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STUDY CONCERNING THE POTENTIAL OF DRIED SEA BUCKTHORN AND LINGONBERRIES TO DEVELOP VALUE-ADDED PORK PRODUCTS

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Abstract

The paper presents a study on the possibility to enrich in bioactive compounds some baked meat products by using in their manufacturing recipe dried and ground sea buckthorn and lingonberries. Both sea buckthorn and lingonberries are valuable fruits due to their high content in bioactive compounds. Pork is also a food appreciated for its content in proteins with high biological value. The aim of the study was to obtain nutritionally balanced products, which benefit at the same time from meat proteins and antioxidant compounds from fruits. In order to preserve as much as possible, the nutrients coming from ingredients, the fruits were dehydrated at a moderate temperature of 45-50°C, and the baking of the designed products was conducted according to a technological diagram in the temperature range 55-70°C. Thus, there were prepared 10 baked products with addition of dried and ground fruits, using pork from different anatomical part such as tenderloin, loin, ham, shoulder and belly. After preparation, the samples were assessed in terms of total antioxidants capacity, total phenolic content and microbiological properties. The experimental results recorded for designed baked products compared to fresh meat samples, without any addition, showed a significant increase in the total antioxidant capacity (up to 4 times) and in the total phenolic content (up to 2 times). The microbiological analysis consisting of assessing the presence and number of coliforms in the fresh meat and in the baked samples with incorporation of dry fruits, both unpackaged and packaged in vacuum and stored at 2-4°C. The microbiological analysis was performed immediately after baked products obtaining, respectively every 7 days for unpackaged products and every 10 days for the packaged samples. Our results reveal the high potential of dried sea buckthorn and lingonberries to be included as valuable ingredients to design value-added pork products.

***Key words**: microbiological properties, sea buckthorn and lingonberries, total antioxidant capacity, total phenolic content, value-added pork products.*

INTRODUCTION

Meat and meat products are known as valuable sources of nutrients due their content in proteins with high biological value, vitamins, minerals, and different other micronutrients which the human body needs. Meat, especially pork, beef and lamb, has been part of human nutrition since ancient times and continues to be a dominant food in the diet of the modern consumer (Savu et. al., 2002; McAfee et al., 2010). In order to be eaten, the meat must be subjected to heat treatment. Also, cooking process makes the meat safe for consumption and for this reason it is often processed at high temperatures for a long time. But this practice has the great drawback that it causes a considerable loss of nutrients in the finished product, such as, water soluble vitamins, fats due to the fusion process, simultaneously with the initiation of browning reactions (Xiong, 2017). Also, the high temperature affects meat proteins being proved that at temperatures up to 100°C these are denatured (Bertram et al., 2006; Suleman et al., 2020). To solve these problems and preserve as much of the nutrients as possible, modern technologies use the technics consisting of application of *Low-Temperature for a Long-Time* in meat processing. This method has many advantages primarily because the doneness can be controlled facilitating the establishment of the thermal balance between the product subjected to baking and the heating medium with effect on improving of meat tenderness. However, this method has the disadvantage that the aroma of the products is lower compared to that formed in meat prepared at high temperatures (Dominguez-Hernandez, 2018). The assortment of meat products is very varied, which are processed by applying different degrees of degradation of muscle structure along with the use of different food ingredients in order to improve their sensory characteristics and their preservation (Jiménez-Colmenero, 2001; Vitaglione & Fogliano, 2004; Nicorescu et al., 2018). There are many suppositions that processed meat consumption may cause different diseases in human body due to the ingredients used in the manufacturing formula and the technological parameters applied during processing (Jiménez-Colmenero, 2001; Vitaglione & Fogliano, 2004). The main factor considered responsible for unwanted changes in meat during processing is oxidation and associated effects (Kanner, 2007; Negre-Salvayre, 2008). The last studies in antioxidant topic have allowed meat researchers to identify new methods of minimizing the damages caused during meat processing by addressing technologies based on low temperatures and using of natural antioxidants instead of the synthetic ones which could have unwanted implication on the human health (Engel, 2015; Predescu, 2016; Kamala Kumari, 2019). A new trend in meat products preservation is the replacement of nitrites and a portion of salt with herbs and berries due their antioxidants and antimicrobial compounds (Haugaard, 2014). Also, meat scientist showed a real interest in the association of meat products with fruits and vegetables to improve their sensorial properties and to increase their biologically active properties by enriching them in vitamins, antioxidants, minerals, etc. (Bazhenova et al., 2020). Take into consideration the presented data, the aim of our study was to assess the potential of two much appreciated fruits, lingonberries and sea buckthorn to improve the biologically active properties of some pork products.

Bitueva & Ayusheeva (2011) used pre-crushed dehydrated pulp of lingonberry into minced meat products in order to replace 13-15% of bread. Lingonberries are recognized and highly valued for their antioxidant properties and the content in biologically active compounds, such as: minerals, vitamin C, carotene, and organic acids (Bitueva & Ayusheeva, 2011).

Sea buckthorn (*Hippophae rhamnoides* L.) is considered one of the most valuable fruits in terms of composition in bioactive compounds due to the high content in polyphenols, of which quercetine and flavonols are present in various forms in large amounts, vitamins, carotenoids and minerals (Rösch et al., 2003; Guliyev et al., 2014). Sea buckthorn is widely used as therapeutic treatment in various diseases of the human body among the best known positive effects on health is the reduction of cholesterol levels in the blood, increase of immunity, preventing thrombosis (Khan et al., 2010; Ma et al., 2019; Shkolnikova et al., 2019). Although the beneficial effects on health are well known, there are few studies of the use of sea buckthorn in the processing of meat products.

The goal of this paper was to presents the effect of using dehydrated lingonberries and sea buckthorn on the antioxidant and microbial properties of cooked pork products.

MATERIALS AND METHODS

Fruit mixtures preparation

After thawing, fruits of lingonberries and sea buckthorn were dehydrated at a moderate temperature of 45-50°C, in order to preserve their nutrients and then were ground with a laboratory mill to a granulation close to that of semolina flour and mixed 3:1w/w.

Baked pork products preparation

10 samples of pork from different anatomical part such as tenderloin, loin, ham, shoulder and belly were prepared by addition of mixture of dried and ground fruits as a filling, but also on the surface in order to form a crust meant to improve the appearance of the products. Along with the dehydrated fruits in the basic manufacturing formula of all baked pork

products, salt and pepper were used. In addition to these ingredients, cinnamon was added to 5 of the samples and chili was added to the other 5 samples (Table 1). After that, the meat samples were backed in a smoking cell with a closed smoke flap according to a technological diagram in the temperature range 55-70°C until it reached 58°C in the technological center of the product. After cooling some of the meat samples were packed in vacuum and together with the unpacked ones were kept at 2-4°C until the analyzes were performed.

The total polyphenolic content was determined by Folin-Ciocalteu method (Folin & Ciocalteu, 1927; Singleton et al., 1999). The method consists in measures the reductive capacity of polyphenols from samples compared to hexavalent molybdenum in polyphosphomolybdate from Folin-Ciocalteu reagent. In order to perform the analysis, 2 g of each sample (fresh meat, baked products and dehydrated fruits were mixed with 20 mL of 70% methanol solution. After two hours, 0.5 mL from each prepared solution was mixed with 2.5 mL of Folin-Ciocalteu reagent 1:10 v/v aqueous solution and 2 mL of a 7.5% sodium carbonate solution. After 30 minutes of incubation in the dark the absorbance of the mixture was read at 750nm wave lengths using a UV–VIS spectrophotometer (SPECORD 205, Analytic Jena). The total polyphenols concentration was expressed as mg gallic acid equivalents per 100 g of sample.

The total antioxidant capacity of the samples was evaluated by CUPRAC method was used (Özyürek et al., 2011). The method consists in the reduction of the copper-neocuproine complex in the presence of ammonium acetate. The product of the reduction reaction is the yellow complex copper-neocuproine [Cu(Nc)2]+, with has a maximum absorption at 450 nm wavelengths. TROLOX (6hydroxy-2,5,7,8-tetramethylchromate-2-carboxylic acid) as references substance was used. The analysis consisted in mixing of 1 mL of copper solution with 1 mL of alcoholic ligand solution, 1mL of acetate buffer and 1.1 mL of sample. After keeping in the dark for 30 minutes the absorbance of the blank at 450nm is determined. The results were expressed in mM TE/100 g sample.

All results are expressed as mean values ± standard deviation (SD) and were obtained in triplicate. The Microsoft Excel 2010 program was used for statistical data processing.

Bacteriological analysis consisting of assessing the presence and number of coliforms germs in the baked samples with incorporation of dry fruits, both unpackaged and packaged in vacuum and stored at 2-4°C was performed immediately after products processing, respectively after 7 days for unpackaged products and every 10 days for 3 weeks in the case of vacuum packed samples (thermoscientific.com/microbiology, 2013). The analysis was performed according to standardized procedures, ISO 4832:2006. Samples were collected under aseptic conditions. After insemination by incorporation and solidification of the culture medium - MacConkey agar, the Petri dishes were placed in a thermostat at 44°C for 24 hours. This culture medium was used to differentiate the members of the coliform group into lactose-positive and lactose-negative germs, respectively.

The coding of the samples is presented in Table 1.

Table 1. Sample coding

Sample name	Sample code
Dehydrated Sea buckthorn	DSb
Dehydrated lingonberries	DL
Dehydrated fruits (lingonberries and Sea buckthorn) mixture	DFM
Baked pork ham with stuffing and crust of dehydrated fruit and chili	P1
Baked pork ham with stuffing and crust of dehydrated fruit and cinnamon	P2
Baked pork shoulder with stuffing and crust of dehydrated fruit and chili	S1
Baked pork shoulder with stuffing and crust of dehydrated fruit and cinnamon	S2
Baked pork tenderloin with stuffing and crust of dehydrated fruit and chili	M1
Baked pork tenderloin with stuffing and crust of dehydrated fruit and cinnamon	M2
Baked pork loin with stuffing and crust of dehydrated fruit and chili	C1
Baked pork loin with stuffing and crust of dehydrated fruit and cinnamon	C2
Baked pork belly with stuffing and crust of dehydrated fruit and chili	PI 1
Baked pork belly with stuffing and crust of dehydrated fruit and cinnamon	PI 2

RESULTS AND DISCUSSIONS

Total antioxidant capacity (TAC) of the raw materials used in manufacturing formula of the baked pork products (DL, DSb, DFM, pork: ham, shoulder, loin, tenderloin, belly) is presented in Table 2 and the influence of the addition of the dehydrated fruit mixture on the antioxidant capacity of the baked pork products is shown in the Figure 1.

Table 2. The total antioxidant capacity (TAC) of the raw materials used in manufacturing formula of the baked pork products

Sample	TAC (mM TE/g)
DSb	29.23±0.021
DL	29.45±0.020
DFM	29.40±0.019
ham	5.03±0.035
belly	4.52±0.032
shoulder	6.01±0.034
loin	6.12 ±0.035
tenderloin	5.85±0.030

The highest antioxidant capacity was registered for dry fruits and their mixture being in range of 29.45-29.23 mM TE/g, as is shown in table 2. The results are according with reported literature data (Bazhenova et al., 2020; Dróżdż et al., 2018). The lingonberries are one of the most appreciated fruits due to their richness in antioxidant compounds, such as: vitamins, organic acids or polyphenolic compounds (Dróżdż et al., 2018). Among the samples of fresh pork the highest antioxidant activity was determined for loin (6.12 mM TE/g) similar to the shoulder (6.01 mM TE/g). The lower TAC value was registered for belly (4.52mM TE/g). The obtained values are correlated with those reported by Serpen et al. (Serpen et al., 2012). Meat and also meat products are considered an important source of bioactive compounds such as vitamins, minerals, proteins or fatty acids. Of these, vitamins (group B, E or C) are considered responsible for the antioxidant activity of meat and come mainly from animal feed (Pogorzelska-Nowicka et al., 2018). The data in Table 2 show that the total antioxidant activity of mixtures of dehydrated fruits is 6.5 times higher than that of belly, 5.85 times higher than that of ham, 5.02 times higher than that of tenderloin, 4.88 times higher than that of loin and shoulder. Figure 1 presents the antioxidant capacity of baked pork products with addition of dried and ground fruits.

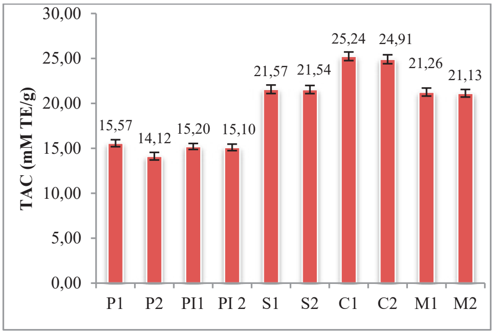

Figure 1. The antioxidant capacity of baked pork products with addition of dried and ground fruits mixture

The addition of dried and grounded fruits mixtures in pork products manufacturing formula has decisively influenced the total antioxidant activities of all baked samples. The TAC of final products is correlated with the TAC of raw meat. As seen in figure 1 and by reference to the data in Table 2 the increasing of total antioxidant capacity was 4.1 times (C1, C2), 3.6 times (S1, S2) and (M1, M2), 3 times (P1, P2), respectively 3.3 times (PI1, PI2) compared to fresh meat samples. The results are similar with that observed by Bazhenova et al., regarding the influence of lingonberry extract on the antioxidant capacity of meat paste (Bazhenova et al., 2020). Using of chili or cinnamon in receipts of pork samples did not influenced the total antioxidant capacity of finished products. The greatly increasing of TAC in baked pork products with the addition of dried fruit mixture is due to the abundance of antioxidant compounds in the fruit.

Total phenolic content (TPC) of the raw materials (DL, DSb, DFM, pork: ham, shoulder, loin, tenderloin, belly) used in manufacturing formula of the baked pork products is presented in Table 3 and the total polyphenol content of baked pork products with addition of the dehydrated fruit mixture is shown in the Figure 2.

The total phenolic content of dried lingonberries and Sea buckthorn (Table 3) are similar and correlated with the value determined for their mixture.

Table 3. The total phenolic content (TPC) of the raw materials used in manufacturing formula of the baked pork products

Sample	TPC (mg GAE/100 g)
DSb	91.49±0.021
DL	96.18±0.020
DFM	95.12±0.019
ham	15.64±0.035
belly	12.24±0.032
shoulder	12.05±0.034
loin	12.41±0.035
tenderloin	22.84±0.030

As results from Table 2, the highest content in phenols was registered by dehydrated lingonberries and is similar those reported in literature (Dróżdż et al., 2018). The phenol content of raw meat samples was substantial lower than the dried fruits mixture: 4.16 times lower tenderloin, 6.1 times lower in case of ham, and 7.7 times lower in average for loin, belly and shoulder. The highest phenolic content was determined for tenderloin (22.84 mg GAE/100 g) and the lower by shoulder (12.05 mg GAE/100 g).

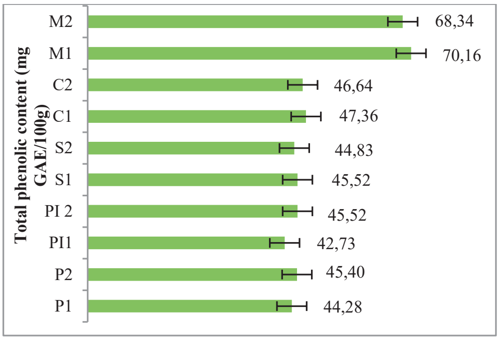

Figure 2. The total phenolic content of baked pork products with addition of dried and ground fruits

Both lingonberries and sea buckthorn are fruits recognized for their substantial content in polyphenols, which have a significant contribution to their antioxidant properties. Their use as a mixture in dehydrated and grounded form (DFM) has led to an increase in the polyphenol content of cooked baked meat products, as shown in the figure 2. Correlated with the phenolic content of fresh meat, addition of dried and ground fruit mixtures led to an increase in the TPC of baked pork products about 1.4 times in case of tenderloin (M1, M2) on average 2 times in loin (C1, C2), shoulder (S1, S2), ham (P1, P2) and belly (PI1, PI2). Similar to the total antioxidant activity, the content in polyphenols of finished baked products was not influenced by the use of cinnamon or chili in their manufacturing formula. Even there many studies which revealed the strong antioxidant character of these spices (Nagy et al., 2015; Wijewardhana et al., 2019), use in low concentrations (1%) in baked pork products did not affect their total phenolic content.

The results of bacteriological analysis of baked pork products with dehydrated and ground fruits showed the absence of coliform germs in all samples after 24 hours of thermostating at 44°C. Keeping the samples in the thermostat at the same temperature for another 24 hours led to the same results, indicating the absence of coliform germs in all processed pork products. Some photos of Petri dishes grown with the analyzed samples in order to isolate and identify the coliform germs are selectively presented in Figures 3-6.

Figure 3. Evaluation of the presence and number of coliform germs in baked pork ham with addition of dehydrated fruit mixture and chili (P1, P2)

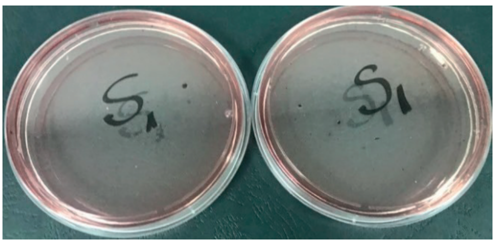

Figure 4. Evaluation of the presence and number of coliform germs in baked pork shoulder with addition of dehydrated fruit mixture and chili (S1, S2)

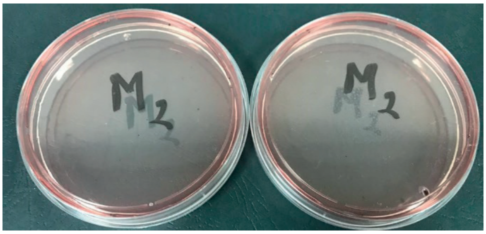

Figure 5. Evaluation of the presence and number of coliform germs in baked pork tenderloin with stuffing and crust of dehydrated fruit and cinnamon (M1, M2)

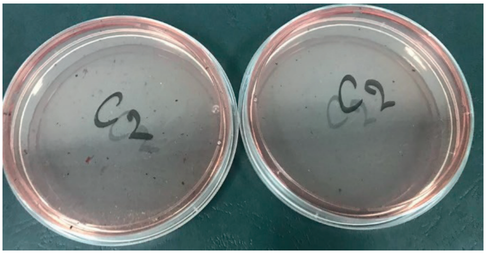

Figure 6. Evaluation of the presence and number of coliform germs in baked pork loin with stuffing and crust of dehydrated fruit and cinnamon (C1, C2)

In order to assess the microbiological stability of the baked pork product with addition of dried and ground fruits mixtures the development of coliform germs was verified after 7 days for unpackaged products and every 10 days for 3 weeks in the case of vacuum packed samples. The obtained results were the same with those registered immediately after processing and are useful for establishing the shelf life of products. Also it has to be mentioned that the using of cinnamon or chili in the manufacturing formula of the products did not influence the results of microbiological analyzes. The microbiological stability of baked pork product with the addition of dried fruits mixture could be attributed to the use of lingonberries and sea buckthorn in their manufacturing formula. The obtained results are according to those reported in the literature (Apostolidis et al., 2008; Wu et al., 2008; Wu et al., 2009; Caillet et al., 2012; Lacombe, 2012) which reveals that many foodborne pathogens including coliforms are inhibited by berries and help preserve food.

CONCLUSIONS

The addition of dehydrated and ground lingonberries and sea buckthorn mixture led to increase of the total antioxidant capacity of designed baked products compared to fresh meat samples up to 4 times and in the total phenolic content up to 2 times. The microbiological analysis conducted on both unpackaged and packaged in vacuum baked pork with dried fruits mixture and stored at 2-4°C demonstrated the absence of coliform germs after 7 days for unpackaged products and after 30 days for the packaged samples. The results of the study reveal the high potential of dried sea buckthorn and lingonberries to be included as valuable ingredients to design value-added pork products.

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