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Development and characterization of biscuits based on sea buckthorn and blueberries by-products

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Abstract

The fruits of blueberry and sea buckthorn are commonly used in food industry and phytotherapy. The aim of the study was develop and characterize a new ingredient derived from sea buckthorn and blueberries by-products, with a complex of nutrients, fibers and vitamins, in the form of powder, which can be used in biscuit-type products. The total phenolic content, antioxidative activity of blueberry and sea buckthorn by-products were determined using spectrophotometric methods. Physico-chemical methods have been used to determine dry matter, fat, alkalinity and mineral substances. The dried powder obtained from blueberries and sea buckthorn by-products is recommended as a new ingredient for digestive biscuit-type products, the mixture of whole wheat flour and ground oat flakes from the conventional composition being succesfulluy substituted by 10% by-product powder.

Keywords: blueberry, sea buckthorn, by-products, biscuits

1. Introduction

Some industrial by-products, which were previously considered food wastes, have now been used as food ingredients with high food value and rich in biologically active principles. Secondary products resulting from fruit processing (bagasse, peel, and seeds), can also be potential ingredients in food formulations or raw material for the extraction of bioactive compounds, including phenolic, anthocyanin and carotenoids pigments, essential oils, and vitamins [1, 2].

The blueberry belongs to the family Ericaceae, subfamily Vaccinoideae, genus *Vaccinium*, and is native to North America and European regions, where it is widely cultivated and commercialized. In Romania this fruit is known for its bioactive composition, being rich in flavonoids, tannins and phenolic acids. Due to the high content of anthocyanins, many studies have indicated that the blueberry has several beneficial health properties associated with the presence of such bioactive compounds [3].

Bioactive compounds from blueberries are widely reported to demonstrate a number of health advantages including: antimicrobial activities, prevention of urinary tract infections, inhibition of development and progression of cancer and cardiovascular diseases, aging, reduction of cholesterol and biofilm formation [4, 5].

Sea buckthorn (*Hippophae rhamnoides* L.) is belonging to family Elaeagnaceae, and it is native in the temperate zone of Europe, Asia, and North of America. Sea buckthorn fruits possess an exclusive composition of natural compounds: phenolic compounds including flavonoids, flavones, phenolic acids, and tannins. Total flavonoids from the fruits of sea buckthorn are a group of compounds containing seven kinds of flavonoids, while isorhamnetin and quercetin are the main constituents [6]. Fruits also contain carbohydrates such as glucose, fructose and xylose, various carotenoids (such as lycopene and β-carotene), that are the major substances existing in a large amount

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in sea buckthorn fruits pulp. Ascorbic acid (vitamin C) is the most important medicinal element in the juice of sea buckthorn fruits, and acts as an antioxidant and sustains cell membrane integrity [7, 8, 9]. Seed oil contains high amounts of unsaturated fatty acids and has important therapeutic effects, such as preventing heart disease and arthritis, and immunomodulatory, neuroprotective and anti-tumor effects [10]. The active constituents of this plant are reputed to have considerable medicinal effects and are frequently used for curing cough, skin wounds, cardiovascular diseases and to improve blood circulation [11].

Therefore, the aim of the study was to develop and characterize a new ingredient derived from sea buckthorn and blueberries by-products, with a complex of nutrients, fibers and vitamins, in the form of powder, which can be used in biscuit-type products.

2. Materials and Methods

A fresh fruit by-product was prepared after obtaining the juice from the fresh fruits, being further subjected to drying in the oven; two different thermal treatments were applied: 80°C, for 5h and 50°C for 12h. After the drying operation, the by-product was finely ground using a grinder, a strong, fruit-specific odor being noticed.

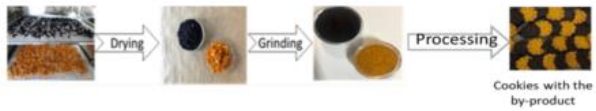

Figure 1. Obtaining the sea buckthorn and blueberries by-products powder and the resulting biscuits as an example of finished good

2.1. Obtaining digestive biscuits

Several types of biscuits were prepared, containing different percentages of powder: 5%, 10%, 15% and 20%. By sensory, it was found that the most appropriate ratio for added powder was 10%. It was considered that the prototype with 5% powder had inferior organoleptic qualities, while for the prototypes with 15% and 20% added powder, the taste was considered too strong, astringent, and the color was not suitable to the product category. Therefore, the whole wheat flour and ground oatmeal mix was replaced by 10% with the powder obtained from the sea buckthorn and blueberries by-products.

2.2. Physico-chemical characterization

The chemical composition of sea buckthorn and blueberries by-products and digestive biscuits obtained, including moisture, ash, crude fat and alkalinity, were determined according to standard procedures.

Moisture content was determined by drying in an oven at 103 ± 2°C for 3 hours, the experiment being repeated until the weight was constant. The samples were cooled in a desiccator for one hour and weighed. The ash content was assessed by calcination at 550- 600°C. The crude fat content of the samples was determined by extracting a known weight of powdered by-products and digestive biscuits sample (3g) with petroleum ether as a solvent, using Soxhlet apparatus [12].

2.3. The total phenolic assay

Total polyphenol content of the powders and related digestive biscuits was determined according to the method described by Mureșan et al. [13].

2.4. Antioxidant capacity assessment by DPPH method

The antioxidant activity was determined using the 2.2- diphenyl-1-picrylhydrazyl (DPPH) method, according to Mureșan et al. [14] and Odriozola-Serrano et al. [15].

2.5. Instrumental texture analysis

A Brookfield CT3 Texture Analyzer, equipped with a 10kg load cell, was used to analyze the textural profile. The following probe and measurement geometry were used: TA41 Brookfield Kit Probes (Cylindrical Shape, Diameter 50.8mm, Clear Acrylic, Mass 23g, Length 20mm), test speed 3 mm/s, probe return speed 3 mm/s. The target value of the compression test was set to 3 mm. The experimental results were processed using Texture Pro CT software, and the parameters recorded were: hardness, as well as total and hardness work done.

3. Results And Discussions

3.1. Physico-chemical characteristics of sea buckthorn and blueberry by-products

In order to evaluate the modifications of the biologically active compounds as a result of the heat treatment and grinding of the fruit by-products, representative samples were subjected to drying, both at 50°C and 80°C, directly from the frozen samples, to avoid any alterations.

However, for confirmation, the defrosting/drying in a very thin layer was attempted at room temperature. In this case, in the by-product sample thus dried, fermentative processes were highlighted, its aroma, taste and smell being specific to a fermented altered product.

On the other hand, the by-product samples dried at 50°C, but also at 80°C, have retained a characteristic odor and taste of fresh berries and blueberries.

Regarding the physico-chemical characteristics of the by-products samples, fresh and dried at various temperatures, as it was expected, a considerable increase of the dry substance was registered from 21.18% to ~ 93%. For each of the two studied temperatures, the drying time was determined as the time after which no significant differences were recorded between two successive weighing: 12h for 50 °C, and 5h for 80 °C.

DPPH antioxidant activity in the case of sea buckthorn increases from 97% (fresh by-product) to ~ 98% in the case of dried by-product for 5h at 80° C.

Same results were obtained for blueberry, as there were increases in antioxidant capacity for the dried by-products at 80°C, confirming that the lower time heat treatment, although at a slightly higher temperature, degrades less the antioxidant compounds.

The total polyphenol content has a gradual increase starting from the lowest value of the fresh by-product of sea buckthorn and blueberries (~12 mg GAE/100g) and reaching the highest value in the case of dried by-products at 80°C, both in the case of sea buckthorn (~30 mg GAE/100g), and in the case of blueberries up to ~65 mg GAE/100 g.

Based on the results obtained, it turns out that the by-products powder obtained by drying at 80°C retains the best phytochemicals.

3.2. Digestive biscuits physico-chemical, sensory and textural characterization

Regarding the finished product, several analyzes were carried out, in order to track its characteristics following the substitution of the mixture of whole wheat flour and oatmeal ground with 10% by-product powders of berries.

Table 1. The physico-chemical characteristics and bioactives properties of sea buckthorn and blueberry by-products samples as influenced by thermal treatment

Parameter	Sea buckthorn by-product			Blueberry by-product		
	Fresh	50 °C, 12h	80 °C, 5h	Fresh	50 °C, 12h	80 °C, 5h
DM [%]	21.18±0.25	92.71±0.57	93.79±0.42	21.18±0.25	77.01±0.57	91.83±0.42
Ash [%]	0.11±0.01	0.21±0.01	0.21±0.01	0.16±0.01	0.31±0.01	0.31±0.01
Fat[%]	1.730±0.13	18.18±0.01	23.33±0.06	1.12±0.11	5.28±0.01	11.94±0.06
DPPH [%]	97.21±0.20	88.94±0.82	98.21±0.27	96.21±0.20	93.41±0.82	98.77±0.27
TPC [mg GAE /100 g]	11.35±0.64	23.54±0.92	29.73±0.56	11,75±0.64	39.91±0.92	64.18±0.56

DM- dry matter; DPPH - antioxidant activity by 2.2- diphenyl-1-picrylhydrazyl method; TPC – total phenolic content

Table 2. The physico-chemical characteristics and bioactives properties of biscuits finished product obtained from sea buckthorn and blueberry by-products samples as influenced by thermal treatment

Parameter	Sea buckthorn by-product Biscuits		Blueberry by-product Biscuits	
	50 °C, 12h	80 °C, 5h	50 °C, 12h	80 °C, 5h
DM [%]	95.23±0.57	96.55±0.42	95.31±0.57	96.61±0.42
Alkalinity [%]	4.22±0.33	5.13±0.05	6.88±0.33	5.01±0.05
Ash [%]	0.25±0.03	0.23±0.02	0.31±0.07	0.29±0.06
Fat[%]	30.11±0.65	30.48±0.06	27.05±0.01	27.69±0.06
DPPH [%]	88.97±0.82	89.14±0.27	95.01±0.82	98.45±0.27
TPC [mg GAE /100 g]	52.87±0.92	19.45±0.56	7.35±0.92	5.64±0.56

DM- dry matter; DPPH - antioxidant activity by 2.2- diphenyl-1-picrylhydrazyl method; TPC – total phenolic content

Table 3. The texture analysis parameters for the biscuits samples obtained from sea buckthorn and blueberry by-products

Sample	Hardness [g]	Sample length [mm]	Hardness work done [mJ]	Total work done [mJ]
SB 50°C	**3730**	**5.86**	**76.3**	**80.02**
SB 80°C	**1727**	**6.35**	**31.2**	**32.9**
BB 50°C	**2740**	**6.62**	**41.9**	**43.7**
BB 80°C	**1633**	**7.02**	**21.3**	**21.7**

SB - sea buckthorn by-product biscuits samples; BB - blueberry by-product biscuits samples; 50°C or 80°C are the by-product drying temperatures.

Since the by-product added to the biscuits was dried at two different temperatures (50 and 80°C), an increase of the dry matter was observed when dried at higher temperature. Therefore, the biscuits containing by-product powder dried at 80°C had a lower percentage of water.

It is well known that the sea buckthorn fruits and seeds are extremely rich in fatty substances and acids, where it turns out that the biscuits containing dried by-product powder have a much higher fat content when compared to the other type of biscuits. It can also be observed that biscuits containing residual powders dried at 80°C, contain more fat than the samples containing powders dried at 50°C.

Sensory analysis was performed on both types of biscuits. The Hedonic test of product acceptability was applied. The test was made by 20 evaluators, aged between 19 and 26 years old. Of these, 65% were women and 35% men. The biscuits obtained from the sea buckthorn by-product powder obtained maximum score (9), while the blueberry powder biscuits obtained 8. Considering the obtained scores, it can be considered that the products fall within the area of acceptability and are likely to be successful on the market.

Hardness was influenced by the drying temperature of the powder contained by the biscuits; for the biscuits containing the powder dried at 80°C, higher hardness values are observed, while the total work at the same temperature (80°C) decreases, due to the more brittle structures, which caused product fracture.

Sensory analysis reveals a very good acceptability in terms of appearance, flavor, consistency and aspect for all three fruit pastes.

The physical and chemical analysis of raw materials and finished products showed that the products obtained have a great antioxidant effect and represent a rich source of antioxidant compounds, that may lead to many beneficial effects on the human body.

4. Conclusion

By drying and grinding the by-products from sea buckthorn and blueberries, a powder was produced. The new ingredient obtained was added to digestive biscuit-type products, the mixture of whole wheat flour and ground oat flakes from the conventional composition of digestive biscuits being successfully substituted by 10% by-product powder.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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