UDC 664.144

USING AN EXTRACT FROM APPLE BY-PRODUCTS IN THE TECHNOLOGY OF BOILED SWEETS

V. Cheliabiieva, PhD in Technical Sciences, Associate Professor
N. Buialska, PhD in Technical Sciences, Associate Professor
N. Denysova, PhD in Technical Sciences, Associate Professor,
Department of Food Technology
Chernihiv Polytechnic National University
95 Shevchenka street, Chernihiv, Ukraine 14035

DOI: https://doi.org/10.15673/fst.v16i2.2374

Article history

Received 22.01.2022
Reviewed 20.02.2022
Revised 14.04.2022
Approved 24.05.2022

Correspondence:

V. Cheliabiieva
*E-mail:*vika.chl@ukr.net

Cite as Vancouver style citation

Cheliabiieva V, Buialska N, Denysova N. Using an extract from apple by-products in the technology of boiled sweets. Foodscienceandtechnology.2022;16(2):55-62. https://doi.org/10.15673/fst.v16i2.2374

Цитування згідноДСТУ 8302:2015

Cheliabiieva V., Buialska N., Denysova N. Using an extract from apple by-products in the technology of boiled sweets//Foodscienceandtechnology. 2022. Vol. 16, Issue2. P.55-62. https://doi.org/ 10.15673/fst.v16i2.2374

Abstract. Boiled sweets are a popular type of sweets. In their classic recipe, boiled sweets are a source of simple carbohydrates. The disadvantage of boiled sweets, though, is the absence of valuable bioactive substances in their composition, such as vitamins, minerals, unsaturated fatty acids, or dietary fibre. A promising direction of current importance is the development of formulations and the creation of technology for manufacturing boiled sweets enriched with bioactive substances through the use of extracts of plant origin, in particular, extracts of secondary apple raw materials. In order to enrich the boiled sweets with bioactive substances, an extract of powder from the seed-containing cavities in the core of apples, a by-product of the preparation of apple crisps, can be added to the composition. Powdered seed-containing cavities of apples include components having a beneficial effect on health. The purpose of this study was to develop a recipe for boiled sweets using an alcohol extract of powdered apple cores with seeds, and to evaluate the sensoryand physicochemical characteristics, as well as the composition of volatile substances in the resulting sweets. The powder extract was added in the amounts 4%, 8%, 12%, and 16% of the total amount of sugar and molasses. The results have shown that when an extract of powderedapple core with seeds is added, the acidity of the boiled sweets slightly increases, butthe other physicochemical parameters of the finished products do not change significantly. When an extract of seed-containing apple cores is introduced into the caramel mass, boiled sweets are enriched with valuable trace elements, in particular, zinc and copper, and with other valuable bioactive components usually found in the stones or seeds of plants. These are tocopherols possessing antioxidant properties, and linolenic and arachidonic acids – essential polyunsaturated acids, myristic acid with antimicrobial properties, andbetulinic acid with antibacterial, anti-inflammatory, and antiviral properties. The results obtained correlate well with the studies by other authors on the phytochemical value of apples, apple products, and by-products.

Keywords:boiled sweets, extract, cores of apples withseeds, bioactive substances.

Introduction. Formulation of the problem

Sweets similar to modern lollipops have been known since ancient times in many countries worldwide. Among the most popular contemporary brands of lollipops today is ChupaChups founded by EnricBernat. In the Ukrainian market, boiled sweets from Roshen, AVK, Conti, Svitoch (Nestlé) are in the highest demand.Popular boiled sweets companies on the European market are Berning's (Germany), Klaus (manufactured in France and Switzerland), Dean's (Scotland), El Almendro (Spain), Valade (France), Lofthouse of Fleetwood (Britain), and in the US market, Hershey's, Vintage Confections.

Boiled sweet products have recently become increasingly popular due to their low cost. The key raw materials required for the production of these sweets are sugar, starch syrup, food acids, flavouring agents, food colorants. Sugar is a refined raw material consisting of simple carbohydrates and containing no other essential substances. Besides maltose, starch syrup contains health promoting macronutrients and trace elements: potassium, phosphorus, sodium, calcium, magnesium, iron. Depending on the ratio of sugar and molasses, sweets of different structure may be obtained: amorphous (boiled sweets) or amorphocrystalline (soft mass with chewing properties).

Boiled sweets are primarily a source of glucose for the human body. Glucose is a key metabolic substrate for energy production in tissues. Around 80% of glucose is consumed by the brain. A stable glucose level is necessary for maintaining all metabolic processes in the body. In the state of physiological rest, the intensity of glucose metabolism in the body is about 2 mg/kg/min [1]. Glucose provides for the functioning of the hormonal system [2]. The traditional boiled sweet formulation completely lacks valuable bioactive substances, such as vitamins, lipids, fibres.Still,boiled sweetsmay be used as a platform for delivering valuable bioactive substances to the human body.

Considering that boiled sweetsare a popular variety of sweets available for different segments of the population, development of new formulations including natural bioactive additives in the form of extracts of phytobiotic origin may prove animportant and promising direction.

Analysis of recent research and publications

A body of research on the use of natural ingredients in food, confectionery, and beverages has been growing recently [3].

The manufacture of functional-purpose and prophylactic boiled sweets for a wide range of consumers demonstrates stability in growth and demand. Instead of ordinary granulated sugar, developers use natural and synthetic sugar substitutes (lactitol, isomalt, stevia) and introduceaqueous and alcohol extracts of herbs as enrichment additives. When using pepper extract (*Capsicum annuum*), lollipops enriched with vitamin C, phenols, and carotenoids were obtained [4]. Powdered dried fruit of*Ficusreligiosa*was used as a source of valuable food components to obtain biologically enriched lollipops with antioxidant and antibacterial properties. Basic compounds detected by gas chromatographic mass spectroscopy (GC-MS) in ethanol extract of *Ficusreligiosa* were caryophyllene, campesterol, itigmasterol, β-amyrin, α-amyrin. Stigma sterolis a powerful antioxidant. Campesterol, for example, is found in dandelion herbal tea and has anti-inflammatory, antioxidant, and antimicrobial properties. Caryophyllene is found in many essential oils [5].

In the food industry, there is a trend towards manufacturing functional products that have a health-improving effect due to their antioxidant properties. The antioxidant properties of phytoextracts have been widely studied in order to use them in the formulations of boiled sweets. Formulations of boiled sweets containing calendula extract enriched with compounds with antioxidant activity were proposed [6]. In the formulation, the optimal content of yellow carotenoid pigments of calendula improving the sensory properties of sweets was 0.30 and/or 0.35%. It was shown [6] that the use of aqueous extracts in the production of boiled sweetswas impractical, since this altered their physicochemical parameters, including the moisture content,and using an ethanol solution for extraction was advisable instead.

In order to impart functional properties to boiled sweets, an extract of *Etlingeraelatior* flowers was used [7]. The flower extract was added in the amount of 4%, 6%, 8%, and 10% of the total sugar and molasses. The results showed that the addition of the *Etlingeraelatior* flower extract had a significant effect on the moisture content, pH, and antioxidant activity, and reduced the sugar content. A high level of antioxidant activity was obtained by adding the extract of *Etlingeraelatior* flowers to boiled sweets in an amount of 10% [7]. The results of the studies [8] showed that Egyptian red cabbage anthocyanin possessed valuable characteristics as a natural source of food colorants that mightbe used instead of synthetic ones. The Egyptian red cabbage anthocyanin produces a wide range of colours, from red to blue,depending on the pH of the medium. The colorant is heat-resistant, shows no loss of colour when temperature increases, andis low-sensitive to photodegradationwhen the pH is 1.0 to 5.0. It has a high antioxidant activity, thus, it is an attractive substance to use in the manufacture of boiled sweets. Addition of the Egyptian red cabbage anthocyanin in the amount of 0.1% does not worsen the organoleptic characteristics of boiled sweets [8].

Plant extracts may be used as natural flavouring agents and colorants for boiled sweets. Fruit of *Cudraniatricuspidata* may be used as a natural additive providing the desired colour and improving the nutritional profile of sweets [9]. Rhizome of red ginger (*Zingiberofficinale* var. *rubrum*) containsalkaloids, flavonoids, saponins, tannins, and triterpenoids, which have potential antibacterial activity, as well as gingerol, shogaol, and zingeron, all effective antioxidants. Red ginger is used as a flavouring agent in sweets, because its essential oils impart a distinctive ginger flavour, and oleoresin imparts a spicy ginger flavour to the product. When adding 1% red ginger extract to the boiled sweet formulation, the organoleptic characteristics (colour, aroma, flavour, and texture) are the most acceptable, and the physicochemical characteristics meet the quality requirements [10].

The use of extracts of viburnum berries, lemongrass, green tea, reindeer'sunossified antlers makes it possible to obtain boiled sweetswith antistress, tonic, and immunostimulating properties [11]. The chemical composition of unossified antlers varies. In the process of growth, the content of phosphorus and calcium increases and the amount of bioactive substances decreases, therefore, it is important to collect raw materials properly. In the study [12],in order to enrich products with biocomplexes, it is proposed to use extracts of sage leaves, liquorice root, and motherwort extracts in the boiled sweet formulation, which allows obtaining new aromatic compositions,apart from the medicinal properties.

A peculiar idea is to saturate sweets with iodine through the use of *Laminariaceae* algae decoction. A decoction made from brown algae allows achieving the same degree of enrichment with iodine as the direct addition of powdered seaweed to the boiled sweet composition [13].

Soluble dietary fibre is added to boiled sweetsfor their enrichment [14]. Extracts of Egyptian purple carrots were used as a source of dietary fibre and as a food colouring agent in the preparation of sweets. Anthocyanins derived from purple carrots were used as alternative natural red colorants for boiled sweets[15].

Clitoriaternatea is a well-known Ayurvedic plant with significant health benefits. The material studied was the extract from the *Clitoriaternatea* flower, blue in colour, high in polyphenolic compounds acting as a source of protection against free radicals. The property of *C. ternatea* flower extract to absorb free radicals showed the highest level of 59.3% [16]. In accordance with the findings, it was concluded that the natural colouring agent from the *Clitoriaternatea* flower might be used in any food compounds, in particular, in the boiled sweet formulations, replacing synthetic colorants. In order to use natural colorants in the manufacture of boiled sweets, the stability of the neocandenatone pigment was studied. Neocandenatone is a newly identified purple pigment present in the cores of *Dalbergiacongestiflora* [17]. The colouring of boiled sweets depended on the concentration of pigments and acid in the formulation. The pigment being stable in boiled sweets, the neocandenatone pigment can be potentially used as a food colouring agent.

In recent years, extraction of bioactive food components from agro-industrial by-products has attracted significant attention, as they may be a cheap and safe source of natural food additives and ingredients. Extracts from such by-products as pomegranate seeds, apple peel, chestnut shells, and black carrot pomace, have been found to be high in phenolic compounds and have a high level of antioxidant activity, hence the need to develop industrial processes to extract phenolic compounds showing biological activity.

Studies by various researchers have shown that the bioactive components of apples have significant potential in preventing and reducing disease in humans. Apples and their by-products, including juices and extracts, are rich in various phytochemicals [18]. There is a potential link between the consumption of apple products and a reduced risk of coronary heart disease, lung cancer, asthma, diabetes [19].

When apples are being processed, 10.9% of by-products, including seeds and pomace [20], is generated. Apple pomace is the primary production waste, accumulated mainly during the processing of apple juice. Phloridzin, chlorogenic acid, epicatechin, and quercetin glucosides were isolated from apple pomace. These phenolic compounds isolated from apple pomace were found to have high antioxidant activity, suggesting that apple pomace might have dietary health and commercial benefits [21]. Annually, tons of apple peel waste are formed in the production of apple purée and canned apples. Powdered apple peel had strong antioxidant activity and significantly inhibited the proliferation of cancerous cells. Since apple skin contains more antioxidants thanapple pulp does, it is a value-added ingredient [22].

Formulations of boiled sweetsusing apple powder were developed [23]. Apple powder was dosed in an amount of 2–6% of the total weight of sugar and molasses. The dosage limits of apple powder are due to the following: the powder is insoluble in water, thus, it will be distributed in the form of inclusions in finished boiled sweets. It was shown [23] that the boiled sweet samples with the addition of 2% apple powder had the best sensory and physicochemical parameters.

In [24], we investigated the possibility of using powder from apple cores with seeds in the technology of the manufacture of boiled sweets. The value of the component composition of a powdered apple core, which includes the vitamins C, B1, B2, B17, P, E, β-carotene, the elements potassium, iron, manganese, calcium, iodine, pectins and organic acids, was shown [25]. It was found that the addition of 6% of this powder to the formulation mixture allowed obtaining caramel, 5 g of which contained as much calcium as 50 ml of apple juice did, and 10 g of caramel satisfied the recommended daily iron intake by 10%. However, when consuming boiled sweets containing powdered apple cores, these sweetshave a somewhat rough surface, which may limit the consumption of the product.

Thus, the analysis of publications shows the importance of solvingthe problem of imparting functional propertiesto boiled sweets, and the prospects of developing recipes using extracts of plant origin, in particular, extracts of secondary apple raw materials.

Purpose and objectives of the research. The purpose of the study is to develop a formulation for boiled sweetsusing an alcohol extract of a powder from apple seeds cavities. The study included the following objectives:

– to develop a formulation for boiled sweetsusing apple by-products;

– to evaluate the sensory and physicochemical parameters, the content of toxic elements in the finished product;

– to evaluate the content of bioactive components in boiled sweets by gas chromatography-mass spectrometry (GC-MS).

Research materials and methods

Applecores with seeds, a by-product obtained from the production of apple crisps, were studied. Cores with seeds of Gala apples were used. The cores were dried at 60°C to the moisture content 6–7.5%, then crushed with a blender, and thus powder was obtained. The powder was extracted with 70% aqueous ethanol. 20 ml of the extractant was added to 1 g of the powder and left for 72 hours, and the mixture was mixed in a shaker. Then the mixture was poured into centrifuge tubes and centrifuged at 4000 rpm for 5 minutes. The centrifugate was filtered through paper filters. The resulting extract filtrate was stored at 4±1°C until used.

The colour of the extract obtained was yellow, the pH was 5.0. The extract was added in the amount of 4%, 8%, 12%, 16% of the total amount of sugar and molasses (Table 1), based on the research by the authors [6, 25, 26]. In this study:

A = Adding 0%of extract from powdered cores with seeds

B = Adding 4%of extract from powdered cores with seeds

C = Adding8%of extract from powdered cores with seeds

D = Adding12%of extract from powdered cores with seeds

E = Adding16%of extract from powdered cores with seeds

Table 1 – Formulation of the materials for making boiled sweets

Materials	Dosage				
	A	B	C	D	E
Sucrose (g)	70	70	70	70	70
Maltose molasses (g)	30	30	30	30	30
Water (g)	30	26	22	18	14
Extract (g)	0	4	8	12	16
Total Material (g)	130	130	130	130	130

The use of aqueous extracts in the production of boiled sweetsis impractical, since this alters the physicochemical parameters, including the moisturecontent,that is why an ethanol solution was used for extraction.

The caramel mass was prepared from granulated sugar (DSTU 4623-2006) and starch molasses (DSTU 4498-2005) by the following method: the materials were weighed, sugar, molasses, and water were mixed. The mixture was heated to 65–70°C, then the extract of powder from the seed-containing cores was added in accordance with Table 1. The mixture was continually heated to 150°C. The resulting mass was poured into moulds and cooled. Ready sweets were stored at room temperature. During the preparation of sweets at 150°C, ethanol volatilises, since its boiling point is 78°C. The use of an extract of seed-containing apple cores does not affect the final temperature of the caramel mass, but increases theintensity of its colour, which is due to the colouring of the extract obtained.

The organoleptic characteristics of the sweets were assessed according to DSTU 3893:2016. By the physicochemical parameters, the moisture content of the caramel mass was determined as a percentage (DSTU 4910:2008), the mass fraction of reducing substances as a percentage (GOST 5059:2008), the acidity of caramelaccording to DSTU 5024:2008 and pH; mass fraction of ash insoluble in solution with a mass fraction of hydrochloric acid of 10% (DSTU 4672:2006).

Statistical treatment of the research results was performed for the probability level of 0.95 (the number of thetest replicates was 5).

The samples with the addition of extract were analysedfor the content of lead, cadmium, copper, and zinc by themethod ofatomic absorption on aspectrophotometer Semy C-115 M 1 (Ukraine), for the mercury content by cold vapour using aspectrophotometer GRG107, for the arsenic content by using anatomic absorption spectrometer Ouagiap Brescia AA 240 with thermal atomisation (Australia).

The composition of volatile substances of the sweets obtained with an extract from seed-containing apple cores added was analysed. The analysis was carried out by chromatography-mass spectrometry on a gas chromatograph FINNIGAN FOCUS. AThermo Electronics massselective detector of the chromatograph was used. The diameter of the HP-5MS quartz capillary column was 0.25 mm, the length 30 m, the vapour deposition film thickness 0.25 μm. The carrier gas was helium, its flow rate in the column was 1.2 ml/min. Split mode (split 1:10) was used. The injector temperature was 250°C, the MSD interface temperature 280°C. Theinitial temperature of the programmable chromatograph oven was 50°C with retention for 0.5 min.Then at the rate 25°C/min, it was raised to 125°C, then at the rate 10 °C/min up to 255°C, andfurther it continued being raised at the rate 25°C/min up to 300°C with retention for 10 min. The electron energy ofelectron impact ionisation was70 eV. The MSD mode of operation involved full scan of ions from 29 to 450 atomic weights (SCAN mode). The components were identified by comparing the retention times of chromatogram peaks and full mass spectra of individual components with the suitable results for pure compounds in the NIST-5 mass spectrum library, using linear retention indices. The relative quantitative content of chemical components was calculated by the method of internal normalisation of peak areas without adjustment sensitivity factors.

Results of the research and their discussion

The sensory characteristics of the resulting sweets meet the requirements of DSTU 3893:2016 in terms of colour, flavour, transparency of the control samples (the ones with no extract added) and the samples with the addition of the extract. The flavour and aroma are typical ofboiled sweets. The structure of the resulting boiled sweets is homogeneous and vitreous. The colouring of individual boiled sweets is of similarintensity, with no stains, and the surface is dry and non-sticky.

The physicochemical parameters of the boiled sweets obtained are shown in Table 2.

Table 2 – Physicochemical parameters of boiled sweets

Parameters	A	B	C	D	E
Moisture content, %	2.3	2.3	2.2	2.1	2.0
Mass fraction of reducing substances, %	20.8	21.0	21.4	21.8	21.8
Caramel acidity, deg	7.5	7.8	8.0	8.3	8.5
pH	6.8	6.3	6.0	5.6	5.3
Mass fraction of ash insoluble in 10% hydrochloric acid solution	0.1	0.1	0.1	0.1	0.1

Accordingto these results, the introduction of an alcohol extract from apple cores with seeds into the caramel mass does not affect the physicochemical parameters (Table 2) of the boiled sweets obtained, and their values meet the DSTU 3893:2016 requirements.

The moisture content of the samples of boiled sweetsunder study ranged 2.0–2.3%. The moisture content of boiled sweets affects their shelf life. It is believed that the manufacture of sweets with an extended shelf life requires the manufacture of products with a minimum moisture content.

The acidity of a product has a significant effect on the feeling of freshness and is an important parameter in determining a product's quality. The addition of the extract from powderedseed-containingapple cores affects the acidity value. The highest titratable acidity and a lower amount of pH, respectively, were determined for the formulation E. With an increase in the percentage of the extract from powdered seed-containing apple cores in the formulation, the total pH value of the sweets decreased and the level of acidity increased based on the pH of the raw material, as the extract from powderedapple cores had the pH value 5.0.

The pH value critical for the oral cavity is usually taken as 5.5.Lower values pose a threat to the health of the oral cavity, namely to the tooth enamel [27]. Thus, the formulation D containing 12% of the extract from powderedapple cores with seeds was selected for further research.

The content of reducing sugars increases slightly when the extract is added. The content of the reducing sugars is affected by the cooking temperature. The higher the heating temperatureis, the greater the percentage of inverted sugar. Also, the increased content of reducing substances is caused by acid. The lower the pH of the sweets, the higher the content of reducing substances. In our study, the content of reducing substances remained within acceptable limits for this type of sugar products.

The ash content in the sweets obtained did not exceed 0.1%. The ash content is among the requirements for the quality ofsweets.The lower the ash content, the more transparent the sweets are. It has been established that the addition of the powder extract from apple cores with seeds does not affect the ash content of sweets.

The results of the study of the component composition of boiled sweets with the addition of 12% alcohol extract from seed-containingapple cores are shown in Table 3 and Fig. 1.

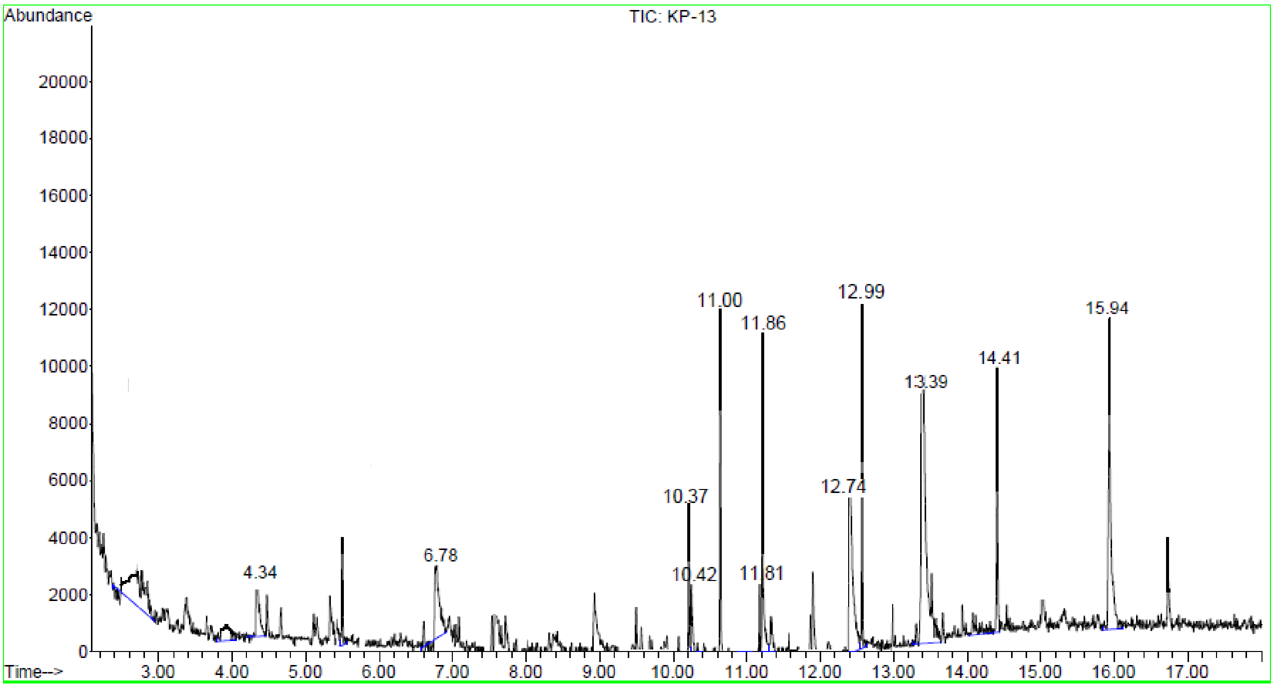

Fig. 1. Chromatogram of the component composition of volatile substances of boiled sweetsmade according to the formulation D

The results of gas chromatography-mass spectroscopy show that sweets produced with the addition of the extract from powderedapple core contained a variety of valuable components.

The components of volatile substances of boiled sweets with the addition of the extract from powderedapple cores with seeds, like apple core powder [25], include tocopherols, betulinic, arachidonic, linoleic, myristic, and other acids.

Analysis of the component composition of volatile substances of boiled sweets produced with the extract from apple cores with seeds (Table 3) shows that the volatile components of these sweets contain a lower percentage of oleic and stearic acids as compared with the volatile components of powderedapple core [25]. This may be explained by the low solubility of oleic and stearic acids in the water/alcohol solution used in the process of extraction. Also, the composition of the volatile substances of the sweets with the extract lacks certain components contained in the composition of the volatile components of the powder from apple cores itself, for example, hexanal, methyl-3,5-heptadiene-2-

one. Of course, this is because the boiling of the caramel mass, to which the extract is added, occurs at the temperature 150°C. Hexanal and some other volatile components of the extract have a lower boiling point, and these substances are absent among the volatile components of the finished product.

From the data in Table 3, it can be concluded that boiled sweets are enriched with valuable trace elements, in particular, zinc and copper, and other valuable bioactive components usually found in stones or seeds of plants. These are tocopherols possessing antioxidant properties, and linolenic and arachidonic acids, which are essential polyunsaturated acids, myristic acid with antimicrobial properties, betulinic acid with antibacterial, anti-inflammatory,and antiviral properties [21-23].

Table 4shows the results of studyingthe content ofheavy metals and arsenic in the boiled sweets supplemented with 12% alcohol extract from seed-containing apple cores.

Table 4 makes it clear that the content of heavy metals and arsenic identified in the boiled sweets does not exceed the permissible levels of these elements in the raw material which boiled sweets are prepared from, namely in granulated sugar and starch molasses. The introduction of an alcohol extract from apple cores with seeds into the caramel mass does not increase the content of mercury, lead, cadmium, and arsenic. When the extract is added to the caramel mass, the zinc content increases by 1.28 times, and the copper content in the finished boiled sweets increasesby 9.5 times. This is due because copper and zinc are biomicroelements included in the composition of many metalloenzymes and are present in the extract obtained from apple cores with seeds. The content of zinc and copper in the sweets with the extract does not exceed the allowable biological limit.

Table 3 – Component composition of volatile substances

No.	Component	Mass fraction of caramel enriched with extract from powdered apple cores with seeds, %
1	Heptanal	1.1
2	Acetophenone	3.0
3	3-Methyl-2-cyclopenten-1-one	2.1
4	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6- methyl- 5.3%	5.6
5	Myristic acid	8.7
6	Linoleic acid	12.5
7	Pentadecanoic acid	11.1
8	Oleic acid	6.5
9	Palmitic acid	12.8
10	Stearic acid	9.7
11	Arachidic acid	10.2
12	Tocopherols	12.2
13	Betylinicacides	5.3

Table 4 – Content of heavy metals and arsenic in the boiled sweets

Parameter	Content of elements, mg/kg					
	Hg	Pb	Cd	Zn	Cu	As
Permissible level in granulated sugar, mg/kg (DSTU 4623-2006)	0.01	0.5	0.05	not standardised	not standardised	1.0
Permissible level in starch molasses, mg/kg (DSTU 4498:2005)	0.02	0.5	0.1	30.0	10.0	0.1
Caramel with no extract added	0.0051±0.0010	0.44±0.02	0.031±0.001	0.486±0.010	0.010±0.008	0.005±0.001
Caramel with the extract added	0.0046±0.0012	0.44±0.03	0.032±0.001	0.621±0.014	0.095±0.012	0.004±0.001

Almond kernels, apple seeds, apricot, plum, cherry kernels, and some other fruit cores are known to contain amygdalin. Amygdalin is highly soluble in alcohol solutions. Decomposition products of amygdalin add a bitter taste to the kernels of almonds and other stone fruit and seed fruit containing amygdalin. Under the action of the enzyme emulsin, which is contained in the stones and seeds of fruit, amygdalin is broken down in aqueous solution into β-glucose, cyanic acid, and benzaldehyde [28]. Cyanic acid is a highly toxic substance that can cause varying degrees of poisoning when consumed in large quantities in raw bitter almond kernels or other plants containing amygdalin. Preliminary heat treatment at temperatures not lower than 70–80°C inactivates the emulsin so that amygdalin does not decompose with the release of cyanic acid, and remains amygdalin, which is not toxic itself.

The alcohol extract from seed-containing apple cores proposed to obtain boiled sweets is introduced into the caramel syrup at the stage of caramel mass preparation. The caramel mass is boiled at 150 °C, and therefore no formation of toxic decomposition products of amygdalin is possible, since emulsin, should it enter the extract, is destroyed at this temperature.

The research results presented in the paper may be used in the preparation of boiled sweets in craft manufactures. For example, the Ukrainian manufacturer of boiled sweetsGogodza produces boiled sweets with dried Carpathian berries and pieces of fruit, which are dried at low temperatures to preserve bioactive substances. Thesesweetsare free of artificial colorants and preservatives. Such industries may be offered the technology of boiled sweets production using extracts of vegetable by-products to expand their unique product ranges.

Conclusion

A recipe for the manufacture of boiled sweets with the addition of 12% extract of seed-containing apple cores, a by-product of apple crisps production and a source of valuable substances (tocopherols, polyunsaturated acids, etc.), has been developed. When an alcohol extract of apple cores with seeds is introduced into the caramel mass, boiled sweets are enriched with valuable trace elements, including zinc and copper, as well as other withbioactive substances.

The use of an extract from seed-containingapple cores in the boiled sweets formulation does not impair its physicochemical parameters.This has a positive effect on the technological process, as it does not require introduction of additional technologies.

The use of an extract from seed-containingapple cores in the boiled sweets formulation does not lead to the accumulation of decomposition products of amygdalin or toxic elements in the finished product.

The use of plant extracts to enrich boiled sweets may be an alternative to the current technology of enriching boiled sweets with dried berries, dried fruit pieces, fruit powders, which make the surface of consumedsweetsnoticeablyrough. It alsoallows expanding the range of boiled sweets made from natural raw materials without artificial colorants and preservatives.

References:

1. Ohkuma T, Zoungas S, Jun M, Lisheng L, Mancia G, Marre M, & ADVANCE Collaborative Group. Intensive glucose-lowering and the risk of vascular events and premature death in patients with decreased kidney function: The ADVANCE trial. Diabetes, Obesity and Metabolism. 2020;22(3):452-457. https://doi.org/10.1111/dom.13878
2. Dienel GA. Brain glucose metabolism: integration of energetics with function. Physiological reviews. 2019;99(1):949-1045. https://doi.org/10.1152/physrev.00062.2017
3. Neves MIL, Silva EK, Meireles MAA. Trends and challenges in the industrialization of natural colorants. Food Public Health. 2019; 9:33-44. https://doi.org/10.5923/j.fph.20190902.01
4. Al Khalaf A, Iss R & Khattab A. Content of Vitamin C, Phenols and Carotenoids Extracted from Capsicum annuum with Antioxidant, Antimicrobial and Coloring Effects. Pakistan Journal of Biological Sciences. 2020;23:1154-1161. https://doi.org/10.3923/pjbs.2020.1154.1161
5. Verma I, Gupta RK. Estimation of phytochemical, nutritional, antioxidant and antibacterial activity of dried fruit of sacred figs (Ficus religiosa) and formulation of value added product (Hard Candy). Journal of Pharmacognosy and Phytochemistry. 2015 [cited 2021 December 18]; 4(3):257-267. Available from: https://www.phytojournal.com/archives/2015/vol4issue3/PartD/4-3-57.pdf
6. Rizk EM, El-Gharably AM & Tolba KH. Carotenoid pigments composition of calendula flower and its potential uses as antioxidant and natural colorant in manufacturing of hard candy. Arab Universities Journal of Agricultural Sciences. 2008;16(2):407-417. https://doi.org/10.21608/ajs.2008.14976
7. Yenrina R, Asben A, Rahmatika Herriyenni. The Influence of Kecombrang Flower (Nicolaia speciosa, Horan) Extract on Physicochemical Properties of Hard Candy. International Journal of Engineering Research and Applications. 2017[cited 2021 December 18];7(9):64-69. Available from: https://www.ijera.com/papers/Vol7_issue9/Part-2/J0709026469.pdf
8. Sror HAM, Rizk E, Azouz A, Hareedy LAM. Evaluation of red cabbage anthocyanin pigments and its potential uses as antioxidant and natural food colorant. Arab Universities Journal of Agricultural Sciences. 2009;17(2):361-372. https://doi.org/10.21608 / AJS.2009.14946
9. Jeon Y, Oh J & Cho MS. Formulation Optimization of Sucrose-Free Hard Candy Fortified with Cudrania tricuspidata Extract. Foods. 2021;10:2464. https://doi.org/10.3390/foods10102464
10. Akib NI, Baane W, Fristiohady A. Formulation of herbal hard candy contains red ginger (Zingiber officinale var. rubrum) extract. Jurnal Farmasi UIN Alauddin Makassar. 2016;4(1):1-8. https://doi.org/10.24252/jurfar.v4i1.2238
11. Frolova NA, Reznichenko IYu. Metodologicheskie podhodyi k sozdaniyu funktsionalnyih saharistyih konditerskih izdeliy : monografiya. Blagoveschensk: Amurskiy gosudarstvennyiy universitet. 2020. ISBN 978-5-93493-345-7.
12. Habarov SN, Popov VG, Rubashanova E.A. Issledovanie vliyaniya biologicheski aktivnyh veshestv dikorastushih rastenij na formirovanie funkcionalnyh svojstv produktov pitaniya. Industriya pitaniya. 2016[cited 2021 December 21];1:61-68. Available from: https://cyberleninka.ru/article/n/issledovanie-vliyaniya-biologicheski-aktivnyh-veschestv-dikorastuschih-rasteniy-na-formirovanie-funktsionalnyh-svoystv-produktov
13. Blagonravova MV Razrabotka tehnologii ledencovoj karameli s ispolzovaniem vodoroslevogo otvara. Vestnik Kamchatskogo gosudarstvennogo tehnicheskogo universiteta. 2017[cited 2021 December 23];42:39-45. Available from:https://cyberleninka.ru/article/n/razrabotka-tehnologii-ledentsovoy-karameli-s-ispolzovaniem-vodoroslevogo-otvara
14. Krylova EN, Kondratev NB, Savenkova TV. Ledencovaya karamel s pishevymi voloknami. Pishevaya promyshlennost. 2008[cited 2021 December 25];6:66-67. Available from: https://cyberleninka.ru/article/n/ledentsovaya-karamel-s-pischevymi-voloknami/viewer
15. Assous MTM, Abdel-Hady MM, Medany GM. Evaluation of red pigment extracted from purple carrots and its utilization as antioxidant and natural food colorants. Annals of Agricultural Science. 2014;59(1):1-7. https://doi.org/10.1016/j.aoas.2014.06.001
16. Caroline A, Padmavati R. Evaluation of C. Ternatea Extract and Incorporation into Hard Candy. International Journal of Latest Technology in Engineering, Management & Applied Science. 2015[cited 2021 December 25];4(2):72-76. Available from: https://www.academia.edu/11475072/Evaluation_of_C_Ternatea_Extract_and_Incorporation_into_Hard_Candy?pop_sutd=false

17. Gutiérrez-Zúñiga CG, Arriaga-Alba M, Ordaz-Pichardo C, Gutiérrez-Macías P, Barragán-Huerta BE. Stability in candy products of neocandenatone, a non-genotoxic purple pigment from Dalbergia congestiflora heartwood. Food Research International. 2014;65:263-271. https://doi.org/10.1016/j.foodres.2014.03.048
18. Hyson DA.A Comprehensive Review of Apples and Apple Components and Their Relationship to Human Health. Advances in Nutrition. 2011;2(5):408-420. https://doi.org/10.3945/an.111.000513
19. Boyer J, Liu RH. Apple phytochemicals and their health benefits. Nutrition journal. 2004;3(5):1-15. https://doi.org/10.1186/1475-2891-3-5
20. Gulsunoglu Z, Karbancioglu-Guler F, Raes K & Kilic-Akyilmaz M. Soluble and insoluble-bound phenolics and antioxidant activity of various industrial plant wastes. International journal of food properties. 2019;22(1): 1501-1510. https://doi.org/10.1080/10942912.2019.1656233
21. Lu Y, Foo L. Antioxidant and radical scavenging activities of polyphenols from apple pomace. Food Chem. 2000;68:81-85. https://doi.org/10.1016/S0308-8146(99)00167-3
22. Wolfe K, Liu RH. Apple peels as a value-added food ingredient J Agric Food Chem. 2003;51:1676-1683. https://doi.org/10.1021/jf025916z
23. Shul`ga OS, Kamenchuk TV, Shul`ga SI. Yabluchny`j poroshok yak dobavka dlya pidvy`shhennya xarchovoyi cinnosti karameli. Ukrainian Food Journal. 2012[cited 2021 December 27];1(2):59-61. Available from: http://dspace.nuft.edu.ua/bitstream/123456789/21511/1/13.pdf
24. Cheliabiieva VM, Semenyuk OM, Gavry`k MV. Vy`kory`stannya netrady`cijnoyi sy`rovy`ny` u kondy`ters`komu vy`robny`cztvi. Texnichni nauky` ta texnologiyi. 2017;2(8):195-201. https://doi.org/10.25140/2411-5363-2017-2(8)-195-201
25. Cheliabiieva VM. Pidvy`shhennya xarchovoyi cinnosti boroshnyany`x kondy`ters`ky`x vy`robiv. Uroven` razvy`ty`ya texny`ky` y` texnology`j v XXI veke. Chast` 1: Sery`ya monografy`j. Odessa. 2019[cited 2021 January 15]. Available from: https://sworld.education/monoua3/urtt.pdf
26. Savchenko OM, Sy`za MV. Gavry`k. Perspekty`vnist` vy`kory`stannya fitoekstraktiv u vy`robny`cztvi. Progresy`vni texnika ta texnologiyi xarchovy`x vy`robny`cztv restorannogo gospodarstva i torgivli. 2016[cited 2021 December 12];24:299-311. Available from: https://elib.hduht.edu.ua/bitstream/123456789/1174/1/3.3.pdf
27. Brand HS, Gambon DL, Paap A, Bulthuis MS, Veerman ECI, Amerongen AN. The erosive potential of lollipops. International dental journal. 2009;59(6):358-362. https://doi.org/10.1922/IDJ_2182Brand05
28. Askarov IR, Abdugapparov FS, Hozhimatov MM. Sintez novyih soedineniy na osnove amigdalina. Universum: Tehnicheskie nauki : elektron. nauchn. zhurn. 2019[cited 2021 December 12];6(63). Available from: http://7universum.com/ru/tech/archive/item/7551

ЕКСТРАКТ ВТОРИННОЇ ЯБЛУЧНОЇ СИРОВИНИ У ТЕХНОЛОГІЇ ЛЬОДЯНИКОВОЇ КАРАМЕЛІ

В.М. Челябієва, кандидат технічних наук, доцент, *E-mail:*vika.chl@ukr.net
Н.П. Буяльська, кандидат технічних наук, доцент, *E-mail:*buialska@gmail.com
Н.М. Денисова, кандидат технічних наук, доцент, *E-mail:*4386793@gmail.com
кафедра харчових технологій
Національний університет «Чернігівська політехніка»,вул. Шевченка, 95, м. Чернігів, Україна 14035

Анотація.Льодяникова карамель - популярний вид цукерок. У своїй класичній рецептурі льодяникова карамель – це джерело простих вуглеводів. Недоліком льодяникової карамелі є відсутність в її складі цінних біологічно активних речовин, таких як вітаміни, мінерали, ненасичені жирні кислоти, харчові волокна тощо. Актуальним і перспективним напрямком є розробка рецептур і створення технології карамелі збагаченої біологічно активними речовинами за рахунок екстрактів рослинного походження, зокрема екстрактів вторинної яблучної сировини. Щоб збагатити льодяники біологічно активними речовинами, можна ввести у їх склад екстракт порошку з яблучних насіннєвих камер з насінням, які є побічним продуктом виробництва яблучних чіпсів. Порошок з яблучних насіннєвих камер з насінням містить компоненти, корисні для здоров'я. Метою цього дослідження була розробка рецептури льодяникової карамелі з використанням спиртового екстракту порошку яблучних серцевин з насінням, оцінка органолептичних, фізико-хімічних характеристик, компонентного складу летких речовин отриманих льодяників. Екстракт порошку додавали в кількості 4%, 8% , 12% і 16% від загальної кількості цукру і патоки. Результати показали, що при додаванні екстракту порошку з яблучних насіннєвих камер кислотність льодяників незначно зростає, інші фізико-хімічні показники готових виробів суттєво не змінюються. При введенні у карамельну масу екстракту яблучних серцевин з насінням льодяникова карамель збагачується цінними мікроелементами, зокрема цинком і купрумом, та іншими цінними біологічно активними компонентами, які зазвичай входять до складу кісточок або насіння рослин. Це токофероли, які володіють антиоксидантними властивостями, ліноленова і арахідонова кислоти – незамінні поліненасичені кислоти, мірістинова кислота, яка проявляє антимікробні властивості, бетулінова кислота, яка має антибактеріальні, протизапальні, противірусні властивості. Отримані результати добре корелюють з дослідженнями інших авторів, стосовно фітохімічної цінності яблук, яблучних продуктів та відходів переробки яблук.

Ключові слова: льодяникова карамель, екстракт, яблучні насіннєві камери, біологічно активні речовини.