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ORIGINAL RESEARCH PAPER

USE OF SEA BUCKTHORN FRUITS IN THE PASTRY MANUFACTURING

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Abstract: Different researches on optimizing the shelf life of pastries (gingerbread, sponge cakes) that are produced by adding sea buckthorn flour (2 - 4 % by weight of the flour used) are presented in this study. This study shows the impact of biologically active substances on structural and mechanical, physicochemical, microbiological properties as well as the antioxidant activity of products under the conditions of *in vitro* gastric digestion. It has been demonstrated that the sea buckthorn flour increases the porosity of pastries, reduces the wet gluten amount and this contributes to moisture loss. The organoleptic assessment indicates that the addition of 2 % sea buckthorn flour improves the appearance, the color and the consistency of pastries. Microbiological analysis showed that samples with added sea buckthorn flour exhibit microbiological stability due to the sea buckthorn chemical composition. The antiradical activity $DPPH^{\bullet}$ in conditions of *in vitro* gastric digestion of the samples with added sea buckthorn flour increases in a positive way, indicating a clearly positive effect on health.

Keywords: *antioxidant activity, indices of quality, microbiological stability, pastry manufacturing, sea buckthorn flour*

INTRODUCTION

The guarantee of an optimum shelf life of processed food has always been a constant concern of modern food industry [1]. For this purpose, synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been widely used in the last decades. However, the use of synthetic antioxidants is mainly restricted because of their toxicity and some undesirable side effects (different allergies, etc.) [2, 3]. Thus, during the last years special attention has been given to the technologies based on natural sources of biologically active substances, that are rich in antioxidants – substances with beneficial effects on our health (antimutagenic and anticarcinogenic) [4, 5]. On the one hand, this leads to a technical and economic growth of the company due to the popularity of these products, but on the other hand, it contributes to the creation of new nutraceuticals (functional products) that are capable to balance the nutritional intake and vary the traditional assortment [6].

Among various berries, sea buckthorn (*Hippophaë rhamnoides* L.) has got a special place because it is an important source of biologically active elements [7]. Its fruits contain a wide range of soluble and fat-soluble vitamins, lipids, carbohydrates, proteins, and macro and micronutrients. The potential of sea buckthorn was discovered when scientists extracted oil from its seeds and peel. This oil is well-known for its high curative capacity and is widely used in medicine [8]. Sea buckthorn represents a raw material consisting of a high energetic value that is mainly present in its seeds and peel, and a rich amount of biologically active substances: microelements (Ca, Mg, Cu, Fe, Zn, K, P), vitamins (B_1, B_2, C, P, PP, β-carotene), proteins, carbohydrates [8 – 10]. The fruits also contain valuable components: 1.54 % pectin substances, 50.5 % fibers, 19.98 % cellulose, 10.69 % hemicellulose, and 18.36 % lignin, these elements have an important capacity of absorption. It has been discovered that 1 g of sea buckthorn powder can absorb 1678 mg ion of Pb. This means that food products with sea buckthorn flour additives are relevant not only for their high biological value due to biologically active substances, but also for their ability to detoxify the body [11].

The flour extracted from sea buckthorn is superior to wheat flour: it exceeds 9 - 10 times the amount of free essential amino acids and the content of lysine is thrice greater. Free amino acids are completely assimilated by the human body without the supplementary hydrolysis of protein. Therefore, a significant part of these amino acids present in sea buckthorn flour can considerably improve the biological value of the finished product. Nevertheless, a certain amount of flour extracted from sea buckthorn berry and seed residues (> 5 %) can reduce the technological properties of flour as a result of the decrease in the quantity of wet gluten and respectively of the smaller degree of hydration [12].

The purpose of the present study consisted in developing the technology of pastry manufacturing by using a certain amount of sea buckthorn flour in order to diversify the array of functional products. The conducted researches were focused on the following aspects: analyzing the chemical content and technological properties of pastries with sea buckthorn flour additives, establishing the indices of quality, microbiological stability, antioxidant capacity, and optimum shelf life of these products.

MATERIALS AND METHODS

Conventional raw materials of pastry technology have been used for this research: white wheat flour with the following properties: moisture (%) = 14.6 ± 0.6; degrees of acidity = 2.7 ± 0.2; ash content compared to the dried substance (%) = 0.76 ± 0.2; wet gluten content (%) = 22.3 ± 0.4; powder sugar; natural honey; chicken eggs, ammonium bicarbonate; sea buckthorn flour, obtained from sea buckthorn fruits dried through convection at the temperature of heating agent of 65 ± 1 °C till the final humidity of 13 ± 0.5 %. Then the fruits were grinded till the powder state with a granular size of 140 μ and sifted through a sieve with bore sizes Nr. 43. The amounts of carbohydrates in the sea buckthorn flour used per 100 g of product are: glucose - 1480 mg; fructose - 1060 mg; cellobiose - 114 mg; pectin - 980 mg; cellulose - 780 mg; inositol - 30 mg; sorbitol - 41 mg; mannitol - 23 mg; glycerine - 146 mg.

There have been used traditional recipes of these products. The blank samples of sponge cake included the wheat flour (1 kg); sugar (0.3 kg); eggs (10 units); ginger bread – wheat flour (1 kg); sugar (0.5 kg); honey (0.25 kg); water (0.3 L); eggs (12 units), manufactured according to the literature [13]. The manufactured products with plant additives contained sea buckthorn flour in the ratio of 2 and 4 % compared to wheat flour weight.

The following physicochemical methods of analysis have been applied for the research of raw materials, dough and finished products: establishing the moisture in sea buckthorn flour, dough, and finished products; the physicochemical indices of wheat flour; the bread crumb porosity; the degree of crumbling and alkalinity of the product, according to the Decision of the Government of the Republic of Moldova No. 204 from March 11, 2009 regarding the Technical regulation “Confectionery food products” [14].

In order to define the microbiological characteristics and stability of products, the following procedures have been applied: the method of establishing the microbiological stability of sea buckthorn berry and seed residues and determining the total number of germs (TNG) and the colouring after Gram, for microorganisms types identification present in pastries (fotonic microscop “Biolam”), according to [15].

The sensory analysis of the products was carried out according to BS ISO 6658-2005 - Sensory Analysis – Methodology – General guidance [16].

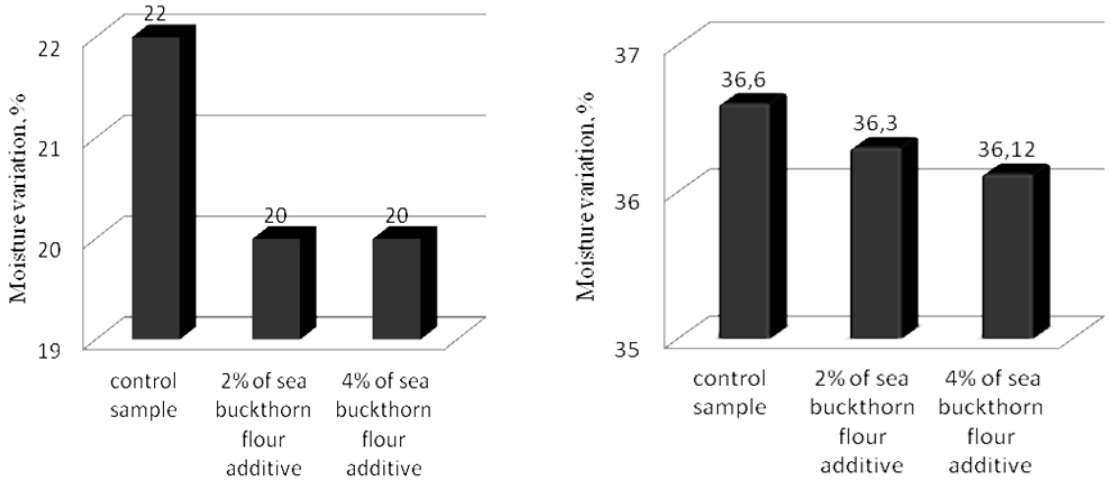
The antioxidant activity of the sea buckthorn flour extract was measured by spectrophotometric method („HACH LANGE DR-5000") with the free DPPH$^{\bullet}$ radical (2.2-diphenyl-1-picrylhydrazyl) [17].

The antiradical DPPH$^{\bullet}$ activity of the products has been determined *in vitro* in order to simulate gastric digestion in the presence of pepsin (150 mg / 100 g of product), at *p*H = 2.0 ± 0.1 (1.5 M HCl), temperature (37.0 ± 0.1) °C, with the agitation speed of 600 rpm, duration of 2 hours [18]. The samples have previously been centrifuged at 6000 rpm during 10 minutes, filtered and tested as well [17].

Variance analysis of the results was carried out by least square method with application of coefficient Student and Microsoft Office Excel program version 2007. Differences were considered statistically significant if probability was greater than 95 % (p-value < 0.05). All tests were performed in triplicate at room temperature (20 ± 1 °C). Experimental results are expressed as average ± SD (standard deviation).

RESULTS AND DISCUSSION

The analysis of the loss of dough weight during baking and moisture content in the products shows that by increasing the ratio of sea buckthorn flour, the product moisture decreases (Figure 1).



a) ***b)***

Figure 1. *Moisture variation in the products with 2 to 4 % sea buckthorn flour compared to the control sample: a) gingerbread; b) sponge cakes*

The addition of sea buckthorn flour decreases the amount of wet gluten in the product that leads to the reduction of moisture (free water content) and growth in the stability of the product by alteration. An increase in the state of crumbling and porosity has been attested at the same time (Table 1). Sponge cakes have a complex disperse system in which the air bubbles form the dispersion medium. The porosity of the processed food product represents the percentage of the pore volume related to the total volume of the bread crumb.

Table 1. *Quality indices of sponge cakes*

Sample	Degree of crumbling of the pastries crumbs [%]	Porosity of the pastries crumbs [% vol.]
Control sample	6.32 ± 1.2	70.0 ± 1.4
Sample containing 2 % sea buckthorn flour	7.44 ± 1.5	72.2 ± 1.7
Sample containing 4 % sea buckthorn flour	7.30 ± 1.2	72.1 ± 1.8

After examining the porosity of the bread crumb for the processed sponge cakes, it has been found that by adding sea buckthorn flour, the total pore volume increases in relation to the control sample. In addition, there has been observed a growth of crumbling degree obviously caused by the reduction of gluten. These technological properties of the sponge cakes with sea buckthorn flour additives do not diminish

considerably the quality of product characteristics. On the contrary, it is an advantage while used for the manufacturing of other kind of pastries (e.g. cream cakes).
A major property of these pastry products is their capacity of absorption that is frequently defined through the soaking index. The soaking index reflects the sorption capacity of food products: incorporation of water vapour, gases and substances dissolved throughout the mass. The soaking index depends on the category of the product. For glazed gingerbread it should not exceed 150 %, however, this is not regulated for sponge cakes. Table 2 presents the variation of the soaking index of gingerbread and sponge cakes with sea buckthorn flour additives in several periods after baking: 45 days for the gingerbread and 7 days for the sponge cakes.

Table 2. *Variation in time of the soaking index of the gingerbread and sponge cakes with sea buckthorn flour additives*

Samples	Values of the soaking index [%]					
	Gingerbread			Sponge cakes		
	After 1 day	After 30 days	After 45 days	After 1 day	After 4 days	After 7 days
Control sample	39.0 ± 0.30	41.7 ± 0.31	42.5 ± 0.38	160.1 ± 0.26	192.0 ± 0.41	228.9 ± 0.38
Sample containing 2 % sea buckthorn flour	41.1 ± 0.32	44.8 ± 0.42	45.3 ± 0.42	150.1 ± 0.34	175.2 ± 0.35	200.3 ± 0.34
Sample containing 4 % sea buckthorn flour	43.0 ± 0.35	45.6 ± 0.42	47.8 ± 0.44	152.1 ± 0.36	180.4 ± 0.34	204.6± 0.39

Considering the gingerbread with sea buckthorn flour additives, there is a 2 - 4 % increase of the soaking index in comparison to the control sample. During the period of storage (45 days, temperature of 22 °C, 300 g each packed in transparent film) the soaking index raises by 4 - 5 % not only in the case of the control sample, but also in the case of the samples containing sea buckthorn flour. When adding sea buckthorn flour to sponge cakes, the soaking index diminishes (8 - 10 % compared to the standard sample). After 7 days of storage an increase of 50 % is evident in this study (sponge cakes with sea buckthorn flour additives). While taking the standard sample into consideration, the augmentation is much greater, 68.8 %.
All the conducted researches show that the use of sea buckthorn flour in the proportion of 2 - 4 % of the flour mass do not reduce the physicochemical and technological properties of pastries.
However a decisive factor when introducing any food product on the market place represents its organoleptic appreciation. From this point of view, different sensory tests of the products with sea buckthorn flour additives have been carried out by the expert committee (Figure 2).
The organoleptic appreciation of these products indicate that the application of 2 % of sea buckthorn flour ameliorates the exterior aspect, colour, texture of the gingerbread in relation to the control sample, nevertheless, their taste has been less taken into consideration (Figure 2a).
The colour and texture of sponge cakes (with 2 % of sea buckthorn flour) have been the most highly appreciated by the tasting committee (Figure 2b). However, the criteria of aspect, smell and taste have been lower in comparison to the standard sample. Both in the case of the gingerbread and sponge cakes the lowest organoleptic characteristic has been attributed to the products obtained with addition of 4 % of sea buckthorn flour.

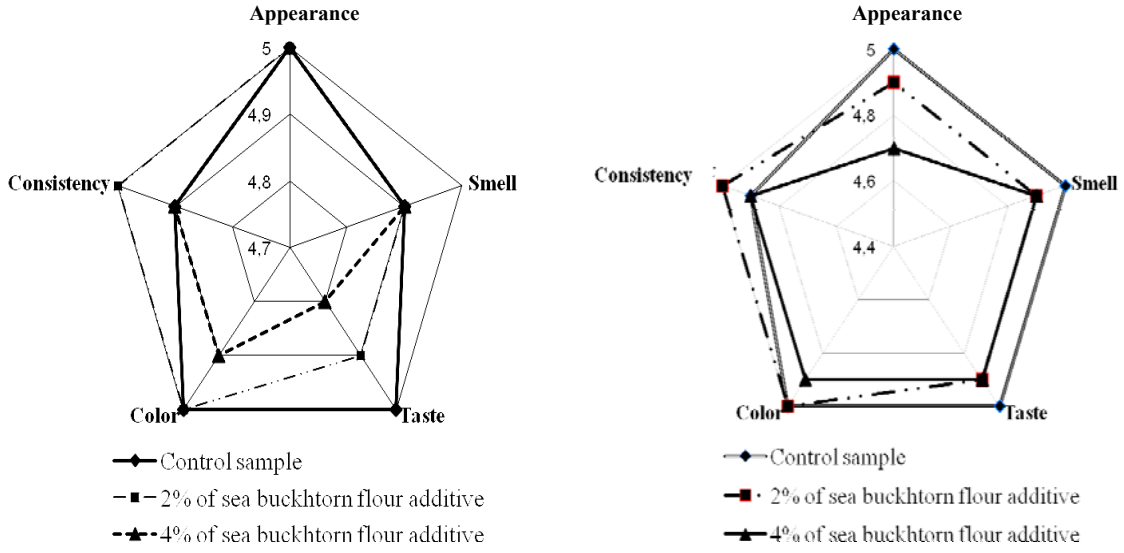


Figure 2. *Sensory spectrum of pastry products with sea buckthorn flour: a) gingerbread; b) sponge cakes*

One of the marketing requirements for the food products is the extension of their shelf life. Thus, a decisive factor constitutes the microbiological stability of the product. The conducted researches have demonstrated that the samples containing sea buckthorn flour show a higher microbiological stability in relation to the control sample (Table 3).

Table 3. *Evolution of the total number of germs (TNG)* during the storage of the products with sea buckthorn flour additives*

Sample	T.N.G., % of the maximal admissible number**				
	Gingerbread		Sponge cakes		
	After 5 days	After 40 days	After 1 day	After 4 days	After 7 days
Control sample	25.6	43.8	45.2	68.2	81.6
Sample containing 2 % of sea buckthorn flour	13.3	30.1	40	56.4	59.2
Sample containing 4 % of sea buckthorn flour	9.0	27.5	38.4	59.2	71.1

*nutritional agar medium (meat peptone agar); **error count estimate at 2.5 %

The TNG reduction is more important in the case of using 4 % of sea buckthorn flour (case of gingerbread). Consequently, sea buckthorn flour slows down the process of product deterioration due to the ability of its components (cellulose, hemicellulose, pectin) to fix and retain water in the product.

The slow migration of moisture during the product storage contributes to a long-time conservation of the structural characteristics and porosity of the bread crumb.

Sea buckthorn flour reduces the possibility of starch and protein distortion in the texture of sponge cakes. This fact is demonstrated by the slow processes of alteration of structural, mechanical and organoleptic properties of the samples with sea buckthorn

flour during their storage compared to the control sample. An important role is played by the antioxidant property of sea buckthorn flour that can be explained by the fact that its chemical composition consists of a series of biological active substances, natural antioxidants and vitamins (E, C, P), that hinder the development of microorganisms and preserve the stability of the system.

The presence of biologically active substances influences essentially the stability and the antioxidant traits of bread and pastry products [1, 3]. It has been observed that the application of some vegetal sources that are rich in antioxidants influence not only the microbiological stability, but also the antioxidant activity. The presence of natural antioxidants decreases the degree of lipid oxidation of products [19]. In this study there has been analysed the antioxidant capacity (% of inhibited free radicals DPPH) of the products with sea buckthorn flour additive under the condition of gastric digestion (2 h, at *p*H = 2.0 in the presence of pepsin, temperature of (37 ± 1) °C, continuous agitation). The obtained results are presented in Figure 3.

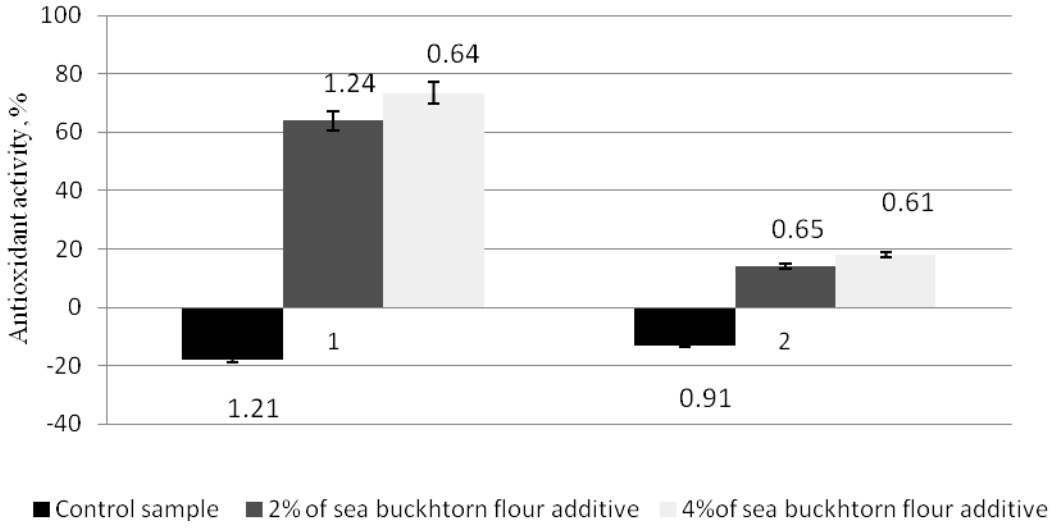


Figure 3. *Antioxidant activity (% of free inhibited DPPH radicals) of the products with sea buckthorn flour additives under the conditions of gastric digestion: 1 - gingerbread; 2 - sponge cakes*

There has been determined that the DPPH value in the control samples is negative: -18.08 ± 1.21 % and -12.98 ± 0.91 %, for both gingerbread and sponge cakes. In the samples containing sea buckthorn flour, the antiradical capacity is positive and has considerable values. In the case of gingerbread, an increase of the value of inhibited % DPPH has been observed for the samples containing sea buckthorn flour: 63.97 ± 1.24 (2 %) and respectively 73.52 ± 0.63 (4 % by the total weight of the flour). Considering the sponge cakes, the same order has been noticed, however the values of inhibited % DPPH are more moderate: 14.1 ± 0.65 % (2 % of sea buckthorn flour additive) and respectively 17.86 ± 0.61 (4 % of sea buckthorn flour additive). The achieved results present a highly important argument in favour of these products.

The validity period is a major factor for the manufacturing and commercialisation of food products. This refers to the period of time during which a product remains acceptable for consumers with regard to its physicochemical, microbiological and

sensory characteristics. An array of factors can influence the shelf life of a food product: loss of moisture, deterioration caused by microorganisms, enzyme alteration, lipid oxidation, etc. The obtained results show that the use of sea buckthorn flour in different pastries (gingerbread, sponge cakes) represents an efficient way to increase the validity period of these products. The conducted researches on the structural and mechanical, physicochemical, microbiological properties have demonstrated that in the case of gingerbread the shelf life has increased by about 10 days, while in the case of sponge cakes – by 72 hours in relation to the control samples (without sea buckthorn flour additives).

The antioxidant capacity (% of inhibited free DPPH radicals) of the products with sea buckthorn flour additives, that has been measured *in vitro* under the conditions of gastric digestion, show that such products have a highly important antioxidant potential and represent genuine nutraceuticals (functional food) that are capable to improve the resistance of human body to various diseases.

CONCLUSIONS

The use of sea buckthorn flour in different pastries has a positive impact on the technological properties of the dough, structural, mechanical, and physicochemical properties as well as microbiological stability of finished products. The antioxidant capacity of pastry products (gingerbread, sponge cakes) with sea buckthorn flour additives is much higher in relation to the control samples. This fact proves that these products have beneficial and therapeutic effects on our health.

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