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Contents

Hydrothermal treatment in organic wheat starch: thermal, structural and pasting properties

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Abstract

Introduction. In this investigation, the aim was to study the effects caused by heat moisture-treatment (HMT), low humidity (< 35%) and heating, on organic wheat starch.

Materials and methods. Organic wheat starch was submitted to hydrothermal treatment in different concentrations of humidity (10%, 15% and 20%) in an autoclave at 121 °C for 1 hour and 15 minutes. Thermogravimetry (TG), viscoamilographic analysis (RVA), X-ray diffractometry by the powder method (XRD) and scanning electron microscopy (SEM) were performed to compare the properties of native and modified starch.

Results and discussion. After heat treatment at low moisture (HMT), the organic wheat starch exhibited greater thermal stability when compared to the untreated. The first mass loss was due the dehydration, followed of stability; the second and third mass loss occurs consecutively with decomposition and oxidation of organic matter, in air atmosphere. Final residues are ashes from starch. Lower pasting temperatures and higher peak viscosity were observed for starch treated with 15 and 20% humidity. Lower retrogradation tendency and viscosity were obtained for organic wheat starch treated with 10% moisture. A decrease in crystallinity was identified for the modified samples, without considerable changing in the diffraction pattern. The main diffraction angles were registered at 15, 17, 18 and 23°, in 2 (θ), with low intensity. This behaviour is characteristic of type A diffraction pattern starch (typical of cereals). By Scanning Electron Microscopy (SEM), the organic wheat starch presented a bimodal distribution without major changes in the morphology of the granules. After HMT starch granules showed a slight increase in the average diameter; 17.9 to 27.7 μm in the major granules (A) and 5.6 to 7.1 μm in the minor granules (B). The shape in (A) is oval and in (B) is lenticular. Some depressions in surface of starches are observed mainly after HMT, which can be due the starch-protein interactions.

Conclusions Some properties were affected after modification by HMT. The decrease in pasting temperature and major thermal stability and viscosity were obtained.

Introduction

Organic food has been highly valued both in the market and by the consumer, since it does not use chemical fertilizers, pesticides or genetically modified materials in its production, contributing to minimize environmental impacts [1, 2]. Therefore, several industrial sectors are adopting this market segment, needing inputs that meet these characteristics. Starch is a basic raw material in several industrial branches, such as textile, pharmaceutical, paper, but mainly, food. This polysaccharide can be found as semicrystalline granules in several botanical sources, formed by the union of several anhydrous glucose molecules, presenting specific characteristics, which can fit in several processes [3].

In order to preserve the organic authenticity of the product, the starch can be extracted in an aqueous way, without the use of chemical products, as well as realized by Andrade et al. [4] in organic cassava starch.

In wheat, the starch corresponds to the largest fraction of the endosperm and is presented in a bimodal form [5]. Many authors classify wheat starch granules as type A and type B. Those with diameter > 10 μm and lenticular format are considered type A, while those with diameter < 10 μm and spherical format are called type B [6, 7].

In its native form, that is, without any alteration suffered in its primitive structure, some limitations in the technological characteristics of starch can be observed, which can be minimized or even optimized by means of modifications (chemical, physical or enzymatic) [8].

Heat-moisture treatment (HMT) is a physical modification that can be applied to organic food, which subjects the starch to high temperature conditions (above the gelatinization temperature, > 90–120 ºC) and low moisture (< 30–35%) to prevent the starch from gelatinizing during the process. This increases thermal stability and gelatinization temperature, while the swelling power is decreased [9–11].

The changes in properties vary according to the conditions employed in the modification and the starch used. Therefore, in this study, the aim was to study the effects caused by low humidity heat treatment on organic wheat starch.

Objectives of research:

- Extraction of organic wheat starch by aqueous process;
- Investigate thermal characteristics by thermogravimetry (TG);
- Analyze pasting properties in rapid viscoanalyzer (RVA);
- To evaluate the structure and morphology of starch granules by X-ray diffractometry (XRD) and scanning electron microscopy (SEM).

Materials and methods

The certified organic wheat flour was obtained in local commerce in the city of Curitiba, PR, Brazil. The modification and analysis were performed at the Food Engineering Department Laboratory and at the Multiuser Laboratory of the State University of Ponta Grossa.

Starch extraction

The organic wheat flour was suspended in distilled water, in the proportion 3:1 (water, flour, v/m). A consistent dough was formed with the kneading and mixing of this suspension, which was continuously pressed and washed with the addition of distilled water, until the starch was separated from the fraction of the dough containing gluten, observing the water

color until it became colorless. Then the suspension was passed through two sieves (150 and 325 mesh, consecutively) and then, kept at rest for starch decantation. The material was centrifuged (Hettich Routine 420R, Zentrifugen, Germany) at 8500 rpm and 4 ºC for 7 min. The white precipitate was recovered and dried in an oven at 40 ºC, kept in a desiccator containing anhydrous calcium chloride until the moment of modification.

Starch modification

Initially, the humidity of the wheat starch sample was determined by the TGA-50 equipment (Shimadzu, Japan), performing the analysis up to 130 ºC (sample mass of 7.0 mg, air flow, flow of 150 mL min^{-1}, at 10 ºC min^{-1}) to proceed with the moisture balance at the desired levels: 10, 15 and 20%. Distilled water was added with the aid of micropipettes until the contents determined from the native starch were reached. Each sample was homogenized with mortar and pistil to avoid points with higher concentration of humidity and transferred to hermetically sealed flasks, where they were left to rest for 24 hours in a desiccator containing anhydrous calcium chloride until the moment of treatment. The modification by HMT occurred in an autoclave at 120 ºC, for 1 h and 15 min. After this time, the samples were dried in an oven at 40 ºC for 24 hours and kept in a desiccator [4].

Thermogravimetry and Derivative Thermogravimetry (TG/DTG)

A thermal analysis system TGA-50 (Shimadzu, Japan), calibrated with calcium oxalate monohydrate was used to evaluate the mass losses suffered by the sample under the following conditions: open α-alumin crucible with approximately 7.0 mg of each sample, under an air flow rate of 150 mL min^{-1} at a heating rate of 10 ºC min^{-1} and temperature range between 30 and 650 ºC. The first derivative was calculated with the aid of software TA-60 WS [12].

Viscoamilographic analysis (RVA)

A suspension containing approximately 2.24 g of starch on a dry basis and 25.76 g of distilled water was prepared, which was homogenized and submitted to a controlled heating and cooling cycle under constant circular agitation in RVA-4 equipment (Newport Scientific, Australia). The parameters used were: temperature maintained at 50 ºC for 2 min, heating to 95 ºC at a heating rate of 6 ºC min^{-1}, temperature maintained at 95 ºC for 5 min, followed by cooling to 50 ºC at 6 ºC min^{-1}. The cycle was finished maintaining the temperature at 50 ºC for 2 min [13].

X-ray diffractometry by the powder method (DRX)

The diffractometers were obtained according to Colman, Demiate and Schnitzler [14], in Ultima IV X-ray diffractometer (Rigaku, Japan), under CuKα radiation (λ = 1.541 Å) configured at 40 kV and 20 mA. The relative crystallinity index (CI) was estimated from the ratio between the area of the crystalline region (A_c) and the total area covered by the curve comprising the sum of the amorphous and crystalline area ($A_c + A_a$). The diffraction pattern of the samples was determined by the occurrence of peaks of crystallinity in the angular range of 5º to 50º (2θ), with a scanning speed of 2º min^{-1}, and a step of 0,02º.

Scanning electron microscopy (SEM)

The morphological analysis was performed in Tescan – VEGA 3 (Kohoutovice, Czech Republic) equipment. The parameters of the analysis for each sample were: 15 kV voltage in the electron beam, tungsten filament and retro mirror electron detector. Each sample was previously prepared by the process of metallization with gold plasma and palladium for conduction of electrons and obtaining the micro-images [15].

Statistical analysis

Differences found for pasting properties, degree of relative crystallinity and granule diameter were analyzed by analysis of variance (ANOVA) and Tukey's test adopting 95% confidence ($p<0.05$) with the SASM-Agri 8.2 software.

Results and discussion

The thermogravimetric curves for native organic wheat starch and after HMT treatment are illustrated in Figure 1.

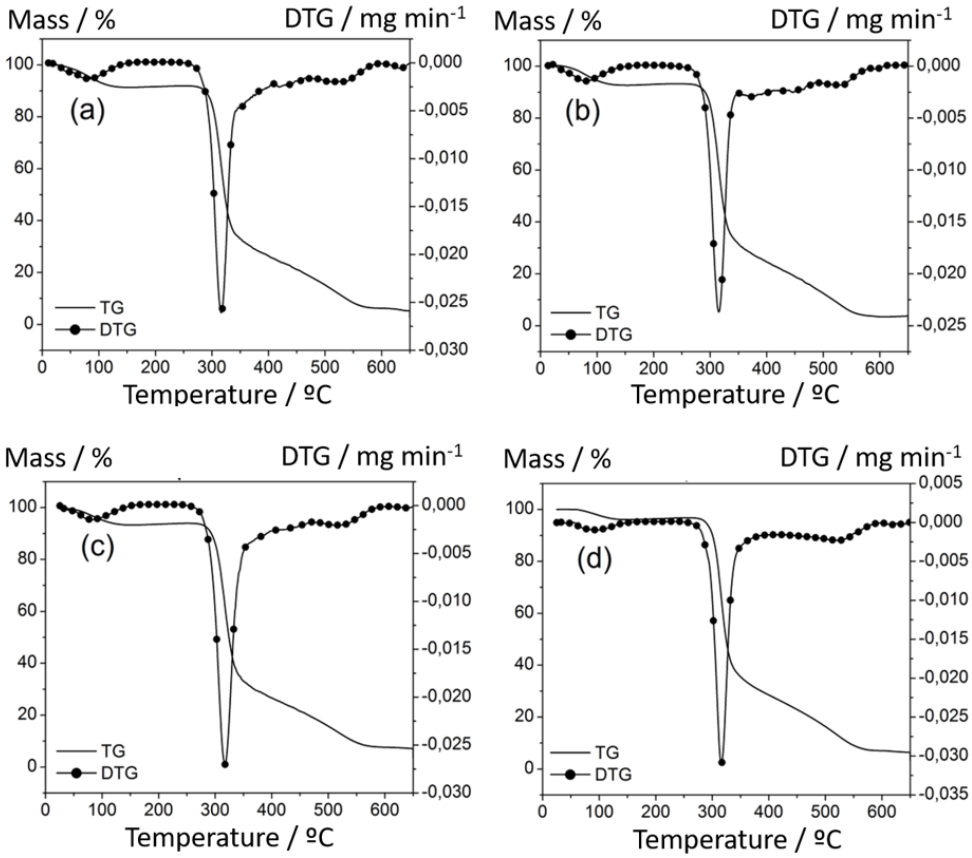

Figure 1. TG/DTG curves for:
(a) – organic wheat starch;
and modified starch by HMT with
(b) – 10% humidity, (c) – 15% humidity, (d) – 20% humidity.

Similar profiles were observed between the curves, and the samples during heating suffered dehydration, followed by thermal stability and, later, degradation of organic matter in two consecutive stages. This is in line with what has already been observed in studies using heat-moisture treatment in cassava organic starch [4] and avocado starch [16].

According to the literature, the heating of starches normally leads to their depolymerization when the temperature used exceeds 300 °C. This polysaccharide undergoes a series of irreversible changes so that the structural change in the polymer initially leads to the formation of pyrodextrins and at higher temperatures, the degradation of macromolecules results in the formation of levoglucosan, furfural and volatile products of lower molecular mass. Finally, only carbon residues remain [12,17].

The last stage of mass loss observed by the inflection in TG curves at temperatures above 400 °C was due to the use of oxidative atmosphere, with the degradation of carbonaceous compounds in the samples, as discussed by Costa et al. [18].

The TG curves were used to define and calculate the losses of mass of each sample in relation to time and temperature. The DTG curve is not a technique but a mathematical resource (derived from the TG curve), used to help in the identification of the respective losses. Since the first derivative of a constant is null, when there is an inflection in the graph, a peak is generated in proportion to the loss of mass of the sample. The DTG peak refers to the maximum deviation from the base line. In other words, it is the instant when the rate of loss of mass is maximum [4].

The results extracted from the curves are presented in Table 1.

Table 1

Results of thermogravimetry and derivative thermogravimetry for (a) native organic wheat starch; and modified by HMT with (b) 10% humidity, (c) 15% humidity and (d) 20% humidity

Samples	TG results			DTG results
	Steps	Δm/%	ΔT/°C	T_p/°C
(a)	1st	8.1	30–168	83.3
	Stability	–	168–241	–
	2nd	69.0	241–430	316.3
	3rd	17.2	430–600	431.3
(b)	1st	7.3	30–160	79.0
	Stability	–	160–251	–
	2nd	72.2	251–427	315.1
	3rd	18.2	427–603	446.1
(c)	1st	6.7	30–165	83.0
	Stability	–	165–247	–
	2nd	69.5	247–416	317.1
	3rd	17.4	416–595	431.2
(d)	1st	4.5	30–167	96.6
	Stability	–	167–248	–
	2nd	69.5	248–411	315.8
	3rd	20.2	411–595	522.4

Δm, mass loss (%); ΔT, temperature range (°C); T_p, peak temperature (°C).

Three characteristic intervals were observed in TG curves. Initially, at a range of 30-168 °C, represented by the evaporation of water. The moisture content lost by the modified samples was lower than the native one, as well as observed for buckwheat starch modified by HMT by Liu et al. [9], who attributed this to the greater ease of losing free water, promoted by the changes in the starch structure with the modification by HMT, leading to a reduction in the water content of the sample. The following inflections refer to the degradation of organic matter (amylose and amylopectin) and oxidation of carbonaceous compounds [15]. The second and third losses occurred in a similar temperature range for wheat starch samples between 241–430 ºC and 411–603 ºC, respectively. After the oxidation of the samples, content of 5.78; 2.31; 6.66 and 5.79% were left referring to the ashes for each sample, respectively, due to minerals such as phosphorus, potassium, magnesium and others.

After the occurrence of dehydration of the samples, a level of stability was observed, which increased after the modification of the organic wheat starch. Thus, the hydrothermal treatment suggests alterations in the starch structure and, consequently, in its thermal decomposition profile, once new and stronger interactions appear between amylose-amylose and amylopectin-amylopectin [11]. Thus, a tendency of increase in the stability temperature of the treated samples when compared to the native starch occurred. On the other hand, the beginning of the last stage of mass loss was anticipated in the process for the same comparison. This result was also observed by Andrade et al. [4] in organic cassava starch.

In Figure 2, the viscosity curves of native organic wheat starch and after physical modification are illustrated.

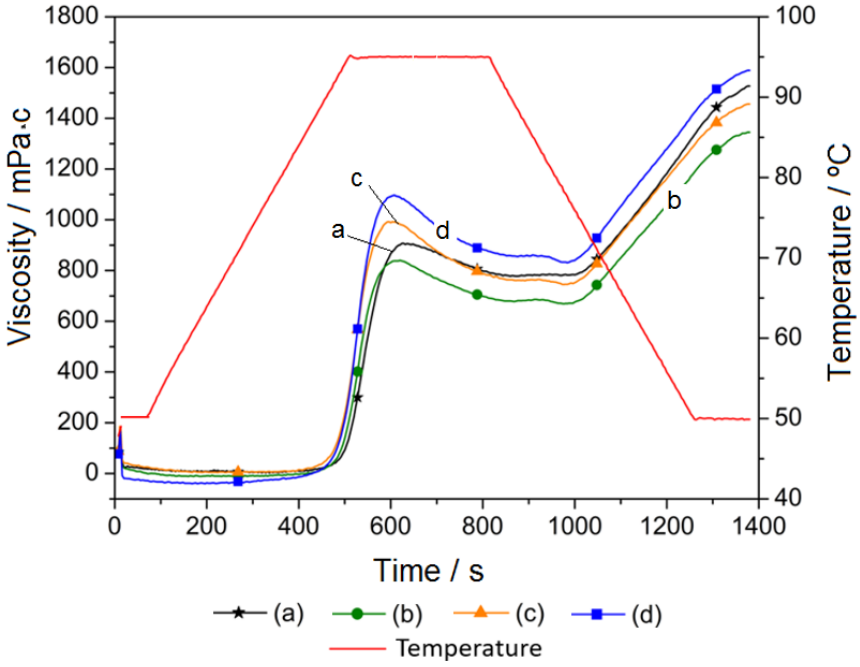

Figure 2. RVA curves for (a) – organic wheat starch; and modified by HMT with: (b) – 10% moisture, (c) – 15% moisture and (d) – 20% moisture

The profile of the curves obtained for organic wheat starch was similar to that of sweet potato [19], with a high tendency to retrograde, reaching a final viscosity higher than the peak viscosity. It can also be observed that the viscosity increased after the modification, except for a modified sample with 10% humidity.

The pasting properties are presented in Table 2.

Table 2

Pasting properties for (a) organic wheat starch; and modified by HMT with (b) 10% moisture, (c) 15% moisture and (d) 20% moisture

Parameters	(a)	(b)	(c)	(d)
T_p/ºC	93.6±0.6^{a}	92.9±0.1^{ab}	91.7±0.1^{b}	91.5±0.6^{b}
Peak viscosity / mPa.s	907.1±0.1^{c}	840.2±0.3^{d}	992.1±0.2^{b}	1097.2±0.3^{a}
Setback / mPa.s	749.1±0.1^{b}	676.4±0.4^{d}	711.1±0.1^{c}	758.1±0.6^{a}
Breakdown / mPa.s	128.9±0.1^{d}	171.3±0.5^{c}	247.1±0.1^{b}	266.1±0.1^{a}
Final viscosity/ mPa.s	1527.2±0.3^{b}	1354.3±0.4^{d}	1456.1±0.2^{c}	1589.1±0.2^{a}
Peak time / min	10.4±0.1^{a}	10.3±0.0^{a}	9,99±0.1^{b}	10.2±0.1^{ab}

(*) Tp, Pasting temperature. Values shown as average±standard deviation of triplicates.
Values with the same letter on the same line have no significant difference by Tukey's Test ($p<0.05$).

It was observed that organic wheat starch exhibited high pasting temperature, characteristic of starches with type A diffraction pattern [19], as evidenced by X-ray diffractometry. The pasting temperature decreased with the increase in moisture employed during the modification by HMT, differing significantly between the native samples and modified with 15 and 20% moisture. In contrast, with the exception of the sample treated with 10% humidity, after the modification there was an increase in peak viscosity, a behavior different from that found in most of the starches modified by HMT, but also observed in rice starch with low amylose content modified by HMT with 25% humidity [20]. The new bonds formed by amylose and amylopectin [21], favored by the higher moisture content employed in the modification, may have influenced this parameter, besides the swelling of the granules as observed by microscopy.

High amylose and lipid contents, which are presented as complexes (amylose-lipids) are generally observed in cereal starches such as corn and wheat, which corroborate with high pasting temperatures, lower viscosities, good shear resistance and high tendency to retrogradation [22]. According to Batista et al. [23], these interactions can be interesting for breads formulation in sensorial and firmness properties. These amylose-lipid complexes can be identified in X-ray diffractometry at 20º in 2 (θ), as visualized in this study and discussed by Cheetam et al. [24] and Frost et al. [25].

The tendency to retrogradation and final viscosity of the samples presented the same behavior, decreasing with the treatment to 10% of humidity, and gradually increasing with the increase of humidity employed, with statistically significant differences. Increase in the retrogradation of HMT modified sorghum starch at 20, 30 and 40% was discussed by Singh et al. [26]. It is suggested that in higher humidity levels, the modification led to the rupture

of long amylopectin chains, favoring the increase of short chains, which also influenced the greater retrogradation of wheat starch, corroborating with DRX analysis. Moreover, a greater breakage was observed after modification, indicating that the swollen granules disintegrated rapidly.

Through Figure 3 it was observed that there was no marked displacement of the peaks after the hydrothermal treatment.

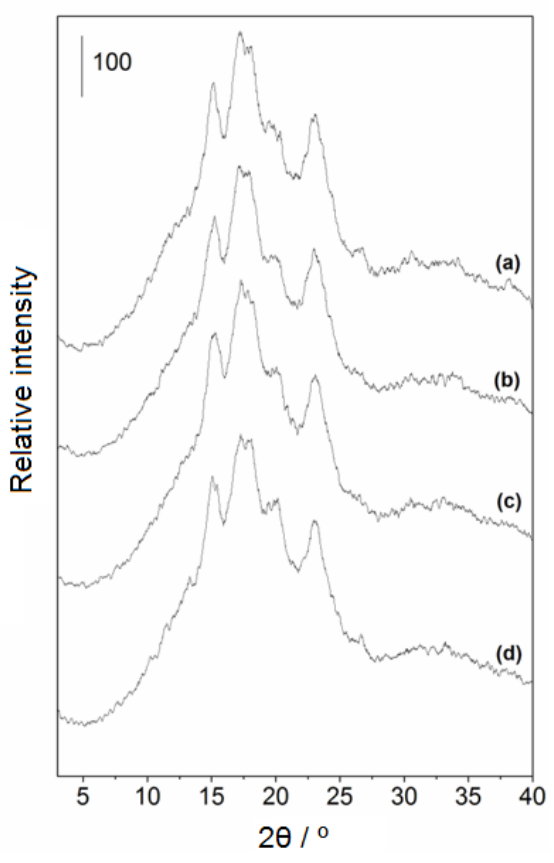

**Figure 3. Difratograms for (a) – organic wheat starch;
and modified by HMT with
(b) – 10% moisture,
(c) – 15% moisture,
(d) – 20% moisture.**

The angles in which the peaks for native and modified HMT wheat starch were recorded were 15, 17, 18 and 23 to 2(θ), which characterizes the diffraction pattern of type A, typical of cereals, as observed buckwheat [9], rice [20], sorghum [26] and corn [27].

With the heat treatment, the double starches propellers with type A diffraction pattern can move promoting rupture in the arrangement of the crystalline region, thus reducing the relative crystallinity as pointed out by Gunaratne and Hoover [10].

A lower intensity peak was observed at 20º, related to the amylose-lipid complex (type V complex), commonly observed in starches submitted to HMT, mainly isolated from cereals [28].

The degree of relative crystallinity (RC) calculated from the diffractograms was of:

(a) 26.97±0.48%^{a};
(b) 26.19±0.69%^{ab};
(c) 25.30±0.75%^{ab};
(d) 25.16±0.77%^{b}.

Similar value for RC of native waxy wheat starch was found by Hu et al. [29].

After the modification, there was a decrease in the RC of the starch, being more accentuated for the treatment employing 20% of moisture differing significantly from the native sample. Less relative crystallinity after HMT treatment was also reported by Huang et al. [19] in sweet potato starch and Chung et al. [21] in corn starch.

The rearrangement of the amylose chains and the unfolding of the amylopectin double helixes after heat treatment may have promoted the formation of more compact amorphous regions, influencing the decrease in the crystallinity of the granules, besides their greater aggregation [9,11], as observed in this study by microscopy. Moreover, Chung et al. [21]

reported a breakdown of covalent bonds due to the greater mobility of the chains by the high temperature employed in the modification by HMT, favoring the formation of short amylopectin chains

Unlike buckwheat starch [9], organic wheat granules had a bimodal distribution (Figure 4), which was not altered after modification applied (HMT).

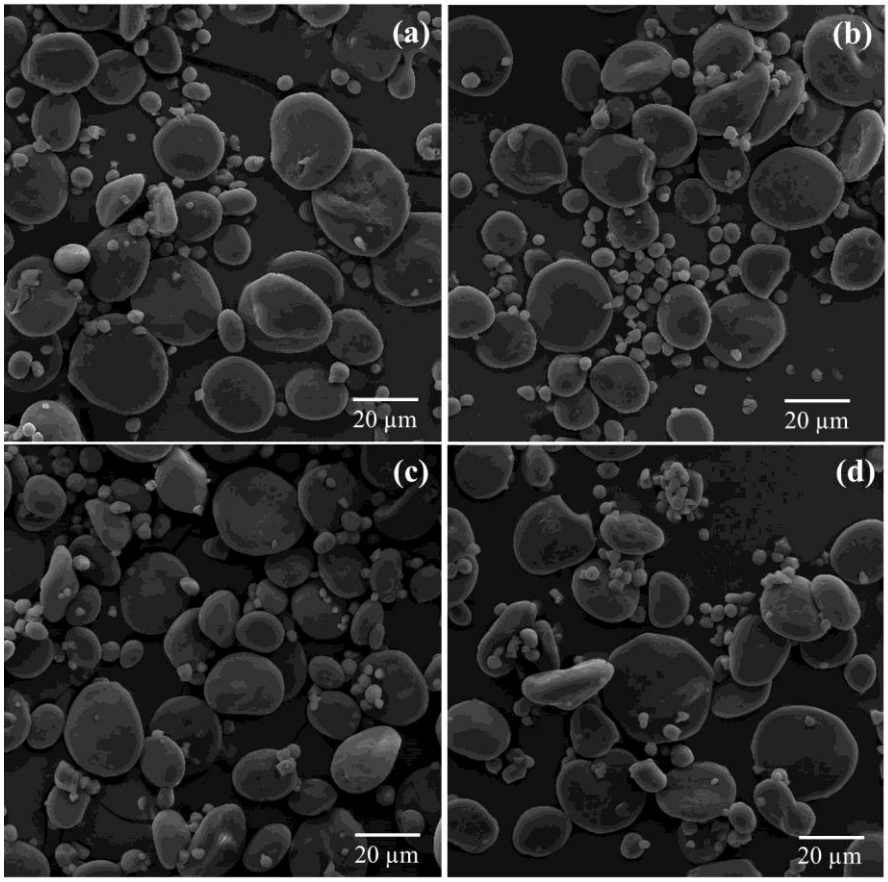

Figure 4. Images obtained by scanning electron microscopy for (a) – organic wheat starch (a) native;
and modified by HMT with:
(b) – 10% moisture, (c) – 15% moisture and (d) – 20% moisture

According to Zeng et al. [5], smaller granules (type B) predominate in the bimodal size distribution of wheat starch, presenting a lower amylose content than type A. This distribution was observed in this study for both native organic wheat starch and treated starches, and the small granules (type B) showed a lenticular shape. The type A granules showed an oval shape.

From the microimages obtained, some depressions in the surface of the starch granules were visualized, which gave them an irregular shape. According to Yonemoto et al. [30], these cavities would result from the strength of starch-protein interaction in wheat grains, causing the protein matrix to press some starch granules, creating these projections.

Thus, there were no changes caused by HMT in the surface of the granule as reported for starch from yams, taro, cassava, potatoes by Gunaratne and Hoover [10], and unlike that found by Rafiq et al. [31] in chestnut starch, in higher humidity levels (25 and 30%) and Sun et al. [32] and in mixtures of wheat starch with xylitol after HMT.

Although without changes in shape, small changes in diameter were observed (Table 3).

Table 3

Average diameter of (a) organic wheat starch granules; and modified by HMT with (b) 10% moisture, (c) 15% moisture and (d) 20% moisture

Samples	Type A	Type B
(a)	17.9 ± 3.3^{b}	5.6 ± 2.0^{a}
(b)	22.2 ± 6.1^{ab}	6.52 ± 1.1^{a}
(c)	23.7 ± 9.7^{ab}	6.6 ± 2.4^{a}
(d)	27.7 ± 7.1^{a}	7.1 ± 2.5^{a}

Values expressed as mean±standard deviation.
Values with the same letter on the same line have no significant difference by Tukey's Test ($p<0.05$).

Type A granules showed a tendency to increase in the average diameter of the granules, according to the increase in humidity content. Lee et al. [33] reported an increase in the central region of HMT modified potato starch. The type B granules did not differ statistically in relation to their diameter.

The differences found in the properties of starch after modification may have occurred due to the treatment time, temperature, humidity employed, as well as the source used in this study [27].

Conclusions

The organic wheat starch was extracted by aqueous process in a satisfactory manner and its technological properties were altered with the application of physical modification, a process considered low cost, environmentally correct, without the use of chemical reagents.

An increase in thermal stability was observed after the modification by HMT. The formation of paste required lower temperatures and higher viscosities, although with less resistance to shear with the use of 15 and 20% humidity. Starch treated with 10% humidity showed a decrease in peak and final viscosities, as well as a lower tendency to retrograde. Diffraction pattern and morphology of the granules remained unchanged after modification, and a decrease in relative crystallinity was observed.

The alterations promoted in the organic wheat starch were dependent to the different moisture contents that caused a reorganization in the amylose chains and dissociation of the amylopectin double helixes, directly impacting its relative crystallinity.

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References

1. Forman J., Silverstein J. (2012), Organic foods: Health and Environmental Advantages and Disadvantages, *Pediatrics*, 130(5), pp. 1406–1415.
2. Ie P.S., Petros D., Stinner D.H., Phelan P.L., Hamaker B., Koelling K.W., Vodovotz Y. (2014), Comparison of the gelatinization behavior of organic and conventional spelt starches assessed by thermal and rheological analyses, *Journal of Agricultural and Food Chemistry*, 60, pp. 9229–9935.
3. Ashogbon A.O., Akintayo ET. (2014), Recent trend in the physical and chemical modification of starches from different botanical sources: A review, *Starch/Stärke*, 66, pp. 41–57.
4. Andrade M.M.P., Oliveira C.S., Colman T.A.D., Costa F.J.O.G., Schnitzler E. (2014), Effects of heat moisture on organic cassava starch – Thermal, rheological and structural study, *Journal of Thermal Analysis and Calorimetry*, 115, pp. 2115–2122.
5. Zeng J., Gao H., Li G.L. (2014), Functional properties of wheat starch with different particle size distribution, *Journal of the Science of Food and Agriculture*, 94, pp. 57–62.
6. Soulaka A.B., Morrison W.R. (1985), The amylose and lipids contents, dimensions, and gelatinization characteristics of some wheat starches and their A– and B– granule fractions, *Journal of Science Food and Agriculture*, 36, pp709–718.
7. Peng M., Gao M., Abdel-Aal E.S.M., Hucl P., Chibbar R.N. (1999), Separation and Characterization of A- and B-type starch granules in wheat endosperm, *Cereal Chemistry*, 76, pp. 375–379.
8. Din Z., Xiong H., Fei P. (2015), Physical and chemical modification of starches: A review, *Critical Reviwes in Food Science and Nutrition*, 57, pp. 2691–705.
9. Liu H., Guo X., Li W., Wang X., Iv M., Peng Q. (2015), Changes in physicochemical properties and in vitro digestibility of common buckwheat starch by heat–moisture treatment and annealing, *Carbohydrate Polymers*, 132, pp. 237–244.
10. Gunaratne A., Hoover R. (2002), Effect of Heat–moisture treatment on the structure and physicochemical properties of tuber and root starches, *Carbohydrate Polymers*, 49, pp. 425–37.
11. Olayinka O.O., Adebowale K.O., Olu-Owolabi, B.I. (2008), Effect of heat moisture treatment on physicochemical properties of white sorghum starch, *Food Hydrocolloids*, 22, pp. 225–230.
12. Lacerda L.G., Azevedo J.A.M., Filho M. A.S.C., Demiate I. M., Schnitzler E., Vandenberghe L.P.S., Socool C.R. (2008), Thermal characterization of partially hydrolyzed cassava (*Manihot esculenta*) starch granules, *Brazilian Archives of Biology and Technology*, 51, pp. 1209–15.
13. Bet C.D., Cordoba L.P., Ribeiro L.S., Schnitzler E. (2016), Common Vetch (*Vicia sativa*) as a New Starch Source: Its Thermal, Rheological and Structural Properties After Acid Hydrolysis, *Food Biophysics*, 11(3), pp. 275–82.
14. Colman T.A.D., Demiate I.M., Schnitzler E. (2014), The effect of microwave radiation on some thermal, rheological and structural properties of cassava starch, Journal of Thermal Analysis and Calorimetry, 115, pp. 2245–2252.
15. Malucelli L.C., Lacerda L.G., Filho M.A.S.C., Rodríguez-Fernández D.E., Demiate I.M., Oliveira, C.S., Schnitzler, E. (2015), Porous waxy maize starch, *Journal of Thermal Analysis and Calorimetry*, 120(1), pp. 525–32.
16. Lacerda L.G., Filho M.A.S.C., Bauab T., Demiate I.M., Colman T.A.D., Andrade M.M.P., Schnitzler E. (2015), The effects of heat–moisture treatment on avocado starch granules, *Journal of Thermal Analysis and Calorimetry*, 120, pp. 387–393.
17. Aggarwal P., Dollimore D. (1998), A thermal analysis investigation of partially hydrolyzed starch, *Thermochimica acta*, 319, pp. 17–25.

18. Costa F.J.O.G., Leivas C.L., Waszczynskyj N., Godoi R.C.B., Helm C.V., Colman T.A.D., Schnitzler E. (2013), Characterisation of native starches of seeds of *Araucaria angustifolia* from four germplasm collections, *Termochimica acta*, 565, pp. 172–177.
19. Huang T.T., Zhou D.N., Jin Z.Y., Xu X.M., Cheb H.Q. (2015), Effect of debranching and heat–moisture treatments on structural characteristics and digestibility of sweet potato starch, *Food Chemistry*, 187, pp. 218–224.
20. Zavareze E.R., Storck C.R., Castro L.A.S., Schirmer M.A., Dias A.R.G.D. (2010), Effect of heat–moisture treatment on rice starch of varying amylose content, *Food Chemistry*, 121, pp. 358–365.
21. Chung H.J., Hoover R., Liu Q. (2009), The impact of single and dual hydrothermal modifications on the molecular structure and physicochemical properties of normal corn starch, *International Journal of Biological Macromolecules*, 44, pp. 203–210.
22. Franco C.M.L., Wong K.S., Yoo S.H., Jane J.L. (2002), Structural and functional characteristics of selected soft wheat starches, *Cereal Chemistry*, 79(2), pp. 243–8.
23. Batista W.P., Silva C.E.M., Liberato M.C. (2010), Propriedades químicas e de pasta dos amidos de trigo e milho fosforilados, *Ciência e Tecnologia de Alimentos*, 30, 88–93.
24. Cheetam N.W.H., Tao L. (1998), Variation in crystalline type with amylose content in maize starch granules: an X-ray powder diffraction study, *Carbohydrate Polymers*, 36(4), pp. 277–284.
25. Frost K., Kaminski D., Kirwan G., Lascaris E., Shanks R. (2009), Crystallinity and structure of starch using wide angle X–ray scattering, *Carbohydrate Polymers*, 78(3), pp. 543–548.
26. Singh H., Chang Y.H., Lin J.H., Singh N., Singh N. (2011), Influence of heat-moisture treatment and annealing on functional properties of sorghum starch, *Food Research International*, 44, pp. 2949–54.
27. Sui Z., Yao T., Zhao Y., Ye X., Kong X., Ai L. (2015), Effects of heat–moisture treatment reaction conditions on the physicochemical and structural properties of maize starch: Moisture and length of heating, *Food Chemistry*, 173, pp. 1125–1132.
28. Kurahashi Y., Hizukuri S. (1998), Modification of maize starch and wheat flows by heat moisture treatment. In: Program Book 1998. AACC Annual Meeting, Minneapolis, MN. 293–4.
29. Hu X.P., Zhang B., Jin Z.Y., Xu X.M., Chen H.Q. (2017), Effect of high hydrostatic pressure and retrogradation treatments on structural and physicochemical properties of waxy wheat starch, *Food Chemistry*, 232, 560–565.
30. Yonemoto P.G., Calori-Domingues M.A., Franco C.M.L. (2007), Efeito do tamanho dos grânulos nas características estruturais e físico–químicas do amido de trigo, *Ciência e Tecnologia de Alimentos*, 27(4), pp. 761–771.
31. Rafiq S.I., Singh S., Saxena D.C. (2016), Effect of heat-moisture and acid treatment on physicochemical, pasting, thermal and morphological properties of Horse Chestnut (*Aesculus indica*) starch, *Food Hydrocolloids*, 57, pp. 103–13.
32. Sun Q., Dai L., Nan C., Xiong L. (2014), Effect of heat moisture treatment on physicochemical and morphological properties of wheat starch and xylitol mixture, *Food Chemistry*, 143, pp. 54–59.
33. Lee C.J., Kim Y., Choi S.J., Moon T.W. (2012), Slowly digestible starch from heat–moisture treated waxy potato starch: preparation, structural characteristics, and glucose response in mice, *Food Chemistry*, 133, pp. 1222–1229.

Influence of plant raw materials on the alcohol infusions quality

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Abstract

Introduction. The aim of the work is to study the influence of plant raw materials on the alcohol infusions quality.

Materials and methods. For the preparation of plant raw materials, samples were taken and crushed: *Echinacea purpurea* root, *Rhodiola rosea* root, *Zingiber officinale* root, dried kelp *Laminaria*.

Study of sensory quality indicators of alcohol infusions from plant raw materials was carried out on a five-point scale, taking into account the weights; physico-chemical parameters is determined in relation to the volume fraction of alcohol, mass fraction of essential oil and the concentration of the general extract in the test solution.

Results and discussion. Consumer properties of alcohol beverages are formed at all stages of their production, so before adding alcohol to the finished drink was considered appropriate to investigate the quality of the obtained semi-finished products.

Organoleptic characteristics of alcohol infusions from plant raw materials have a harmonious pleasant taste and aroma, transparent, attractive color, no sediment.

The strength of the samples is in the range from 43.0 to 55.0% and is explained by the different concentration of alcohol in the water-alcohol mixture during the extraction of plant components. Fluctuations in the content of essential oil and extractives are due to the peculiarities of the chemical composition of vegetable raw materials.

The presence of biologically active substances, a number of vitamins and mineral compounds in the experimental samples of infusions allows them to be used in multi-component alcohol beverages, characterized by reduced toxic effect.

Conclusion. Alcohol infusions for further production of multicomponent alcohol beverages were obtained. The conducted researches for organoleptic and physico-chemical indicators give the bases to create a drink with the forecasted high indicators of quality.

Introduction

A large number of multicomponent alcohol beverages appear on the consumer market (Hall, Howe, 2012; Fujii, Kondo, 2018) [1, 2], which include ingredients that form the taste and aromatic characteristics of products, reduce the toxic effects of ethyl alcohol on the internal organs and reduce the effect of alcohol intoxication (Ahmed et al., 2010; Chandrasekara, Shahidi, 2018) [3, 4]. There are various ingredients added to alcohol beverages: plant extracts, organic salts and acids, vitamin and mineral complexes, antioxidants of plant and synthetic origin, biologically active additives and others (Iannitti, Palmieri, 2009; Buglass et al, 2012; Grunert et al, 2018; Kuzmin et al, 2020) [5-8] .

The most common ingredients (Andreou et al, 2018) [9] are extracts from plant materials, which alleviate the effects of intoxication, show a fairly high and stable therapeutic and prophylactic effect (Buglass, Caven-Quantrill, 2012) [6]. Modern technologies make it possible to obtain certain biologically active substances from plants (Bubalo et.al, 2018; Kuzmin et al, 2016) [10, 11] in the maximum amount with the least destruction, while maintaining high natural properties. Plant raw materials contain leukoanthocyanidins, catechins, sterols, aromatic aldehydes, organic acids, lignins, flavonols, reducing sugars, etc (Vergun et al, 2019; Gulua et al, 2018; Ahmed, Tavaszi-Sarosi, 2019; Igarashi, Miyazaki, 2013) [12-15].

Careful selection and quality control of the ingredients that make up alcohol beverages, their comprehensive study will allow to create a drink with specified properties and expand the range of alcoholic beverages .

Production of such products consists of three stages: preparatory, main and final. At the preparatory stage, semi-finished products are obtained: alcohol juices, infusions, morses, aromatic alcohols. The main stage of liquor production consists of blending components, thorough mixing, filtration and adurance. At the final stage of production, the finished drink is poured and decorated.

Ingredients such as *Echinacea purpurea, Rhodiola rosea, Ginger, Laminaria hyperborea* dried are selected to create new alcoholic beverages, based on the method of a priori ranking of factors (Holovko et al, 2017) [16].

Echinacea purpurea root has multiple biological effects, including immunomodulatory and antioxidant activity. The most active compounds of E. purpurea are polyphenols – caffeic acid derivatives: caftaric acid, chlorogenic acid, cynarin, echinacoside and cichoric acid (Oniszczuk et al, 2016) [17]. *Echinacea purpurea* contains: antioxidant enzymes catalase, peroxidase, ascorbate peroxidase and superoxide dismutase, dry matter of processes, chlorophyll, carotenoid, proline, phenol, flavonoid and Malondialdehyde (Darvizheh et al, 2018) [18]. The hydroethanolic extract of fresh plant revealed the highest activity, directly related with its higher contents in phenolic (229.22±4.38 mg gallic acid equivalent [GAE]/mL), flavonoids (124.83±7.47 mg GAE/mL), organic acids (8.89±0.10 g/100 g), and tocopherols (4.55±0.02 mg/100 g) (Pires et al, 2016) [19].

The herbal supplement *Rhodiola rosea* extract reduced the oxidative stress produced, could exert a protective antioxidant role during intense physical exercise (Sist et al, 2018) [20]. *Rhodiola rosea* has significant activity that destroys free radicals and increases antioxidant activity (Zhou et al, 2018) [21]. Rhodiola rosea root used as an adaptogen to increase an organism's resistance to physical stress. Recent research has demonstrated its ability to improve mental and physical stamina, to improve mood, and to help alleviate high-altitude sickness (Schriner et al, 2009) [22].

Ginger root is widely used as a spice and in practice of traditional Chinese herbal medicine (Zhao et al, 2011; Masuda et al, 2004; Tapsell et al, 2006) [23–25]. *Ginger* and its

main compounds have shown various pharmacological effects including immunomodulatory, antitumorigenic, antiinflammatory, antiapoptotic, antihyperglycemic, antilipidemic, and antiemetic effects (Zhao et al, 2011; Ali et al, 2008) [23, 26]. *Ginger* has been reported to enhance animals' nutrient digestion and absorption because of the positive effects on the gastric secretion, enterokinesia, and digestive enzyme activities (Zhao et al, 2011; Platel, Srinivasan, 2000) [23, 27]. Furthermore, ginger contains several compounds such as gingerol, shogaols, gingerdiol, gingerdione, and some relating phenolic ketone derivatives (Zhao et al, 2011; Kikuzaki, Nakatani, 1996; Fuhrman et al, 2000) [23, 28, 29] that possess antioxidant activity.

Brown seaweed *Laminaria* represents a good source of polysaccharides with significant antioxidant activity (Sun et al, 2018) [30]. *Laminaria* contains about 40 macro- and microelements, vitamins A, B, C, D, E and other nutrients, alginates, which have powerful sorption properties, remove toxins, radionuclides and other harmful substances from the body.

These circumstances determine the relevance of this work, which is to find and develop multicomponent alcohol beverages with reduced toxic effects.

The aim of the work is to study the influence of plant raw materials on the alcohol infusions quality.

When achieving this goal, it is necessary to solve the following *problems*:

– identify the most promising sources of plant raw materials for use in the technology of alcohol beverages;
– investigate the quality indicators of alcohol infusions from plant raw materials.

Materials and methods

Materials

Plant raw materials samples of *Echinacea purpurea* (root), *Rhodiola rosea* (root), *Ginger* (root), *Laminaria* (dried) were selected and crushed, in accordance with the requirements of technological instructions on liquor production, with the help of a herbal cutter to a particle size of 15– 20 mm.

Infusion parameters were chosen in accordance with the Technological Regulations for the production of alcoholic beverages.

During the development of the recipe composition of semi-finished products, the maximum permissible concentration of the introduction of plant raw materials is essential.

According to (Mashkovskiy et al, 1990) [31] amount of raw materials, which reveals the minimum therapeutic effect, when added to liquor products should not exceed 1/3 of its daily rate per 1 liter of the drink.

The amount of single alcohol consumption varies within significant limits depending on individual sensitivity, diet features, social status, physical activity, etc. Based on the experience of studying phytoextractors by scientists of the National Pharmaceutical University (Kharkiv), a rational range of the amount of introduction of plant raw materials was determined, provided that its preventive action was maintained and taking into account the maximum possible disposable amount of alcohol consumption . Rational interval of the number of components for alcohol infusions (Holovko et al, 2011; Holovko et al, 2013) [32, 33]:

Echinacea purpurea root – 5.0–7.0 kg,
Rhodiola rosea root – 1.0– 2.0 kg,
Ginger root – 3.0– 5.0 kg,
Laminaria dried – 4.0– 6.0 kg.

The principle scheme of preparation is given in Table 1.

Table 1

Principle scheme of the alcohol infusions preparation from vegetable raw materials

Raw materials	Raw	Pouring 1			Infusion 1 drain			Pouring 2			Infusion 2 drain			
		water-alcohol mixture			Number			water-alcohol mixture						
	consumption, kg	quantity, dm^3	strength, %	infusion period, days	dm^3	% of poured water-alcohol mixture	strength, %	quantity, dm^3	strength, %	infusion period, days	dm^3	% of poured water-alcohol mixture	strength, %	received all infusions 1 and 2 drain, dm^3
Echinacea purpurea (root)	5.0	50	60	5	40.0	80	59	40.0	50	5	40.0	100	53	80.0
	6.0	60			48.0			48.0			48.0			96.0
	7.0	70			56.0			56.0			56.0			112.0
Rhodiola rosea (root)	1.0	10	70	5	7.5	75	69	7.5	50	5	7.5	100	55	15.0
	1.5	15			11.3			11.3			11.3			22.5
	2.0	20			15.0			15.0			15.0			30.0
Ginger (root)	3.0	30	70	5	25.5	85	69	25.5	50	5	25.5	100	53	51.0
	4.0	40			34.0			34.0			34.0			68.0
	5.0	50			42.5			42.5			42.5			85.0
Laminaria (dried)	4.0	80	45	7	64.0	80	43	–	–	–	–	–	–	64.0
	5.0	100			80.0			–			–			80.0
	6.0	120			96.0			–			–			96.0

Description of methods

Methods of organoleptic evaluation and physicochemical parameters

To effectively assess the organoleptic properties of infusions, a list of descriptors was formed. The most acceptable is the method of visualization of organoleptic parameters of products in the form of profilograms, which can be used to assess the intensity, originality, coherence, expression of taste, aroma and color of alcohol semi-finished products. The obtained values of organoleptic parameters were used to determine the quality criterion of the profile [7, 16].

The quality of infusions by physico-chemical parameters is determined in relation to the volume fraction of alcohol, mass fraction of essential oil and the concentration of the general extract in the test solution. The number of these indicators is fundamental in determining the quality of alcohol beverages [16, 33, 34].

Chromatographic method

To determine the content of the active compounds that go into the infusions obtained, the method of highly effective gas chromatography [5, 11, 14, 34] was used. The study was carried out on the Agilent GC System gas chromatography with a mass selective detector, with a column "HP-5" with a length of 30 mm, an internal capillary diameter of 0.32 mm, a layer of stationary phase 0.25 μm.

When conducting chromatographic analysis according to this method, the appropriate temperature regime of the chromatograph is observed: from the moment of injection of the analyzed raw materials into the evaporator of the chromatograph in the column thermostat, the initial temperature of 30 °C is observed, which is gradually increased to 300 °C at a speed of 20 °C/min., sample volume – (1,0±0,1) mg, time of experiment 18 min.

Results and discussions

Results of organoleptic characteristics

Consumer properties of multicomponent alcohol beverages are formed at all stages of their production, so before adding to the finished drink, the quality of semi-finished products was investigated (Table 2)

Table 2

Results of organoleptic characteristics of the alcohol infusions quality from plant raw materials

Samples	Indicator	
	Appearance	Color, taste, aroma
Prototype	Clear, without sediment and impurities liquid, permissible opalescence, which disappears after filtration	Inherent in the plant raw materials from which they are made, without extraneous taste and smell
Infusion of Echinacea purpurea (root)	Clear liquid without sediment and impurities	Brown color with shine, taste coordinated, pleasant, aroma corresponding to the raw materials used, without extraneous taste and smell
Infusion of Rhodiola rosea (root)		Brown color, pleasant taste and aroma that fully corresponds to the raw materials used, without extraneous taste and smell
Infusion of Ginger (root)		Burning and spicy taste, pleasant aroma that corresponds to the raw materials used, without extraneous taste and smell, light yellow color
Infusion of Laminaria (dried)		Light green color, corresponding to the basic raw material, inherent taste and aroma, without extraneous taste and smell.

Analyzing the obtained data, we can conclude that the sensory indicators of developed alcohol infusions from plant raw materials have a harmonious pleasant taste and aroma, are transparent, have no sediment, attractive color and fully meet the requirements of the prototype (Holovko et al, 2011; Holovko et al, 2013) [32, 33].

Results of physico-chemical studies

The study results of the alcohol infusions on physico-chemical parameters are given in Table 3.

Table 3

Results of physico-chemical parameters of the alcohol infusions quality from plant raw materials

$p \geq 0,95$, n=5

Samples	Volume fraction of ethyl alcohol, %	Mass fraction of essential oil, %	Mass concentration of general extract, g/100 cm^3
Prototype	20.0 – 90.0	0.0 – 15.0	0.1 – 20.0
Infusion of Echinacea purpurea (root)	53.0±1.1	–	3.2±0.1
Infusion of Rhodiola rosea (root)	55.0±1.1	–	2.5±0.1
Infusion of Ginger (root)	53.0±1.1	0.048±0.002	2.6±0.1
Infusion of Laminaria (dried)	43.0±0.9	–	1.2±0.1

According to the results of physico-chemical parameters of developed infusions, it can be concluded that the strength of the samples is in the range from 43.0 to 55.0% and is explained by the different concentration of alcohol in the water-alcohol mixture during the extraction of plant components (Holovko et al, 2015) [34]. Fluctuations in the content of essential oil and extractive substances is associated with the peculiarities of the chemical composition original plant raw materials.

Results of chromatographic studies

According to the results of the study of the qualitative composition of alcohol infusions from plant raw materials, chromatograms of experimental samples were obtained (Fig. 1-4).

In the Figure 1 shows the presence in experimental samples vitamin C (peak 13.640) and vitamins A, E, peaks of 15.996 and 17.826, respectively. Peak 16.665 is responsible for the presence of selenium, and peaks of 10.585 and 12.676 for polysaccharides. The alcohol content characterizes a peak of 5,837.

From the Figure 2 it can be argued that the composition of the alcohol infusion from the Rhodiola rosea (root) contains phenolic compounds (peak 10.636), organic acids, namely amber, lemon (12.1262, 14.537), flavonoids (peak 4.566), alkaloids (10.636) and ethyl alcohol (peak 5.792).

As can be seen from the Figure 3 to the infusion of alcohol from the Ginger (root) go linoleic, caprylic, caffeic and oleic acids (peaks 16.665, 18.090, 18.349, 19.205), vitamin C (12.709), capsaicin (peak 4.697) and curcumin (4.599). The content of ethyl alcohol is peak 5.792.

The chromatogram of alcohol infusion of Laminaria (dried) (Figure 4) noted the presence of polysaccharides (peak 12.684), alginic acid (19.383), B vitamins (12.658). Peak 5.762 determines the content of ethyl alcohol.

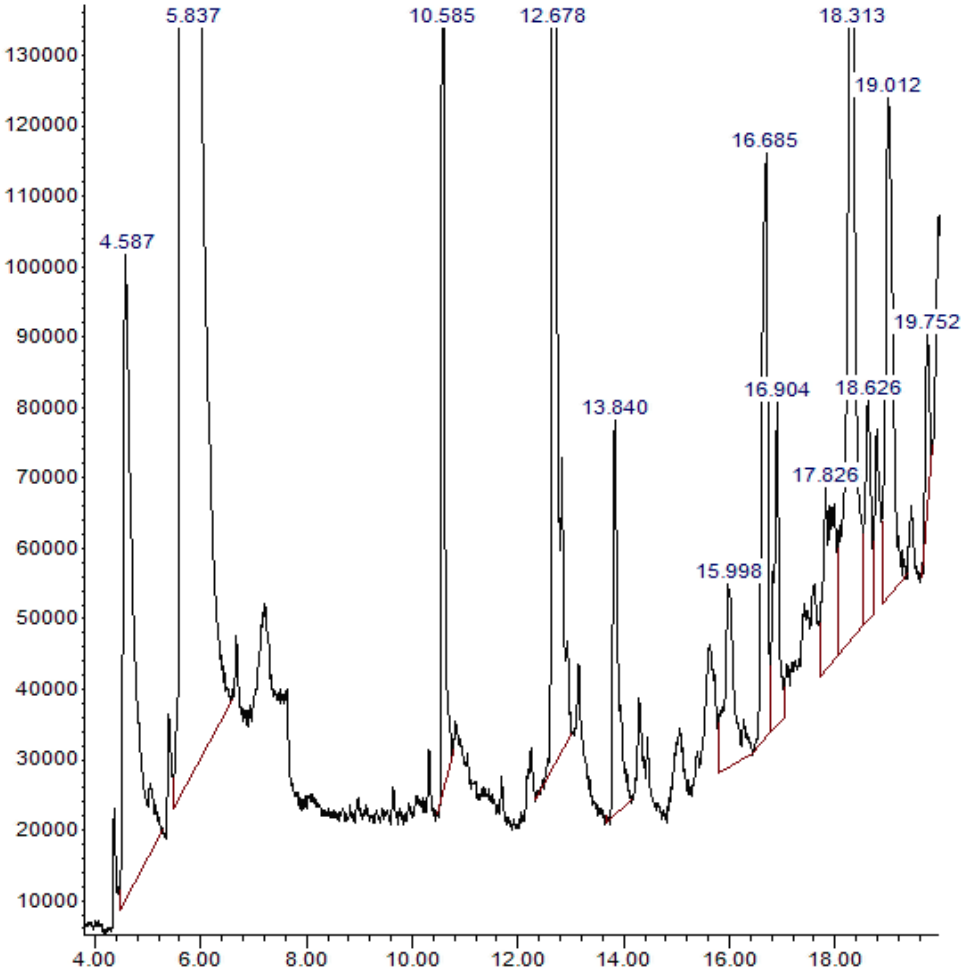

Figure 1. Chromatograms of the alcohol infusions from plant raw materials: *Echinacea purpurea* (root)

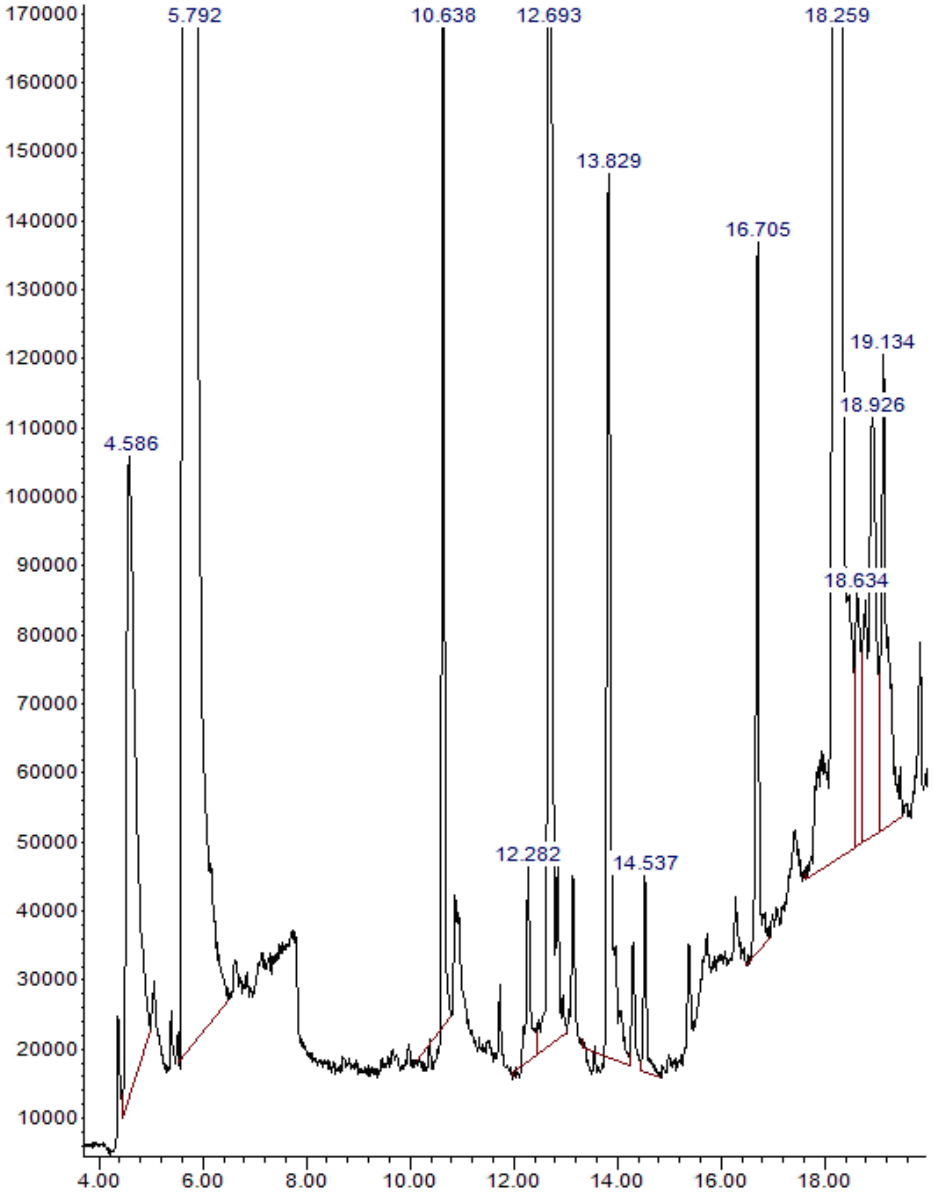

Figure 2. Chromatograms of the alcohol infusions from plant raw materials: *Rhodiola rosea* (root)

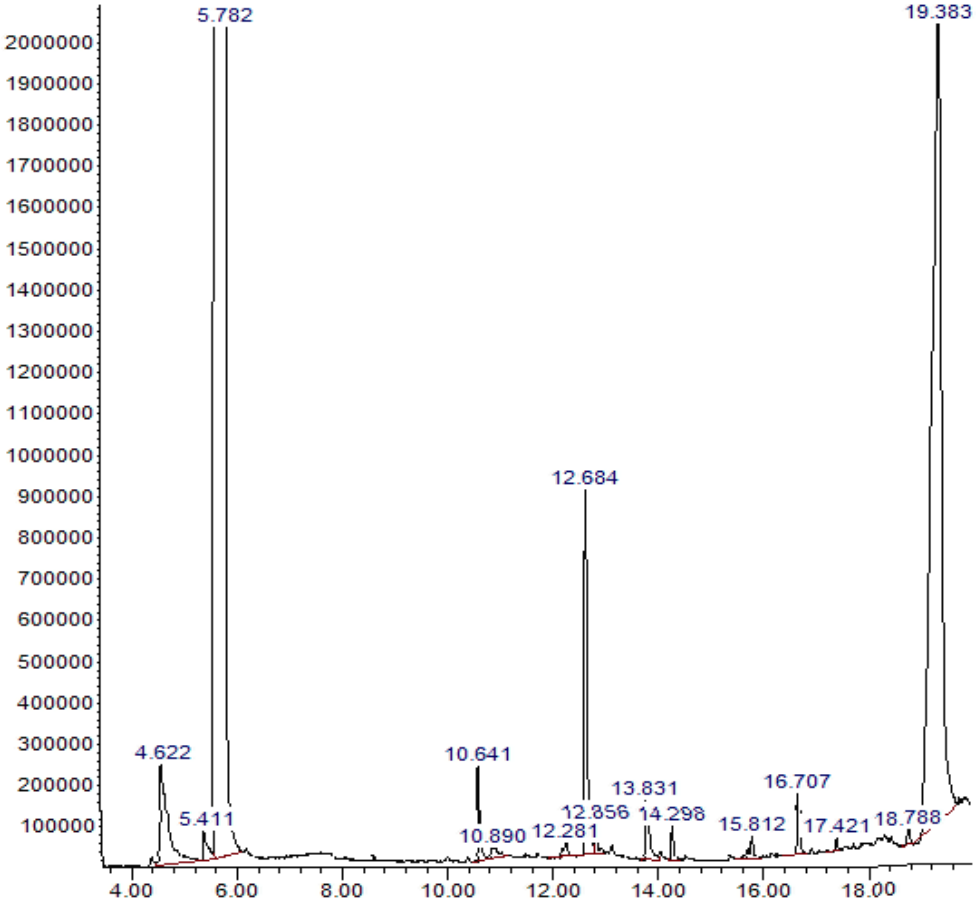

Figure 3. Chromatograms of the alcohol infusions from plant raw materials: *Ginger* (root)

According to chromatographic studies, there is a presence of biologically active substances, a number of vitamins and mineral compounds in the experimental samples of infusions.

This suggests that the formed multicomponent alcohol beverages have a reduced toxic effect. This is manifested in the inhibition of ethanol metabolism or in the weakening of the toxic effects of acetaldehyde – an essential intermediate in the process of ethanol utilization, which determines the full range of dysfunction of human systems and organs [4, 5, 8, 12, 32, 34].

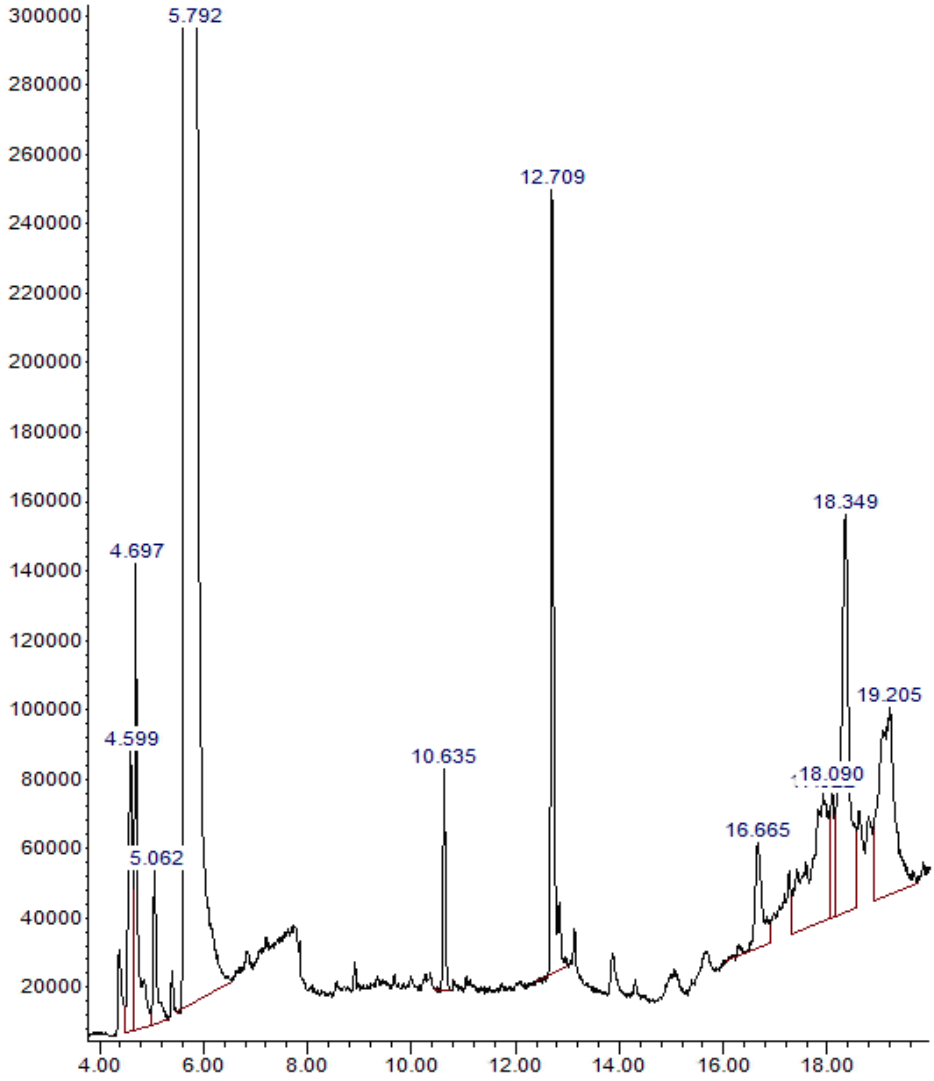

Figure 4. Chromatograms of the alcohol infusions from plant raw materials: *Laminaria* (dried).

Conclusions

1. Alcohol infusions for further production of multicomponent alcohol beverages were obtained.
2. Conducted studies on organoleptic and physico-chemical parameters are in good agreement with control samples.
3. These chromatograms suggest the presence of biologically active substances, a number of vitamins and mineral compounds in experimental infusion samples, which allowed us to create a drink with predicted high quality indicators.

References

1. Hall G.M., Howe J. (2012), Energy from waste and the food processing industry, *Process Safety and Environmental Protection*, 90(3), pp. 203–212.
2. Fujii H., Kondo Y. (2018), Decomposition analysis of food waste management with explicit consideration of priority of alternative management options and its application to the Japanese food industry from 2008 to 2015, *Journal of Cleaner Production*, 1881, pp. 568–574.
3. Ahmed O.M., Moneim A.A., Yazid I.A., Mahmoud A.M. (2010), Antihyperglycemic, antihyperlipidemic and antioxidant effects and the probable mechanisms of action of Ruta graveolens infusion and rutin in nicotinamide–streptozotocin–induced diabetic rats, *Diabetologia croatica*, 39(1), pp. 15–35.
4. Chandrasekara A., Shahidi F. (2018), Herbal beverages: Bioactive compounds and their role in disease risk reduction – A review, *Journal of Traditional and Complementary Medicine*, 8(4), pp. 451–458.
5. Iannitti T., Palmieri B. (2009), Antioxidant therapy effectiveness: an up to date, *European Review for Medical and Pharmacological Sciences*, 13, pp. 245–278.
6. Buglass A.J., Caven–Quantrill D.J. (2012), Applications of natural ingredients in alcoholic drinks, *Natural Food Additives, Ingredients and Flavourings*, 16, pp. 358–416.
7. Grunert K.G., Hieke S., Juhl H.J. (2018), Consumer wants and use of ingredient and nutrition information for alcoholic drinks: A cross-cultural study in six EU countries, *Food Quality and Preference*, 63, pp. 107–118.
8. Kuzmin O., Kucherenko V., Sylka I., Isaienko V., Furmanova Y., Pavliuchenko E., Hubenia V. (2020), Antioxidant capacity of alcoholic beverages based on infusions from non–traditional spicy–aromatic vegetable raw materials, *Ukrainian Food Journal*, 9(2), 404–424.
9. Andreou V., Strati I.F., Fotakis C., Liouni M., Sinanoglou V.J. (2018), Herbal distillates: A new era of grape marc distillates with enriched antioxidant profile, *Food Chemistry*, 253, pp. 171–178.
10. Bubalo M.C., Vidovic S., Redovnikovic I.R., Jokic S. (2018), New perspective in extraction of plant biologically active compounds by green solvents, Food and Bioproducts Processing, 109, pp. 52–73
11. Kuzmin O., Kovalchuk Y., Velychko V., Romanchenko N. (2016), Improvement technologies of aqueous-alcoholic infusions for the production of syrups, *Ukrainian Journal of Food Science*, 4(2). pp. 258–275
12. Vergun O., Svydenko L., Grygorieva O., Shymanska O., Rakhmetov D., Brindza J., Ivanišová E. (2019), Antioxidant capacity of plant raw material of Scutellaria baicalensis Georgi, *Potravinarstvo Slovak Journal of Food Science*, 13(1), pp. 614–621.
13. Gulua L., Nikolaishvili L., Jgenti M., Turmanidze T., Dzneladze G. (2018), Polyphenol content, anti–lipase and antioxidant activity of teas made in Georgia, *Annals of Agrarian Science*, 16 (3), pp. 357–361.
14. Ahmed H.M., Tavaszi-Sarosi S. (2019), Identification and quantification of essential oil content and composition, total polyphenols and antioxidant capacity of Perilla frutescens (L.) Britt, *Food Chemistry*, 2751, pp. 730–738.
15. Igarashi M., Miyazaki Y. (2013), A review on bioactivities of perilla: progress in research on the functions of perilla as medicine and food, *Evid Based Complement Alternat Med*, 2013, pp. 1–7.
16. Holovko M., Penkina N., Kolesnyk V., Polupan V. (2017), Vykorystannya metodu apriornoho ranzhyruvannya chynnykiv pid chas stvorennya retseptur alkohol′nykh napoyiv, *Naukovi pratsi NUFT*, 23, pp. 200–207
17. Oniszczuk T., Oniszczuk A., Wójtowicz A. (2016), Active polyphenolic compounds, nutrient contents and antioxidant capacity of extruded fish feed containing purple

coneflower (Echinacea purpurea (L.) Moench.), *Saudi Journal of Biological Sciences*, 26(1), pp. 24–30.
18. Darvizheh H., Zahedi M., Razmjoo J. (2018), Changes in some antioxidant enzymes and physiological indices of purple coneflower (Echinacea purpurea L.) in response to water deficit and foliar application of salicylic acid and spermine under field condition, *Scientia Horticulturae*, 247, pp. 390–399.
19. Pires C., Martins N., Ferreira I.C.F.R. (2016), Phytopharmacologic preparations as predictors of plant bioactivity: A particular approach to Echinacea purpurea (L.) Moench antioxidant properties, *Nutrition*, 32(7–8), pp. 834–839.
20. Sist P., Tramer F., Sciancalepore M. (2018), Rhodiola rosea, a protective antioxidant for intense physical exercise: An in vitro study, *Journal of Functional Foods*, 48, pp. 27–36.
21. Zhou Q., Han X., Dong X. (2018), Anti-atherosclerosis of oligomeric proanthocyanidins from Rhodiola rosea on rat model via hypolipemic, antioxidant, anti–inflammatory activities together with regulation of endothelial function, *Phytomedicine*, 51, pp. 171–180.
22. Schriner S.E., Avanesian A., Jafari M. (2009), Protection of human cultured cells against oxidative stress by Rhodiola rosea without activation of antioxidant defenses, *Free Radical Biology and Medicine*, 47(5), pp. 577–584.
23. Zhao X., Yang Z.B., Zhang G.G. (2011), Effects of ginger root (Zingiber officinale) on laying performance and antioxidant status of laying hens and on dietary oxidation stability, *Poultry Science*, 90(8), pp. 1720–1727.
24. Masuda Y., Kikuzaki H., Hisamoto M., Nakatani N. (2004), Antioxidant properties of gingerol related compounds from ginger, *Biofactors*, 21, pp. 293–296.
25. Tapsell L.C., Hemphill I., Cobiac L., Patch C.S., Sullivan D.R., Fenech M., Roodenrys S, Keogh J.B., Clifton P.M., Williams P.G., Fazio V.A., Inge K.E. (2006), Health benefits of herbs and spices: The past, the present, the future, *Med. J. Aust.*, 185, pp. 4–24.
26. Ali B.H., Blunden G., Tanira M.O., Nemmar A. (2008), Some phytochemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): A review of recent research, *Food Chem. Toxicol.*, 46, pp. 409–420.
27. Platel K., Srinivasan K. (2000), Influence of dietary spices and their active principles on pancreatic digestive enzymes in albino rats, *Nahrung*, 44, pp. 42–46.
28. Kikuzaki H., Nakatani N. (1996), Cyclic diarylheptanoids from rhizomes of Zinnger officinale, *Phytochemistry*, 43, pp. 273–277.
29. Fuhrman B., Rosenblat M., Hayek T., Coleman R., Aviram M. (2000), Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein E–deficient mice, *J. Nutr.*, 130, pp. 1124–1131.
30. Sun Y., Hou S., Liu N., (2018), Impact of acidic, water and alkaline extraction on structural features, antioxidant activities of Laminaria japonica polysaccharides, *International Journal of Biological Macromolecules*, 112, pp. 985–995.
31. Mashkovskiy M. (1990), Obshchiye metody analiza. Lekarstvennoye rastitel'noye syr'ye, pp. 399.
32. Holovko M., Penkina N., Kolesnyk V. (2011), Antyoksydantni vlastyvosti deyakykh vydiv roslynnoyi syrovyny, *Eastern-European Journal of Enterprise Technologies*, 4/6(52), pp. 9–11.
33. Holovko M., Penkina N., Kolesnyk V. (2013), Otsinka yakosti novykh vydiv nastoyanok zi znyzhenym toksychnym efektom, *Prohresyvni tekhnika ta tekhnolohiyi kharchovykh vyrobnytstv restorannoho hospodarstva i torhivli*, 2(18), pp. 211– 21.
34. Holovko M., Penkina N., Kolesnyk V. (2015), Kompleksna otsinka yakosti novykh vydiv spyrtovykh nastoyanok, *Visnyk Khersonskoho natsionalnoho tekhnichnoho universytetu*, 2(53), pp. 23–27.

Assessing the quality of fried bean cake made from blend of cowpea and walnut flours

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Abstract

Introduction. This work evaluated the quality of dried fried cake from the flour blends by examining the functional and physicochemical properties, as well as safety of the final product.

Materials and methods. Flour of walnut was blended with that of cowpea in the ratio 3% to15% to produce dried bean cake, which was analysed for physico-chemical properties and storability, as well as the functional properties of the flour samples.

Results and discussion. Cowpea flour had higher bulk density (0.86g/ml>0.77g/ml), while water and oil absorptions and swelling capacities of the cowpea were significant ($p \leq 0.05$) to that of walnut (1.78g/g > 0.85g/g), (1.97g/g > 1.29g/g) and (1.04 > 0.64) respectively. Control sample (sample without walnut) had higher protein (17.81%), moisture (6.55%) and fibre (1.58%), but fat and ash contents were significant lower in sample with walnut incorporation. Sample with 15% walnut had higher quantities of calcium (1.69mg/l) and magnesium (3.70mg/l), but the control was higher in sodium (4.00 mg/l) and potassium (3.14 mg/l). Sample with 6% walnut was the hardest (163.58 N), and 12% walnut sample, the least (26.27N). The L*, a* and b* values were significant. Control sample was lighter, and 15% walnut sample, the darkest, which may be to the high walnut content. Samples with 12% and 15% samples respectively had the least bacterial (4.0×10^4 cfu/g) and fungal (1.4×10^4 cfu/g) counts after eight weeks. Walnut addition inhibited microbial growth due to its antimicrobial and antioxidant properties. The control sample was rated best for appearance, crispiness and texture, while 9% walnut sample was the best accepted and rated for flavour and taste.

Conclusion. Walnut addition conferred extended shelf life and improved nutritional quality to the product.

Introduction

Cowpea *(Vigna unguiculata*) is a pulse belonging to the *leguminosae* family (Hoover *etal*., 2010), and native to West Africa, particularly Nigeria, and considered main species diversity according to Leao *et al*., 2016. It is a cheap and good source of protein that contributes substantially to protein intake of large portion of the world's population (Gepts *et al*., 2005). As a result of the expensive cost of animal protein sources, most especially in the third world countries of the world, where per capital income is very low, legumes have thus become a very good alternative source of protein to animal meats (Akinyele and Onigbinde, 1988), as its regular consumption could help improve protein intake of people (Oyeleke and Oyedeji, 2011), thoughprotein energy malnutrition (PEM) is still a prevalent deficiency in many countries worldwide with its high consumption, probably due to increasing world population or unavailability. Cowpea could be boiled or processed into bean pudding (*moin moin),* bean cake (*akara*) or used locally to make indigenous soup called *gbegiri* in Yoruba speaking area of Nigeria or processed into flour for other uses. Legume protein is deficient in sulfur amino acid such as cysteine and methionine (Ihekoronye and Ngoddy, 1985), likely due to the presence of oligosaccharides and phenolic compounds. Low protein digestibility, presence of anti-nutritional factors such as trypsin inhibitors, tannins and phytates, polyphenols and flatulence factors could be reasons legumes are under-utilised (Enujiugha, 2003; Olapade *et al*., 2002), but processing techniques with longer cooking time probably reduced the challenges (Olapade *et al*., 2002).

African walnut (*Tetracarpidium conophorum*), a member of the *Euphorbiaceae* family, is a climber found in the wet parts of East and West part of Nigeria and the Western Africa (Kanu *et al*., 2015). It is known as *Ekporo* by Efik and Ibibios of Cross River and Akwa Ibom, Ukpa (Igbo), Awusa or Asala (Yoruba), Okhue or Okwe (Edo), and Gawudi bairi by the Hausas in Nigeria etc. The fruits (four brown round seeds) are up to 3 inches in diametre (Nuhu *et al*., 2000). They could be cooked and consumed as snacks (Enujiugha and Ayodele,2003); roasted or sun dried and grounded like melon seeds to be used as soup thickener. Walnuts are nutrient-rich, as they are high in fat, proteins, vitamins and minerals, and a good source of calories, about 600J (Ndie *et al*., 2010). According to Hassan and Umar (2006), plant foods that sourced over 12% of its energy from protein is considered a high protein source, and according to Kanu *et al*. 2015, walnut supplies about 23.0–28% of daily protein needs, while Amaral *et al.*, 2004 and Savage *et al*., 2001 reported 18.1%. However, Harold and Tatura (2002) reported that on percentage wet basis, protein has (14.92%), oil (45.84%), fibre (1.14%), ash (3.52%) and carbohydrate (15.38%). Despite its richness, walnut is yet to be an industrial raw material in Nigeria, probably due to unavailability of improved storage facilities (Hemery, 2001).

Dried fried cake known as "*Akara egbe*" in this part of the world is a traditional snack native to Ogbomoso town in Oyo State, Nigeria (Falade *et al*., 2003), and produced from cowpea paste seasoned with salt, flattened with palms and deep-fried to produce a reddish brown, hard textured and low moisture product (Giami *et al*., 2004). It is usually eaten as snacks alone or with cereal porridge or soaked cassava flakes (*garri*)(Falade *et al*., 2003). However, its consumption has spread nationwide (Lateef *et al*., 2010), and worldwide, with research work on it acceptability done by McWatters *et al.*, 1997; Patterson *et al.*, 2002.

Antioxidant properties of walnut could help lower the risk of chronic oxidative stress; anti-inflammatory properties could help reduce chronic inflammation, as the two activities posed great threat to cancer development. Walnut extracts, which are rich in dietary Omega-3- fatty acids, may equally play role in the prevention of some disorders including depression, as well as dementia especially Alzheimer's disease, with lowering cholesterol properties

(Chauhan *et al*., 2004). As a result of these numerous benefits, blending walnut with cowpea to produce dry bean cakecould help extend shelf life, keep consumers safe from a number of diseases and equally lead to increased planting and income generation to farmers. This work evaluated the quality of dried fried cake from the flour blends by examining the functional and physicochemical properties, as well as safety of the final product.

Materials and methods

Cowpea was sourced within Ilorin metropolis, while the walnuts used were purchased from Ilesha, all in Nigeria. Cleaned cowpeas were soaked in water for five minutes, de-hulled, washed and drained to remove excess water and dried at 70 ºC for 9 hours. Dried walnut (at 60 ºC for 5 hours) and cowpea were milled into fine flour and stored at 4 ºC. The walnuts were thinly sliced before drying. The walnut flour was added to the cowpea flour to make dried bean cake at 3, 6, 9, 12 and 15% respectively. A thick paste was formed with little quantity of water added to the flour blend, stirred properly after seasoning with salt, molded and flattened into various shapes and deep-fried at 100 ºC for 3–5 minutes, drained and cooled (10–15 minutes). Deep fried again at 100 ºC for 5–10 minutes for dryness, drained and cooled for 20–30 minutes before packaging.

Proximate Analysis

The proximate composition of the samples was determined according to the standard method of AOAC (2005).

Functional Properties of Cowpea and Walnut flours

Determination of Bulk Density (BD). The method of Oyeyinka *et al*., 2014 was adopted for bulk density, where a measuring cylinder (100 ml) was filled to mark, and the content weighed. It was tapped 50 times prior to re-weighing. Bulk density was calculated as the ratio of the bulk weight and the volume of the container (g/ml).

Determination of Water Holding Capacity (WAC). The method of Oyeyinka *et al*., 2013 was adopted. 1g of sample was weighed into a dry, clean centrifuge tube.10ml of water was poured into the tube and properly mixed. The suspension was allowed to stand for 30 minutes and centrifuged at 3500rpm for 30 minutes. The supernatant was discarded and the tube with its content re-weighed and weight gain expressed as percentage water bound.

Determination of Oil Absorption Capacity (OAC). The oil absorption capacity (OAC) was determined by the method of Oyeyinka *et al*., 2013. The format for water holding capacity was adopted, but here, oil was used instead of water.

Determination of Swelling Index (SI). One gram of the flour was weighed into a 10ml graduated measuring cylinder, leveled, and volume recorded. 5ml of distilled water was added, swirled and allowed to stand for 30 minutes. The change in volume after swelling was recorded (Abbey and Ibbeh, 1998).

Texture Analysis of Fresh and Stored Samples. The method of Friedman *et al*., 1963 was adopted for the textural quality of the fried cake samples. The samples were compressed twice in a reciprocating motion in an Instron universal testing machine equipped with a 50kg

load cell. The tests were conducted at crosshead with chart speeds of 60 and 102mm/min respectively. Textural parameters were derived from force-deformation curves based on the Friedman *etal*., 1963 definition.

Microbial Analysis of the Fried Cake Samples. Bacterial and fungal counts of the samples were carried at 4-week interval using Fawole and Osho's method (2007). Quantitative bacteriological analysis was done using total plate count on nutrient agar (NA), while fungi isolation was done with potato dextrose agar (PDA) and expressed in cfu/g. The plates were incubated at 37 ºC for 24 hours for bacterial counts, and 72 hours at 27 ºC for fungal counts.

$$\text{Counts } (\text{cfu/g}) = \frac{\text{Number of colonies} \times \text{dilution factor}}{\text{Volume of diluent plated}}$$

Colour Determination of the Fried Cakes. Fried cake samples were evaluated for L*, a*, b* parameters with a Minolta CR-310 (Minolta camera Co. Ltd., Osaka, Japan) tristimulus colorimeter. L* represented lightness (with 0=darkness/blackness to 100=perfect/brightness); a*(extent of green colour, ranging from negative=green to positive=redness); and b* represents blue and range from negative=blue to positive=yellow. The colorimeter was calibrated against a standard white reference tile.

Mineral Contents Determination. AOAC, 2005 standard method was adopted using atomic absorption spectrometry, flame photometry and spectrophotometry. For wet digestion of sample, 1g of the powdered sample was measured into the digesting glass tube, with 12mls of HNO_3 added and the mixture kept overnight at room temperature. About 4 mls of perchloric acid ($HClO_4$) was added and the mixture placed in the fume block for digestion, with the temperature increased gradually from 50 ºC to between 250-300 ºC for complete digestion within 70-85 minutes. Upon cooling, the content of the tube was transferred to 100 ml volumetric flask and made up to 100 ml with distilled water. It was then transferred into plastic bottles, and used for mineral determination.

Sensory Evaluation. Sensory evaluation was done by 50-member panelist who assessed samples' appearance, taste, aroma, texture and general acceptability on 9-point hedonic scale ranging from liked extremely (9) to disliked extremely (1).

Statistical Analyses. The result was analyzed using SPSS version 16.0, and mean separated by Duncan multiple tests. The analysis was done in triplicate.

Results and discussion

Functional properties of cowpea and walnut flours

Bulk density of walnut flour was 0.77g/ml, and that of cowpea was 0.85g/ml (Table 1), with no significant difference noticed. Cowpea value was similar to that of other cowpea varieties, according to Ikpeme *et al*., 2010. The differences could be due to particle sizes, density and possibly, moisture content of the flour, which is important for packaging and material handling (Kumar *et al*., 2010). However, higher values show greater compactness

of particles, but low value influenced loose structure of starch polymer (Oyeyinka *et al*., 2015).

Oil absorption capacity of walnut (1.29g/g) was significantly ($p \leq 0.05$) lower than that of cowpea (1.98g/g), but higher than 1.06g/g reported for walnut by Ekwe and Ihemeje, 2013, and higher than 0.39-0.53g/g reported by Chinma *et al*., 2008**.** Oil absorption indicates the rate at which proteins bind to fat in food formulations and important for flavour retention, shelf life and palatability (Oyeyinka *et al*., 2013), thus favouring low value (Odedeji and Oyeleke, 2011).

Water absorption capacity of cowpea flour (1.77g/g) was significantly ($p \geq 0.05$) higher than that of walnut (0.85g/g), depicting the extent of protein incorporation into aqueous food formulations (Giami *et al*., 2003). Low water absorption of walnuts may be due to its high oil content, which might have limited the absorption, or affected by differences in starch content, composition and granule structure (Oyeyinka *et al.,* 2015), as higher water absorption ability helps to improve yield and consistency of products. The swelling capacity showed significant difference with 1.05 reported for cowpea, and 0.64 for walnut. This parameter is controlled by strength and character of the micellar network between starch granules.

Table 1

Functional properties of cowpea and walnut flours

Samples	Bulk Density (g/ml)	Water Absorption Capacity (g/g)	Oil Absorption Capacity (g/g)	Swelling Index
Cowpea	$0.86^{a} \pm 0.01$	$1.78^{a} \pm 0.00$	$1.98^{a} \pm 0.01$	$1.05^{a} \pm 0.01$
Walnut	$0.77^{a} \pm 0.1$	$0.85^{b} \pm 0.00$	$1.29^{b} \pm 0.03$	$0.64^{b} \pm 0.03$

Proximate Composition of Fresh and Stored Fried Bean Cakes

In Table 2, the composition (mean±standard deviation) of fresh and stored fried cake samples is as presented. Protein contents of fresh samples vary significantly from each other (16.24-17.81%), and reduced slightly during storage (15.92%-17.16%), with the control sample having the highest value at the fresh state, but second to the last during storage. Carbohydrate had between 68.33-71.9%; 15% walnut samples had the least value, but sample with 6% walnut was the highest. The moisture contents ranged from 4.92-6.55%, but Falade, 2003, reported 7.6-8.3% for dried fried cake made from cowpea substituted with soybean. It is a fact that moisture is a shelf life determinant, as spoilage microorganisms need moistened environment. 6% walnut sample, at production, had the lowest moisture content (4.92%), while the control had the highest (6.55%), and even after storage (7.19%). Different moisture content recorded could be attributed to low water absorption nature of walnut.

Fat content of fried cake samples varied from 1.92–3.60%, increasing with walnut addition, with 15% walnut sample having the highest value. This confirmed the report that walnut was very high in poly-unsaturated fatty acid, which could aid the proper functioning of the heart and lowers cholesterol level (Chauhan *et al*., 2004). At week eight, no significant reduction was noticed, but for the control sample that reduced from 1.92 to 1.53%. Low fat was advantageous, as it reduces the number of health challenges (Thompson *et al*., 1998) that decreases human life span. Fibre content of the samples ranged from 1.15–1.58%, showing that the flours to be poor sources of dietary fibre. The control sample had the highest crude

fibre, and 15% walnut sample, the lowest. No significant difference was noticed after storage, however, sample with 9% increased. Crude fibre was known to aid bowel movement and digestion (Abu *et al.*, 2010).

The ash, which represents mineral content in foods, was found to increase with the addition of walnut flour (2.58-4.01%). The control sample had the lowest value (2.58%), while sample with 15% walnut had the highest (4.01%). The increase could be attributed to the added walnut, an excellent source of micro nutrients according to Ekwe and Ihemeje, 2013. After eight weeks, samples with 3% and 9% walnut showed significant reduction, as against other samples attributable to nutrient loss at storage.

Table 2

Proximate composition of fresh and stored fried cake samples

Sample	% Moisture	% Protein	% Fat	% Fibre	% Ash	% Carbohydrat
Day 0						
A	$6.55^{a}\pm0.01$	$17.81^{a}\pm0.04$	$1.92^{d}\pm0.04$	$1.58^{a}\pm0.02$	$2.58^{e}\pm0.01$	$69.58^{c}\pm0.06$
B	$5.91^{b}\pm0.00$	$16.90^{c}\pm0.03$	$1.97^{d}\pm0.01$	$1.47^{b}\pm0.02$	$2.77^{d}\pm0.06$	$70.99^{b}\pm0.03$
C	$4.92^{e}\pm0.01$	$16.24^{d}\pm0.04$	$2.35^{c}\pm0.01$	$1.40^{b}\pm0.02$	$3.20^{c}\pm0.03$	$71.90^{a}\pm0.10$
D	$5.39^{d}\pm0.01$	$16.98^{c}\pm0.05$	$3.03^{b}\pm0.02$	$1.25^{c}\pm0.04$	$3.63^{b}\pm0.06$	$69.75^{c}\pm0.13$
E	$6.10^{b}\pm0.01$	$17.22^{b}\pm0.06$	$3.19^{b}\pm0.01$	$1.22^{c}\pm0.04$	$3.73^{b}\pm0.03$	$68.55^{d}\pm0.06$
F	$5.81^{d}\pm0.01$	$17.12^{bc}\pm0.49$	$3.60^{a}\pm0.02$	$1.15^{d}\pm0.04$	$4.01^{a}\pm0.54$	$68.33^{d}\pm0.04$
After 8 weeks						
A	$7.19^{a}\pm0.01$	$15.92^{d}\pm0.03$	$1.53^{e}\pm0.01$	$1.67^{a}\pm0.02$	$2.08^{f}\pm0.03$	$71.60^{a}\pm0.01$
B	$6.28^{c}\pm0.01$	$16.99^{b}\pm0.02$	$1.95^{d}\pm0.08$	$1.45^{b}\pm0.02$	$2.37^{e}\pm0.01$	$70.97^{c}\pm0.03$
C	$6.40^{b}\pm0.01$	$15.77^{e}\pm0.04$	$2.34^{c}\pm0.04$	$1.41^{b}\pm0.01$	$3.07^{c}\pm0.05$	$71.02^{b}\pm0.05$
D	$5.66^{e}\pm0.01$	$16.86^{b}\pm0.06$	$2.90^{b}\pm0.04$	$1.40^{b}\pm0.01$	$2.87^{d}\pm0.02$	$70.32^{d}\pm0.04$
E	$7.11^{a}\pm0.01$	$17.16^{a}\pm0.11$	$3.02^{b}\pm0.06$	$1.24^{c}\pm0.03$	$3.21^{b}\pm0.07$	$68.18^{f}\pm0.15$
F	$5.92^{d}\pm0.00$	$16.54^{c}\pm0.03$	$3.14^{a}\pm0.05$	$1.11^{d}\pm0.03$	$3.54^{a}\pm0.35$	$69.48^{e}\pm0.14$

Values are means ± standard deviation of scores. Column values with different superscript are significantly ($p \leq 0.05$) different.

Keys:

A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

Mineral Analysis of both Fresh and Stored Fried Cakes

Mineral elements analyzed were calcium, magnesium, sodium, and potassium (Table 3). Sample with 15% walnut was highest in calcium and magnesium contents at production in line with the report of Ekwe and Ihemeje, 2013 that walnut has 45.01mg/100g of calcium and60.20mg/100g of magnesium, but low in sodium (8.07mg/100g). However, low value of sodium intake is good, as high sodium intake is associated with health challenge such as hypertension in human (Kanu *et al*., 2015)**.**

Significant difference was not noticed after eight weeks, however, sample with 3% walnut reduced significantly from 2.87 to 2.52mg/l for magnesium and sodium (0.51-4.04mg/L). The control and 3% walnut samples, however, showed slight increase in sodium level. Potassium content changed from 1.19-2.96mg/l after eight, with slight increase noticed in the 9% walnut sample.

Table 3

Mineral determination of fresh and stored fried cakes

Sample code	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)
Week zero				
A	1.67^{a}±0.08	2.85^{b}±0.06	4.00^{a}±0.00	3.14^{a}±0.07
B	1.30^{c}±0.14	2.87^{b}±0.49	1.61^{c}±0.16	1.79^{b}±0.04
C	1.41^{b}±0.12	2.90^{b}±0.19	2.75^{b}±0.07	1.35^{c}±0.04
D	1.41^{b}±0.12	2.85^{b}±0.04	1.25^{d} ±0.71	1.12^{c}±0.19
E	1.55^{ab}±0.04	3.53^{a}±0.91	1.40^{c}±0.00	1.67^{b}±0.10
F	1.69^{a}±0.00	3.70^{a}±0.15	0.60^{e} ±0.00	1.76^{b}±0.16
After 8 weeks				
A	1.52^{a}±0.07	2.82^{b}±0.04	4.04^{a} ±0.1	2.96^{a}±0.2
B	1.24^{c}±0.02	2.52^{c}±0.01	1.74^{b}±0.05	1.60^{b}±0.07
C	1.39^{b}±0.01	2.93^{b}±0.1	1.51^{c}±0.01	1.23^{c}±0.3
D	1.36^{b}±0.01	2.74^{b}±0.02	0.89^{e}±0.05	1.19^{c}±0.1
E	1.56^{a}±0.1	3.42^{a}±0.01	1.18^{d}±0.1	1.54^{b}±0.1
F	1.57^{a} ±0.04	3.54^{a}±0.2	0.51^{f}±0.02	1.81^{b}±0.0

Values are means ± standard deviation of scores. Column values with different superscript are significantly ($p \leq 0.05$) different.

Keys:

A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

Textural properties of both fresh and stored fried cakes samples

The textural properties of the sample cakes are presented in Table 4. Sample substituted with 6% walnut was the hardest (163.58N), while that with 12% walnut was least (26.27N). Springiness is the rate at which a product physically springs back to its original condition after deforming force is removed (Szczesniak, 2002). It showed significant differences, with the control sample having the least value (0.014mm), while sample with 15% walnut had the highest (0.092mm). Chewiness is the energy required to masticate a solid food to a state for swallowing. Significant differences were observed for chewinesswithin the samples except for the control and sample with 12% walnut. The sample with 3% walnut was least (0.014N) for chew-ability i.e. required the least energy; while 15% walnut was highest (1.92N) i.e. needed more energy. The fracturability of the samples ranged from 7.21-40.81N. The control sample was the easiest to fracture, and sample with 15%, the hardest to fracture. There was no significant difference in stringiness of the samples except that sample with 3% that had the highest value (4.32mm), and control, the least (3.38mm).

During storage, hardness of samples reduced significantly for most of the sample. Sample with 6% walnut was the hardest, while that with 15%, the least. Springiness was not significant, but reduced in value. The control sample was the springiest and 15% walnut, the least. Chewiness was significant except for sample with 9% walnut. There was no significant difference in fracturability during storage safe for the control sample. Sample with 3% recorded a significant decrease, 15%, sample, significant increase, while no significance was recorded for other samples (for stringiness).

Colour Parameters of Fresh and Stored Fried Cakes

The L*, a*, and b* parameters of colours of cakes is presented in Table 5. The results show that fresh samples were all significant. Control sample was the lightest, while 15% walnut sample was more golden than others, with variations noticed attributed to incorporation of walnut flour, similar to the sensory results in Table 5.

Table 4

Textural properties of fresh and stored fried cakes samples

Sample	Hardness (N)	Springiness (mm)	Chewiness (N)	Fracturability (N)	Stringiness
Day 0					
A	$129.14^{a}\pm37.1$	$0.03^{d}\pm0.00$	$0.06^{d}\pm0.01$	$40.81^{a}\pm14.41$	$3.38^{b}\pm0.01$
B	$44.81^{c}\pm1.28$	$0.023^{d}\pm0.07$	$0.014^{e}\pm0.00$	$12.77^{b}\pm0.28$	$4.32^{a}\pm0.02$
C	$163.58^{a}\pm5.2$	$0.054^{b}\pm0.01$	$1.43^{c}\pm0.01$	$26.65^{ab}\pm0.64$	$4.01^{ab}\pm0.00$
D	$114.49^{b}\pm0.54$	$0.042^{c}\pm0.00$	$1.87^{b}\pm0.02$	$12.18^{bc}\pm0.25$	$3.40^{b}\pm0.07$
E	$26.27^{c}\pm0.81$	$0.014^{e}\pm0.00$	$0.04^{e}\pm0.00$	$19.29^{bc}\pm0.44$	$3.50^{b}\pm0.09$
F	$61.75^{c}\pm18.82$	$0.092^{a}\pm0.01$	$1.92^{a}\pm0.00$	$7.21^{c}\pm0.00$	$3.41^{b}\pm0.28$
After 8 weeks					
A	$91.43^{b}\pm0.31$	$0.11^{a}\pm0.14$	$0.07^{c}\pm0.02$	$15.29^{b}\pm2.07$	$3.62^{b}\pm0.11$
B	$38.52^{c}\pm2.40$	$0.02^{a}\pm0.01$	$0.007^{c}\pm0.01$	$28.23^{a}\pm1.10$	$3.76^{b}\pm0.30$
C	$105.45^{a}\pm6.47$	$0.05^{a}\pm0.00$	$0.93^{a}\pm0.14$	$12.90^{bc}\pm1.30$	$3.98^{b}\pm0.05$
D	$107.76^{a}\pm3.31$	$0.06^{a}\pm0.00$	$0.64^{b}\pm0.02$	$16.99^{b}\pm2.20$	$3.42^{b}\pm0.29$
E	$15.67^{d}\pm2.23$	$0.04^{a}\pm0.01$	$0.01^{c}\pm0.02$	$15.10^{bc}\pm1.41$	$3.73^{b}\pm0.10$
F	$14.45^{d}\pm0.93$	$0.013^{a}\pm0.01$	$0.02^{c}\pm0.00$	$12.51^{c}\pm1.81$	$6.28^{a}\pm1.23$

Values are means ± standard deviation of scores. Column values with different superscript are significantly ($p\leq0.05$) different.

Keys:
A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

Table 5

Colour determination of fresh and stored fried cake samples

Sample code	L*	a*	b*
Day 0			
A	$49.73^{a}\pm2.81$	$8.62^{b}\pm0.79$	$16.16^{a}\pm1.72$
B	$47.34^{b}\pm2.39$	$7.77^{c}\pm2.39$	$14.11^{b}\pm2.43$
C	$46.51^{c}\pm2.28$	$8.59^{b}\pm0.93$	$13.51^{c}\pm2.23$
D	$46.57^{c}\pm1.99$	$9.13^{a}\pm0.98$	$13.64^{c}\pm1.97$
E	$48.93^{ab}\pm1.96$	$9.19^{a}\pm1.11$	$15.57^{a}\pm2.06$
F	$45.96^{d}\pm1.96$	$9.33^{a}\pm0.93$	$12.86^{d}\pm1.47$
After 8 Weeks			
A	$50.32^{a}\pm1.83$	$8.38^{ab}\pm1.00$	$15.71^{ab}\pm2.58$
B	$46.53^{b}\pm2.53$	$7.30^{b}\pm0.90$	$13.57^{b}\pm2.57$
C	$45.93^{b}\pm3.15$	$8.67^{ab}\pm1.37$	$13.66^{b}\pm3.21$
D	$46.54^{b}\pm2.62$	$9.01^{a}\pm1.30$	$12.77^{bc}\pm1.33$
E	$48.75^{ab}\pm2.87$	$8.20^{ab}\pm0.93$	$16.32^{a}\pm2.14$
F	$46.02^{b}\pm1.08$	$9.53^{a}\pm1.16$	$11.82^{c}\pm1.31$

Values are means ± standard deviation of scores. Column values with different superscript are significantly ($p\leq0.05$) different.

Keys:
A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

During storage, colour parameters increased in value i.e. became lighter, though less difference was noticed for the control and those of 9% and 12% walnut samples. However, for others, significance in lightness was noticed, which could be attributable to oxidative changes caused by the presence of oxygen within the packaging material that could have altered samples' quality.

Microbiological Analysis of fresh and stored fried cake samples

Microbial analyses done at 4-week interval are shown in Tables 6a and 6b respectively. At week zero, the control sample had the highest bacterial load of 2.0×10^4cfu/g, while the walnut incorporated samples had no fungal growth. The lowest bacterial count was recorded for sample with 15% walnut (0.2×10^4 cfu/g). By the 4th week, control sample was the highest with microbial and fungal counts of 3.7×10^4 cfu/g and 2.0×10^4 cfu/g respectively, but the lowest was 15% walnut sample with bacterial and fungal growth of 1.9×10^4 cfu/g and 0.1×10^4 cfu/g respectively.

After storage, bacterial and fungal counts of the control rose to 5.9×10^4 cfu/g and 4.7×10^4 cfu/g respectively. Least bacterial and fungal growths were 2.3×10^4 cfu/g and 1.0×10^4 cfu/g in samples with 15% and 12% walnut respectively. The result showed walnut addition protected the treated samples from microbial attack, attributable to antioxidant activity of the walnut (Ajaiyeoba and Fadare, 2006). Increased microbial count during storage may be due to moisture uptake and nutrient utilization/depletion by microorganisms. Added walnut inhibited the growth of microorganisms.

Table 6a

Total bacterial count of fresh and stored fried cake samples

Samples	WK 0 (cfu×10^4)	4th Week (cfu×10^4)	8th Week (cfu×10^4)
A	2.0	3.7	5.9
B	0.3	2.6	3.4
C	0.3	2.8	4.6
D	0.6	2.5	4.2
E	1.0	2.1	3.0
F	0.2	1.9	2.3

Table 6b

Total fungal count of fresh and stored fried cake samples

Samples	WK0 (cfu×10^4)	4th Week (cfu×10^4)	8th Week (cfu×10^4)
A	NIL	2.0	4.7
B	NIL	1.1	2.5
C	NIL	1.1	2.2
D	NIL	1.5	1.9
E	NIL	1.0	1.0
F	NIL	0.1	1.1

Keys:
A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

Sensory evaluation of the fried cakes

From the sensory scores (Table 7), the control sample was rated highest for appearance, crispiness and texture. Sample with 15% was rated lowest for appearance, but for flavour, texture and taste, 6% walnut sample was rated lowest, while 12% walnut rated lowest for crispiness. Sample with 9% walnut was most accepted and rated highest for flavour and taste, and having improved sensory attributes and acceptability.

Table 7

Sensory evaluation of the samples of the fried bean cakes

Samples	Appearance	Texture	Flavour	Taste	Crispiness	G/A
A	$7.75^{a}\pm0.77$	$7.65^{a}\pm0.88$	$6.80^{a}\pm0.95$	$6.65^{b}\pm0.88$	$7.70^{a}\pm0.98$	$7.40^{a}\pm0.75$
B	$7.15^{a}\pm0.75$	$7.25^{b}\pm0.79$	$7.05^{a}\pm0.95$	$6.95^{ab}\pm0.83$	$7.40^{a}\pm0.82$	$7.40^{a}\pm0.75$
C	$5.95^{b}\pm1.39$	$6.75^{b}\pm1.37$	$6.30^{b}\pm1.34$	$6.20^{c}\pm1.51$	$7.20^{a}\pm1.00$	$6.60^{b}\pm0.99$
D	$6.02^{b}\pm1.39$	$7.55^{a}\pm0.95$	$7.20^{a}\pm0.89$	$7.45^{a}\pm0.83$	$7.60^{a}\pm0.88$	$7.55^{a}\pm0.99$
E	$7.35^{a}\pm1.14$	$7.15^{b}\pm1.04$	$7.05^{ab}\pm0.95$	$6.90^{abc}\pm0.97$	$7.05^{a}\pm0.88$	$7.20^{ab}\pm0.89$
F	$5.80^{b}\pm1.06$	$7.45^{a}\pm0.95$	$7.00^{ab}\pm0.97$	$6.60^{bc}\pm1.23$	$7.20^{a}\pm1.15$	$7.00^{ab}\pm1.08$

Values are means ± standard deviation of scores. Column values with different superscript are significantly ($p\leq0.05$) different.

Keys:

A: 100% Cowpea; **B**:97% Cowpea and 3% Walnut; **C**: 94% Cowpea and 6% Walnut;
D: 91% Cowpea and 9% Walnut; **E**: 88% Cowpea and 12% Walnut;
F: 85% Cowpea and 15% Walnut

Conclusion

Though cowpea flour possessed better functional properties than that of walnut, inclusion of walnut flour to fried bean cake improved proximate and mineral compositions of products, though showed slight hardness, but conferred better shelf stability on the products. It improved sensory attributes of the fried cake and equally increased the textural properties, except for stringiness, which was highest in the control sample. It is therefore recommended that walnut flour of up to 9% could be added to cowpea flour to produce quality dried fried bean cakes.

References

Abbey BW., Ibeh G.O. (1998), Functional properties of raw and heat processed cowpea flour, *J. Food Sci*., 53, pp.1775–1991.

Abu J.O., Duodu K.G., Minnaar A. (2010), Effect of irradiation on some physico-chemical and thermal properties of cowpea (Vigna unguiculata L. Walp) starch, *Food Chemistry*, 95, pp. 386–393.

Ajaiyeoba E.O., Fadare D.A. (2006), Antimicrobial potential of extracts and fractions of the African walnut (Tetracarpidium conophorum), *African Journal Biotechnology*, 5(22), pp. 2322–2326.

Akinyele I.O. and Onigbinde A.O. (1988), Stability of protein digestibility and composition of cowpea (Vigna unguiculata L.Walp) during sealed storage at different temperatures, *International Journal of Food Science and Technology*, 23, pp. 293–296.

Amaral J.S., Seabra R.M., Andrade P.B., Valentao P., Pereira J.A., Ferreres F. (2004), Phenolic profile in the quality control of walnut (Juglans regia L.) leaves, *Food Chemistry*, 88, pp. 373–379.

AOAC (2005), Official methods of analysis (18th edition), *Association of official analytical chemistry*, Washington D.C, pp. 930–935.

Chauchan N., Wang K.C., Weigel J., Malik M.N. (2004), Walnut extract inhibits the fibrilization of myloid beta protein and defribrillizes its pre informed fibrils, *Curr Alzhe Res*., 1(3), pp. 183–188.

Chinma C.E., Alemede I.C., Emelife I.G. (2008), Physicochemical and Functional Properties of Some Nigerian Cowpea Varieties, *Pak. Journal. Nutrition*, 7(1), pp. 186–190.

Ekwe C.C. and Ihemeje A. (2013), Evaluation of physiochemical properties and preservation of African walnut (Tetracarpidium conophorum), *Academic Research Institutes*, 4(6), pp. 501–512.

Enujiugha V.N. (2003), Chemical and Functional Characteristics of Conophor Nut, *Pakistan Journal of Nutrition*, 2(6), pp. 335–338.

Enujiugha V.N. and Ayodele O.O. (2003), Evaluation of nutrients and antinutrients in lesser known under–utilized oil seeds, *Int. J. Food Sci. and Technol*, 38, pp. 525–528.

Falade K.O., Adedeji A.A., Akingbala J. (2003), Effect of soybean substitution for cowpea on physical, compositional, sensory and sorption properties of akara Ogbomoso, *European Food Research and Technology*, 217, pp. 492–497.

Fawole M.O., Oso B.A. (2007), Laboratory Manual of Microbiology, 5th Edition, *Spectrum Books Limited*, Ibadan, pp. 22–23.

Friedman H.H., Whitney J.E. and Szczesniak A.S. (1963), The texturometer – A new instrument for objective texture measurement, *Journal of Food Science*, pp. 28–390.

Gepts P., Beavis W.D., Brummer E.C., Shoemaker R.C., Stalker H.T., Weeden N.F., Young N.D. (2005), Legumes as a model plant family: Genomics for food and feed report of the Cross-legume advances through genomics conference, *Plant Physiology*, 137, pp. 1228–1235.

Hassan L.G. and Umar K.J. (2006), Nutritive value of balsam, Momordicabalsanina L. apple and leaves, *Pakistan J. Nutr*., 5(6), pp. 522–529.

Giami S.Y., Akusu M.O., Jaja I.R. (2003), Production, organoleptic assessment and nutritional properties of akara from cowpea/maize flour blends, *Plant Foods for Human Nutrition*, 58, pp. 1–9.

Harold A. and Tatura D.P.I. (2002), The "Australian Nutgrower". Australian Walnut. Industry, *Association Journals* (AWIA), 49, pp. 75–89.

Hemery G.E. (2001), Growing walnut in mixed stands, *Quart J. Forestry*, 95, pp. 31–92.

Hoover R., Hughes T., Chung H., Liu Q. (2010), Composition, molecular structure, properties, and modification of pulse starches, *Food Research International*, 43, pp. 399–413.

Ihekoronye A.I. and Ngoddy P.O. (1985), Integrated food science and technology for the tropics, *Macmillan London.*

Ikpeme C.N., Osuchukwu N.C., Oshieel L. (2010), Functional and Sensory Properties of Wheat (*Aestium triticum*) and Taro Flour (*Colocasia esculenta*) Composite Bread, *African Journal of Food Science*, 4(5), pp. 248–253.

Kanu A.M., Kalu J.M., Okorie A.C. (2015), Nutritional And Health Values Of African Walnut (Tetracarpidium Conophorum), *International Journal of Scientific and Technology Research*, 4, pp. 1–8.

Kumar V., Sinha A.K., Makkar H.S., Becker K. (2010), Dietary roles of phytate and phytase in human nutrition: A review from Food Chemistry, 120: pp. 945–959.

Lateef A., Davies T.E., Adelekan A., Adedeji A.A., Fadahunsi A.H., (2010), Akara Ogbomoso; Microbiological examination and identification of hazards and critical control points, *Food Science and Technology international*, 16, pp. 389–392.

Leao U.S., Eiras M., Da–Rocha Nogueira M.D.S., Rodrigues L.K., Ribiero V.Q., Lopes ACDA. (2016), Selection of phenotypic traits and resistance to 'Cowoea severe mosaic virus' and 'Cowoea aphid–borne mosaic virus' in cowpea (Vigna unguiculata) seeds with rugose white coat, *Australian Journal of Crop Science*, 10, pp. 470.

McWatters K.H., Fletcher S.M., Resurreccion A.V.A. (1997), Evaluation of the sensory quality of Akara (Fried cowpea paste) by teenage consumers, *Journal of Food Quality*, 20, pp. 117–125.

Ndie E.C., Nnamani C.V., Oselebe H.O. (2010), Some physico–chemical characteristics of defatted flour derived from African walnut (Tetracarpidium conophorum): an underutilized legume, *Pak Journal nutrition*, 9(9), pp. 909–911.

Nuhu A.M., Mshelia M.S., Yakubu Y. (2000), Antimicrobial screening of the bark extract of Pterocarpus erinaceous tree, *Journal chemical society of Nigeria*, 25, pp. 85–92.

Odedeji J.O. and Oyeleke W.A. (2011), Proximate, physiochemical and organoleptic properties of whole and dehullee Cowpea seed flour (Vigna unguiculata), *Pakistan Journal of Nutrition*, 10(12), pp. 1175–1178

Olapade A., Okafor G.I., Ozumba A.U., Olatunji O. (2002), Characterization of common Nigeria cowpea (Vigna unguiculata L.Walp) varieties, *Journal of Food Engineering*, 55, pp. 101–105.

Oyeyinka S.A., Karim O.R., Kayode R.M.O., Balogun M.A. (2013), Quality attributes of weevils (*Callosobruchus maculatus*) infested cowpea (Vigna unguiculata) products, *Nigerian Journal of Agriculture, food and environment*, 9, pp. 16–22.

Oyeyinka S.A., Oyeyinka A., Opaleke D., Karim O.R., Kolawole F.L., Ogunlakin G., Olayiwola O. (2014), Cake production from wheat and cowpea flours using date fruit as a sweetener, *Annals. Food Science and Technology*, 15, pp. 20–28.

Oyeyinka S.A., Singh S., Adebola P.O., Gerrano A.S., Amonsou E.O. (2015), Physicochemical properties of starches with variable amylose contents extracted from Bambara groundnut genotypes, *Carbohydrate Polymers*, 133, pp. 171–178.

Patterson S.P., McWatters K.H., Hung Y.C., Chinnan M.S., Phillis R.D. (2002), Physico-chemical properties and consumers' acceptability of akara (fried paste) made from three cowpea cultivars, *Food Research International*, 35, pp. 691–696.

Savage G.P., McNiel D.L., Dutta P.C. (2001), Some Nutritional Advantages of Walnuts. *Acta Hort.*, 544, pp. 557–563.

Szczesniak A.S. (2002), Texture is a sensory property, *Food Quality and Preference*, 13, pp. 215–225.

Thompson D., Edelsberg J.I., Kinsey K. and Oster G. (1998), Estimated economic costs of obesi to U.S business, *American Journal of Health Promotion*, 13, pp. 120–127.

Thermophysical characteristics of frozen semi-finished products for restaurant technology

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Abstract

Introduction. The aim of the study is to determine the influence of thermophysical characteristics of frozen semi-finished products on the quality of desserts.

Materials and methods. To determine the quality of frozen semi-finished products in the technology of the desserts the raw materials Raw materials were used: glucose-fruit syrup, maltodextrin, apple puree, kiwi, banana, pumpkin; semi-finished products in the form of blended pairs: apple – kiwi; apple – banana; apple – pumpkin. As control sample it was used traditional apple sambuk .The study of sensory quality indicators was carried out on a 10-point scale. Determination of physicochemical parameters of the samples was carried out by mass fraction of dry matter; active acidity; water activity; enthalpy; moisture content.

Results and discussion. The use of cryoprotectant (glucose – fructose syrup) equalizes the osmotic pressure of concidered food system, as in the syrup glucose and fructose are contained, which reduces the cryotemperature of the samples and inhibits the formation of intracellular ice, which allows preserving the quality of the blended semi-finished product on the content of biologically active substances.

Differences in the freezing parameters of fruit puree semi-finished products with cryobiotics, namely glucose-fructose syrup and maltodextrin, were established. Monosaccharides, glucose and fructose, have been found to have lower cryoscopic temperatures than sucrose, due to the nature of the crystallization and the size of the crystals formed in the system. With the same chemical formula and molecular weight of sugars, the value of cryoscopic temperature depends on the hydration of sugars.

Based on the identified quality indicators and weighting factors, a comprehensive quality indicator of ready-made desserts (using developed blended semi-finished products) made by the developed technology was calculated, and a quality model was built.

The rating of the dishes showed that the studied samples of sambuca with blended pairs have a high rating of 92.9 points^2 and 96.9 points^2, compared to the control sample – 91.2 points^2. The apple-pumpkin sambuk has a little below 88.8 points^2. The decrease in the rating of sambuk «apple – pumpkin» is due to the specific aroma of the blended pair «apple – pumpkin».

Conclusion. Cryoscopic temperatures of fruit purees, semi-finished products and ready-made desserts with the introduction of cryoprotectants were determined. Studies on sensory and physicochemical parameters give grounds to create desserts with predicted high quality indicators.

Introduction

The problem area in the development of desserts is the preservation of vitamins [1], microelements [2, 3], biologically active substances [4] and their use for enrichment of the dessert, using fruit and berry raw materials.

To reduce the technological and physiological losses of vitamins and organic acids, the most effective way is to use low-temperature technologies [4]. The advantages of using shock freezing of foods are bacteriological purity, significant reduction in weight loss of foods, increased shelf life, and significantly higher quality of frozen products compared to the traditional method [4, 5].

However, the method of rapid freezing does not guarantee the high quality of the products, especially after their defrosting [4, 5]. The sensitivity of cells and tissues of different fruits and berries is different to the effects of low temperatures (and related physical and mechanical processes), and the quality and consumer characteristics are determined by the successful choice of cryoprotectant, its concentration, duration of contact with frozen materials, which necessitates the study of indicated factors.

Scientists around the world proved [4, 5], that the use of artificial cold provided minimal change in the nutritional and biological value of ready meals, products and semi-finished products, but also influenced their sensory characteristics. However, freezing of the range of fruit and berry semi-finished products has advantages over other methods of heat treatment, namely drying, pasteurization, sterilization, and canning.

Hydrocolloid Stabilizers. A wide variety of hydrocolloid chemistry studies have examined the physical and chemical properties and behavior of typically larger molecules or particles dispersed within or residing at the interface of an aqueous continuous phase [4]. The chemical and physical actions of the hydrocolloids involve mechanisms based on various factors, including the presence of charged moieties, hydrophobic regions, and high water-holding capacities of such ingredients [6]. Advances in this realm have led to the inclusion of a vast array of stabilizers derived from a variety of sources [7, 8] that affect the rheological, stability, and sensory properties. In general, these stabilizers impede the outgrowth of ice crystals and the sublimation of water [9] while increasing the viscosity of the mix, sensory smoothness, and foam stability [10].

Characteristics of fruit raw materials for restaurant technology. *Kiwifruits* exhibit antioxidative, antiproliferative, antiinflammatory, antimicrobial, antihypertensive, antihypercholesterolemic, neuroprotective, antiobese properties and promote gut health [11-15]. Contents of total dietary fiber and free phenolics and in vitro antioxidant capacities of kiwifruit flour were significantly higher than those of potato, maize and wheat flours [12, 13]. Pasting, gel texture and dynamic oscillatory analysis showed that the starchy kiwifruit flours had some similar characteristics to traditional flours with differences. The viscosity and gelation were little developed in the flours of eating-ripe kiwifruit. The flour properties were much determined by starch content and properties. The starchy kiwifruit flour may be used for “novel” and “healthy” food formulations [12]. The amounts of PPs and vitamin C were encouragingly high. Health beneficial compounds, dimethyl-caffeic acid hexoside, caffeic acid derivatives, protocatechuic acid, syringic acid, salicylic acid/o-coumaric acid, lutein and beta-carotene, were detected in the final products [14].

Bananas are a worldwide crop for food and traditional medicine [15]. Banana fruit has high nutritional value and is consumed worldwide [16]. Bananas contain phenols, flavonoids and antioxidants [17–20]. The highest total antioxidants capacity and total phenols concentration were found in the ripe banana fruit. 2,2-Diphenyl-1-picrylhydrazyl radical scavenging activity remained constant and the highest total flavonoids concentration was

found in the mature green fruit [18]. Banana peel was found to contain phenolic compounds ranging from 0.90 to 3.0 g/100 g dry weight [19].

Pumpkin flesh contains a variety of phenolic compounds, flavonoids, vitamins, as well as minerals. It also has low calorie content (17 kcal/100 g flesh) [21]. One of the major carotenoids in pumpkin fruit (>80%) is β-carotene, which contributes to the high nutritional value of pumpkins [22]. Traditionally pumpkin is cooked in variety of dishes or used to make desserts and beverages. However, pumpkin contains a high level of insulin-dependent sugars, which is problematic for diabetic patients [23]. Therefore, in this study, fermentation is utilized in the development of pumpkin based beverage in which the microorganisms could utilize the sugar during fermentation [24]. This reduces the insulin-dependent sugars so that this beverage is more suitable for the consumption of diabetic patients. Moreover, fermentation of vegetables and fruits such as pumpkin may not only improve the food safety levels and prolong the shelf life, but may also enhance the availability of certain nutrients [25].

Apples. The results showed great quantitative differences in the composition of the apple cultivars, particularly in their phenolic contents. Fructose was the most dominant sugar in the different apple cultivars, followed by glucose and sucrose, while malic acid was the principal organic acid. Asparagine and serine were the principal amino acids. Chlorogenic acid and protocatechuic acid were the dominating phenolic compounds [26]. The fruit of apple possessed five quercetin glycosides, namely hyperin, isoquercitrin, reynoutrin, avicularin and quercitrin, as the major flavonol components. Total flavonol levels were in the range 26.4 to 73.9μg/g fresh wt (expressed as aglycone) with hyperin the dominant form, where quercitrin predominated, and the cider apples, where avicularin predominated. The proportion of flavonol in the peel ranged from 63.0 to 97.1% for the dessert and cooking apples and was not dependent on fruit size. Juice produced from the three varieties of cider apple contained 9.9 to 12.7% of the flavonols with the remainder retained in the pomace [27].

Taking into account the aforementioned, the *aim* of this work is to determine the cryoscopic temperatures and the intensity of ice formation in blended semi-finished products, made on the basis of fruit and vegetable raw materials. Attention is paid to the formation of recommendations on the use and dosage of blended semi-finished products while developing new types of desserts.

Indicated aim can be achieved through a number of *tasks*, namely:

- determination of influence of the cryoprotectants use on technological process and changes in structures of bioobjects;
- study of the changes in product quality during the use of rapid freezing;
- analysis of the influence of selected freezing conditions on the sensory characteristics of prepared desserts;
- formation of recommendations on the use and dosage of blended semi-finished products while developing new types of desserts.

Materials and methods

Materials

Raw materials were used: glucose-fruit syrup, maltodextrin, apple puree, kiwi, banana, pumpkin; semi-finished products in the form of blended pairs: apple – kiwi; apple – banana; apple – pumpkin.

Apple puree was prepared with subsequent adding of 10% of sugar, 10% of glucose-fructose syrup, and 1% of maltodextrin. The study of blended semi-finished products was

performed using a cryoprotectant – 10% of glucose-fructose syrup.

As control sample it was used traditional apple sambuk – a jelly dessert based on whipped egg whites [29].

Methods

Determination the quality criteria of desserts [28–30]

To effectively assess the sensory properties of infusions, a list of descriptors was formed. The most acceptable is the method of visualization of sensory parameters of products in the form of profilograms, which can be used to assess the intensity, originality, coherence, expression of taste, aroma and color of alcohol semi-finished products. The obtained values of sensory parameters were used to determine the quality criterion of the profile [28].

The method of determining the quality criterion of products by quantitative indicators includes the definition of specific indicators and descriptors that characterize the product, the conversion of units into dimensionless units (if necessary), drawing up a mathematical model and the calculation of the criterion of product quality. The quality criterion is constructed on the area principle, that is the value of the complex criterion corresponds to the area of the polygon in which the distance from its center to the vertices is equal to the normalized values of the individual quality indicators f_j, $j = \overline{1,N}$, where N – the number of individual quality scores [29]:

$$S = \sum_{j=1}^{N}\left(\frac{1}{2}\cdot f_j \cdot f_{j+1}\cdot sin\frac{2\pi}{N}\right) = \frac{1}{2}sin\frac{2\pi}{N}\cdot\sum_{j=1}^{N}\left(f_j \cdot f_{j+1}\right), \qquad f_{N+1} = f_1$$

For each sample with a set of values of individual indicators $(f_1, f_2, ..., f_N)$, it is possible to calculate the value of the complex criterion S.

The qualitative area (S) of polygon is equal to the total sum of the areas of the triangles, formed by corresponding lines of the individual (partial) quality indicators. Instead of the function S, it is advisable to use another function F, which differs from S only by a constant multiplier, which doesn`t affect the choice of the largest value. To choose the most successful option with the largest value of the complex criterion, it is enough to use the criterion formula [30]:

$$F = f_1 f_2 + f_2 f_3 + ... f_{N-1} f_N + f_N f_1, \text{ points}^2.$$

The problem of finding the optimal value and effect of a new ingredient (in our case – the blended pair) on the food system was solved as a problem of finding the extremum of the target multicriteria quality function of quality of nonlinear product with a system of restrictions on individual quality indicators.

Determination of cryoscopic temperatures of fruit and berry raw materials [31]

Measurements of the cryoscopic temperature of the model samples were performed by the method of thermal analysis based on the construction of curves of temperature change over time. The temperature was recorded and recorded using a measuring complex [31].

The complex includes a device for temperature control with a set of copper-constantan thermoelectric transducers type T with a measurement error of not more than 0.05 °C, a primary transducer and a signal converter brand i7520. Temperature values were recorded using a personal computer through the program NDCONUTILv3xx [31].

The thermocouple junction was placed in the center of the sample (weight 7.5 g) and transferred to a SAMSUNG freezer with refrigerant freon R134a and a working chamber temperature of minus 25 °C. With continuous stirring of the mixture performed automatic recording of temperature change at equal intervals (10 s) in experimental and control samples [31]. Frozen (in portions) blended semi-finished products were added into the egg white, and started whipping after 8–10 minutes at the room temperature. Other ingredients were added to the whipped mass and whipping was continued.

Results and discussions

Physico-chemical parameters of fruit blended semi-finished products

The results of the research presented in Table 1 allow obtaining several patterns that require scientific explanation. Firstly, the obtained data show that the chemical composition of plant raw materials has an effect on presented indicators and retains different contents of bound and free moisture (it is supposed to be an affect of the esterification degree of plant pectin), which positively or negatively affects cryoscopic temperatures.

Table 1

Physico-chemical parameters of fruit blended semi-finished products

Sample description	Mass fraction of dry matter, %	pH	Water activity, Aw	Enthalpy, J/g	Moisture content, U %
Apple (control sample)	10.10±1.54	6.4	0.986	63.36	19.560±1.530
Apple-sugar	11.30±0.85	7.3	0.986	60.74	18.064±1.100
Apple-glucose-fructose syrup	12.15±1.10	6.9	0.970	61.22	18.259±1.200
Apple-maltodextrin	10.10±1.14	7.5	0.986	62.10	18.920±1.240
Blended pairs					
Apple-kiwi	15.00±0.70	7.5	0.990	63,90	17.647±1.100
Apple-banana	14.00±1.20	7.3	0.986	62.77	16.279±1.160
Apple-pumpkin	14.00±0.90	6.5	0.986	62.86	16.279±1.120

As a result of the conducted researches, optimum limits of pH values for blending pairs, making 6.5–7.5, were established. Also the purposefulness of glucose-fructose syrup and maltodextrin use as cryoprotercopes was proved.

Determination of cryoscopic temperature in fruit purees

According to the cryoscopic temperatures of studied blended pairs, the content of frozen water in samples at negative temperatures in the range of values from -5 to -10 ºC was calculated (Figure 1).

Such calculations are very important, because in blended purees during storage of the blended semi-finished product the ratio between frozen and unfrozen water is constantly changing, which significantly affects the formation of physicochemical parameters of the finished product [29].

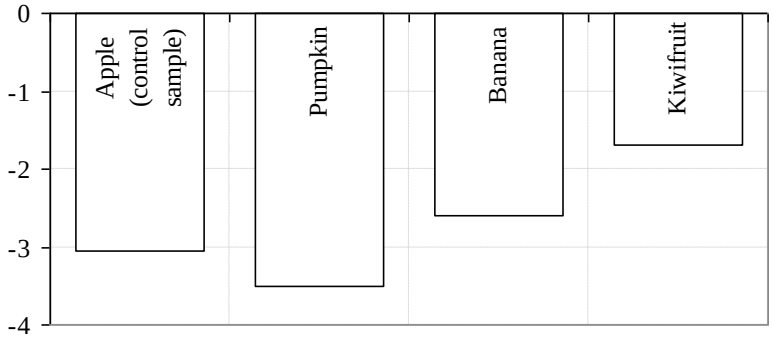

Figure 1. Determination of cryoscopic temperature in fruit purees

Determination of cryoscopic temperature in blended semi-finished products

Analysis of the content of frozen water in blended semi-finished products (Figure 2), in comparison with native apple puree, has an improved chemical composition and allows identifying samples with the biggest risk of appearing of defects appropriate for frozen fruits and berries of long-term storage, namely blend delamination and formation of iced structure.

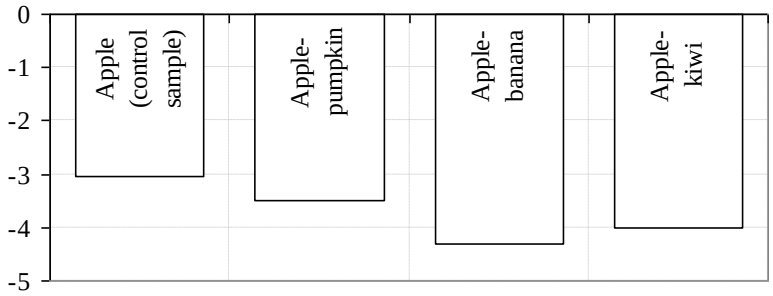

Figure 2. Determination of cryoscopic temperature in blended semi-finished products

Cryoscopic temperature of fruit and berry blends is one of the main physical characteristics that determine the technological modes of the storage process of the semi-finished product and after defrosting of the finished product [7, 29].

Further experiments were performed to determine the quality of ready-made cold desserts using blended pairs.

Cryoscopic temperature of desserts model systems

The obtained cryotemperatures in samples of desserts with different blending pairs are presented in Figure 3.

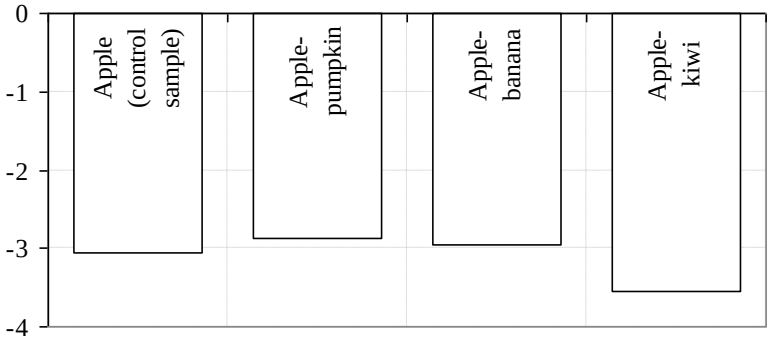

Figure 3. Cryoscopic temperature of desserts model systems

The obtained results show that the use of cryoprotectant (glucose – fructose syrup) equalizes the osmotic pressure of considered food system, as in the syrup glucose and fructose are contained, which reduces the cryotemperature of the samples and inhibits the formation of intracellular ice, which allows preserving the quality of the blended semi-finished product on the content of biologically active substances.

In the calculated blending mixtures, water is frozen in the form of ice crystals, due to which the concentration of sucrose, fructose and mineral salts in the rest of the water increases significantly. This concentration of low molecular weight substances in the water phase of the mixtures and their saturation with air during subsequent whipping of the dessert allows getting a soft and light dessert with excellent quality indicators.

During the blended semi-finished products storage, at the high content of the frozen water, slow defrosting and, especially, at violation of storage regimes, processes of recrystallization of the water phase can occur in a product, which essentially reduce its consumer properties.

Determining of desserts rating

The results of model samples studies are shown in Table 2.

Table 2

Determining of desserts rating

Sensory characteristics, points	Weight ratio	Dessert with blended pair apple-kiwi, points[2]	Dessert with blended pair apple-pumpkin, points[2]	Dessert with blended pair apple-banana, points[2]	Control sample (with apple puree) traditional apple sambuk, points[2]
Appearence	3.0	28.4	25.8	29.4	27.6
Colour	2.0	18.5	17.7	19.3	18.1
Taste	2.0	18.8	18.3	19.4	18.5
Smell	1.5	13.7	13.5	14.6	13.6
Consistency	1.5	13.5	13.5	14.2	13.4
Rating:		92.9	88.8	96.9	91.2

Based on the identified quality indicators and weighting ratios, a complex quality indicator of desserts (prepared using developed blended semi-finished products) was calculated, and a quality model was built. Analysis of the rating of new dishes showed that the studied samples of sambuk prepared with blended pairs have a high rating of 92.9 and 96.9 points[2], compared with the control sample (91.2 points[2]). The apple-pumpkin sambuk has a little less rating (88.8 points[2]). This fact can be explaned by the presence of a specific aroma in «Apple-pumpkin» sambuk.

Conclusions

The cryoscopic temperatures and the intensity of ice formation in blended semi-finished products, made on the basis of fruit and vegetable raw materials, were determined. The recommendations on the use and dosage of blended semi-finished products while developing new types of desserts were formed.

Based on the results of comprehensive research, the next conclusions were made:

1. The use of cryoprotectants made allows significantly reducing the technological process, preventing cryodamage of cells and structures of bioobjects, resulting in the formation of fine crystalline ice in cells and intercellular space, which prevents the destraction of plant cells. Therefore, their structure changes a little and even after defrosting blends almost do not change the mass fraction of dry matter, while maintaining the quality and taste properties, which is the main requirement of consumers.
2. The advantages of foods shock freezing are bacteriological purity, a significant reduction in weight loss, increased shelf life, the possibility of rapid use and significantly sufficient quality of frozen semi-finished products compared to the traditional method.
3. Analysis of the chemical composition of the developed desserts with the use of traditional apple puree and with the use of blended fruit semi-finished products showed that developed desserts have reduced caloric content.
4. When developing new types of desserts, recommendations for the composition, use and dosage of blended pairs of fruit semi-finished products were given: the recommended defrosting time is up to 25 minutes, with rapid defrosting temperature (as an example when whipping dessert), which eliminates the loss of biologically active substances.

References

1. Pimentel T.C., Oliveira L.I.G., Souza R.C., Magnani M. (2020), Probiotic non-dairy frozen dessert: Technological and sensory aspects and industrial challenges, *Trends in Food Science & Technology*, 107, pp. 381–388.
2. Simiqueli A.A., Filho T.L., Minim L.A., Oliveira E.B., Torres I.V. , Vidigal M.C.T.R., Minim V.P.R. (2018), The W/O/W emulsion containing FeSO4 in the different phases alters the hedonic thresholds in milk–based dessert, *LWT – Food Sci. Technol*,, 99, pp. 98–104.
3. Auld G., Boushey C.J., Bock M.A., Bruhn C., Gabel K. , Gustafson D., Holmes B., Misner S., Novotny R., Peck L., Pelican S., Pond-Smith D., Read M. (2002), Perspectives on intake of calcium–rich foods among Asian, Hispanic, and White preadolescent and adolescent females, *J. Nutr. Educ. Behav*, 34, pp. 242–251.

4. Hartel R.W., Rankin S.A., Bradley R.L. (2017), A 100–Year Review: Milestones in the development of frozen desserts, *Journal of Dairy Science*, 100(12), pp. 10014–10025.
5. Quinzio J. (2009), *Of Sugar and Snow: A History of Ice Cream Makingm*, University of California Press, Berkeley.
6. Schmidt K.A., Smith D.E. (1992), Milk reactivity of gum and milk protein solutions, *J. Dairy Sci*., 75, pp. 3290–3295.
7. Regand A., Goff H.D. (2002), Effect of biopolymers on structure and ice recrystallization in dynamically frozen ice cream model systems, *J. Dairy Sci*, 85, pp. 2722–2732.
8. Javidi F., Razavi S.M.A., Behrouzian F., Alghooneh A. (2016), The influence of basil seed gum, guar gum and their blend on the rheological, physical and sensory properties of low fat ice cream, *Food Hydrocoll*, 52, pp. 625–633.
9. Dubey U.K., White C.H. (1997), Ice cream shrinkage: A problem for the ice cream industry, *J. Dairy Sci*, 80, pp. 3439–3444.
10. Goff H.D., Hartel R.W. (2013), *Ice Cream (7th ed.)*, Springer, New York, NY.
11. Sanz V., López-Hortas L., Torres M.D., Domínguez H. (2021), Trends in kiwifruit and byproducts valorization, *Trends in Food Science & Technology*, 107, pp. 401–414.
12. Li D., Zhu F. (2019), Physicochemical, functional and nutritional properties of kiwifruit flour, *Food Hydrocolloids*, 92, pp. 250–258.
13. Li D., Zhu F. (2017), Physicochemical properties of kiwifruit starch, *Food Chemistry*, 220, pp. 129–136.
14. Sun-Waterhouse D., Edmonds L., Wadhwa S.S., Wibisono R. (2013), Producing ice cream using a substantial amount of juice from kiwifruit with green, gold or red flesh, *Food Research International*, 50(2), pp. 647–656.
15. Ward C., Courtney D. (2013), Chapter One – Kiwifruit: Taking Its Place in the Global Fruit Bowl, *Advances in Food and Nutrition Research*, 68, pp. 1–14.
16. Amri F.S.A., Hossain M.A. (2018), Comparison of total phenols, flavonoids and antioxidant potential of local and imported ripe bananas, *Egyptian Journal of Basic and Applied Sciences*, 5(4), pp. 245–251.
17. Chen J., Li F., Li Y., Wang Y., Wang C., Yuan D., Jiang Y. (2019), Exogenous procyanidin treatment delays senescence of harvested banana fruit by enhancing antioxidant responses and in vivo procyanidin content, *Postharvest Biology and Technology*, 158, 110999.
18. Youryon P., Supapvanich S. (2017), Physicochemical quality and antioxidant changes in 'Leb Mue Nang' banana fruit during ripening, *Agriculture and Natural Resources*, 51(1), pp. 47–52.
19. Fatemeh S.R., Saifullah R., Abbas F.M.A., Azhar M.E. (2012), Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: influence of variety and stage of ripeness, *Int. Food. Res. J*, 19(3), pp. 1041–1046.
20. Sulaiman S.F., Yusoff N.A.M., Eldeen I.M., Seow E.M., Sajak A.A., Supriatno A.A., Ooi K.L. (2011), Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (Musa sp.), *J. Food Compos. Anal*, 24, pp. 1–10.
21. Tamer C.E., Incedayi B., Parseker Yönel S., Yonak S., Çopur Ö.U. (2010), Evaluation of several quality criteria of low calorie pumpkin dessert, *Not. Bot. Horti Agrobot. Cluj–Napoca*, 38, pp. 76–80
22. Kim N.-R., Kim H.-Y., Kim M.-H., Kim H.-M., Jeong H.-J. (2016), Improvement of depressive behavior by Sweetme Sweet Pumpkin™ and its active compound, β–carotene, *Life Sci*, 147, pp. 39–45.
23. Zhao Q., Liu J., Chen W., Zhou D., Song C., Zhang Y., Ni Y., Li Y. (2015), Microbiological and physicochemical analysis of pumpkin juice fermentation by the basidiomycetous fungus Ganoderma lucidum, *J. Food Sci*, 80, pp. 241–251.
24. Koh W.Y., Uthumporn U., Rosma A., Irfan A.R., Park Y.H. (2018), Optimization of a fermented pumpkin–based beverage to improve Lactobacillus mali survival and α–glucosidase

inhibitory activity: A response surface methodology approach, *Food Science and Human Wellnes*, 7(1), pp. 57–70.
25. Vanajakshi V., Vijayendra S.V.N., Varadaraj M.C., Venkateswaran G., Agrawal R. (2015), Optimization of a probiotic beverage based on Moringa leaves and beetroot, *LWT – Food Sci. Technol*, 63, pp. 1268–1273.
26. Wu J., Gao H., Zhao L., Liao X., Chen F., Wang Z., Hu X. (2007), Chemical compositional characterization of some apple cultivars, *Food Chemistry*, 103(1), pp. 88–93.
27. Price K.R., Prosser T., Richetin A.M.F., Rhodes M.J.C. (1999), A comparison of the flavonol content and composition in dessert, cooking and cider-making apples; distribution within the fruit and effect of juicing, *Food Chemistry*, 66(4), pp. 489–494.
28. Kuzmin O., Kucherenko V., Sylka I., Isaienko V., Furmanova Y., Pavliuchenko E., Hubenia V. (2020), Antioxidant capacity of alcoholic beverages based on infusions from non–traditional spicy–aromatic vegetable raw materials, *Ukrainian Food Journal*, 9(2), pp. 404–424.
29. Polyovyk V., Koretska I., Kuzmin O., Zinchenko T. (2020), Modeling of innovative technology of fruit and berry desserts, *Restaurant and hotel consulting. Innovations*, 3(2), pp. 221–236.
30. Koretska I., Kuzmin O., Zinchenko T. (2020), Sample rating in water–alcohol technology by profile non-linear quality criteria, *Restaurant and hotel consulting. Innovations*, 3(1), pp. 12–24.
31. Potapov S.H., Maslikov M.M. (2009), Laboratorna ustanovka dlia bezperervnoho kontroliu ta reiestratsii parametriv hazovoho seredovyshcha, *Naukovi pratsi NUKhT*, 29, pp. 78–80.

Effect of germinated lentil seeds eddition on the nutritional value of the beverage

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Abstract

Introduction. The properties of dry and germinated lentils are compared, and the influence of germinated lentils on the properties of the beverage is determined.

Materials and methods. Dry and germinated lentil seeds are studied, as well as a beverage, the technology of which involves soaking dry lentil seeds, germination, grinding, extraction of biologically active substances, filtration and bottling. Determination of amylase activity was studied by the method of Wolgemuth. The amino acid composition of proteins in plant raw materials was determined by ion exchange chromatography. The biological value of proteins was determined by calculating the amino acid score

Results and discussion. Under the action of proteolytic enzymes during germination changed the protein composition of the seeds, and as a consequence of the beverage from it. The protein content in germinated seeds increased by 2.2%, and in beverages from it by 3.3% in terms of dry matter compared to the beverage from dry seeds. An increase in amylase activity during germination was detected, which leads to the breakdown of starch into dextrins and simple sugars. The amount of water and salt solvent protein fractions (albumins and globulins) increased, within 1.1–2.9%, which leads to increased protein extractivity.

The total level of protein digestibility of the beverage from germinated lentil seeds is 63.31%, while the mass fraction of protein used by the body is not rational – only 20.85%.

In the drink from germinated lentil seeds there is an increase in the amount of extracted protein by 3.3%, B vitamins and minerals compared to the beverage from dry seeds. This is due to the activity of α-amylase, which cleaves high molecular weight carbohydrates, which are the basis of cell membranes of plant materials. This allows you to increase the extractivity and as a result more nutrients are transferred to the beverage.

Conclusions. The beverage based on germinated lentil seeds has an improved chemical composition and better digestibility of protein compared to a beverage made from dry seeds.

Introduction

Development of protein products from plant raw materials is actual for scientists and food industry. For example, it is developed a beverage based on soy milk with the addition of Brazil nut milk. Beverage is characterized by combined sensory properties of both types of raw materials and a balanced chemical composition of the product [1]. It was researched ways to obtain and enrich almond milk, and developed a number of recipes with the addition of biologically active substances to almond milk, which allowed to expand the range of protein products of plant origin. [2]. Sometimes these raw materials are expensive, so it is advisable to choose alternative raw materials, such as lentils.

It was investigated the production of beverage from germinated soybeans and the establishment of the effect of biochemical reactions that occur during germination on the physicochemical properties of the final product [3]. The main disadvantage of this technology is the presence of a specific soy flavor, which necessitates additional technological stages of processing and addition of food additives, while lentils have pleasant sensory properties, so beverage made from it do not require additional components.

It wasstudiedthe technology of preventive beverages based on aqueous extraction of compositions of soybeans, oatmeal and oat bran [4]. The main disadvantage of soybeans is that a significant share of the world market is genetically modified. Because the use of genetically modified raw materials is not a sufficiently studied area, this product can be potentially dangerous.

It wasstudiedthe technology ofyogurt beverage from soy suspension and bee keeping products [5]. Because soybeans and beverages from themare quite common and researched, it is important to introduce new plant raw materials to provide nutrients.

Lentils can be used to enrich flour products [6], in confectionery production [7], for making sauces and textures [8,9]. Lentils were not used in the technology of beverage production, so it is advisable to investigate its use in dry and germinated form for the manufacture of beverages, because of the sensory characteristics and chemical composition, [10] this type of legume is a promising raw material.

Lentils are a valuable bean raw material that is a source of dietary protein with a balanced amino acid composition and contains a small amount of fat, is also a valuable source of complex carbohydrates, soluble and insoluble fiber, vitamins and minerals (Na, Ca, Fe, P and Cu). Also, lentils do not accumulate harmful and toxic substances (nitrates, radionuclides, etc.), so it is considered an environmentally friendly product [11]

As a result of research it was established [8] that the best method of preparation of lentils for culinary processing is germination, ie biotransformation of raw materials compounds. The process of germination not only includes all the benefits of inactivation of anti-nutrients, but also is accompanied by an increase in catalysis by enzymes breaking down complex substances of the endosperm into simpler ones, which are more soluble and promote embryo development.

The germination temperature is 17±2 °C, which is sufficient to minimize the loss of nutrients during germination. Germination ends when the sprout reaches a length of 1 cm, which lasts an average of 72 hours to 88 hours. According to studies [12], under such conditions there is a maximum accumulation of extractives – up to 29.9 mg/100 g, the maximum yield of germinated lentil grains at a given technological parameters is 92%, reduced losses of germinated sprouts. Germination is completed by removing water, which prevents further growth of the roots of the embryo.

The aim of our study is to determine the effect of germination of lentil seeds on the nutritional value of a beverage made from it.

Materials and methods

Materials

Dry and germinated lentil seeds are studied, as well as a beverage, the technology of which involves soaking dry lentil seeds, germination, grinding, extraction of biologically active substances, filtration and bottling.

Preparation of research samples

Germination of lentil seeds was performed in a special round container containing a lattice. The bottom of the tank is equipped with a hole for draining water. The water tank under the grates is filled with water to soak the lentils. Grinding of lentil grains is carried out with the help of laboratory mills [12]

Technology of beverage

The technology of beverage from dry lentil seeds includes the following stages:

- Soaking dry seeds with water at a temperature of 18–22 °C for 6–24 hours, with a seed: water ratio of 1: 3 (the ratio may vary depending on the type of raw material);
- Decantation of excess water, after swelling of seeds;
- Grinding of moistened seeds to a puree-like state;
- Extraction of biologically active substances with preheated water to 50–90 °C in the ratio 1: 6 and maintaining the temperature for 10–60 min;
- Filtration.

Therefore, when making a beverage from germinated lentil seeds, it is necessary to add such an additional stage as germination, but save the stage of soaking. The soaking stage before germination is necessary to moisten the dry seeds to a moisture content of 35–40%, which will soften the seed coat and activate biochemical processes in the middle of the seed.

The technology involves soaking dry lentil seeds, this stage reduces the duration of heat treatment and reduces the negative impact of oligosaccharides (raffinose, stachyose) and high-polymer protein structures on the digestive process.

Grinding is carried out to a particle size of 0.2–0.5 mm in order to improve the extractivity of the raw material, because the amount of extracted biologically active substances (BAS) is directly proportional to the degree of grinding.

Extraction is carried out according to the parameters recommended for the manufacture of plant protein beverages, namely at a temperature of 50–90, at a ratio of water 1:6 for 10–60 minutes These extraction parameters allow to make a beverage with high nutritional value, because they allow to remove the maximum amount of BAS from raw materials

The technological scheme of making a beverage from germinated lentil seeds is presented in Figure 1.

Before germination, the lentils are washed twice in cold running water and placed in an even layer in a container for germination, where the grain is soaked for 8 hours. When soaking lentils, water penetrates into the grain germ, and then through the side shells into the grain. Water absorption capacity depends on the duration of soaking, temperature, grain size.

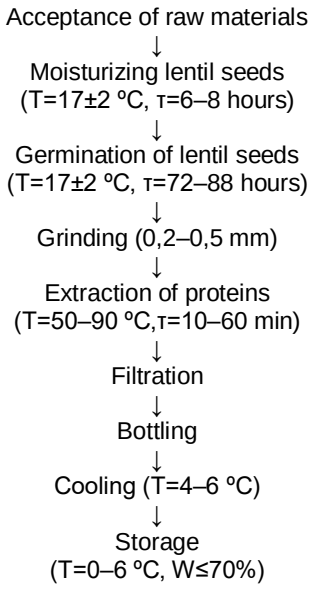

Figure 1. Technological scheme of making a beverage from germinated lentil seeds

Description of methods

Chromatographic method. The amino acid composition of proteins in plant raw materials was determined by the method of ion exchange chromatography on columns using a T339 analyzer. Ion-exchange column chromatography is based on the acid-base properties of amino acids. Ninhydrin detection is used to register amino acids in eluates.Özlem Bahadir Acikara (April 10th 2013) [13,14].

Determination of amylase activity. Determination of amylase activity was investigated by the method of Wolgemuth, which is based on the detection of the minimum amount of enzyme capable of completely breaking down 2 mg of starch in 15 minutes. This amount of enzyme is taken as a unit of amylase activity [15,16].

Amino acid score. The biological value of proteins is determined by calculating the amino acid score (Cj), which is the ratio of the content of a certain essential amino acid (EAA) in the protein of the product to the content of the same EAA in the reference protein:

$$p_j = \frac{A_j}{A_{jr}} \cdot 100 \quad (1)$$

where Aj–the content of the j-th EAA in the protein of the product, g per 100 g of protein;

Aje–the content of the j-th EAA in the reference protein, g per 100 g of protein.

The total level of digestibility of protein is estimated by the utilitarian coefficient (u,%), which is calculated by the equation:

$$u = C_{min} \frac{\sum_{j=1}^{e} A_{jr}}{\sum_{j-1}^{e} A_j} \cdot 100 \quad (2)$$

where Cmin–amino acid, the score of which is the lowest;

Aj–the content of the j-th EAA in the protein of the product, g per 100 g of protein;

Aje–the content of the j-th EAA in the reference protein, g per 100 g of protein.

The coefficient of redundancy EAA (σ), as the mass fraction of EAA in 100 g of protein in product used by the body is not rational:

$$\sigma = \frac{\sum_{i-1}^{8}\left(A_j - C_{min} \cdot A_{jr}\right)}{C_{min}} \cdot 100 \quad (3)$$

where Cmin–amino acid, the score of which is the lowest;

Aj–the content of the j-th EAA in the protein of the product, g per 100 g of protein;

Aje–the content of the j-th EAA in the reference protein, g per 100 g of protein[17].

Results and discussion

Result of chemical compositionstudies

Comparative characteristics of the chemical composition of dry and germinated lentil seeds and beverages from them are given in Table 1.

Table 1

Comparative characteristics of the chemical composition of dry and germinated lentil seeds and beverages from its

Indicators	Mass fraction in terms of solids, g/100g			
	Dry seeds	Germinated seeds	Beverage from dry seeds	Beverage fromgerminated seeds
Solids, %	91,0±5,0	60,0±5,0	7,3±0,6	7,8±0,6
Proteins	31,3±2,0	33,5±2,0	19,8±2,0	23,1±2,0
Fats	1,3±0,1	1,0±0,1	0,9±0,1	0,6±0,1
Digestible carbohydrates	54,3±4,0	54,2±4,0	48,5±4,0	49,1±4,0
Indigestible carbohydrates	8,6±0,5	7,8±0,5	1,3±0,2	1,1±0,2
Ash content	3,4±0,2	3,5±0,2	2,6±0,2	2,6±0,2
Vitamins, mg/100g				
B-carotene	0,03±0,005	0,03±0,005	0,02±0,005	0,02±0,005
Vitamin B_1 (thiamine)	0,58±0,01	1,0±0,01	0,49±0,01	0,8±0,01
VitaminB_2 (riboflavin)	0,25±0,01	0,63±0,01	0,20±0,01	0,59±0,01
VitaminPP (niacin)	2,1±0,05	3,8±0,05	1,9±0,05	3,7±0,05
VitaminE	0,58±0,05	11,3±0,05	0,28±0,05	6,3±0,05
Mineral compounds, mg/100g				
Ca	99,5±5,0	137,2±5,0	69,5±5,0	87,1±5,0
Mg	93,6±5,0	92,4±5,0	82,6±5,0	82,4±5,0
P	249,0±10,0	291,4±10,0	201,0±10,0	232,8±10,0
Fe	13,7±1,0	14,0±1,0	12,6±1,0	13,1±1,0

The above data show that the chemical composition of germinated lentil seeds and the beverage from it are characterized by a higher content of biologically active substances compared to products without germination. This is due to the high enzymatic activity, which improves the extractive properties of raw materials. Germination of lentil seeds has an effect on the content of biologically active substances in the beverage made from it.

Amylase activity studies

An important indicator of biochemical changes that occur during germination is the increase in the hydrolytic activity of enzymes[9]. Especially high activity is α – amylase (Figure 2).

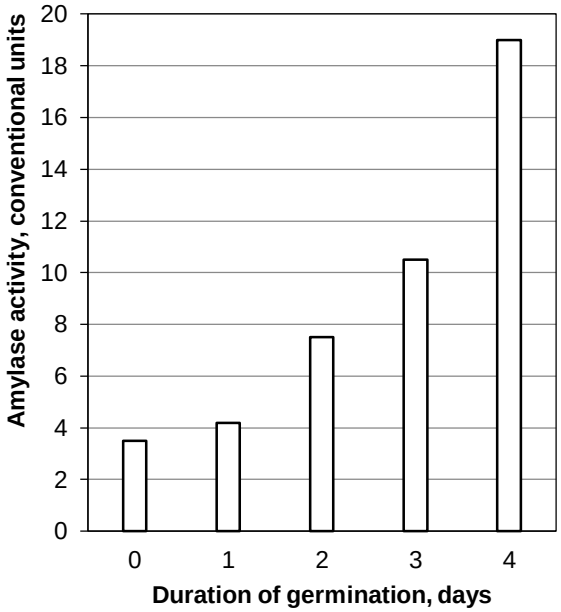

Figure 2. Change in lentil amylase activity during germination

As can be seen from Figure 2. amylase, an enzyme of the amylolytic complex, accumulates during the maturation and germination of seeds [18]. This process leads to the splitting of about 20– 24% of starch. The obtained data confirm the results of scientific [22] studies on the enzymatic activity of amylase in the process of seed bioactivation

Protein fractional composition studies

Along with the breakdown of starch, under the action of proteolytic enzymes, there is a hydrolysis of protein substances, which leads to the formation of easily digestible substances. A study of the effect of germination on the change in protein fractional composition was also performed (Figure 3).

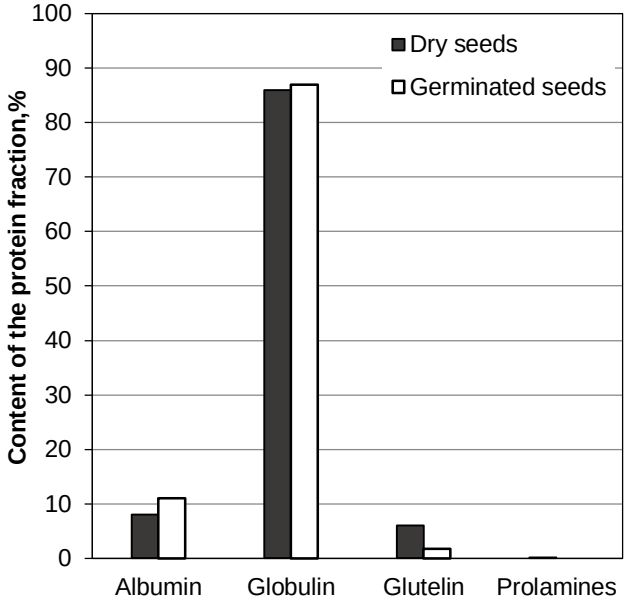

Figure 3. Fractional composition of protein of dried and germinated lentil seeds

From Figure 3 it is seen that during germination the amount of water- and salt-soluble fractions of protein increases, which allows to improve their extractive properties in the manufacture of a drink from germinated lentil seeds and to use water as a solvent.

Analyzing the results of scientific research [19], there is a general trend of increasing albumin and globulin in germinated legumes due to the redistribution of peptide bonds and activation of enzymes.

Amino acid compositionstudies

As a result of germination, grain enzymes are activated, under the action of which the decomposition of deposited starch into dextrins and maltose, and proteins into amino acids begins. The change in the chemical composition of lentil seeds during germination is reflected in the content of biologically active substances in beverages from it.The study of the comparative characteristics of the amino acid composition of the protein of beverage from germinated and dried lentils is presented in Table 2.

By analyzing the data in Table 2, we can conclude that the overall level of digestibility of protein drink from germinated lentil seeds is 63.31%, while the mass fraction of protein used by the body is not rational – only 20.85%. This allows to position the beverage from the germinated lentil seeds as a product with high biological value

Table 2

Amino acid composition of protein beverages from germinated and dried lentils

Amino acid	Reference protein according to FAO/WHO, g/100 g of protein	Content in beverage from germinated lentils		Content in beverage from dried lentils	
		g/100g of protein	Amino-acid score, %	g/100g of protein	Amino-acid score, %
Lysine	5,5	7,52	136	7,4	132
Threonine	4,0	3,91	98	3,8	90
Methionine + Cystine	3,5	9,3	265	8,8	250
Valine	5,0	3,95	80	3,5	70
Isoleucine	4,0	3,99	99	2,9	75
Leucine	7,0	8,55	122	7,9	115
Tyrosine	6,0	5,88	98	4,9	81
Tryptophan	1,0	2,65	265	1,6	169
Coefficient of utilitarianism		63,31		62,91	
Coefficient of redundancy		20,85		21,25	

Conclusions

1. The undeniable useful properties of the beverage from germinated lentil seeds are the absence of lactose and cholesterol; low caloric content; increased content of mono- and polyunsaturated fats; high content of vitamins and minerals; balanced amino acid composition.
2. For bioactivation of lentil seeds, and as a consequence of improving its chemical composition by splitting macromolecular compounds into smaller compounds, it is proposed to germinate seeds at a temperature of 17±2 °C for 72–88 hours.
3. Technological scheme of making a beverage from germinated lentil seeds includes soaking, germination, grinding, extraction, filtration, packaging and storage.
4. An increase in amylase activity during germination was revealed, which leads to the breakdown of starch into dextrins and simple sugars.
5. Under the action of proteolytic enzymes during germination changed the protein composition of the seeds, and as a consequence of the drink from it. The amount of water- and salt-solvents of protein fractions (within 1.1–2.9%) increased, which leads to increased protein extractivity.
6. The total level of protein digestibility of the drink from germinated lentil seeds is 63.31%, while the mass fraction of protein used by the body is not rational – only 20.85%.

References

1. Felberg I., Antoniassi R., Deliza R. Cordeiro de Freitas S., Celia Della Modesta R. (2009), Soy and Brazil nut beverage: processing, composition, sensory, and color evaluation, *Ciênc. Tecnol. Aliment. Campinas. J,* 29(3), pp. 29.

2. Florentina Dan A. (2014), *Research regarding the production and the improvement of quality and nutritional value of almond milk as a possible substitute for cow's milk*, Lucia Blaga University of Sibiu, Sibiu
3. Susu Jiang, Weixi Cai, Baojun Xu. (2013), Food Quality Improvement of Soy Milk Made from Short-Time Germinated Soybeans, *Foods Journa*l, 2, pp. 198–212.
4. Doronin A.F., Soboleva N.P., Pakhomova T.A. (2011), Kombinirovannye napitki na soevoi osnove, *Pishchevaia promyshlennost*, 8, pp. 32–33.
5. Butova S V . Shakhova M.N. (2003), Razrabotka tekhnolohii polucheniia yohurta na osnove soevoi dispersii, *Mezhrehionalnaia nauchn-prak konf Molodykh uchenykh i spetsyalistov «Vklad molodykh uchenykh v razvitie ahrarnoi nauki v nachale XXI veka*», pp. 228–229
6. Botasheva Kh.Yu. (2015), Povyshenie biotekhnolohicheskoho potentsyala muchnykh konditerskykh izdelii, *Fundamentalnye issledovaniia*, 11, pp. 32–36.
7. Cheliabiieva V., Semeniuk O, Havryk M. (2017), Vykorystannia netradytsiinoi syrovyny u kondyterskomu vyrobnytstvi, *Tekhnichni nauky ta tekhnolohii*, 2 (8), pp. 195–201.
8. Telezhenko L. M., Atanasova V. V. (2010), Sochevytsia yak vazhlyvyi natsionalnyi resurs roslynnoho bilka, *Kormy i kormovyrobnytstvo*, 66, pp. 158–163.
9. Telezhenko L. M. Atanasova V. V. (2011), Doslidzhennia iakosti prorоshchenoho zerna sochevytsi pry kholodylnomu zberihanni, *Naukovi pratsi ONAKhT*, 1(39), pp. 270–273.
10. Erskine W., Muehlbauer F.J., Sarker A. (2009), *The lentil botany, production and uses*. CAB International.
11. Gordeev, A. V., Butkovskij A. V. (2004), Rol' zerna v formirovanii struktury pitanija naselenija, *Zernovi produkti i kombikormi*, 3, pp. 4–9.
12. Hamicaeva A. S. (2010), Prorashhennaja chechevica i ee ispol'zovanie, *Vestnik Saratovskogo gosagrouniversiteta*, 6, pp. 14–15.
13. Bhattacharyya L, Rohrer JS. (2012), *Applications of Ion Chromatography for Pharmaceutical and Biological Products*, New Jersey: John Wiley & Sons.
14. Cummins PM, Rochfort KD, O'Connor BF (2017), Ion-exchange chromatography: basic principles and application, *Protein Chromatography*, 2, pp. 209–223.
15. Rizliya Visvanathan, Chathuni Jayathilake, Ruvini Liyanage (2016), A simple microplate-based method for the determination of α-amylase activity using the glucose assay kit (GOD method), *Food Chemistry*, 211, pp. 853–859.
16. Nikola Sakač, MilanSak-Bosnar, MarijaHorvat (2011), A new potentiometric sensor for the determination of α-amylase activity, *Talanta*, 83 (5), pp. 1606–1612.
17. Dubinina A.A., Lenert S.O., Popova T.M. (2015), Analiz aminokyslotnoho skladu ta biolohichnoi tsinnosti bilka krupy hrechky iz hrechky riznykh sortiv, *Tekhnolohycheskii audit i rezervy proizvodstva*, 4 (24), pp. 55–61.
18. Souza P. M., Bittencourt M. L. de A, Caprara C. C., Freitas M., Almeida R. P. (2015), A biotechnology perspective of fungal proteases, *Brazilian Journal of Microbiology*, 46(2), pp. 337–346.
19. Arsenieva L.Yu., Bondar N.P., Usatiuk S.I., Dotsenko V.F. (2017), Doslidzhennia zminy khimichnoho skladu nasinnia bobovykh pid chas prorоshchuvannia ta ekstruduvannia, *Khranenye y pererabotka zerna*, Available at: http://hipzmag.com/tehnologii/pererabotka/doslidzhennya-zmini-himichnogo-skladu-nasinnya-bobovih-pid-chas-proroshhuvannya-ta-ekstruduvannya/
20. Kondykov I.V., Ikonnikov A.V., Chuvasheva E.S. (2013), To the problem of biofortification and diversification of lentil crop, *Vestnik Orel GAU*, 3, pp. 16–23.

21. Joaquín Navarro del Hierro, Teresa Herrera, Mónica R.García-Risco (2018), Ultrasound-assisted extraction and bioaccessibility of saponins from edible seeds: quinoa, lentil, fenugreek, soybean and lupin *Food Research International*, 109(15), pp. 440–447.
22. Van der Maarel, M Van der Veen B., Uitderhaag H. (2002), Properties and applications of starch-converting enzymes of the α-amylase family, *Ibid*, 94, pp. 137–155.

Effect of frozen storage, light, and heating temperature on the stability of anthocyanins of natural color extracted from pomegranate peel (*Punica granatum* L.)

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Abstract

Introduction. Pomegranate peel is a rich source of anthocyanin pigment, antioxidants as well as minerals. The focus of this study is to investigate the stability of anthocyanin of color obtained from Pomegranate peel under selected conditions and antioxidant activity as well as mineral composition.

Materials and methods. The anthocyanin pigment procured from Pomegranate peel (*Punica granatum* L.) was identified with UV-Visible Spectrophotometer under the frozen condition (at -10 °C) as well as the presence & absence of light for three days intervals and under various heating temperatures (30, 45, 60 °C and 75 C respectively). The antioxidant capacity and selected minerals content (Mg, Ca, P, Fe, and K) of natural color were determined by the DPPH method using the UV-Visible Spectrophotometer and the biochemical analyzer (Humalyzer, 3000) respectively. The sensory analysis of the prepared products as jelly with the addition of natural & artificial color compared with commercial one was done based on a hedonic rating test.

Result and discussion. The stability of anthocyanin extracts had significantly been affected by the frozen condition resulted in 62.96% reduction after 9th day, temperature (29.59–51.61% degradation from initial to final temperature), and exposure to light generated 44.87% reduction after 9th day. The mineral content (Mg, Ca, P, Fe, and K) of natural (extracted from Pomegranate peel) and artificial color (a mixture of E110, E122 and E330) were 7.2, 20.6, 2.15, 1.4 and 147.6 mg/100g respectively for natural colors as well as 0.2, 0 (no phosphorus), 0.39, 0.56 and 7.2 mg/100g for artificial color respectively. The antioxidant capacity of natural color resulted in 0.04 µg/mL of IC50 value. No significant difference ($p<0.05$) was found regarding the color, appearance, and general acceptance of the jelly samples.

Conclusion. The natural color from pomegranate peel could be the replacement of synthetic color as well as a good source of antioxidants and minerals.

Introduction

Color is an important quality attribute of foods which is generally added to foods to make them appealing, augment the loss of color during processing, to improve the quality, and also to influence the consumer to buy a product [13].

The pomegranate peels (*Punica granatum* L.) made up about 60% of the fruit abound with bioactive compounds (e. g phenolics, flavonoids) and many minerals [26]. Anthocyanins, the most important and abundant natural pigments belonging to the flavonoid family, possess antioxidative properties [19, 27].

Recently, it has been found that synthetic dyes are undesirable for human consumption in terms of toxicity [3]. Apart from that, the color attributes together with anthocyanins from plant sources are reportable to be useful to health with potential physiological effects, like antineoplastic, radiation-protective, vasotonic, vaso-protective, anti-inflammatory drug, chemo- and hepato-protective effects [10, 16. 17]. However, the stability of anthocyanins is influenced by a variety of factors, such as temperature, pH, light, oxygen, enzymes, presence of antioxidant, sugars, sulfite salts, metal ions, and copigments [6, 9] having a significant impact on food processing, formulation, and storage.

Therefore, *the objective of this study* was to find out the stability of anthocyanin of natural color obtained from pomegranate peel under selected conditions (frozen storage, light exposure, and heating temperatures).

In addition to this, the antioxidant capacity of the natural color, mineral content (Mg, Ca, P, Fe, and K) as well as sensory evaluation of developed jellies with added color (both natural and artificial) and commercially available jellies were done.

Material and method

Sample collection

Pomegranae (*Punica granatum* L), apple (*Malus pumila*) for making jelly for sensory evaluation, and commercial apple jelly were collected from the local market of Chittagong, Bangladesh.

Place of the experiment

All the experiments were conducted in the laboratory of Food Processing and Engineering, at the Dept. of Applied Food Science and Nutrition as well as Dept. of Physiology, Biochemistry, and Pharmachology at Chittagong Veterinary and Animal Sciences University (CVASU).

Sample preparation

The pomegranate was washed by tap water to remove adherences, dirt, and other surface impurities. Then thin peels of pomegranate were taken manually with a stainless-steel knife and cut into small pieces.

Extract preparation

Pomegranates peels were washed with water, chopped into small pieces, transferred into respective beakers added with absolute ethanol, subsequently shaken with the help of a magnetic stirrer, and then left for 72 h at room temperature. After separating the solvent from the residue by straining, the filtrate was collected and stored at room temperature while the

residue was re-extracted twice, each time with fresh solvent. Then, the evaporation of all filtrates was done under reduced pressure at 60 °C using a rotary evaporator to obtain the crude extracts that were weighed and stored at 4 °C, until further analysis. The stability of anthocyanin extracts under the influence of frozen condition (-10 °C) and natural light was studied at 3 days intervals. On the other hand, the stability of anthocyanin was examined at 30, 45, 60 and 75 °C for 30 minutes in a water bath so as to observe the impact of heating temperature. In order to observe the influence of natural light on the stability of anthocyanin extracts, some samples were stored in the light and the dark. UV-Visible Spectrophotometer was used for measuring total anthocyanin content (TAC).

Total anthocyanin content (TAC) assay

TAC of the Pomegranate peel extracts was determined by adopting a slightly modified method described by Selim et al. [23]. TAC was calculated and expressed as milligrams per 100g (mg/100g) using the following equation:

$$\text{TAC} = \frac{\text{Absorbance of the sample} \times \text{DF} \times 100}{\text{m} \times \text{E}} \quad (1)$$

where DF stands for dilution factor; m means the weight of the sample for making stock solution; E refers to the extinction coefficient (55.9).

Determination of antioxidant capacity

The antioxidant capacity of the extracts was determined using the DPPH method described by Azlim Almey et al. [2]. Antioxidant capacity based on the DPPH free radical scavenging ability of extracts was calculated using the following equation:

$$\%\ \text{inhibition} = \left[1 - \frac{\text{Absorbance of sample}}{\text{Absorbance of sample}}\right] \times 100\% \quad (2)$$

Each experiment was replicated three times.

Analysis of minerals

The contents of Phosphorus (P), Iron (Fe), potassium (K), calcium (Ca), and Magnesium (Mg) were measured by Biochemical Analyzer (Humalyzer, 3000) commercially available biochemical kit (Randox®) used for biochemical assay for both natural & artificial color.

Preparation of apple jelly with natural and artificial color (a mixture of E110, E122, and E330)

Apple jelly was prepared by using a method by Panchal et al. [22]. 250 mL of clear fruit juice was poured into a stainless-steel pan for boiling. A required amount of pectin (4.9g) with a small amount of sugar (40g) was added in a stainless-steel pot. Another 100g sugar was mixed with juice followed by boiling until the TSS become nearer to 55°Brix. Then sugar mixed pectin was added with continuous boiling until TSS becomes nearer to 58 °Brix. After that, 1.25g citric acid was added with continual boiling till the desired consistency and TSS (67° Brix). Finally, the sodium benzoate and a small amount of natural color were added. Jelly with artificial color was also made in the same way.

Sensory evaluation of jelly

The Sensory evaluation of apple jelly samples (sample with natural color; sample with artificial color, and commercial jelly) were performed using 9 points Hedonic scale [1] (Amerine et al., 1965).

The scale were organized such that: Like extremely = 9, Like very much = 8, Like moderately = 7, Like slightly = 6, Neither like nor dislike = 5, Dislike slight = 4, Dislike moderately = 3, Dislike very much = 2, Dislike Extremely = 1.

Statistical analysis

Data collected in this study were analyzed by one way ANOVA (Tukey's Multiple Comparison Test), while significant differences between means of natural and artificial colors at the level of $p<0.05$ were analyzed by independent sample t-test using SAS (Statiscally analysis system) 9.3 and SPSS (Statistical Package for the Social Sciences) version 16.0.

Result and discussion

Total anthocyanin content (TAC) in mg/100g at the frozen storage and influence of light

Table 1 showed a significant difference ($p< 0.05$) of anthocyanin content among the different conditions corresponding to the frozen storage, presence of light, and absence of light at three days intervals (except in the 3rd and 6th days regarding the absence of light). The result of the frozen pomegranate peel color showed that total anthocyanin content decreased by 62.96% (48.3±0.4 to 17.89±1.29) approximately after 9th days' frozen storage (−10 °C). A similar effect was found in frozen pomegranate juice [18] in which total anthocyanins decreased by 11% after 20 days' frozen storage (−25 °C) attributed to a concentration effect due to moisture loss or enhanced extraction of anthocyanins resulted from tissue softening [18] (Hager et al., 2008).

The effects of light on anthocyanins (in Table 1) showed that the total anthocyanin content was decreased by 44.87% (48.3±0.4 to 26.63±1.6) in the presence of light, opposed to 33.29% (48.3±0.4 to 32.22±1.38) in the absence of light after 9th day of storage. The similar effect found by Laleh et al. [14] for four Berberis species in which the destruction of total anthocyanin content were 85.22%, 79.04%, 59.22%, and 26.4% respectively in the presence of light, opposed to 72.06%, 21.23%, 96.61%, and 75.24% respectively in the absence of light for *B. integerrima*, *B. vulgaris*, *B. khorasanica* and *B. orthobotrys*.

Total Anthocyanin Content (TAC) in mg/100g at Different Heating Temperature

Table 2 showed the total anthocyanin content (mg/100g) with the increase in heating temperature (30°, 45°, 60°, and 75 °C) were 34.01 mg/100g, 30.43 mg/100g, 26.85 mg/100g, and 23.37 mg/100g indicating the destructive effect of temperature on anthocyanin of color from pomegranate peel. A similar effect was found by Maccarone et al. [15] for red-orange juice at 15°C, 25°C, and 35°C during a 15-day period that revealed that the increase in temperature accelerates the destruction of anthocyanins.

Table 1

Total anthocyanin content (mg/100g) at the frozen storage (at -10 °C) and the influence of light

Total Anthocyanin Content (mg/100g)			
Days	**Frozen storage (at -10 °C)**	**Presence of light**	**Absence of light**
0	48.3 ± 0.4^{a}	48.3 ± 0.4^{a}	48.3 ± 0.4^{a}
3	32.22 ± 2.02^{b}	39.61 ± 1.71^{b}	41.7 ± 2.98161^{b}
6	25.06 ± 1.16^{c}	32.48 ± 0.78^{c}	35.8 ± 2.57099^{b}
9	17.89 ± 1.29^{d}	26.63 ± 1.6^{d}	32.22 ± 1.38^{c}

Values containing different superscript letters stand for a significant difference; the comparison was held across the days.
Results are means ± standard deviation of triplicates (n=3).

Table 2

Total anthocyanin content (TAC) in mg/100g at different heating temperature

Heating temp (°C)	Total anthocyanin content
Control (no heat exposure)	48.3 ± 0.4^{a}
30	34.01 ± 3.53467^{b}
45	30.43 ± 3.61316^{bc}
60	26.85 ± 2.55^{bc}
75	23.37 ± 3.17^{c}

Values consisting of different superscript letters refer to a significant difference; the comparison was held across temperatures.
Results are means ± standard deviation of triplicates (n=3).

Antioxidant Activity by DPPH (2, 2-Diphenyl-1-Picrylhydrazyl) Assay

Figure 1 shows the % inhibition of the natural color extracted from pomegranate peel against the concentration (mg/mL) displaying the increase in the % inhibition with the dose. The % inhibition was sharply increased (67.31%) initially (0.1 mg/mL) and increased slowly later. Besides, the % inhibition at concentration 0.1 mg/mL is significantly different from 0.2 mg/mL, 0.4 mg/mL, 0.6 mg/mL & 0.8 mg/mL and vice versa whereas the % inhibition at 0.2 mg/mL is significantly different from 0.1 mg/mL, 0.4 mg/mL & 0.6 mg/mL and vice versa. The IC50 value of the natural color was 0.04 µg/mL calculated from this non-linear regression curve while Kanatt et al. [11] and Kasliwali & Quadri [12] found the IC50 value of Peel extract for DPPH radical scavenging was 4.9 µg mL–1 and 20 mg/mL respectively which are higher than the current research probably caused by the impact of environmental and cultivar differences of pomegranate fruit [5, 7, 20] (Gil et al. 2000; Opara et al. 2009; Fawole et al. 2011).

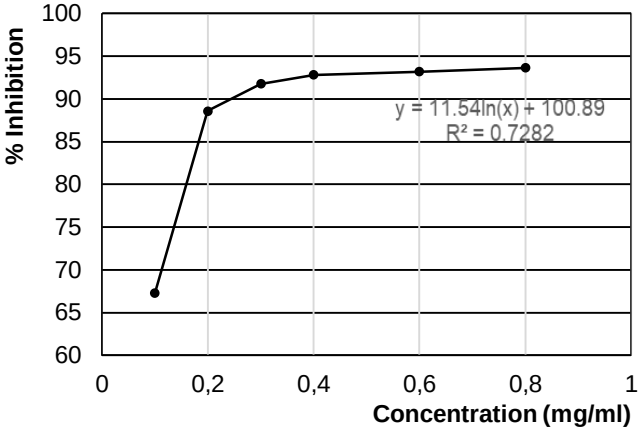

Figure 1. Dose-response curve for antioxidant activity of pomegranate peel color against concentration (mg/mL) by the DPPH method

Analysis of Minerals of Natural & Artificial Color

Figure 2 shows the significant difference of mineral content (mg/100g) between two colors (natural and artificial) at $p<0.05$ which shows 7.2 mg/100g Magnesium (Mg), 20.6 mg/100g Phosphorus (P), 2.15 mg/100g Calcium (Ca), 1.4 mg/100g Iron (Fe) and 147.6 mg/100g Potassium (K) for natural color whereas, the content of these minerals were 0.2 mg/100g (Mg), 0.39 mg/100g (Ca), 0.56 mg/100g (Fe) and 7.2 mg/100g (K) for artificial color.

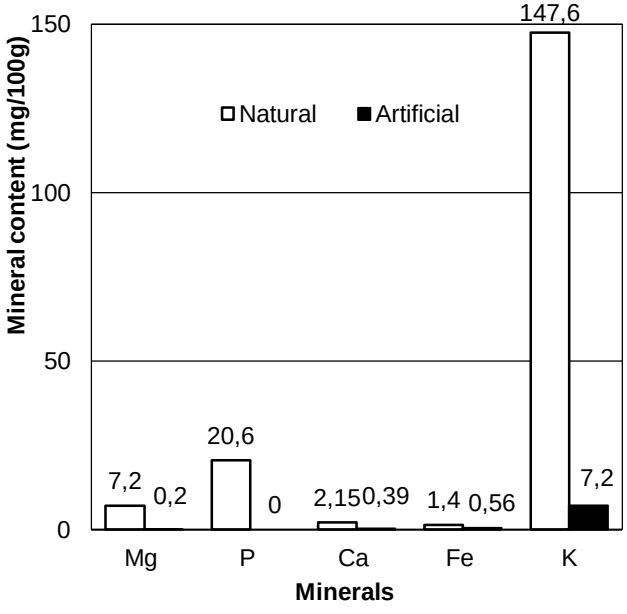

Figure 2. Mineral content (mg/100 g) of Natural and artificial color

No Phosphorus (P) was found in this artificial color. This variation might be due to their compositions. On the other hand, Sharma et al. [24] found 667.95 mg/100g Ca, 72.82 mg/100g Mg, 52.48 mg/100g K, 5.7 mg/100g phosphorus, and 1.8 mg/100g closed to the result for pomegranate peel extract powder. This variation between two results might be originated due to the differences in pomegranate cultivar, soil type, agro-climatic & environmental conditions, soil contamination, the bioavailability of trace elements, analytical methods, e.t.c [4] (Fadavi et al., 2005).

Sensory Analysis of Jelly with Natural Color Extracted from Pomegranate Peel, Artificial Color, and Commercial Jelly

Table 3

Sensory analysis of jelly

Attributes	Samples	Mean ±SD
Color	SN	8.2 ± 0.68^{a}
	SA	7.8 ± 0.86^{a}
	SC	7.7 ± 1.84^{a}
Flavor	SN	8.07 ± 0.8^{a}
	SA	7.7 ± 0.9^{ab}
	SC	6.6 ± 2.2^{b}
Texture	SN	8.1 ± 0.52^{a}
	SA	7 ± 0^{b}
	SC	7.7 ± 1.1^{a}
Taste	SN	8.5 ± 0.64^{a}
	SA	8.1 ± 0.74^{a}
	SC	6.6 ± 1.4^{b}
Appearance	SN	7.9 ± 0.74^{a}
	SA	7.5 ± 0.92^{a}
	SC	8.3 ± 1.03^{a}
General Acceptance	SN	8.1 ± 0.52^{a}
	SA	7.6 ± 0.99^{a}
	SC	7.2 ± 1.57^{a}

Here, SN= Sample of jelly with natural color, SA= Sample of jelly with artificial color, and SC= Commercial sample of jelly. Value containing different superscript letters refer to a significant difference; the comparison was held across attributes. Results are means ± standard deviation of triplicates (n=3).

The mean score for appearance, color, flavor, texture as well as overall acceptability of the jellies were evaluated, and the mean score of their responses ($p<0.05$) are represented in Table 3, revealing that difference among sample with natural color (SN), the sample with artificial color (SA) and commercial sample (SC) was not significant regarding color, appearance, and general acceptance, indicating equal acceptability of all samples corresponding to that attributes. Additionally, it also signified that color from pomegranate peel did not affect the quality attributes of prepared jellies.

Conclusion

The overall results of this study can be concluded that anthocyanin content of color obtained from pomegranate peel are sensitive to the frozen condition, light exposure as well as heating temperature. Also, the color possesses antioxidative properties having the IC_{50} value of 0.04 μg/mL and also rich in minerals. As the synthetic colors have safety and legislative issues, it can be replaced by a natural one. From this point of view, these results suggest that color extract from the pomegranate peel (*Punica granatum* L.), rich in both antioxidants and minerals, could be sources of anthocyanins for the food colorant market. Thus it could be a way of the utilization of pomegranate peel as by-products.

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References

1. Amerine M.A., Pangborn R.M., Rossler E.B. (1965), *Principles of Sensory Evaluation of Foods*, Academic Press New York, pp. 350–375.
2. Azlim Almey A., Ahmed Jalal Khan C., Syed Zahir I., Mustapha Suleiman K., Aisyah M., Kamarul Rahim K. (2010), Total phenolic content and primary antioxidant activity of methanolic and ethanolic extracts of aromatic plants' leaves. *International Food Research Journal*, 17(4), pp. 1077–1084.
3. Carvalho P.R. (1992), Potencialidade dos conservantes naturais. *Revista Brasileira de Corantes Naturais*, 4, pp. 244–245.
4. Fadavi A., Barzegar M., Azizi M.H., Bayat M. (2005), Note. Physicochemical composition of ten pomegranate cultivars (*Punica granatum* L.) grown in Iran, *Food Science and Technology International*, 11(2), pp. 113–119.
5. Fawole O.A., Opara U.L., Theron K.I. (2012), Chemical and phytochemical properties and antioxidant activities of three pomegranate cultivars grown in South Africa, *Food and Bioprocess Technology*, 5(7), pp. 2934–2940.
6. Francis F.J., Markakis P.C. (1989), Food colorants: anthocyanins, *Critical Reviews in Food Science & Nutrition*, *28*(4), pp. 273–314.
7. Gil M.I., Tomás-Barberán F.A., Hess-Pierce B., Holcroft D.M., Kader A.A. (2000), Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing, *Journal of Agricultural and Food Chemistry*, *48*(10), pp. 4581–4589.
8. Hager A., Howard L.R., Prior R.L., Brownmiller C. (2008), Anthocyanins, percent polymeric color, and antioxidant capacity of processed black raspberry products, *Journal of Food Science*, 73 (6), pp. H134–H140.
9. Jackman R.L., Yada R.Y., Tung M.A. & Speers R.A. (1987), Anthocyanins as food colorants–review, *Journal of Food Biochemistry*, 11(3), pp. 201–247.
10. Kamei H., Kojima T., Hasegawa M., Koide T. Umeda T., Yukawa T., Terabe, K. (1995), Suppression of tumor cell growth by anthocyanins in vitro, *Cancer Investigation*, 13(6), pp. 590–594.

11. Kanatt S.R., Chander R., Sharma A. (2010), Antioxidant and antimicrobial activity of pomegranate peel extract improves the shelf life of chicken products, *International journal of food science & technology*, 45(2), pp. 216–222.
12. Kasliwal A., Quadri F. (2016), Evaluation of Antioxidant Activity of Punica granatum, *International Journal of Innovative Research in Science, Engineering and Technology*, 5(7), pp. 2347–6710.
13. Lakshmi G.C. (2014), Food coloring: the natural way, *Research Journal of Chemical Sciences*, 4(2), pp. 87–96.
14. Laleh G.H., Frydoonfar H., Heidary R., Jameei R., Zare, S. (2006), The Effect of Light, Temperature, pH and Species on Stability of Anthocyanin Pigments in Four Berberis Species, *Pakistan Journal of Nutrition*, 5 (1), pp. 90–92.
15. Maccarone E., Maccarrone A., Rapisarda, P. (1985), Stabilization of anthocyanins of blood orange fruit juice, *Journal of Food Science*, 50(4), pp. 901–904.
16. Mazza G., Miniati E. (1993), *Anthocyanins in Fruits, Vegetables and Grain*, CRC Press, Boca Raton.
17. Minkova M., Drenska D., Pantev T., Ovcharov R., (1990), Antiradiation properties of alpha tocopherol, anthocyans, and pyracetam administered combined as a pretreatment course, *Acta physiologica et pharmacologica Bulgarica*, *16*(4), pp. 31–36.
18. Mirsaeedghazi H., Emam-Djomeh Z., Ahmadkhaniha R. (2014), Effect of frozen storage on the anthocyanins and phenolic components of pomegranate juice, *Journal of food science and technology*, *51*(2), pp. 382–386.
19. Negi P.S., Jayaprakasha G.K., Jena B.S. (2003), Antioxidant and antimutagenic activities of pomegranate peel extracts, *Food chemistry*, *80*(3), pp. 393–397.
20. Opara, L.U., Al-Ani, M.R. and Al-Shuaibi, Y.S. (2009), Physico-chemical properties, vitamin C content, and Antimicrobial properties of Pomegranate fruit (Punica granatum L.), *Food and Bioprocess Technology*, 2, pp. 315–21.
21. Opara L.U., Al-Ani M.R., Al-Shuaibi Y.S. (2009), Physico-chemical properties, vitamin C content, and antimicrobial properties of pomegranate fruit (Punica granatum L.), *Food and Bioprocess Technology*, *2*(3), pp. 315–321.
22. Panchal J.B., Gaikwad R.S., Dhemre J.K., Chavan, U.D. (2018), Studies on preparation and storage of jelly from dragon fruit (Hylocereus undatus), *Journal of Pharmacognosy and Phytochemistry*, 7(4), pp. 2648–2655.
23. Selim K.A., Khalil K., Abdel-Bary M.S., Abdel-Azeim N.A. (2008), Extraction, encapsulation and utilization of red pigments from roselle (Hibiscus sabdariffa L.) as natural food colorants, *Alex J Food Sci Technnol*, Special Vol Conf, pp. 7–20.
24. Sharma K., Akansha, Chauhan E.S. (2018), Comparative studies of proximate, mineral and phytochemical compositions of pomegranate (Punica granatum) in peel, seed and whole fruit powder, *International Journal of Food Science and Nutrition*, 3(2), pp.192–196.
25. Stanciu G., Lupşor S., Sava C., Zăgan, S. (2010), Spectrophotometric study on stability of anthocyanins extracts from black grapes skins, *Ovidius University Press*, 21(1), pp. 101–104.
26. Viuda-Martos M., Fernández-Lóaez J., Pérez-Álvarez J.A. (2010), Pomegranate and its many functional components as related to human health: A review, *Comprehensive Reviews in Food Science and Food Safety*, 9(6), pp. 635–654.
27. Williams C.A., Grayer R.J. (2004), Anthocyanins and other flavonoids, *Natural product reports*, 21(4), pp. 539–573.

Regulation of pectin properties by combination of raw materials

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Abstract

Introduction. An important direction in the development of pectin technology is the development of a method for extracting pectin from mixtures of secondary raw materials. By mixing raw materials containing low- and high-esterified pectins, it is possible to obtain pectins with specified functional properties: improved structure-forming and complexing ability

Materials and methods. The subject of the study is the pulp of potatoes, pumpkins and citrus peels and pectins, which were obtained from each type of raw material, and from mixtures of potato-citrus and potato-pumpkin raw materials. Extraction of pectin was carried out by carrying out successive stages of enzymatic treatment of raw materials, acid-thermal hydrolysis, precipitation of pectin with ethanol, drying of the finished pectin.

Results and discussion. The parameters of hydrolysis of combined potato-citrus and potato-pumpkin raw materials are set. Based on the research of methods of obtaining pectin from combined raw materials, it was found that the optimal ratio of potato-citrus and potato-pumpkin raw materials is 50:50. The hydrolysis process is carried out in two stages: the first – with the participation of cellulases at a temperature of 45–50 °C, pH 5.5–6.0 for 1.0–1.5 hours at a hydromodule of 1 : 8–10, and acid-thermal hydrolysis is carried out in the presence of hydrochloric acid at a temperature of 75–90 °C, the pH of the hydrolysis mixture is 1.3–1.6 for 70–75 minutes.

The obtained pectins from the combined raw materials have a high content of uronide component 60–74%, the degree of esterification over 70% and high gelly-forming ability compared to potato pectin, which has a degree of esterification of 40-50% and a significant content of ballast substances. The combination of raw materials makes it possible to obtain pectins with different properties.

Conclusions. It is established that by combining potato pulp with pumpkin and citrus raw materials and adjusting the parameters of the hydrolysis process, it is possible to achieve high rates of pectin extraction with predicted properties in terms of gelling and complexing ability and more efficient use of secondary raw materials.

Introduction

Natural polysaccharide pectin is a unique biopolymer contained in plant raw materials and has a wide range of functional properties. Industry produces pectins of three main types – highly esterified, low esterified, low esterified amidated [2–4, 14]. Along with classical pectins, for certain foods that have specific properties, Combi pectins are produced, which are obtained from mixed vegetable raw materials, mainly from a mixture of apple and citrus pomace [2].

The industrial raw materials for the production of pectin in the world are citrus peels, apple pomace and to a lesser extent beet pulp [1, 3, 5, 7, 9–11]. Particularly valuable in terms of the formation of complex complexes with heavy metals and radionuclides are low-esterified pectins with a high uronic component and complexing ability. Natural low-esterified pectin is obtained from beet. Apple and citrus pectins are highly esterified. Combined pectins are pectins obtained by hydrolysis of a mixture of different secondary raw materials, which combine the properties of low- and high-esterified fractions [2]. In terms of gem-forming properties, they occupy an intermediate position between classic apple and citrus pectins. The viscous properties of apple pectins are complemented by the high elasticity of citrus pectins [2]. There are also literature data on the study of combined pectins from citrus peels and inflorescences of sunflower baskets [3]. However, there are many types of pectin-containing raw materials that are not used for industrial production of pectin due to the instability of the properties and composition of pectin substances, but in combination with other raw materials that contain more pectin, could be of interest to industry. The issue of extraction and use of potato and pumpkin pectin is insufficiently covered in the literature.

Processing pectin of secondary vegetable raw materials, which is a waste of canning, juice, sugar and starch production, will solve the problem of waste disposal. Potato pulp, waste of starch production as a raw material for pectin production is promising [6–8, 14], however, potato pectin has an average degree of esterification of 40–50% and weak gelling ability, depending on the variety of potato [3, 4]. Therefore, it was important to investigate methods of combining potato raw materials with pumpkin and citrus, containing highly esterified pectins, to obtain pectins with specified functional properties: improved structure and complexing ability [7].

The aim of the research is to determine the influence of methods of combining secondary raw materials containing low- and high-esterified pectins on the extraction of pectins and their physicochemical properties.

Materials and methods

Materials

Fresh potato pulp, pumpkin pulp and citrus peels were used in the work. The raw material was pre-washed from starch and ballast compounds, dehydrated and used with a moisture content of not more than 70–72%. Pectic substances were extracted from each type of raw material and mixtures thereof.

Chemical reagents and enzymes

Hydrochloric acid (concentrated solution, concentration 0.1 N, 0.5), ammonia (concentrated solution), sodium hydroxide (concentration 0.1 and 0.5 N), ethyl alcohol (96.6%).

Cellulad (manufacturer Enzyme, Ukraine) is a complex microbial-enzyme preparation. Contains fungi of the genus Trichoderma – the most active and most common destructors of cellulose and lignin. Optimal parameters of action: temperature 25–50 °C, pH 5–7.

Methods of extracting pectin from secondary vegetable raw materials

Obtaining combined pectin from potato pulp and citrus peels. Extraction of pectin was carried out by carrying out successive stages of acid-thermal hydrolysis-extraction, separation of pectin extract, precipitation of pectin with ethanol, drying and grinding of the finished pectin.

When obtaining pectin from a mixture of raw potato pulp – citrus peels, the following methods were performed: for hydrolysis, a mixture of crushed potato pulp, dried at 60 °C, and crushed citrus peels, dried at room temperature, was taken.

Due to the fact that the content of protopectin in citrus raw materials is quite high, and the amount of potato pulp in the mixture is greater than citrus peels, hydrolysis was performed at different pH values, temperature and duration of the process, namely: the first series of experiments – for optimal extraction parameters potato pectin [3, 4], the second – for optimal parameters of citrus pectin. All test samples were subjected to pre-treatment with enzyme preparations of cellulolytic action under the following conditions: temperature 50 °C, pH 5.5–6.0, process duration 180 minutes.

In different series of experiments, the percentage of potato pulp (PP) and citrus peels (CP) is 50:50, 60:40, 70:30, 80:20, respectively.

To study the effect of pH on the yield of pectin, a series of experiments were performed at a ratio of raw materials PP:CP as 60:40 at pH 1.0; 1.3; 1.6 and 2.0 at a hydromodule of 1:10 at a hydraulic module of 1:10, a temperature of 75 °C and a duration of 70 minutes (Figure 1).

In order to study the effect of temperature on the yield of pectin and its physicochemical properties, a series of experiments on the hydrolysis of raw materials at a temperature of 90 °C. The ratio of PP:CP was chosen as 50:50, 60:40, 70:30, pH within 1.3, the duration of the process 30 min (Table 1).

To study the hydrolysis process, the accuracy of setting the hydrolysis parameters: pH, temperature and duration of the process was decisive.

Obtaining combined pectin from potato and pumpkin pulp. The combined pectin was obtained by acid-thermal method with pre-enzymatic treatment. Raw material ratio potato pulp and pumpkin pulp 50:50. After washing and pressing, the mixture was subjected to the treatment of enzyme preparation of cellulolytic action at a temperature of 50 °C, pH 6.0 for 1.0 h, adding Cellulad in the amount of 9 units. ClA/g of cellulase activity at a hydromodule of 1:10. After completion of the enzymatic hydrolysis, the process was continued by adding a solution of hydrochloric acid to the pH of the hydrolysis mixture 1.4–1.6 at a hydraulic modulus of 1:10, the hydrolysis temperature of 72–75 °C, the duration was 70–75 minutes.

At the end of the hydrolysis process, the solid phase was separated from the liquid and cooled to room temperature, after which the extract was neutralized with ammonium hydroxide to pH 3.5–4.5, coagulated pectin substances in the extract with ethyl alcohol, separated the coagulate, washed with ethanol, dried and crushed.

Methods of research of pectin extract

In the pectin extract was determined: dry matter content (DM) by refractometric method, pH – potentiometrically [3, 4]. The yield of the target product (%) was calculated by weight of the raw material.

Methods of research of pectin powder

The obtained dry pectin was investigated by the following methods: content of ballast substances – by weight method; analytical characteristics – the content of free and esterified carboxyl groups, uronic component was determined by titrimetric method [3, 4].

Determination of the mass fraction of ballast compounds [3, 4]

A portion of pectin weighing 3–4 g was placed in a conical flask, filled with acidified alcohol (100 cm^3 of 70% ethyl alcohol and 5 cm^3 of concentrated hydrochloric acid) and stirred for 15 minutes. The mixture was then quantitatively transferred to a glass filter and washed with acidified alcohol until negative for Calcium ions and Aluminum ions.

The precipitate was washed with pure 75% alcohol until a negative reaction to chlorine ions, then pure 96% alcohol and dried in an oven at a temperature of 80–85 °C to constant weight. The number of ballast compounds (B, %) was calculated by the formula:

$$B = \frac{(G_1 - G_2)}{G_1} \cdot 100 \quad (1)$$

where G_2 – mass of pectin g.; G_2 – mass of pectin after washing with alcohol, g.

Determination of the mass fraction of free carboxyl groups [3, 4]

1 g of industrial and dried pectin was placed in a 300 ml flask, moistened with pure 96% ethyl alcohol to pre-form lumps and 100 ml of distilled water was added, stirred and left overnight until the pectin was completely dissolved. The solution was titrated with 0.1 N NaOH by adding six drops of Hinton indicator until a red color appeared, which did not disappear for 1 minute.

The content of free carboxyl groups is calculated by the formula, %:

$$K_F = \frac{a \cdot 0,45}{G_2} \cdot 100 \quad (2)$$

where, a – amount of 0.1N NaOH solution that went to the titration 1 ml of solution corresponds to 0.0045 g of –COOH

The content of methoxylated carboxyl groups was determined in the same solution [3, 4]. To the neutralized sample after determining the content of free carboxyl groups was added from a burette 10 ml of 0.5N NaOH. The flask was closed and left for 2 hours at room temperature to hydrolyze methoxylated carboxyl groups. Then 10 ml of 0.5 N HCl was added to the solution from a burette and the excess of the latter was titrated with 0.1 N NaOH.

The amount of 0.1N NaOH, which was spent on the second titration, corresponds to the number of esterified groups KE, % in the test sample, which was calculated by the formula:

$$K_E = \frac{b \cdot 0,45}{G_2} \cdot 100 \quad (3)$$

where, b – amount of 0.1N NaOH spent on the second titration, ml; G_2 is the mass of washed and dried pectin.

The degree of esterification of pectin λ, % was calculated by the formula:

$$\lambda = \frac{K_E}{K_T} \cdot 100 \quad (4)$$

where K_T – total content of carboxyl groups, $K_T = K_F + K_E$.

Results and discussion

Research on methods of extracting pectin from a mixture of potato pulp and citrus peels

In different series of experiments, the percentage of potato pulp (PP) and citrus peels (CP) is 50:50, 60:40, 70:30, 80:20, respectively. One of the important factors influencing the yield and properties of pectin is pH [1, 5]. The hydrolysis of the protopectin complex should be carried out in such a way that the intermolecular bonds of protopectin with metal ions are cleaved, but the glycosidic bonds in pectin are not broken [1]. The results of a series of studies of the effect of pH hydrolysis on the yield of pectin are shown in Figure 1.

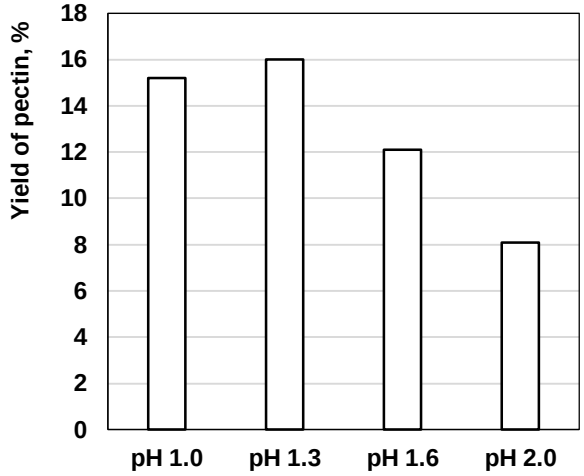

Figure 1. Effect of pH on the yield of potato-citrus pectin

According to the diagram, the highest yield of pectin, respectively 15.0 and 15.34%, is observed at low pH values – 1.0 and 1.3. Slightly less pectin was removed at pH 1.6–11.82%. The lowest yield of pectin (7.7%) was observed at pH 2.0. Also, it should be emphasized that the coagulates obtained by ethanol precipitation are quite strong in the first three samples, in contrast to the latter, where the precipitated pectin was mainly in the form of small flakes. Thus, the pH of the hydrolysis of the mixture of raw materials 2.0 is not effective for the hydrolysis of both potato and citrus raw materials. The use of a mixture of raw materials requires more stringent conditions for the hydrolysis of protopectin and its conversion into a soluble state. Thus, the following studies were performed at pH 1.3.

According to the literature, insoluble protopectin predominates in citrus peel cells [1, 2, 5], so acid hydrolysis is carried out at sufficiently high temperatures, as the rate of hydrolysis of glycoside bonds of protopectin increases with increasing temperature. The next series of studies was carried out at the optimal pH value of 1.3 and the process temperature of 90 °C in order to determine the optimal ratio of raw materials (Table 1).

Table 1

Physico-chemical parameters of the combined pectin obtained from a mixture of potato pulp and citrus peels under conditions of acid hydrolysis: temperature 90 °C, pH 1.3, process duration 30 min

Characteristics	Sample 1 (raw material ratio 50:50)	Sample 2 (raw material ratio 60:40)	Sample 3 (raw material ratio 70:30)
Yield of pectin, %	17,3	15,4	13,7
Content of ballast substances, %	12,0	10,0	9,0
Content of free carboxyl groups, %	4,0	3,06	2,98
Content of methoxyl groups, %	8,75	8,55	7,43
Degree of esterification, %	68,90	73,60	71,40
Content of pure pectin (uronide component), %	52,50	48,10	43,0
Molecular weight	10445	9660	9162

Table 1 shows that the highest yield of alcohol-precipitated pectin and the best physicochemical parameters are observed at a ratio of 50:50, ie when for hydrolysis took equal proportions of citrus and potato raw materials. As the citrus content decreases and the content of raw potato increases, the yield of pectin decreases, which can be explained by the higher content of pectin substances in citrus peels, as well as the partial destruction of potato pectin at high hydrolysis temperature. Accordingly, the uronic component of the combined pectin decreases. The decrease in the content of the uronic component, in our opinion, is due to the presence of starch polysaccharides, which also coagulate in the presence of alcohol. The amount of dextrins – products of starch hydrolysis – increases with increasing proportion of potato pulp. On the photomicrograph of the sample of the combined pectin made by means of the scanning electron microscope (Figure 2), even not destroyed grains of starch are clearly visible.

When the ratio of potato and citrus raw materials as 50:50 were obtained samples of pectins with the highest molecular weight values (Table 1). This indicator indicates the best gelling properties of combined pectin.

Study of the method of extracting pectin from a mixture of potato pulp and pumpkin pulp

To obtain the combined pectin by the second method used potato pulp and waste of canning production – pumpkin pulp. This choice of raw materials is due to the availability and high content of pectin [2–4]. For experiments, fresh raw materials were taken in different proportions. To obtain pectin used enzymatic–acid hydrolysis of each type of raw material separately and mixtures thereof.

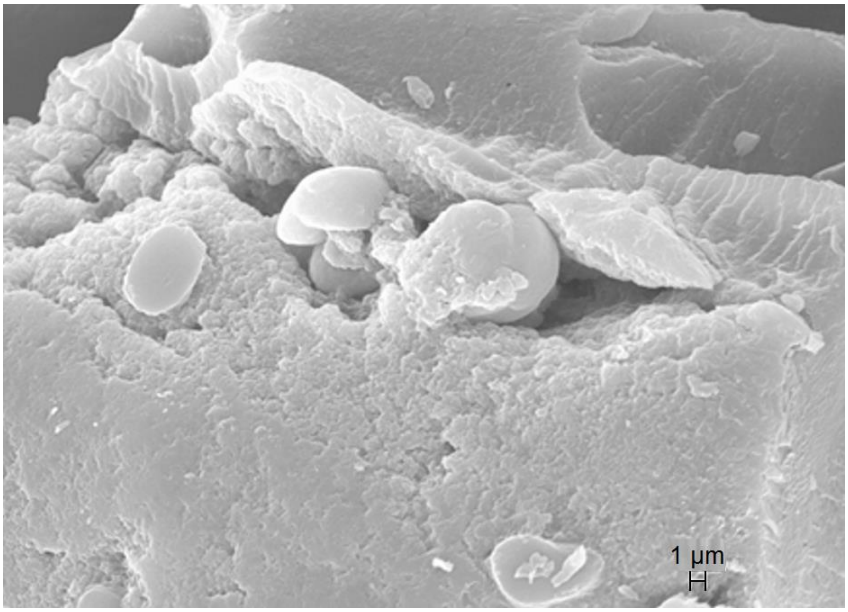

Figure 2. Scanning electron micrograph of a sample of potato-citrus pectin (raw material ratio 50:50, resolution 1 nm)

As can be seen from Figure 3, the yield of alcohol-precipitated pectin from a mixture of raw materials taken in equal proportions is higher than from each raw material separately, which in our opinion is due to the interaction of these raw materials and pectin properties and more complete ethanol precipitation. We noticed that the degree of esterification and uronic component are values closer to the highly esterified sample of the two taken in the mixture.

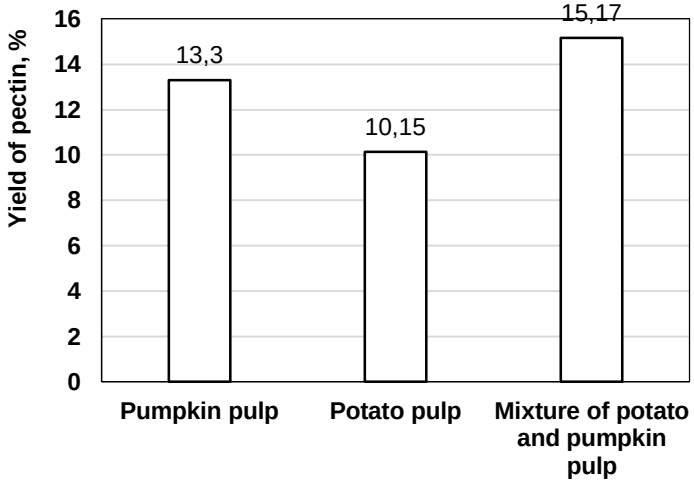

Figure 3. Pectin yield from pumpkin, potato pulp and their mixture

The indicators of the combined pectins obtained using raw materials in equal proportions, determined by the titrometric method, are shown in Table 2.

Table 2

Physico-chemical parameters of pectin

Parameters	Potato	Citrus	Pumpkin	Potato-pumpkin	Potato-citrus
Yield of pectin, %	13,0±0,2	21,3±0,5	13,3±0,2	13,50±0,5	17,3±0,1
Content of ballast substances, %	6,70±0,2	31,7±0,2	9,80±0,1	8,80±0,10	12,0±0,5
Content of free carboxyl groups, %	5,26±0,5	7,45±0,2	3,6±0,1	3,60±0,10	4,0±0,5
Content of esterified carboxyl groups, %	4,80±0,5	19,65±0,1	14,3±0,2	14,23±0,5	8,75±0,5
Content of esterified carboxyl groups, %	10,06±0,5	27,0±0,1	17,9±0,3	17,83±0,5	12,75±0,5
Uronides component, %	41,1±0,5	68,30±0,5	69,4±0,5	74,0±0,5	63,0±0,2
Degree of esterification, %	47,7±1,0	73,0±1,5	80,01±1,0	79,0±1,0	70,9±1,0

The obtained data show that pectin from combined potato-pumpkin raw materials has improved properties compared to potato pectin. The degree of esterification of pectins from the combined raw material is close in value to pectins with a high degree of esterification inherent in pumpkin raw materials. As can be seen from the data of Table 2, obtained in this way samples of combined pectins have a content of uronic component of 74%, the degree of esterification of 70–80%. Testing for gelly-forming ability showed that combined pectins have a better ability to structure than pectins obtained from each type of raw material. The obtained samples of combined pectin have a high complexing and gelling ability. Thus, the combination of raw materials makes it possible to obtain pectins with different physicochemical properties.

Conclusions

Based on the research of methods of obtaining pectin from combined potato-citrus and potato-pumpkin raw materials, it is established that the optimal ratio of raw materials is 50:50. The hydrolysis process is carried out in two stages: the first – with the participation of cellulases at a temperature of 45–50 °C, pH 5.5–6.0 for 1.0–1.5 hours. at a hydraulic modulus of 1:8–10, and acid-thermal hydrolysis is carried out in the presence of hydrochloric acid at a temperature of 75–90 °C, the pH of the hydrolysis mixture 1.3–1.6 for 70–75 min.

It is established that by combining potato pulp with other raw materials it is possible to increase the yield of pectin and change its physicochemical properties. The content of uronic component 74%, the degree of esterification of 80%, high complexing and gelling ability indicate the possibility of using pectins from combined raw materials in the creation of functional foods. The combination of pumpkin and citrus raw materials with potato pulp allows you to get new types of pectin and more efficient use of secondary raw materials.

References

1. Gómez B., Yáñez R., Parajóa J.C., Alonso J.L. (2016), Production of pectin-derived oligosaccharides from lemon peels by extraction, enzymatic hydrolysis and membrane filtration, *Journal of Chemical Technology and Biotechnology*, 91(1), pp. 234–247.
2. Herbstreith & Fox, (2014), Combi Plus Pectin – Advantages of Apple and Citrus Pectins, *Combined Technical Application Information [Internet]*.
3. Hrabovska O., Pastukh H., Demenyuk O., Miroshnyk V. (2015) et al. Kinetics of hydrolysis-extraction of pectin substances from the potato raw materials, *Ukrainian Food Journal*, 4(4), pp. 596–604
4. Hrabovska O., Pastukh H., Moiseeva V., Miroshnyk V. (2015), Potato pectin: extract methods, physical and chemical properties and structural features, *Ukrainian Food Journal*, 4 (1), pp. 7–13.
5. Kaya M., Sousa A.G., Crepeau M.J. (2014), Characterization of citrus pectin samples extracted under different conditions: influenc e of acid type and pH of extraction, *Annals of Botany*, 114(6), pp. 1319–1326.
6. Klaassen M., Trindade L. (2020), RG-I galactan side-chains are involved in the regulation of the water-binding capacity of potato cell walls, *Carbohydrate Polymers*, 227(1), 115353.
7. Popov S., Ovodov Yu. (2013), Polypotency of the immunomodulatory effect of pectins, *Biochemistry*, 78, pp. 823–835.
8. Ravn H.C., Sørensen O.B., Meyer A.S. (2015), Time of harvest affects the yield of soluble polysaccharides extracted enzymatically from potato pulp, *Food and Bioproducts Processing*, 93, pp. 77–83.
9. Srivastava P., Malviya R. (2011), Sources of pectin, extraction and its applications in pharmaceutical industry, *Indian Journal of Natural Products and Resources*, 2(1), pp. 10–18.
10. Wikiera A., Mika M., Starzynska-Janiszewska A., Stodolak B. (2015), Development of complete hydrolysis of pectins from apple pomace, *Food Chemistry*, 172, pp. 675–680.
11. Yupeng Lin, Fengping Ana, Hong He, Fang Geng, Hongbo Song. (2020), Structural and rheological characterization of pectin from passion fruit (Passiflora edulis f. flavicarpa) peel extracted by high-speed shearing, *Food Hydrocolloids*, 114, 106555.
12. Yang, Jin-Shu; Mu, Tai-Hua; Ma, Meng-Mei (2018), Extraction, structure, and emulsifying properties of pectin from potato pulp, *Food Chemistry*, 244, pp. 197-205 .
13. Zema Demetrio Antonio, Calabro Paolo Salvatore, Folino Adele, Tamburino Vincenzo, Zappia Giovanni, Zimbone, Santo Marcello (2019), Wastewater Management in Citrus Processing Industries: An Overview of Advantages and Limits, *Water*, 11(12), 2481.
14. Lesiecki M., Białas W., Lewandowicz G. (2012), Enzymatic hydrolysis of potato pulp, *Acta Sci Pol Technol Aliment*, 11(1), pp. 53–59.

Chemical resistance of sunflower oil enriched with cumin oil

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Abstract

Introduction. The antioxidant properties of cumin oil are used to inhibit destructive processes in sunflower oil. The chemical resistanse of sunflower oil and f mixtures of sunflower oil and cumin seed oil was studied.

Materials and methods. The chemical values for samples for vegetable oils and their binary mixtures during long-term heating at 180-195 °C were monitored. The content of free acids and unsaturated compounds was determined by titrometric method, the content of polyphenols and carbonyl compounds – by spectrophotometric analysis..

Results and discussion. The most change of acid value from the start of the frying experiment to the end of the 20 hour frying was shown for sunflower oil. The least change of the acid value during frying was found for mixture of sunflower oil and black cumin oil, especially for a mixture with a higher content of cumin oil. The higher oxidative resistance of black cumin oil compared to sunflower oil is due to the higher content of saturated acids and oleic acid (monounsaturated) and the low content of polyunsaturated fatty acids in triacylglycerols.

As expected, the iodine value of oils decreases during frying, that means a destruction double C-C bonds of fatty acids residue in triglyceride molecules. The most significant relative decrease in iodine value was noticed for sunflower oil, and the percentage of iodine value decrease was 6.62% at the end of the frying terms. However, the decrease in the iodine value of the mixtures of cumin oil and sunflower oil in the ratio of 10:90 and 20:80 was less.

An increase in thiobarbituric acid value (TBA) during frying was observed for all oil samples. The highest TBA was shown for sunflower oil at the end of the frying terms. At the same time, for oil mixture with most content of cumin oil the TBA was lowest at the end of the frying terms. The less changes in TBA of oils indicates that natural antioxidants in cumin oil have an inhibitory effect on the formation of secondary oxidation products during frying terms.

Conclusions. Blending sunflower oil with cumin oil leads to a positive effect on the chemical resistance of oil compositions under heating conditions.

Introduction

Sunflower oil is widely used in food, cosmetic and pharmaceutical industries. This vegetable oil is a suitable medium for fat-soluble vitamins – important components in the human diet.

Like most vegetable oils known for a high content of triglycerides of unsaturated fatty acids, sunflower oil tends to oxidize during contact with atmospheric oxygen, that leads to a deterioration of the organoleptic characteristics for the oil, a decrease in its nutritional value, as well as the formation and accumulation carbonyl and carboxyl compounds of various length carbon chain. Oxidation processes in oils accelerate significantly with increasing temperatures and especially under deep-fat frying conditions, where the temperature reaches 190 °C [1]. Chemical transformations of triglycerides are influenced by different components, for instance, moisture, that contained in food immersed in hot oil[2]. Oxidative reactions of lipids are inhibited in various ways, for example, by inactivation of enzymes that catalyze oxidation, the addition of chelating agents, or the addition of antioxidants of both synthetic and natural origin.

Among antioxidants, substances of natural origin are of particular interest, since, unlike synthetic analogues, they are ecologically safe. As nature antioxidants, some extracts from various herbal plants, such as rosemary, Chinese green tea, and cumin containing substances with antioxidant activity that can inhibit radical oxidation processes and thereby extend the shelf life of the oil, are used.

Blending has long been used to modify oils and fats in order to improve their functional properties and therefore better use them in food. Blending oils with other oils influences their physicochemical properties not changing their chemical composition [3]. Blending oils is used to obtain compositions with good resistance to oxidation under frying conditions through some substances in one of the oils providing protective effect. Such oil compositions can be safely reused for frying foods [4].

Phenol derivatives are important components of vegetable oils, the amount of them correlates with the resistance of triglycerides of the oil to the action of oxidants [5, 6]. Sunflower oil has a good nutritional profile and low oxidation stability. Oxidative degradation of unsaturated fatty acids is one of the main reasons for the deterioration of the organoleptic properties of the oil and a decrease in its nutritional value [7].

Black cumin seeds contain 36% oil, and the fatty acid profile of cumin oil is similar to sunflower oil. Black cumin has unique nutritional profile, its oil, used in both cooking and medicine, is enriched with phytochemicals. Due to the content of tocopherols, carotenes and, especially, various polyphenols in cumin oil, it can be considered as a source of natural antioxidants.

The aim of this study was to evaluate the chemical parameters of binary mixtures of sunflower and cumin oils subjected to prolonged high-temperature exposure by determining the acid value, iodine value and thiobarbituric acid value (TBA).

Materials and methods

Black cumin seeds and refined sunflower oil were purchased from a local supermarket. All reagents and chemicals used in the work were of analytical grade.

Extraction of black cumin seed oil

The seeds were crushed and pressed on a hydraulic laboratory press. The resulting oil was dried over anhydrous sodium sulfate. Filtered dry oil was stored at 4 ± 0.5 °C in a brown glass bottle.

Preparation of binary mixtures. Black cold pressed cumin oil was mixed with sunflower oil in proportions (% vol.); 0: 100, 10:90, 20:80. The initial analysis of binary mixtures was carried out after preliminary homogenization of the samples at 60 °C.

Frying process. about 500 ml of refined sunflower oil and its binary mixtures with black cumin seed oil were placed in a stainless steel food container and heated to 185-190 °C with 10-15 g of frozen mushrooms were immersed in the heated oil. Oil samples were taken every 5 hours with continuous frying for 20 hours, cooled and stored at –10 °C until chemical analysis.

Determination of fatty acid composition of black cumin seed oil and refined sunflower oil

The fatty acid composition of the individual oil samples was determined by gas chromatography (GC) [15]. The triglycerides of the studied oils were subjected to hydrolysis and subsequent methylation. The obtained methyl esters of carboxylic acids were analysed on an automatic gas chromatograph with a flame ionization detector to identify the composition and determine the mass fraction of individual fatty acids.

Determination of thiobarbituric acid value

For samples of sunflower oil and binary oil mixtures subjected to heat treatment, the thiobarbituric acid value was additionally determined. The 2-thiobarbituric acid (TBA) value is a frequently used measure of the oxidation degree of oils, fats, and fatty foods and characterizes the accumulation of carbonyl compounds in oil that are intermediate products being resulted by oxidized destruction triglycerids and do not influence acid value of oil. The method for determining the thiobarbituric value is based on the reaction of thiobarbituric acid with different aldehydes [16], formed during the oxidation of unsaturated fatty acids, among them malondialdehyde [17] (Figure 1).

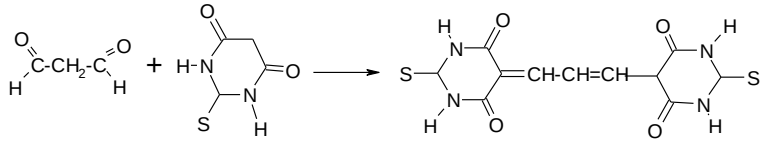

Figure 1

Therefore, the TBA-value is often expressed in mg of malondialdehyde per 1000 g of vegetable oil [2]. Carbonyl compounds react with thiobarbituric acid to form colored compounds, the content of which can be determined photometrically at a wavelength of 532 nm [16, 17]

1000 mg of each oil sample is dissolved in propan-1-ol, and the solution of thiobarbituric acid (TBA) is made up with the same solvent by dissolving 400 mg TBA in 100 ml propan-1-ol. A volume of 3 ml each sample solution and 3 ml TBA-reagent are mixed, stoppered, the content placed into a silicon oil bath and stirred at 95 °C for 2 h. Then the mixture is cooled by running tap water for about 10 min, and the absorbance is measured (within 30 min) at 530 nm using the blank solution in the reference cell (the molar extinction coefficient is $1.56 \cdot 10^5$ $cm^{-1} \cdot M^{-1}$). A blank is carried out in the same way using 3 ml of propan-1-ol instead of the oil sample solution.

Results and discussion

Chemical analysis of black cumin seed oil and refined sunflower oil

Based on the results obtained, it can be argued that the oils used have a similar composition according dominant fatty acids – linoleic and oleic. It should also be noted the presence of ~ 10% polyunsaturated acids (Omega-3) in the cumin seed oil and a higher content of saturated carboxylic acids than in sunflower oil.

Table 1

Fatty acid composition of Black Cumin seed oil and refined Sunflower oil

Fatty acid type	Cumin oil	Sunflower oil
Total unsaturated fatty acids, including;	79.85	83.64
Oleic acid	16.59	28.47
Linoleic acid	42.76	56.71
Total saturated fatty acids	15.13	9.75
Total fatty acids	94.98	93.39

Chemical indicators of the quality of the studied oils: acid value, iodine value, as well as the total content of phenolic compounds in black cumin seed oil and in sunflower oil are shown in Table 2 [8].

Table 2

Chemical indicators for Black Cumin seed oil and refined Sunflower oil

Value	Black Cumin seed oil	Refined Sunflower oil
Acid value (as mg KOH/g oil)	2.8 (up to14)	0.4
Iodine value	112	123
Content of polyphenols (in terms of gallic acid, mg / 100 g)	135	-

Changes in acid value

The acid value was used to assess the degree of hydrolysis of oil triglycerides during frying and the dynamics of change them influenced by the product subjected to heat treatment [9, 10]. Changes in the acid value of sunflower mixed with various portions of black cumin oil during deep-frying at 185-190 °C are shown in Figure 2.

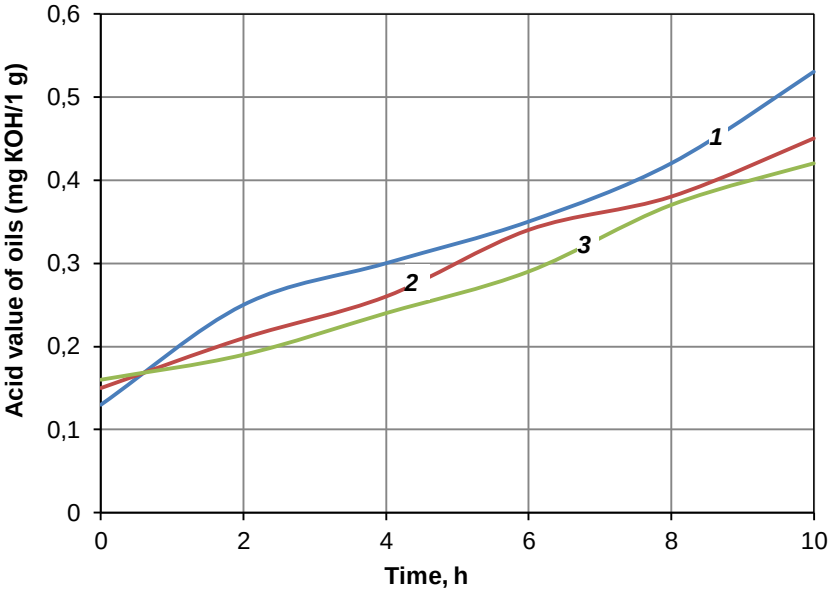

Figure 2. Changes in acid value for oils during deep-frying:
1 – sunflower oil;
2 – cumin and sunflower oil as 10:90;
3 – cumin and sunflower oil as 20:80

The most initial acid value of the oil as 0.16 mg KOH/g oil is determined for binary oil mixture containing cumin and sunflower oil as 20:80. The least acid value as 0.13 mg KOH/g oil is characterized for refined sunflower oil.

Frying of the studied oils at 185–190 °C for 20 hours led to a gradual increase in the acid value that indicates the formation of free fatty acids with an increase in the frying time as a result of the oxidation and hydrolysis of oil triglycerides [11, 12]. The most change of acid value from 0.13 at the start of the frying experiment up to 0.53 (relative change is as 307 %) at the end of the frying period was shown for sunflower oil. The least change of the acid value is found for mixture of sunflower oil and black cumin oil with a higher content of cumin oil. The increase in the acid value of the mixtures of cumin oil and sunflower oil in the ratio of 10:90 and 20:80 was less and amounted to 200 % and 163 % at the end of frying, respectively.

The higher oxidative resistance of black cumin oil compared to sunflower oil is due to the high content of saturated acids and oleic acid (monounsaturated) and the low content of polyunsaturated fatty acids in triacylglycerides and by content of a large amount of phenolic compounds with antioxidant and anti-hydrolysis properties [8]. The data obtained on the

relative increase in the acid number of the samples indirectly confirm the formation of free acids not only as a result of hydrolysis of triglycerides, but as a result of oxidative destruction of double C-C bonds of unsaturated fatty acid residues.

Changes in iodine value

The iodine value is one of the parameters used to assess the quality of oil [13] that correlates with the degree of unsaturation in oils. The most initial iodine value is found for sunflower oil, the least one – for mixture of cumin and sunflower oils in ratio as 20:80. The lower initial values of the iodine value of the obtained binary oil mixtures in comparison with sunflower oil one are explained by the higher content of monounsaturated fatty acids in cumin oil.

As expected, the iodine value of oils decreases during frying, that means a destruction double C-C bonds of fatty acids residue in triglyceride molecules [14]. The most significant relative decrease in iodine value was noticed for sunflower oil, and the percentage of iodine value decrease is 6.62 % at the end of the frying terms. However, the decrease in the iodine value of the mixtures of cumin oil and sunflower oil in the ratio of 10:90 and 20:80 is less and amounted to 6.29 % and 5.88 % at the end of frying, respectively. Auto-oxidation of triglycerides of sunflower oil proceeds faster, since it contains about 65% polyunsaturated linoleic acid [15]. The phenolic compounds contained in caraway oil largely suppress the course of radical oxidation processes. Therefore, the addition of cumin oil with a higher content of monounsaturated acids and natural antioxidants to sunflower oil reduces the oxidation rate, as evidenced by the relatively low decrease in the iodine value (Figure 3).

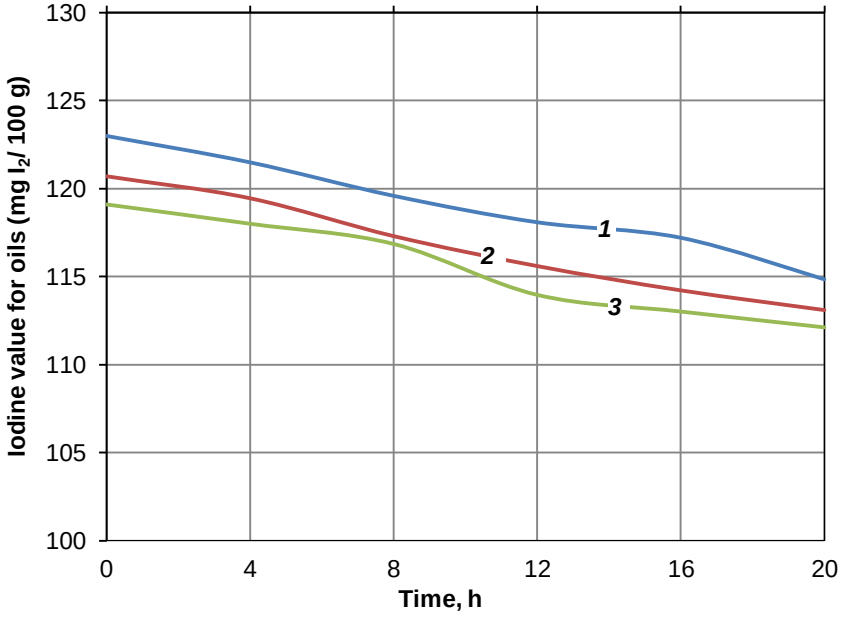

Figure 3. Changes in iodine value for oils during deep-frying:
1 – sunflower oil;
2 – cumin and sunflower oil as 10:90;
3 – cumin and sunflower oil as 20:80

Changes in thiobarbituric acid value (TBA)

Changes in the thiobarbituric value (absorbance at 532 nm) for sunflower oil and binary mixtures of oils during deep-frying at 185-190 °C are shown in Figure 4. An increase in TBA during frying was observed for all three oil samples. The most change of thiobarbituric acid value from 0.07 at the start of the frying experiment up to 0.92 was shown for sunflower oil (0.97 as absorbance at 532 nm) at the end of the frying terms. At the same time, the TBA of mixture consisted of cumin oil and sunflower oil in ratio 20:80 was lowest at the end of the frying terms.

The relative change in thiobarbituric acid values for all samples was found to be approximately the same, which can be explained by the higher content of polyunsaturated fatty acids in cumin oil. Linoleate hydroperoxides are known to decompose faster than oleate ones [18]. The ratio of oxidated oleate: linoleate: linolenate has been reported to be on the order of 1:12:25 [18]. These literature data are consistent with the discussed results of carried out experiment.

However, it may be concluded, the less changes in TBA of oils indicates that the presence of natural antioxidants in cumin oil has an inhibitory effect on the formation of these secondary oxidation products during frying terms.

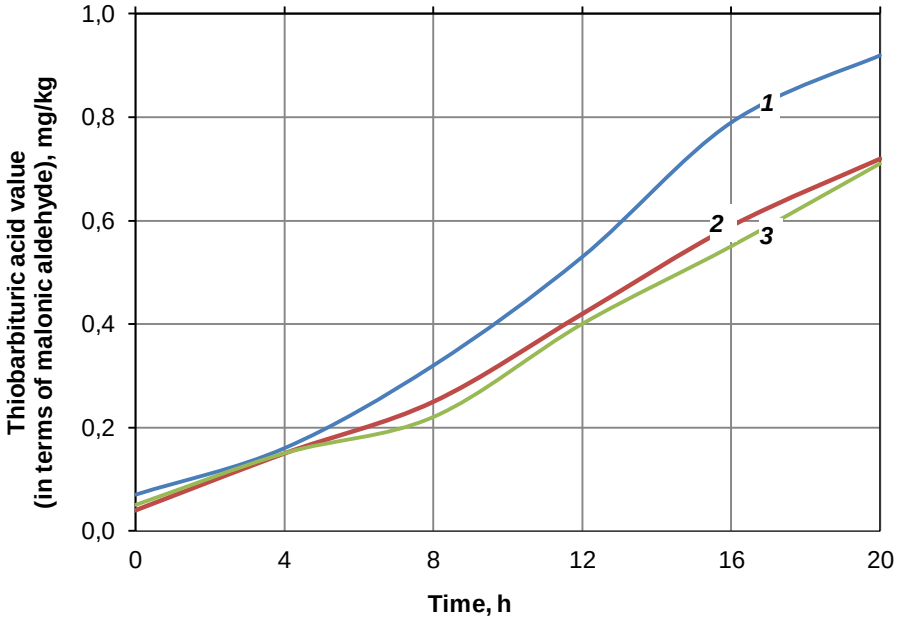

Figure 3. Changes in thiobarbituric value for oils during deep-frying:
1 – sunflower oil;
2 – cumin and sunflower oil as 10:90;
3 – cumin and sunflower oil as 20:80

Conclusions

Cumin oil contains a significant amount of polyphenolic compounds and is therefore a promising source of natural antioxidants to create oil compositions.

It is shown that the blending sunflower oil with cumin oil has a positive effect on the resistance of triglycerides under deep-heating conditions and to hydrolysis.

Comparative analysis of the chemical parameters of the studied oil compositions shows that the greater resistance of triglycerides to thermal destruction correlates with a higher concentration of cumin oil in the mixture.

Thus, mixtures of cumin and sunflower oil are more suitable for deep frying than just sunflower oil.

References

1. Yamsaengsung R., Moreira R.G. (2002), Modeling the transport phenomena and structural changes during deep fat frying. Part II: Model solution and validation, *Journal of Food Engineering*, 53(1), pp. 11–25.
2. Andrikopoulos N.K., Dedoussis G.V., Falirea A., Kalogeropoulos N., Hatzinikola H.S. (2002), Deterioration of natural antioxidant species of vegetable edible oils during the domestic deep-frying and pan-frying of potatoes, *International Journal of Food Sciences and Nutrition*, 53(4), pp. 351–363.
3. Abdelbaset Salama M. etc. (2020), Erratum to: Oxidative stability of Opuntiaficus–indica seeds oil blending with Moringaoleifera seeds oil, *Oilseeds and fats, Crops and Lipids*, 27, DOI: 10.1051/ocl/2020045
4. Toliwal S.D., Tiwari M.R., Verma S. (2005), Studies on Thermal stability of Palm Corn Oil Blends. Oil Technologists' Association of India, *J Oil TechnolAssoc India*, 37, pp. 18–20.
5. Henna Lu F.S., Tan P.P. (2009), A Comparative study of storage stability in virgin coconut oil and extra virgin Olive oil upon thermal treatment, *International Food Research Journal*, 16, pp. 343–354.
6. Cheikh–Rouhou S., Hentati B., Besbes S., Blecker C., Deroanne C., et al. (2006), Chemical Composition and Lipid Fraction Characteristics of Aleppo Pine (*Pinushalepensis* Mill.), Seeds Cultivated in Tunisia, *Food Science and Technology International*, 12, pp. 407–415.
7. Hemalatha G., Ghafoorunissa (2007), Sesame lignans enhance the thermal stability of edible vegetable oils, *Food Chemistry*, 105, pp. 1076–1085.
8. Topcagic A., Zeljkovic S.C., Karalija E., Galijasevic S., Sofic E. (2017), Evaluation of phenolic profile, enzyme inhibitory and antimicrobial activities of *Nigella sativa* L. seed extracts, *Bosnian Journal of Basic Medical Sciences*, 17(4), pp. 286–294.
9. Melton S.L., Jafar S., Sykes D., Trigiano M.K. (1994), Review of stability measurements for frying oils and fried food flavor, *Journal of the American Oil Chemists' Society*, 71, pp. 1301–1308.
10. Jung-Min Park, Jin-Man Kim (2016), Monitoring of Used Frying Oils and Frying Times for Frying Chicken Nuggets Using Peroxide Value and Acid Value, *Korean Society for Food Science of Animal Resources*, 36(5), pp. 612–616.
11. Ruixue M.A., Tian G.A.O. etc. (2016), Effects of oil-water mixed frying and pure-oil frying on the quality characteristics of soybean oil and chicken chop, *Food Science and Technology*, 36(2), pp. 329–336.
12. Choe E., Min D.B. (2007), Chemistry of Deep-Fat Frying Oils, *Journal of food science*, 72(5), pp. 77–85.

13. Azmil Haizam Ahmad Tarmizi, Siew Wai Lin, Ainie Kuntom (2008), Palm–Based Standard Reference Materials for Iodine Value and Slip Melting Point, *Analytical Chemistry Insights*, 3, pp. 127–133.
14. Ayodeji Osmund Falade, Ganiyu Oboh (2015),Thermal Oxidation Induces Lipid Peroxidation and Changes in the Physicochemical Properties and *β*–Carotene Content of Arachis Oil, *International Journal of Food Science*, DOI: 10.1155/2015/806524.
15. Murat Reis Akkaya (2018), Prediction of fatty acid composition of sunflower seeds by near–infrared reflectance spectroscopy, *Journal of Food Science and Technology*, 55(6), pp. 2318–2325.
16. Alam Zeb, Fareed Ullah (2016), A Simple Spectrophotometric Method for the Determination of Thiobarbituric Acid Reactive Substances in Fried Fast Foods, *Journal of Analytical Methods in Chemistry*, 2016, pp. 1–5.
17. Teruo Matsushita, Shin-ichi Inoue, Ryusuke Tanaka (2010), An Assay Method for Determining the Total Lipid Content of Fish Meat Using a 2-Thiobarbituric Acid Reaction, *Journal of the American Oil Chemists' Society*, 87, pp. 963–972.
18. Aparicio R., Roda L., Albi M.A., Gutiérrez F. (1999), Effect of various compounds on virgin olive oil stability measured by Rancimat, *Journal of Agricultural and Food Chemistry*, 47, pp. 4150–4155.

Functional properties and sensory acceptability of shelf stable condiment from blends of fermented locust bean seeds, ginger and onion

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Abstract

Introduction. This study investigated the possibility of producing condiments from fermented locust bean seeds, onion and ginger flour blends

Materials and methods. The fermented locust bean seeds, onion and ginger were milled into flours and mixed in different proportions using a simplex-centroid design with resulting into 13 different experimental runs to produce different blends of condiments.

Results and discussion. The functional properties of fermented locust bean, onion and ginger blends ranged from 5.89-6.72%, 5.27-10.87%, 3.31-4.59%, 2.31-3.03%, 0.64-1.12%, 0.59-63 g/ml for swelling power, solubility, gelation capacity, water absorption capacity, oil absorption capacity, and bulk density respectively. The swelling power and solubility index ranged from 5.89 to 6.72% and 5.27 to 10.87% respectively. Sample 72.25: 24.25:3.5 had the least value for swelling power while sample 75:21:4 had the highest value for swelling power. The interactive effect of fermented locust bean and onion powder had a significant ($p<0.05$) effect on swelling power and solubility index of fermented locust bean, onion and ginger flour blends. Water absorption capacity ranged from 2.31 to 3.03%. Sample 72.25: 24.25: 3.5 had the least value for water absorption capacity while sample 75:21:4 the highest. The interactive effect of fermented locust bean and onion powder as well as fermented locust bean and ginger had a significant ($p<0.05$) effect on oil absorption capacity. Lightness, redness and yellowness ranged from 39.49 to 45.07, 2.01 to 2.71 and 12.66 to 15.30 with sample of 72: 25:3 having the highest for lightness and yellowness while sample 75: 21:4 the least for lightness and yellowness. The pH varied between 5.51 and 5.65. There were no significant ($p>0.05$) effect of fermented locust bean, onion and ginger flour on pH. The sensory attributes for all the parameters were scored liked slightly and liked moderately.

Conclusion. The incorporation of onion and ginger flour to fermented locust bean had a significant effect on the functional properties of the condiments from flour blends.

Introduction

Condiments are generally defined as a substance applied to food in the form of a sauce, powder, spread or anything similar to increase or improve the flavour [1]. In some developing countries such as Nigeria, condiments are always produced from fermented beans, fermented melon seed, fermented soybeans, fermented cotton seed and fermented pigeon pea which were commonly used to season food. The making of condiments is mainly on a traditional small-scale, household basis under extremely variable conditions [1].

Fermented locust beans are products locally known as *"iru", "dawadawa*" or *"ogiri"* in Yoruba, Hausa and Igbo languages respectively according to Adejumo *et al.* [2]. They are produced locally from mature seeds of African locust bean (*Parkia biglobosa*) pods. They are usually used as flavor enhancer and in soups and stew. African locust bean is nutritious as it is rich in protein and some other beneficial food components. It serves as a cheap source of protein for most low-income families in Nigeria whose protein intake is low due to high costs of animal protein sources [3]. According to Omafuvbe *et al.* [4] fermented locust bean is well-known for its characteristic ammoniacal odour and flavour which enhances the taste of traditional soups and sauces. Although this special flavour is generally acceptable by most consumers of delicacies made with fermented locust bean, sometimes, this strong flavour as well as the appearance of the seeds in foods limits its consumption. Hence, depriving consumers' access to the health benefits embedded in the consumption of this fermented locust bean condiment product [5]. However, spices such as ginger and onion as well as some other spices can be used to mask these undesirable sensory characteristics and enhance its acceptability.

According to Ajayi *et al.* [5], fermented locust bean (*Iru*) condiment has a shelf life of about 2 to 3 days without any additives or preservation process such as drying, refrigerating or freezing where it is available to reduce its deterioration. Locally or traditionally, the deterioration of fermented locust bean condiment is reduced by the addition of salt and/or sun drying in most homes. Drying reduces the moisture content of food thus inhibiting microbial activities and hence extends shelf life. It will also help to reduce the intensity of the flavor associated with fermented locust bean seeds that is detested by some consumers. Hence, the production of a shelf stable condiment from ground dried fermented locust bean seeds will increase its availability, acceptability and utilization. Thus, this study was aimed at evaluating the functional properties and sensory acceptability of a shelf stable condiment from fermented locust bean seeds, ginger and onion powders.

Materials and methods

Materials

Fresh ginger roots and onion bulbs was obtained from Osiele market in Abeokuta, Nigeria while fermented locust beans were purchased from the local producers in Adatan market, Abeokuta, Nigeria.

Processing of Fermented locust bean seeds flour

The modified method described by Omafuvbe *et al.* [4] was used in preparing the fermented locust bean. The seeds were sorted to remove foreign matters. It was then washed to remove dirt and other impurities. After which it was drained to remove excess water and spread on a tray to begin the drying process. The samples were dried at 60 °C for 9 h using

the hot air oven (Model T12H Genlab, England) The dried samples were milled using laboratory hammer milling machine (Fritsch, D-55743, Idar-oberstein-Germany) and the milled sample was sieved (using 250μm screen) to obtain the flour. Locust bean seed flour was packed sealed in polyethylene bag for further analysis.

Processing of ginger flour

The method described by Adebayo-Oyetoro *et al.* [6] was used in the preparation of ginger flour. The fresh ginger roots were carefully sorted and peeled. After which it was cut into smaller pieces and then washed. It was wet milled, after which it was dried in a hot air oven (Model T12H Genlab, England) at 65 °C for 9 h and was milled using laboratory hammer milling machine (Fritsch, D-55743, Idar-oberstein-Germany and was further sieved (using 250μm screen) to obtain a flour for further analysis.

Processing of onion flour

The method described by Michalak-Majewska *et al.* [7] was used in the preparation of onion flour. The onions bulbs were carefully selected, cleaned and washed to remove dirt and impurities. It was then peeled, sliced thinly and soaked in 15 litres of water containing 3 g of potassium metabisulphite for 15 min. After which it was dried in a cabinet dryer at 60 °C for 24 h. The dried samples were milled, sieved to obtain fine flour and packed in polyethylene bag for further analysis.

Composition of the different formulations based on experimental design

A Simplex-centroid design of the mixture experimental design was used to optimize ingredient blends for obtaining condiment blends with onion and ginger powder as process variables on some attributes of condiments made from these mixtures as dependent variables (Table 1).

Table 1

Composition of the Different Formulations Based on Experimental Design (%)

Fermented locust bean flour	Onion flour	Ginger flour
73.75	23.75	2.5
73	25	2
75	21	4
75	22	3
72.25	24.25	3.5
71	25	4
73	25	2
71	25	4
73	23	4
72	25	3
75	23	2
75	21	4
74.25	22.75	3

Each flour blend composition was thoroughly mixed to obtain a homogenous blend. The composite flour blends were packed in different polythene bag and stored in airtight containers at room temperature prior to analysis and use.

Determination of swelling power and solubility index

The swelling power and solubility index were determined using the method described by Takashi and Siebel [8] and Oke *et al*. [9]. One gram of flour was weighed into a 50 ml centrifuge tube. Fifty millilitres of distilled water was added and mixed gently. The slurry was heated in a water bath at 90 °C for 15 min. During heating the slurry was stirred gently to prevent clumping of the flour. On completion, the tube containing the paste was centrifuged at 3,000 rpm for 10 min using a centrifuge machine (Centrifuge model 90-1, England). The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of gel was thereafter determined to get dry matter content of the gel.

$$Swelling\ Power = \frac{weight\ of\ wet\ mass\ of\ sediment}{weight\ of\ dry\ matter\ in\ the\ gel}.$$

$$Starch\ solubility\ index\ \% = \frac{weight\ of\ dry\ solids\ after\ drying}{weight\ of\ sample} \times 100$$

Water absorption capacity (WAC)

The method described by Onwuka [10] was used. About 1 g of the flour sample was weighed into a 15 ml centrifuge tube and suspended in 10 ml of water. It was shaken on a platform tube rocker for 1 min at room temperature. The sample was allowed to stand for 30 min and centrifuged at 1200 rpm for 30 min. The volume of free water was read directly from the centrifuge tube.

$$WAC\ (\%) = \frac{Amount\ of\ water\ added - Free\ water}{Weight\ of\ sample} \times Density\ of\ water \times 100$$

Oil absorption capacity (OAC)

The method described by Onwuka [10] was used for oil absorption capacity. About 10 ml refined olive oil was added to 1g of each sample of powder in a weighed 25 ml centrifuge tube. The tube was agitated on a vertex mixer for 2 min. It was centrifuged at 4000 rpm for 20 min. The volume of free oil was recorded and decanted. Oil absorption capacity is expressed as ml of oil bound by 100 g dried powder

$$OAC\ (\%) = \frac{Amount\ of\ oil\ added - Free\ oil}{Weight\ of\ sample} \times Density\ of\ refined\ corn\ oil \times 100$$

Bulk density

Bulk density was determined using the method described by Wang and Kinsella [11] and Oke *et al*. [12]. Ten grams of the sample were weighed into a 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top. The volume of the sample was recorded.

$$Bulk\ density\left(\frac{\text{g}}{\text{ml}}\right) = \frac{Weight\ of\ sample}{Volume\ of\ sample\ after\ tapping}$$

Gelation capacity

This was determined using the method described by Adeleke and Odedeji [13]. About 2-20% suspension was prepared with 5 ml distilled water in a test tube. The tubes containing the suspension were heated for 1 hour in a boiling water bath. It was cooled under running water at 4 °C for 2 h. The test tu was inverted to see if content will fall or slip off. The least gelation concentration is that concentration when the sample from the inverted test tube does not fall off.

Colour measurement of fermented locust bean, onion and ginger condiment flour blends

Tolour measurement ocondiment flour samples were measured by Minolta Chroma meter (CR-410, Japan). The colour meter was calibrated against a standard calibration plate of a white surface and set to CIE Standard Illuminant C. The L*, a*, b*values are average of ten readings. The color brightness co-ordinate L*measures the whiteness value of a color and ranges from black at 0 to white at 100. The chromaticity co-ordinate a*measures red when positive and green when negative, and chromaticity coordinate b*measures yellow when positive and blue when negative.

Sensory evaluation of fermented locust bean, onion and ginger condiment flour blends

The method described by Iwe [14] was used for the sensory evaluation. Thirty untrained panelists were asked to score the condiment samples using a 9point hedonic scale based on the degree of likeness where 1 represent dislike extremely, 5 represent neither like nor dislike and 9 represent like extremely. The condiment attributes evaluated was appearance, aroma, taste, flavour and overall acceptability.

Statistical analysis

Statistical analysis was carried out using the Analysis of Variance (ANOVA) and in cases where there was significant difference, means were separated using the Duncan's multiple range test. The effect of optimization procedure was investigated using Design Expert version (8.0) and significant effects of the independent variables were determined at 5% confidence level.

Results and discussion

Functional properties of fermented locust bean, onion and ginger condiment flour blends

The functional properties of fermented locust bean, onion and ginger condiment blends is shown in Table 2.

Table 2

Functional properties of condiments from fermented locust bean, onion and ginger blends

FLBF	OF	GF	Swelling Power (%)	Solubility (%)	Gelation capacity (%)	WAC (%)	OAC (%)	Bulk density (g/ml)	Oil absorption capacity (%)	Bulk density (g/ml)
73.75	23.75	2.5	5.97^{a}	6.43^{b}	3.54^{ab}	2.40^{ab}	1.08^{e}	0.60^{a}	1.08	0.60
73	25	2	6.41^{e}	8.92^{g}	4.59^{cd}	2.81^{b}	0.75^{b}	0.63^{b}	0.75	0.63
75	21	4	6.72^{f}	10.87^{i}	5.19^{d}	3.03^{c}	0.64^{a}	0.61^{a}	0.64	0.61
75	22	3	6.24^{c}	7.69^{e}	4.19^{b}	2.71^{b}	0.86^{bc}	0.60^{a}	0.86	0.60
72.25	24.25	3.5	5.89^{a}	5.27^{a}	3.31^{a}	2.31^{a}	1.02^{d}	0.59^{a}	1.02	0.59
71	25	4	6.10^{b}	7.49^{d}	3.83^{ab}	2.64^{b}	0.96^{cd}	0.60^{a}	0.96	0.60
73	25	2	6.43^{e}	8.92^{f}	4.56^{cd}	2.77^{b}	0.72^{b}	0.61^{a}	0.72	0.61
71	25	4	6.18^{c}	7.49^{d}	3.83^{ab}	2.65^{b}	1.01^{d}	0.59^{a}	1.01	0.59
73	23	4	6.26^{cd}	7.57^{de}	3.90^{ab}	2.62^{b}	0.91^{c}	0.60^{a}	0.91	0.60
72	25	3	6.10^{b}	7.48^{d}	3.83^{ab}	2.33^{a}	1.04^{e}	0.59^{a}	1.04	0.59
75	23	2	6.32^{cd}	8.73^{f}	4.27^{c}	2.75^{b}	0.78^{b}	0.60^{a}	0.78	0.60
75	21	4	6.26^{cd}	7.71^{e}	4.22^{c}	2.72^{b}	0.91^{c}	0.60^{a}	0.91	0.60
74.25	22.75	3	6.08^{b}	6.67^{c}	3.63^{ab}	2.46^{ab}	1.12^{f}	0.60^{a}	1.12	0.60

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
FLBF- Fermented locust bean flour, OF- Onion flour, GF: Ginger flour,
WAC: Water absorption capacity, OAC: Oil absorption capacity

The swelling power and solubility index ranged from 5.89 to 6.72% and 5.27 to 10.87% respectively. Sample 72.25: 24.25:3.5 had the least value for swelling power while sample 75:21:4 had the highest value for swelling power.

The interactive effect of fermented locust bean and onion powder had a significant ($p<0.05$) effect on swelling power and solubility index while the interactive effect of onion and ginger powder also had a significant ($p<0.05$) effect on swelling power and solubility index as shown in the regression coefficient in Table 3. The high swelling power obtained in this study could be as a result of high protein content in fermented locust bean. Swelling power has been reported to be influenced by temperature, water availability, carbohydrate, and protein [15, 16]. Swelling power is the volume of expansion of molecules in response to water uptake, which it possessed until a colloidal suspension is achieved or until further expansion and uptake are prevented by intermolecular forces in the swollen particles [17, 18] while the differences in the solubility of the flour blends indicate the existence of strong bonding forces within the flour granules arising from coagulated protein or fat that form complexes with amylose preventing it from leaching from the granules [19, 20].

Table 3
Regression coefficient of functional properties of condiments from fermented locust bean, onion and ginger blends

Parameter	Swelling power (%)	Solubility (%)	Gelation capacity (%)	Water absorption capacity (%)	Oil absorption capacity (%)	Bulk density (g/ml)
A	6.62	11.64	5.29	3.33	0.61	0.60
B	6.78	12.24	5.92	3.06	0.52	0.62
C	11.61	38.96	14.00	9.12	-3.22	0.78
AB	1.52*	14.14*	5.36*	1.84*	0.91*	0.34
AC	7.95	50.86	15.42*	10.57	6.39*	-0.23*
BC	-10.14*	61.33*	-21.52*	11.04*	7.61	-0.37*
F-Value	3.35	2.98	4.99	5.64	3.52	2.65
Press	0.69	31-01	2.87	0.48	0.27	0.00
R^2	0.71	0.68	0.78	0.80	0.72	0.65

*****Significant at $p<0.05$; A: Fermented locust bean flour, B: Onion flour, C: Ginger flour,
AB: Interaction of Fermented locust bean and ginger flour,
AC: Interaction of fermented locust bean and ginger flour, R^2: Coefficient of determination

Factors capable of influencing the solubility of flours include flour composition and particle size, density and pH, processing conditions and storage conditions [21]. In terms of gelation capacity, the sample varied between 3.31 and 4.59%. Sample 73:25:2 had the highest gelation capacity while sample 72.25:24.25: 3.5 had the least. From Table 3, the interactive effect of fermented locust bean, onion and ginger flour had a significant ($p<0.05$) effect on gelation capacity. However, only the interaction between onion and ginger powder had a negative effect on gelation capacity. The low gelation capacity observed in this study could be as a result of protein concentration in fermented locust bean. However, Akubor [22] and Khuthadzo *et al.* [23] reported that gelation capacity of flours is caused by protein concentration, particularly fraction of globulin, and interaction between proteins, carbohydrates, and lipids. Least gelation capacity (LGC) measures the minimum amount of flour needed to form a gel in a measured volume of water. It varies from flour to flour depending on the relative ratios of their structural constituents like protein, carbohydrates, and lipids [24, 25]. Water absorption capacity ranged from 2.31 to 3.03%. Sample 72.25: 24.25: 3.5 had the least value for water absorption capacity while sample 75:21:4 the highest as shown in Table 2. The interaction effect of fermented locust bean, onion and ginger condiment blends had a significant ($p<0.05$) effect on the water absorption capacity as shown in regression Table 3. The low water absorption capacity obtained in this study could be due to less due to less availability of polar amino acids. Water absorption capacity describes the flour-water association ability under limited water supply and it is also used as an indication of performance in several food formulations [26, 27]. The result agrees with the work of Ubbor and Nwaogu, [28]. Therefore, the low water absorption capacity observed in this study will be of good potentials in soups and gravies as a thickener. The interactive effect of fermented locust bean and onion powder as well as fermented locust bean and ginger had a significant ($p<0.05$) effect on oil absorption capacity. The oil absorption capacity ranged from 0.64 to 1.12%. The low value of oil absorption capacity observed in this study could be attributed to the high amount of protein in fermented locust bean flour. However,

Jitngarmkusol *et al.* [29] reported that the major component affecting oil absorption capacity is protein, which is composed of both hydrophilic and hydrophobic parts. Oil absorption capacity is an important property in food formulations because fat improves the flavour and mouthfeel of foods [30]. The value for oil absorption capacity in this work is lower than the values reported by Zakari *et al*. [31]. The bulk density of fermented locust bean, onion and ginger condiment blends ranged from 0.59 to 0.63 g/ml. The interaction between fermented locust bean and ginger flour as well as onion and ginger flour had a negative significant ($p<0.05$) effect on bulk density. Bulk density is an index of the heaviness of flour materials and expresses the relative volume of packaging material needed [18]. The low bulk density of fermented locust bean, onion and ginger condiment blends implies that less quantity of it would be packaged in constant volume, therefore, ensuring economic package. The low bulk density observed in this study might be due to their differences in the chemical composition of the individual flours blended together.

Colour parameters and pH of fermented locust bean, onion and ginger condiment blends

The mean value of lightness, redness and yellowness ranged from 39.49 to 45.07, 2.01 to 2.71 and 12.66 to 15.30 with sample of 72: 25:3 having the highest lightness and yellowness while sample 75: 21:4 the least value for lightness and yellowness as presented in Table 4.

Table 4

Colour parameters and pH of condiments from fermented locust bean, onion and ginger blends

FLBF	OF	GF	Lightness	Redness	Yellowness	pH
73.75	23.75	2.5	40.91^{ab}	2.25^{cd}	13.44^{bc}	5.57^{b}
73	25	2	42.11^{bc}	2.30^{d}	14.22^{cd}	5.56^{b}
75	21	4	39.49^{a}	2.01^{a}	12.66^{ab}	5.65^{c}
75	22	3	42.24^{bc}	2.11^{abc}	14.04^{cd}	5.64^{c}
72.25	24.25	3.5	40.39^{ab}	2.06^{ab}	13.34^{abc}	5.56^{b}
71	25	4	43.47^{cd}	2.14^{abcd}	14.68^{de}	5.56^{b}
73	25	2	40.80^{ab}	2.11^{abc}	13.32^{abc}	5.61^{c}
71	25	4	39.64^{a}	2.06^{ab}	12.46^{a}	5.62^{c}
73	23	4	43.42^{cd}	2.81^{f}	14.73^{de}	5.55^{b}
72	25	3	45.07^{d}	2.71^{f}	15.30^{e}	5.51^{a}
75	23	2	42.14^{bc}	2.17^{abcd}	14.17^{cd}	5.57^{b}
75	21	4	43.53^{cd}	2.48^{e}	14.54^{de}	5.62^{c}
74.25	22.75	3	42.46^{bc}	2.20^{bcd}	14.26^{cd}	5.58^{b}

Mean values with different superscripts within the same column are significantly different ($p<0.05$); FLBF- Fermented locust bean flour, OF- Onion flour, GF: Ginger flour

The regression coefficients of the models developed for the interaction effect of fermented locust bean, onion and ginger condiment flour blends on colour parameters and pH is presented in Table 5.

Table 5
Regression coefficient of functional properties of condiments from fermented locust bean, onion and ginger blends

Parameter	Lightness	Redness	Yellowness	pH
A	40.74	1.06	12.99	5.74
B	41.88	1.83	13.37	5.64
C	24.03	3.29	6.59	5.79
AB	-1.02*	3.20*	2.90	0.47
AC	-29.40*	-2.05*	12.75*	0.55
BC	26.53*	-0.74	11.72*	0.50
F-Value	0.07	0.53	0.09	1.51
Press	149.80	3.09	36.31	0.05
R^2	0.78	0.88	0.86	0.62

*****Significant at $p<0.05$; A: Fermented locust bean flour, B: Onion flour,
C: Ginger flour, AB: Interaction of Fermented locust bean and ginger flour,
AC: Interaction of fermented locust bean and ginger flour, R^2: Coefficient of determination

The interactive effect of all the variable had significant ($p<0.05$) effect on lightness. However, the inclusion of fermented locust bean had a negative effect on the lightness of the condiment. Similarly, the interaction of fermented locust bean and ginger flour also had a negative significant ($p<0.05$) effect on redness while it was positive on yellowness. The colour of any food product is a significant sensory property that determines the acceptability of the product. The high value observed in the yellowness of condiment flour blends might be as a result of yellow pigment in ginger flour. The pH varied between 5.51 and 5.65 with sample 72:25:3 having the highest while sample 75: 21:4 had the least. There were no significant ($p>0.05$) effect of fermented locust bean, onion and ginger flour on pH as shown in Table 5. pH measures the acidity and alkalinity of a substance. The pH of the condiment flour blends in this study was acidic and this will enhance the sour taste of the condiments, thereby giving preferences to its consumer acceptability [32].

Sensory score of condiments from fermented locust bean, onion and ginger flour blends

The result in Table 6 represents the mean result of the sensory attributes of fermented locust bean, onion and ginger condiment blends. The appearance, aroma, colour, hand feel, overall acceptability ranged from 6.17 to 7.27, 6.03 to 6.97, 6.20 to 7.00, 6.30 to 7.27 and 6.50 to 7.30 respectively. The sensory attributes for all the condiments were scored between like slightly and liked moderately. Condiments prepared from fermented locust bean, onion and ginger flour were all accepted by the panelist.

Table 6

Sensory attributes of condiments from fermented locust bean, onion and ginger blends

FLBF	OF	GF	Appearance	Aroma	Colour	Hand Feel	Overall Acceptability
73.75	23.75	2.5	6.67^{d}	6.03^{a}	6.33^{bc}	6.93^{g}	6.77^{bc}
73	25	2	6.60^{cd}	6.07^{a}	6.27^{b}	6.83^{d}	6.50^{a}
75	21	4	6.83^{e}	6.63^{cd}	7.00^{f}	7.27^{f}	7.23^{g}
75	22	3	6.80^{e}	6.77^{d}	6.87^{f}	7.23^{f}	7.30^{gh}
72.25	24.25	3.5	6.53^{c}	6.27^{b}	6.77^{d}	6.30^{a}	6.80^{c}
71	25	4	6.57^{c}	6.50^{c}	6.77^{d}	7.00^{e}	7.17^{ef}
73	25	2	7.00^{f}	6.80^{e}	6.87^{e}	7.00^{e}	7.00^{d}
71	25	4	6.40^{b}	6.97^{f}	6.83^{e}	6.67^{b}	6.87^{d}
73	23	4	7.27^{f}	6.27^{b}	6.90^{f}	6.77^{c}	7.07^{e}
72	25	3	6.63^{c}	6.73^{d}	6.70^{d}	6.80^{d}	6.80^{c}
75	23	2	6.53^{c}	6.20^{b}	6.20^{a}	6.97^{e}	6.63^{b}
75	21	4	6.53^{c}	6.57^{c}	6.80^{e}	6.83^{d}	6.90^{d}
74.25	22.75	3	6.17^{a}	6.17^{b}	6.43^{c}	6.73^{c}	6.73^{b}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); FLBF- Fermented locust bean flour, OF- Onion flour, GF: Ginger flour

Conclusions

1. This study has been able to show that the incorporation of onion and ginger flour to fermented locust bean had a significant effect on the functional properties of the flour blends
2. Condiments prepared from fermented locust bean, onion and ginger flour were all accepted by the panelist

References

1. Oboh G. (2006), Nutrient and antinutrient composition of condiments produced from some fermented underutilized legumes, *Journal of Food Biochemistry*, 30, pp. 579–588.
2. Adejumo A.A., Azeez I.O., Geply J.J., Oboite F.O. (2013), Processing, utilization and challenges of African locust bean (*Parkia biglobosa Jacque Benth*) in Arigidi Akoko, Ondo State, Nigeria, *Journal of Agriculture and Social Research*, 13(1), pp. 39–48.
3. Gibson L.A., Maimuna S., Akeem O.R. (2017), Comparative evaluation of anti-oxidative potentials of fermented locust bean condiment and its moringa fortified variant, *African Journal of Biotechnology*, 16(45), pp. 2134–2141.
4. Omafuvbe B.O., Falade O.S., Osuntogun B.A., Adewusi S.R.A. (2004), Chemical and biochemical changes in African locust bean (*Parkia biglobosa*) and melon (*Citrullus vulgaris*) seeds during fermentation to condiments, *Pakistan Journal of Nutrition*, 3(3), pp. 140–145.

5. Ajayi O.A., Akinrinde I.M., Akinwunmi O.O. (2015), Towards the development of shelf stable 'Iru' (*Parkia biglobosa*) condiment bouillon cubes using corn, cassava and potato starch extracts as binders, *Nigerian Food Journal*, 33, pp. 67–72.
6. Adebayo-Oyetoro A.O., Ogundipe O.O., Azoro C.G., Adeyeye S.A.O. (2016), Production and evaluation of ginger spiced cookies from wheat-plantain composite flour, *Pacific Journal of Science and Technology*, 17(1), pp. 280–287.
7. Michalak-Majewska M., Teterycz D., Muszyński S., Radzki W., Sykut-Domańska E. (2020), Influence of onion skin powder on nutritional and quality attributes of wheat pasta, *PLoS ONE*, 15(1), pp. e0227942.
8. Takashi S., Seib P.A. (1988), Paste and gel properties of prime corn and wheat starches with and without native lipids, *Journal of Cereal Chemistry*, 65, pp. 474–480.
9. Oke E.K., Idowu M.A., Omoniyi S.A. (2016), Proximate, functional, pasting and rheological properties of wheat-tiger nut composite flour, *Annals Food Science and Technology*, 17(2), pp. 411–420.
10. Onwuka G. I. (2005), *Food Analysis and Instrumentation: Theory and Practice*, Naphtali Prints, Lagos.
11. Wang, J.C., Kinsella, J.E. (1976), Functional properties of novel proteins; alfalfa leaf protein, *Journal of Food Science*, 41, pp. 286–289.
12. Oke E.K., Idowu M.A., Adeola A.A., Abiola T.O., Adeniji I.O. (2019), Evaluation and storage studies of sausage roll produced from wheat-tigernut flour blends, *Croatian Journal of Food Technology, Biotechnology and Nutrition*, 14(3-4), pp. 82–90.
13. Adeleke R.O., Odedeji M.J. (2010), Functional Properties of Wheat and Sweet Potato flour blends, *Pakistan Journal of Nutrition*, 9(6), pp. 535–538.
14. Iwe M.O. (2002), *Hand Book of Sensory Methods and Analysis Rojoint Communication*, Publishers Ltd. Enugu.
15. Yellavila S.B., Agbenorhevi J.K., Asibuo J.Y., Sampson, G.O. (2015), Proximate composition, minerals content and functional properties of five lima bean accessions, *Journal of Food Security*, 3, pp. 69–74.
16. Arinola S.O., Oje O.J., Omowaye-Taiwo O.A. (2019), Evaluation of Physicochemical properties and phytochemical composition of African locust bean (*Parkia biglobosa*) Pulp, *Applied Tropical Agriculture*, 24(1), pp. 64–69.
17. Houssou P., Ayernor G.S. (2002), Appropriate processing and food functional properties of maize flour, *African Journal of Science and Technology, Science and Engineering Series*, 3, pp. 126–131.
18. Akoja S.S., Adebowale O.J., Makanjuola O.M., Salaam, H. (2016), Functional properties, nutritional and sensory qualities of maize-based snack (*Kokoro*) supplemented with protein hydrolysate prepared from pigeon pea *(Cajanus Cajan*) seed, *Journal of Culinary Science and Technology*, 1–14.
19. Sung W.C., Stone, M. (2003), Characterization of various wheat starch in pasta development, *Journal of Marine Science and Technology*, 11(2), pp. 61–69.
20. Asaam E.S., Adubofuor J., Amoah I., Apeku, O-J.D. (2018), Functional and pasting properties of yellow maize–soya bean–pumpkin composite flours and acceptability study on their breakfast cereals, *Cogent Food and Agriculture*, 4, pp. 1501932.
21. Mirhosseini H., Amid B.T. (2013), Effect of different drying techniques on flowability characteristics and chemical properties of natural carbohydrate-protein Gum from durian fruit seed, *Chemistry Central Journal*, 7(1), pp. 1–14.

22. Akubor P.I., Adamolekun F.A., Oba C.O. Obari, I.T. (2003), Chemical composition and functional properties of cowpea/plantain flour blends cookies production, *Plant Foods for Human Nutrition*, 58 (3), pp. 1–9.
23. Khuthadzo N., Mpho E.M., Henry, S. (2019), Physicochemical and functional properties of chemically pretreated Ndou sweet potato flour, *Hindawi International Journal of Food Science*, Article ID 4158213, pp. 1–8.
24. Abbey B.W., Ibeh, G.O. (1988), Functional properties of raw and heat processed cowpea (*Vigna unguiculata* Walp) flour, *Journal of Food Science*, 53, pp. 1775–1777.
25. Ohizua E.R., Adeola A.A., Idowu M.A., Sobukola O.P., Afolabi F.A., Ishola R.O., Ayansina S.O., Oyekale T.O., Falomo, A. (2017), Nutrient composition, functional, and pasting properties of unripe cooking banana, pigeon pea, and sweetpotato flour blends, *Food Science and Nutrition*, pp. 1–13.
26. Choonhahirun A. (2010), Proximate composition and functional properties of (*Elateriospermun tapos* Blume) seed flour, *African Journal of Biotechnology*, 9(36), pp. 5946-5949.
27. Koledoye A.O., Akanbi, C.T. (2013), Optimisation of process conditions for dehulling and softening of locust bean (*Parkia biglobosa*, Jacq. Benth) seeds prior to fermentation in *Iru* production, *International Journal of Postharvest Technology and Innovation*, 3, pp. 123–139.
28. Ubbor S.C., Nwaogu, C.F. (2010), Production and evaluation of noodles from flour blends of cocoyam, breadfruit and wheat, *Nigerian Food Journal*, 28(1), pp. 173–198.
29. Jitngarmkusol S., Hongsuwankul J., Tananuwong, K. (2008), Chemical composition, functional properties, and microstructure of defatted macademice flours, *Food Chemistry*, 110, pp. 23–30.
30. Aremu M.O., Olaofe O., Akintayo, E.T. (2007), Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelation properties, *Journal of Food Technology*, 5(2), pp. 109–115.
31. Zakari U.M., Hassan A., Ndife J. (2014), Quality characteristic of African locust bean fruit pulp cakes, *African Journal of Food Science*, 9(1), pp. 17–22.
32. Oladeji B.S., Irinkoyenikan O.A., Akanbi C.T., Gbadamosi S.O. (2018), Effect of fermentation on the physicochemical properties, pasting profile and sensory scores of normal endosperm maize and quality protein maize flours, *International Food Research Journal*, 25(3), pp. 1100–1108.

Анотації

Харчові технології

Гідротермічна обробка органічного пшеничного крохмалю: термічні, структурні та клейстерні властивості

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Вступ. Мета досліджень – вивчити ефекти, спричинені гідротермічним обробленням, низькою вологістю (<35%) та нагріванням органічного пшеничного крохмалю.

Матеріали і методи. Органічний пшеничний крохмаль піддавали гідротермічній обробці за різних концентрацій вологості (10, 15 та 20%) в автоклаві за температури 121 °C протягом 1 год 15 хв. Для порівняння властивостей природного і модифікованого крохмалю проводили термогравіметрію, віскоамілографічний аналіз, рентгенівську дифрактометрію порошковим методом (XRD) та сканувальну електронну мікроскопію (SEM).

Результати і обговорення. Після термічної обробки за низької вологості органічний пшеничний крохмаль мав більшу термостійкість порівняно із необробленим. Перша втрата маси відбулася через зневоднення; друга і третя втрати маси відбуваються послідовно під час розкладання й окислення органічної речовини в атмосфері повітря. Кінцевим залишком був попіл із крохмалю. Більш низькі температури склеювання та вища пікова в'язкість спостерігалися для крохмалю, обробленого за вологості 15 і 20%. Нижня тенденція до ретроградації та в'язкості були отримані для органічного пшеничного крохмалю, обробленого за 10% вологості. Для модифікованих зразків було виявлено зниження кристалічності без значних змін у дифракційній картині. Основні кути дифракції реєструвались при 15, 17, 18 і 23 °, в 2θ, з низькою інтенсивністю. Така поведінка характерна для дифракційного крохмалю типу A (типового для круп). За допомогою сканувальної електронної мікроскопії органічний пшеничний крохмаль мав бімодальний розподіл без значних змін у морфології гранул. Після гідротермічного оброблення крохмальні гранули мали незначне збільшення середнього діаметра – від 17,9 до 27,7 мкм в основних гранулах (A) та від 5,6 до 7,1 мкм у незначних гранулах (B). Форма в (A) овальна, у (B) – сочевична. Незначні западини на поверхні крохмалю спостерігаються, головно, після термічної обробки, що може бути наслідком взаємодії крохмаль-білок.

Висновок. Після модифікації органічного пшеничного крохмалю гідротермічним обробленням спостерігалося зниження температури клейстеризації, також зазнали змін показники основної термостійкості і в'язкості.

Ключові слова: *пшениця, крохмаль, модифікація, термогравіметрія, клейстеризація.*

Вплив рослинної сировини на показники якості настоїв спиртових

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Вступ. Метою дослідження є визначення впливу рослинної сировини на показники якості настоїв спиртових.

Матеріали і методи. Для підготовки рослинної сировини відібрано та подрібнено такі зразки: корінь ехінацеї пурпурної (*Echinacea purpurea*), корінь родіоли рожевої (*Rhodiola rosea L.*), корінь імбиру (*Zingiber officinale*), сушена ламінарія (*Laminaria*). Дослідження органолептичних показників якості спиртових настоїв із рослинної сировини здійснено за п'ятибальною шкалою з урахуванням вагових коефіцієнтів. Визначення фізико-хімічних показників спиртових настоїв проведено за об'ємною часткою спирту, масовою концентрацією ефірної олії та концентрацією загального екстракту в досліджуваному розчині. Методом високоефективної газової хроматографії визначено вміст активних сполук, які переходять в отримані настої.

Результати і обговорення. Споживні властивості алкогольних напоїв формуються на всіх етапах їх виробництва, тому перед додаванням спиртових настоїв до готового напою вважали за доцільне дослідити якість отриманих напівфабрикатів.

Органолептичні показники спиртових настоїв із рослинної сировини мають гармонійний приємний смак і аромат, прозорі, привабливого кольору, не мають осаду.

Міцність зразків знаходиться в діапазоні від 43,0 до 55,0% та пояснюється різною концентрацію спирту у водно-спиртовій суміші під час екстрагування рослинних компонентів. Коливання вмісту ефірної олії й екстрактивних речовин пов'язане з особливостями хімічного складу вихідної рослинної сировини.

Наявність біологічно активних речовин, низки вітамінів і мінеральних сполук у дослідних зразках настоїв дає змогу використовувати їх у складі багатокомпонентних алкогольних напоїв, що характеризуються зниженим токсичним ефектом.

Висновки. Отримано спиртові настої для подальшого виробництва багатокомпонентних алкогольних напоїв. Проведені дослідження за органолептичними та фізико-хімічними показниками дають підстави створювати напій з прогнозованими високими показниками якості.

Ключові слова: *рослинна сировина, настій, алкогольний напій.*

Оцінка якості смаженого печива, виготовленого із суміші борошна з бобів *вінги китайської* та африканського горіха

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Вступ. Оцінювали якість висушеного смаженого печива із борошняних сумішей, функціональні та фізико-хімічні властивості, а також безпечність кінцевого продукту.

Матеріали і методи. Борошно волоського горіха змішували з борошном бобів *вінги китайської* у співвідношенні 3% до 15% для одержання висушеного бобового печива, визначали фізико-хімічні та функціональні властивості, а також термін зберігання.

Результати і обговорення. Борошно з бобів мало вищу об'ємну щільність (0,86> 0,77 г/мл), тоді як абсорбція води та олії, здатність до набухання бобів були вищими ($p \leq 0,05$) порівняно з волоським горіхом (1,78>0,85 г/г), (1,97г>1,29 г/г) і (1,04> 0,64) відповідно. Контрольний зразок (зразок без волоського горіха) мав більший вміст білка (17,81%), вологи (6,55%) та клітковини (1,58%), але жирність і зольність значно нижчі в зразку з додаванням волоського горіха. Зразок з 15% волоського горіха мав більшу кількість кальцію (1,69 мг/л) і магнію (3,70 мг/л), але контрольні показники були вищі для натрію (4,00 мг/л) та калію (3,14 мг/л). Зразок із 6% волоського горіха був найтвердішим (163,58 N), найнижчу твердість (12%) мав зразок волоського горіха (26,27 N). Значення L *, a * і b * були значущими. Контрольний зразок був світлішим порівняно із найтемнішим 15% зразком з волоського горіха. Зразки з 12 та 15% волоського горіха, відповідно, мали найменший вміст бактерій (4,0 × 104 КОЕ/г) та грибків (1,4 × 104 КОЕ/г) через вісім тижнів. Додавання волоського горіха пригнічувало ріст мікроорганізмів завдяки своїм антимікробним та антиоксидантним властивостям. Найкращі показники за зовнішнім виглядом, крихкістю і текстурою мав контрольний зразок, тоді як 9% зразок волоського горіха – за ароматом і смаком.

Висновок. Додавання волоського горіха збільшило термін придатності та покращило харчові якості смаженого бобового печива.

Ключові слова: *африканський горіх, вінга китайська, печиво, зберігання*.

Теплофізичні характеристики заморожених напівфабрикатів для технології ресторанного господарства

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Вступ. Метою дослідження є визначення впливу теплофізичних характеристик заморожених напівфабрикатів на якість десертів.

Матеріали і методи. Для визначення якості заморожених напівфабрикатів у технології десертів використовували таку сировину: глюкозно-фруктовий сироп, мальтодекстрин, пюре з яблук, ківі, банана, гарбуза; напівфабрикати у вигляді купажованих пар: «яблуко-ківі», «яблуко-банан», «яблуко-гарбуз». Дослідження органолептичних показників якості здійснено за 10-бальною шкалою з урахуванням вагових коефіцієнтів та розрахунку критерію якості. Визначення фізико-хімічних показників зразків проведено за масовою часткою сухих речовин, активною кислотністю, активністю води, ентальпією, вологовмістом.

Результати і обговорення. Визначено теплофізичні характеристики фруктових пар купажованого пюре. Досліджено зміни температур замерзання води в системі.

Встановлені відмінності у параметрах заморожування фруктових пюреподібних напівфабрикатів з кріобіотиками, зокрема глюкозно-фруктозним сиропом і мальтодекстрином. Моносахариди – глюкоза і фруктоза, мають нижчі значення кріоскопічної температури порівняно з сахарозою, що пов'язано з характером кристалізації і величиною утворених кристалів у системі. За однакової хімічної формули і молекулярної маси цукрів величина кріоскопічної температури залежатиме від гідратації цукрів.

На основі визначених якісних показників і коефіцієнтів вагомості розраховано комплексний показник якості готових десертів (з використанням розроблених купажованих напівфабрикатів), виготовлених за розробленою технологією, та побудовано модель якості.

Рейтинг страв показав, що досліджені зразки самбуків з купажованими парами мають високий рейтинговий показник – 92,9 бал^2 та 96,9 бал^2, порівняно з контрольним зразком – 91,2 бал^2. Дещо нижчий показник (88,8 бал^2) має самбук «яблуко-гарбуз». Зниження рейтингу самбуку «яблуко-гарбуз» відбувається завдяки специфічному аромату купажованої пари «яблуко-гарбуз».

Висновки. Визначено кріоскопічні температури фруктових пюре, напівфабрикатів і готових десертів з додаванням кріопротекторів. Проведені дослідження за органолептичними та фізико-хімічними показниками дають підстави створювати десерти з прогнозованими високими показниками якості.

Ключові слова: *десерт, якість, купаж, напівфабрикат, заморожування*.

Вплив пророщеного насіння сочевиці на харчову цінність напою

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Вступ. Порівняно властивості сухої та пророщеної сочевиці та визначено вплив пророщеної сочевиці на властивості напою

Матеріали і методи. Досліджуються сухе і пророщене насіння сочевиці, а також напій, технологія якого передбачає замочування сухого насіння сочевиці, пророщування, подрібнення, екстрагування біологічно активних речовин, фільтрацію і розливання. Визначення активності амілази досліджено за методом Вольгемута. Амінокислотний склад білків у рослинній сировині визначено за допомогою методу іонообмінної хроматографії. Біологічну повноцінність білків визначено за розрахунком амінокислотного скору.

Результати і обговорення. Під дією протеолітичних ферментів при пророщуванні змінився білковий склад насіння і, як наслідок, напою з нього. Вміст білка в пророщеному насінні збільшився на 2,2%, а в напої з нього – на 3,3% в перерахунку на суху речовину порівняно з напоєм із сухого насіння. Виявлено зростання активності амілази впродовж пророщування, що призводить до розщеплення крохмалю до декстринів і простих цукрів. Збільшилась кількість водо- та солерозчинних фракцій білка (альбуміни та глобуліни) в межах 1,1–2,9%, що призводить до підвищення екстрактивності білка.

Загальний рівень засвоюваності білка напою з пророщеного насіння сочевиці становить 63,31%, тоді як масова частка білка, що використовується організмом, нераціональна – всього 20,85 %.

У напої з пророщеного насіння сочевиці відзначається збільшення кількості екстрагованого білка на 3,3%, вітамінів групи В і мінеральних речовин порівняно з напоєм із сухого насіння. Це відбувається за рахунок активності α-амілази, яка розщеплює високомолекулярні вуглеводи, що є основою клітинних мембран рослинної сировини. Це дає змогу підвищити екстрактивність, завдяки чому більша кількість нутрієнтів переходить у напій.

Висновки. Напій на основі пророщеного насіння сочевиці має покращений хімічний склад і кращу засвоюваність білка, якщо порівняти з напоєм із сухого насіння.

Ключові слова: *сочевиця, пророщення, напій, білок.*

Вплив замороження, світла і температури нагрівання на стабільність антоціанів природного барвника, вилученого з гранатової шкірки

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Вступ. Шкірка граната є багатим джерелом пігменту антоціану, антиоксидантів, а також мінералів. Метою цієї статті є дослідження стабільності антоціану в барвнику, отриманому з гранатової шкірки, антиоксидантної активності, а також мінерального складу.

Матеріали і методи. Антоціановий пігмент, отриманий з гранатової шкірки (*Punica granatum* L.), ідентифікували за допомогою УФ-спектрометрії, у замороженому стані (при -10 °C), а також за наявності та відсутності світла протягом трьох днів і при різних температурах нагрівання – 30, 45, 60 і 75 °C відповідно. Антиоксидантну здатність і вміст вибраних мінералів (Mg, Ca, P, Fe та K) природного барвника визначали методом DPPH із використанням УФ-спектрофотометрії та біохімічного аналізатора (Humalyzer, 3000). Сенсорний аналіз підготовлених продуктів у вигляді желе з додаванням природного і штучного барвників порівняно із комерційним проводився на основі гедонічного рейтингового тесту.

Результати і обговорення. На стабільність екстрактів антоціану суттєво впливав заморожений стан, що призвело до зниження на 62,96% на 9-й день температури (29,59–51,61% погіршення від початкової до кінцевої температури), вплив світла призвів до зменшення екстрактів антоціану на 44,87% після 9-ї доби. Вміст мінеральних речовин (Mg, Ca, P, Fe та K) природного (вилученого з шкірки граната) та штучного барвників (суміш E110, E122 та E330) становив 7,2, 20,6, 2,15, 1,4 та 147,6 мг/100г відповідно для натуральних барвників, а також 0,2, 0 (без фосфору), 0,39, 0,56 та 7,2 мг/100 г для штучного барвника відповідно. Антиоксидантна здатність природного барвника призвела до 0,04 мкг/мл значення IC50. Істотної різниці ($p < 0,05$) щодо кольору, зовнішнього вигляду та загальної прийнятності зразків желе не виявлено.

Висновок. Натуральний барвник шкірки граната може бути замінником синтетичного кольору, а також джерелом антиоксидантів і мінералів.

Ключові слова: *гранат, шкірка, барвник, антоціанін, антиоксидант, DPPH.*

Регулювання властивостей пектину шляхом комбінування сировини

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Вступ. Актуальним напрямком розвитку технології пектину є розроблення способу вилучення пектину із сумішей вторинної сировини, що містить низько- і високоетерифіковані пектини, для отримання пектинів із заданими функціональними властивостями (покращеними структуроутворювальною і комплексоутворювальною здатністю).

Матеріали і методи. Предметом дослідження є мезга картоплі, гарбуза та шкірки цитрусових і пектини, які отримували з кожного виду сировини, і з сумішей картопляно-цитрусової і картопляно-гарбузової сировини. Вилучення пектину здійснювали шляхом проведення послідовних стадій ферментативного оброблення сировини, кислотно-термічного гідролізу, осадження пектину етанолом, висушування готового пектину. Параметри процесів уточнювали залежно від використовуваної сировини. Наведено аналітичні характеристики пектину, отриманого з комбінованої сировини.

Результати і обговорення. Встановлено параметри гідролізу комбінованої картопляно-цитрусової і картопляно-гарбузової сировини. На основі проведених досліджень способів отримання пектину з комбінованої сировини встановлено, що оптимальне співвідношення картопляно-цитрусової і картопляно-гарбузової сировини – 50:50. Процес гідролізу передбачав два етапи: перший – за участі целюлаз при температурі 45–50°С, pH 5,5–6,0 протягом 1,0–1,5 год при гідромодулі 1:8–10, другий (кислотно-термічний гідроліз) – хлоридної кислоти за температури 75–90°С, pH гідролізної суміші 1,3–1,6 протягом 70–75 хв.

Отримані пектини з комбінованої сировини мають високий вміст уронідної складової 60–74 %, ступінь етерифікації понад 70 % і високу драглеутворювальну здатність порівняно з картопляним пектином, що має ступінь етерифікації на рівні 40–50 % і значний вміст баластних речовин. Комбінування сировини дає змогу отримувати пектини з різними властивостями.

Висновки. Встановлено, що шляхом комбінування картопляної мезги з гарбузовою і цитрусовою сировиною та регулювання параметрів процесу гідролізу можна досягти високих показників вилучення пектину з прогнозованими властивостями щодо драглеутворювальної і комплексоутворювальної здатності і більш ефективно використати вторинні сировинні ресурси.

Ключові слова: *пектин, гідроліз, мезга, властивості, сировина, комбінування*.

Хімічна стійкість соняшникової олії, збагаченої олією кмину

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Вступ. Антиоксидантні властивості олії кмину використано для інгібування деструктивних процесів в олії соняшника. Досліджено хімічну стійкість зразків соняшникової олії і сумішей соняшникової олії та олії насіння кмину.

Матеріали і методи. Досліджено хімічні показники зразків соняшникової олії та її сумішей з олією кмину під час тривалого нагрівання при 180-195 °С. Вміст вільних кислот і ненасичених сполук визначено титриметричним методом, вміст поліфенолів і карбонільних сполук – спектрофотометричним аналізом.

Результати і обговорення. Найбільше зростання кислотного числа олії від початку смаження до кінця експерименту було виявлено для соняшникової олії. Найменші зміни цього показника вмісту вільних кислот за тих самих умов було зафіксовано для сумішей соняшникової олії та олії кмину, особливо для суміші з більшим вмістом олії кмину. Більш висока хімічна стійкість олії кмину до дії окисників обумовлена більшим вмістом насичених кислот та олеїнової кислоти (мононенасичених) та низьким вмістом поліненасичених жирних кислот порівняно з олією соняшника.

Як і слід було очікувати, йодне число всіх зразків олій зменшувалося під час смаження, що означає руйнування подвійних С-С-зв'язків залишків жирних кислот у молекулах тригліцеридів. Найбільше відносне зменшення йодного числа було знайдено для соняшникової олії, а відсоток зниження цього показника становив 6,62% наприкінці терміну смаження. Також показано, що відносне зменшення йодного числа сумішей олії кмину та соняшникової олії у співвідношенні 10:90 та 20:80 було меншим.

Зростання числа тіобарбітурової кислоти (ТБК) спостерігалось під час смаження для всіх зразків олії. Найвищий показник ТБК було знайдено для соняшникової олії наприкінці терміну смаження, тоді як для суміші олій з найбільшим вмістом олії кмину за тих самих умов показник ТБК був найнижчим, що свідчить про те, що природні антиоксиданти в олії кмину чинять інгібуючу дію на утворення вторинних продуктів окиснення під час смаження.

Висновки. Додавання олії кмину до соняшникової олії позитивно впливає на хімічну стійкість олійних композицій за умов нагрівання.

Ключові слова: *олія, кмин, соняшник, антиоксидант, смаження, поліфенол.*

Функціональні та органолептичні властивості приправи з сумішей ферментованого насіння ріжкового дерева, імбиру і цибулі

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Вступ. Досліджена властивості приправ із ферментованих насіння ріжкового дерева, сумішей цибулі та імбирного борошна

Матеріали і методи. Ферментоване насіння ріжкового дерева, цибуля та імбир подрібнювали у борошно і змішували у різних пропорціях у змішувачі симплекс-центроїдної конструкції. Проводили 13 експериментальних циклів для отримання різних сумішей приправ.

Результати і обговорення. Функціональні властивості насіння ферментованого ріжкового дерева, цибулі та імбиру складали від 5,89-6,72%, 5,27-10,87%, 3,31-4,59%, 2,31-3,03%, 0,64-1,12%, 0,59-63 г/мл для ступеню набухання, розчинності, гелеутворювальної здатності, водопоглинальної здатності, жиропоглинальної здатності та об'ємної щільності відповідно. Показник ступеню набухання і розчинності коливався від 5,89 до 6,72% і від 5,27 до 10,87% відповідно. Зразок 72.25:24.25:3.5 мав найменше значення ступеню набухання, тоді як зразок 75:21:4 – найвище. Інтерактивна дія ферментованого ріжкового дерева і порошку цибулі мала значний ($p < 0,05$) вплив на ступінь набухання і індекс розчинності сумішей ферментованого ріжкового дерева, цибулі та імбирного борошна. Водопоглинальна здатність становила від 2,31 до 3,03%. Зразок 72.25:24.25:3.5 мав найменше значення для здатності поглинання води, тоді як зразок 75:21:4 – найбільше. Інтерактивна дія ферментованого порошку ріжкового дерева і цибулі, а також ферментованого ріжкового дерева і імбиру мала значний ($p<0,05$) вплив на здатність до жиропоглинальну здатність. Яскравість, почервоніння та жовтизна коливалися в діапазоні від 39,49 до 45,07, від 2,01 до 2,71 та від 12,66 до 15,30, при цьому зразок 72:25:3 мав найвищий рівень яскравості та жовтизни, тоді як зразок 75:21:4 - найменший для яскравості та жовтизни, pH коливався в межах 5,51–5,65. Суттєвого ($p> 0,05$) ефекту ферментованого ріжкового дерева, цибулі та імбирного борошна на pH не спостерігалося. Органолептичні показники для всіх параметрів були оцінені як допустимі та помірні.

Висновок. Включення цибулевого та імбирного борошна до борошна із плодів ріжкового дерева суттєво вплинуло на функціональні властивості приправ із борошняних сумішей.

Ключові слова: *приправа, ріжкове дерево, цибуля, імбир.*

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Всі елементи після року видання розділяються **комами**.

Приклади:

1. Yannick Fayolle, Sylvie Gillot, Arnaud Cockx, Laetitia Bensimhon, Michel Roustan, Alain Heduit (2010), In situ characterization of local hydrodynamic parameters in closed-loop aeration tanks, *Chemical Engineering Journal*, 158(2), pp. 207–212.
2. Carlo Tocchi, Ermanno Federici, Laura Fidati, Rodolfo Manzi, Vittorio Vincigurerra, Maurizio Petruccioli (2012), Aerobic treatment of dairy wastewater in an industrial three-reactor plant: Effect of aeration regime on performances and on protozoan and bacterial communities, *Water Research*, 46(10), pp. 3334–3344.

Приклад оформлення статті, оригінал якої українською мовою:

1. Pyroh T.P., Konon A.D., Skochko A.B. (2011), Vykorystannia mikrobnykh poverkhnevo-aktyvnykh rechovyn u biolohii ta medytsyni, *Biotekhnolohiia*, 4(2), pp. 24–38.

За бажання після транслітерованої назви статті або журналу в {фігурних дужках можна дати переклад англійською мовою}.

Посилання на книгу

Автори (рік), *Назва книги (курсивом)*, Видавництво, Місто.

Всі елементи після року видання розділяються комами.

Приклади:

1. Harris L. (1991), *Money theory*, McGraw-Hill Companies, Hardcover
2. Rob Steele (2004), *Understanding and measuring the shelf-life of food*, CRC Press.

Приклад оформлення статті, оригінал якої українською або російською мовою:

1. Kirianova H.A. (2008), Udoskonalennia tekhnolohii termostabilnykh zheleinykh nachynok shliakhom ratsionalnoho vykorystannia hidrokoloidiv roslynnoho ta mikrobnoho pokhodzhennia: PhD tethis, NUHT, Kyiv.
2. Zalutskyi I.R., Tsymbaliuk V.M., Shevchenko C. H. (2009), Planuvannia i diahnostyka diialnosti pidpryiemstva, Novyi svit, Lviv.

За бажання після транслітерованої назви книги в {фігурних дужках можна дати переклад англійською мовою}.

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Приклад посилання на статтю із електронного видання:

1. Barbara Chmielewska (2012), Differentiation of the standard of living of families in countries of the European Union, *Ukrainian Food Journal*, 2(2), pp. 230–241, available at: http://ufj.ho.ua/Archiv/UKRAINIAN%20FOOD%20JOURNAL%202013%20V.2%20Is.2.pdf
2. (2013), *Svitovi naukovometrychni bazy*, available at: http://www1.nas.gov.ua/publications/q_a/Pages/scopus.aspx

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