] who found that addition of natural antioxidants enhanced texture characteristics of refrigerated stored porcine liver pate by reducing hardness, adhesiveness, gumminess and chewiness. Thus opposite results may be a rise from the different type of meat product under investigation.

TABLE IV
TEXTURE PROFILE ANALYSIS OF MEAT PRODUCTS AT DIFFERENT TIME OF MEASUREMENT

	Hardness [N]		Cohesiveness [-]		Springiness [mm]		Gumminess [Nm]		Chewiness [N]	
	Day 0	Day 28	Day 0	Day 28	Day 0	Day 28	Day 0	Day 28	Day 0	Day 28
F1	28,43	40,18	7,54	7,46	0,80	0,86	15,74	20,80	12,91	17,86
F2	31,78	42,14	7,40	7,23	0,79	0,83	14,95	19,33	11,77	16,08
F3	15,08	21,68	7,14	7,21	0,73	0,79	5,10	8,32	3,73	6,69
F4	33,38	37,88	7,54	7,27	0,84	0,84	18,20	20,21	15,18	17,02
F5	35,38	37,22	7,40	7,54	0,82	0,84	18,76	20,76	15,33	17,48

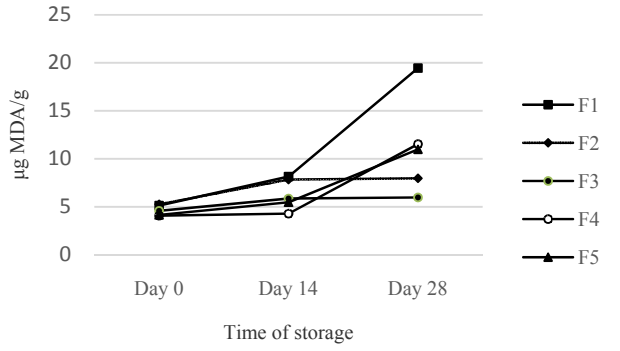

Fig. 1 Dynamics of TBARS values in the course of storage time

The effect of Sea buckthorn preparations on lipid oxidation processes in experimental meat products is shown in Fig. 1. Analysis of results obtained in this study indicated that storage time had a significant influence (P<0.05) on lipid oxidation. TBARS values in all experimental samples were considerably lower (P<0.05) than in control. The lowest amount of thiobarbitiuric acid reactive substances after 14 days of cool storage was measured in case of meat products manufactured with addition 12.5 g of Sea buckthorn infusion (4.28 µg MDA/g), but this preparation was not efficient in inhibiting rancidity deterioration during next two weeks of storage. It was observed that SBP preparation addition to meat-fatty batter caused higher protection against lipid oxidation in cooked sausages. Powder obtained from dried Sea buckthorn berries added on the highest level showed strong lipid stabilisation during storage. Püssa et al. [17] also reported inhibition effect of Sea buckthorn on lipid oxidation in mechanically deboned meat supplemented with 1, 2 and 4% of

berry residues macerated in ethanol. The effectiveness of substances of plant origin in retardation of lipid oxidation process were presented by many authors. Jia et al. [18] demonstrated inhibition of TBARS production in pork patties treated with 5, 10, or 20 g/kg by black currant (*Ribes nigrum* L.) ethanolic extracts. Skowyra et al. [19] also reported a high level of antioxidant protection in oil-in-water emulsion with addition of tara (*Caesalpinia spinosa*) extracts obtained with 75% ethanol. Strong inhibition properties were confirmed also for water and ethanol extracts of green tea [3], [11], [20], [21]. Bastida et al. [22] reported the reduce of fat deterioration in cooked meat during chilled and frozen storage by addition extracts rich in condensed tannins from carob fruit **(***Ceratonia siliqua*). Similar results are shown utilization of rosemary extracts in cooked pork patties packed in modified atmosphere [10].

IV. Conclusion

Sea buckthorn berries are good functional supplement and may be used to improve the quality of meat products and to work out new functional foods. The fortification of meat-fatty batters using powder of dried Sea buckthorn berries strongly inhibit lipid oxidation during storage and that suggest that it can be used as natural preservative instead of chemical food additives. Further research is needed to restrict it negative effect on technological characteristic of cooked pork sausages.

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