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CHEMICAL AND TECHNOLOGICAL PROPERTIES OF IMPROVED BISCUIT BY CHESTNUT FLOUR

Nefisa A. Hegazy, Mohie M. Kamil, Ahmed M.S. Hussein* and Gamil F. Bareh
Food Technology Department, National Research Centre, Dokki, Giza, Egypt.

*Corresponding Author: a_said22220@yahoo.com

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ABSTRACT

Improved biscuit was prepared using chestnut flour (CNF) at three levels (10, 20 & 30%) to wheat flour 72% (WF). Technological properties of improved biscuit were evaluated by testing Rheological properties of dough, baking quality, color, sensorial properties and shelf-life of biscuit. Improved biscuit was also evaluated chemically by determining gross chemical composition, antioxidant activity and total phenolic content. The obtained results revealed that, increasing the percentage level of CNF led to increase fat, fiber, ash and minerals contents. Chestnut flour contained an appreciable amount of monounsaturated fatty acids, where palmetic, oleic and eicosenoic acids were 1.2, 45.80 and 5.90% of total fatty acids, respectively. Furthermore, CNF characterized by its higher phenolic content (3778 µg/g) compared to WF (501 µg/g). Also, antioxidant activity of CNF (DPPH = 37.5 µg /g) was higher than WF (DPPH = 4.17 µg /g). Consequently, antioxidant capacity and total phenolic compounds of biscuit significantly increased with increasing CNF. On the other hand, determination baking quality of biscuits showed that, biscuit height and volume were increased as a result of CNF addition, while the diameter and spread ratio were slightly decreased; and the increase of the biscuit specific volume was more pronounced when CNF was added at levels of 10%, 20% and 30%. Also, sensory Evaluation indicated that, increasing CNF levels in biscuit led to decrease in the sensory scores of color and texture but in the same time, taste was increased and odor, appearance, and overall acceptability were not affected significantly.

Key Words: Antioxidant activity, total phenolic compounds, chestnut flour, biscuit, quality characteristics

INTRODUCTION

Chestnut (*Castanea sativa* Mill.) is one widely diffused crop in European and Asiatic countries. The kernel of chestnut is typically consumed whole (raw, boiled, or roasted, without skin) or used as ingredient in a variety of processed foods, especially in bakery and confectionery products. The agricultural and industrial processing of these plant foods results in the production of by-products that are rich sources of bioactive compounds, including polyphenolic compounds with high antioxidant activity (Moure *et al*., 2001).

Chestnut (*Castanea sativa M.*) is an important seasonal nut of the Mediterranean countries with a world production about 1,960,000 t in 2010 (FAO, 2012). These raw materials can be used for making bread, cookies, snacks, pasta, etc. Products made from chestnut characterized with two specific advantages: source of essential fatty acids and free gluten content. (Borges *et al.*, 2007).

Chemical composition of the chestnuts flour showed high level of starch (80%), while protein, lipid, crude fiber and ash were 5.58, 5.39, 2.34 and 2.14 % on dry basis (Demiate *et al*., 2001). Chestnuts have become ever more important in human nutrition because of their nutritional qualities and potential beneficial health effects (Xu, 2005). Several researcher (Pereira-Lorenzo *et al*., 2006;Borges *et al*., 2008; Peña-Méndez *et al*., 2008) stated that chestnuts are rich in carbohydrates and are a good source of essential unsaturated fatty acids, minerals vitamins and fibre. These fruits also have a significant content of polyphenols, with gallic acid and ellagic acid predominant among hydrolysable and condensed tannins (Barreira *et al*., 2008; De Vasconcelos *et al*., 2010; Gonçalves *et al*., 2010). Dietary polyphenols receive considerable interest for their presumed role in the prevention of various degenerative human diseases such as cancers coronary heart disease (CHD), type-2 diabetes, inflammation and cardiovascular diseases (Rice-Evans *et al*., 1997; Scalbert & Williamson, 2000; Scalbert *et al*., 2002). Chestnuts are important sources of polyphenolic and antioxidants that have high free radical scavenging properties being associated to protective effects against coronary heart disease (Engler & Engler, 2006), cancer (Nichenametla *et al*., 2006), neurodegenerative diseases (Lau *et al*., 2005) and osteoporosis (Weaver & Cheong, 2005).

Nowadays, the need to replace synthetic antioxidants used in the pharmaceutical, cosmetic and food industries (i.e. BHT, BHA, TBHQ), whose safety has been questioned, has promoted the research on new sources of antioxidant molecules (Moure *et al*., 2001), so undervalued agricultural or industrial byproducts could be an inexpensive supply of these compounds. Extracts of natural antioxidants from chestnuts skin could potentially be used as nutraceuticals and dietary supplements. So, the aim of this investigation was to study the effect of adding chestnut flour on biscuit quality regarding rheological properties, baking quality, color characteristics, organoleptic properties and shelf- life effect.

MATERIALS AND METHODS

MATERIALS

Wheat flours (72%) were obtained from North Cairo Flour Mills Company, Egypt. Chestnut (*Castanea sativa* Mill.) fruits, sugar, shortening, vanellia and baking powder were obtained from local herbal shop (Dokki, Egypt).

Chestnut flour (CNF) was prepared as follows: Chestnut fruits were exposed to the flame for 5 seconds to remove hair and crust. The fruits pulp were cut to small parts and roasted in oven at 60°C/1 hr, then milled to obtain the flour.

The biscuits were prepared by mixing 100 g wheat flour (72% extraction) and their blends containing 10, 20 and 30% CNF. Biscuit formula was as follows: 100g flour, 50 g sucrose, 28 g shortening, 0.93 g salt, 1.11 g sodium bicarbonate and 1 g vanellia.

Chestnut seed

METHODS

Moisture, ash, fiber, protein and fat of raw materials and different snacks were determined according to AOAC (2000). Total carbohydrates were calculated by difference. Individual elements (Ca, P, K, Na, Fe, and Mn) in all samples were determined according to the method described by Chapman & Pratt (1978).

DETERMINATION OF FATTY ACID

Fatty acids composition was carried out according to the method of (Senter *et al*., 1994). Chromatography analysis carried out using GLC apparatus (DANI 86.10) equipped with flame ionization detector. Fatty acids were separated on a capillary column coated with FFAP-TPA stationary phase (30 cm length; 0.32 mm internal diameter; 0.25 mm film thickness). Temperature programming of column started at 160 °C and reached 220 °C, with 2 °C/min. increase. Temperature of the detector was set at 260 °C. Methyl esters were identified by their retention time and expressed as percentage of total detected methyl esters.

DETERMINATION OF TOTAL PHENOLICS CONTENT

Total phenolic content of biscuit samples were determined using Folin–Ciocalteau colourimetric method as described previously (Inglett *et al.*, 2011 , Waterhouse, 2001 ; Yu & Zhou, 2004). Briefly, ground biscuit samples (200 mg) were extracted with acidified methanol (HCl/methanol/water, 1:80:10 v/v) at room temperature for 2hr. The obtained extracts were oxidized with Folin-Ciocalteu reagent, and the reaction mixture was neutralized with sodium carbonate. The mixture was incubated at room temperature for 90 min, and its absorbance was measured at 725 nm. Acidified methanol was used as the blank. Gallic acid was used as the standard and total phenolic content expressed as mg gallic acid equivalents/g sample dry weight. All analyses were performed in triplicate.

DETERMINATION OF ANTIOXIDANT ACTIVITY

DPPH RADICAL SCAVENGING ACTIVITY ASSAY

Di(phenyl)-(2,4,6-trinitrophenyl) iminoazanium (DPPH) radical scavenging capacities of biscuit samples were determined by the reduction of the reaction color between DPPH solution and sample extracts as previously described by (Huang *et al.*,2005). A final concentration of DPPH solution was 0.15 mM. DPPH solution (3.9 ml) was mixed with sample solution (0.1 ml). The mixture was kept in the dark at ambient temperature. The absorbance of the mixtures was recorded at 515 nm for 30 min. Blank was made from 3.9 ml of DPPH and 0.1 ml methanol and recorded absorbance at t = 0. All the measurements were done in three replicates. The scavenging of DPPH was calculated according to the following equation (Liyana-Pathirana and Shahidi, 2007):

% DPPH scavenging = {(Abs (t=0) - Abs (t=30) / Abs (t=0)} x 100;
Where Abs (t=0) = absorbance of DPPH radical + methanol at t = 0 min;
Abs (t=30) = absorbance of DPPH radical + phenolic extracts at t = 30 min.

ABTS RADICAL CATION DECOLORIZATION ASSAY

The spectrophotometric analysis of $ABTS^-$ radical scavenging activity of biscuit samples were determined according to the method described by Chien *et al.* (2007). The $ABTS^-$ radical cation was produced by the reaction between 7mM $ABTS^-$ in H2O and 2.45mM potassium persulfate, stored in the dark at room temperature for 12 h. Before usage, the $ABTS^-$ solution was diluted to get an absorbance of 0.7±.025 at 734nm with phosphate buffer (0.1M, pH 7.4). Then, 2 ml of $ABTS^-$ solution was added to 1mL of CF-MRPs. the reactive mixture was allowed to stand at room temperature for 6min, and the absorbance was immediately recorded at 734 nm using UVspectrophotometer. A standard curve was obtained by using Trolox standard (0.25-1Mm) in ethanol. The absorbance of the resulting oxidized solution was compared as mM Trolox equivalents (TE).

THERMAL PROPERTIES

Starch gelatinization was studied in a differential scanning calorimeter (Mettler Toledo DSC 823-E, Switzerland) under oxygen free N_2 flow rate at 50 ml/min, using 1:3 (w/v) starch-water mixtures. The samples were hermetically sealed in a pre-weighed aluminum pan at room temperature and re-weighed in a microbalance. After sealing the pan and leaving it to equilibrate for about 1 h, the samples were heated from 30 to 110°C at the rate of 10°C /min. An empty pan was used as a reference. The temperatures of the characteristic transitions, onset temperature (To), peak temperature (Tp) and end temperature (Te) were recorded and the temperature range (Te-To, ΔT) was calculated. The enthalpy (ΔHG) of the transition was expressed as mJ/g on a dry weight basis.

RHEOLOGICAL PROPERTIES

Rheological properties of dough were evaluated using Farinograph according to AACC (2000). The viscoelastic properties of the prepared chestnut (*Castanea sativa* Mill.) flour and wheat flour were examined using a Rapid Visco Analyser-4 (Newport Scientific, Australia) according to AACC (2000).

ORGANOLEPTIC EVALUATION OF BISCUITS

Weight, volume, specific volume, diameter, thickness and spread ratio of biscuits were recorded. Organoleptic characteristics of biscuits were evaluated with some modifications, according to Hussein *et al* (2010) by 15 trained panelists. The tested characteristics were surface color (10), texture (10), flavour (10), taste (10), appearance (10) and overall acceptability (10).

STATISTICAL ANALYSIS

The obtained results were evaluated statistically using analysis of variance as reported by McClave & Benson (1991).

RESULTS AND DISCUSSION

GROSS CHEMICAL COMPOSITION

The gross chemical composition of wheat flour 72% (WF), chestnut flour (CNF) and the biscuits of different chestnut flour levels (10, 20 and 30%) is presented in Table (1). Means and standard deviations were expressed as percentage on the dry weight basis due to the differences in the moisture content that were detected among the samples. The chemical composition of the chestnut flour reveals high levels of fat, fiber and ash compared to wheat flour. Also, Table (1) showed that biscuit contains higher percentage of fat, fiber, ash and carbohydrate in case of increasing the level of chestnut flour. The nutritional composition of the biscuit of different chestnut levels (10-30%) ranged between 7.62-5.16, 32.70-31.75, 4.65—3.81, 2.05-1.80 and 55.44-55.02 % for protein, fat, fiber, ash and total carbohydrate, respectively. It was possible to observe also that the biscuit of 100% wheat flour showed some similarity with blended biscuit with chestnut flour. These results are in agreement with those reported by other authors (De la Montana Miguelez *et al*, 2004; Barreira *et al*., 2009a&b; Borges *et al*., 2007; Borges *et al*., 2008; Vasconcelos *et al*., 2007; Vasconcelos *et al*., 2010; Nazni *et.al.*, 2010, Correia *et al.* 2012; Jozinovic *et al*.2012).

Table 1: Gross chemical composition of raw materials and biscuits of chestnut (dry weight basis)

Samples	Moisture (%)	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	T.C. (%)
Raw materials						
WF	11.12^{a}±0.11	9.80^{a}±0.13	1.13^{b}±0.06	0.51^{b}±0.11	0.45^{b}±0.0	88.11^{a}±0.72
CNF	4.75^{b}±.009	5.58^{b}±0.03	4.39^{a}±0.25	3.09^{a}±0.18	2.44^{a}±0.001	84.5^{b}±0.44
LSD at 0.05	0.216	0.178	0.04	0.037	1.833	0.394
Biscuit of :						
100% WF	7.17^{a}±0.03	8.87^{a}±0.06	31.12^{d}±0.13	3.50^{d}±0.05	1.65^{d}±0.003	54.86^{d}±0.39
10% CNF	6.39^{b}±0.05	7.62^{b}±0.05	31.75^{c}±0.22	3.81^{c}±0.07	1.80^{c}±0.006	55.02^{c}±0.46
20% CNF	5.79^{c}±0.01	6.35^{c}±0.03	32.20^{b}±0.17	4.22^{b}±0.09	1.92^{b}±0.009	55.31^{b}±0.52
30% CNF	5.60^{d}±0.08	5.16^{d}±0.01	32.70^{a}±0.12	4.65^{a}±0.05	2.05^{a}±0.008	55.44^{a}±0.65
LSD at 0.05	0.074	0.019	0.002	0.085	0.074	0.056

WF = wheat flour of 72% extraction. CNF = chestnut flour TC = Total carbohydrate.

MINERALS CONTENT

The contents of six minerals were determined in raw flours (wheat and chestnut) and biscuit samples (Table 2). All of these minerals varied significantly according to flour type and percentage of blending chestnut flour. Chestnut flour and its biscuit product, characterized by higher calcium and potassium compared to wheat flour and its biscuit product. Biscuit of 30% chestnut could be used for cardiac patients for its higher content in potassium and calcium that reached to 130 and 45 mg/100g, respectively; and also contains enough nutrients from iron, magnesium, phosphorus and sodium. These results agree with those reported by many previous studies Ribeiro *et al*., 2007; Neri *et al*., 2010; Peña -Méndez *et al*.,2008; Gonçalves *et al*., 2010 and Stefano *et al*., 2012.

Table 2: Minerals content of raw materials and biscuits (mg/100 gm)

Samples	Calcium	Iron	Magnesium	Phosphorus	Potassium	Sodium
Raw materials						
Wheat flour 72% (WF)	35^{b}±0.11	2.5^{a} ±0.13	110^{a} ±0.06	190.12^{a}±1.11	102.0^{b} ±0.0	630^{a} ±2.72
Chestnut flour (CNF)	50^{a}±0.11	0.94^{b} ±0.03	74^{b}±1.25	124^{b}±2.18	930^{a}±10.00	5.5^{b}±0.11
LSD at 0.05	0.074	0.019	0.002	0.085	0.074	0.056
Biscuits (WF: CNF)						
Control from 100% WF	35^{d}±0.03	2.02^{a}±0.06	110^{a}±0.13	190^{a}±1.05	102^{d}±0.003	630^{a}±2.39
90%WF + 10% CNF	38^{c}±0.05	2.0^{b}±0.05	105^{b}±0.22	180^{b}±0.07	111^{c}±0.006	620^{b}±0.46
80%WF + 20% CNF	42^{b}±0.01	1.90^{c}±0.03	100^{c}±0.17	175^{c}±0.09	120^{b}±0.009	610^{c}±0.52
70%WF + 30% CNF	45^{a}±0.08	1.70^{d}±0.01	95^{d}±0.12	168^{d}±0.05	130^{a}±0.008	600^{d}±0.65
LSD at 0.05	0.074	0.019	0.002	0.085	0.074	0.056

FATTY ACID

The composition of chestnut flour fatty acids was determined and presented in Table 3. Chestnut flour contained 20.43% saturated fatty acids (SFA), 72% unsaturated fatty acids (USFA) consisting of 52.91% monounsaturated fatty acids (MUFA) and 19.09% of polyunsaturated fatty acids (PUFA). The obtained proportion of SFA and USNFA are similar to those reported by Borges *et al* (2007) and Ferreira-Cardoso (2002). Results showed that chestnut flour contained an appreciable amount of monounsaturated fatty acids, where palmetic, oleic and eicosenoic acids amounted to 1.2, 45.80 and 5.90% of total fatty acids, respectively. It is worthy to mention that monounsaturated fat consumption has been associated with decreased low-density lipoprotein (LDL) cholesterol, and possibly increased high-density lipoprotein (HDL) cholesterol (Wikipedia, 2014).

Table 3: Fatty acids composition of chestnuts flour

<table>
<tr><th>Type</th><th colspan="7">Saturated fatty acids (%)</th></tr>
<tr><td>Common name</td><td>Myristic</td><td>Pentadecanoic</td><td>Palmitic</td><td>Stearic</td><td>Arachidic</td><td>Behenic</td><td>Lignoceric</td></tr>
<tr><td>Molecular name</td><td>C14:0</td><td>C15:0</td><td>C16:0</td><td>C18:0</td><td>C20:0</td><td>C22:0</td><td>C24:0</td></tr>
<tr><td>(%)</td><td>0.22</td><td>1.17</td><td>14.7</td><td>0.24</td><td>1.42</td><td>0.52</td><td>2.16</td></tr>
<tr><td colspan="8">Total saturated fatty acids</td></tr>
<tr><td>(%)</td><td colspan="7">20.43</td></tr>
<tr><td rowspan="2">Type</td><td colspan="7">Unsaturated fatty acids (%)</td></tr>
<tr><td colspan="4">Monounsaturated fatty acids</td><td colspan="3">Polyunsaturated fatty acids</td></tr>
<tr><td>Common name</td><td>Palmetic</td><td>Oleic</td><td colspan="2">Eicosenoic</td><td>Linoleic</td><td colspan="2">Linolenic</td></tr>
<tr><td>Molecular name</td><td>C16:1</td><td>C18:1</td><td colspan="2">C20:1</td><td>C18:2</td><td colspan="2">C18:3</td></tr>
<tr><td>(%)</td><td>1.21</td><td>45.80</td><td colspan="2">5.90</td><td>17.98</td><td colspan="2">1.11</td></tr>
<tr><td></td><td colspan="4">Total mono unsaturated fatty acids</td><td colspan="3">Total polyunsaturated fatty acids</td></tr>
<tr><td>(%)</td><td colspan="4">52.91</td><td colspan="3">19.09</td></tr>
</table>

TOTAL PHENOLIC CONTENT AND ANTIOXIDANT ACTIVITY

Total phenolic contents of wheat flour (WF), chest nut flour (CNF) and their mixture were determined. The antioxidant activity of all samples was tested for their general antioxidant capacity based on their ability to scavenging DPPH and ABTS free radicals. Table 4 showed that CNF characterized by its higher phenolic content (3778 µg/g) compared to WF (501 µg/g). Also, antioxidant activity of CNF (DPPH = 37.5 µg /g) was higher than WF (DPPH = 4.17 µg /g). Consequently, increasing incorporation levels of CNF with WF associated with increasing in the phenolics content and antioxidant activity. This finding showed that bioactive compounds of CNF might be potential resources for the development of high antioxidant biscuit product. Whereas, Table 4 showed that even there was some loss in the phenolic content and antioxidant activity during processing of biscuit there was an increase in phenolic content and antioxidant activity in biscuits by the incorporation of CNF. Thus, the incorporation of CNF into biscuits increases health benefits by increasing antioxidant properties as reported by Ajila *et al.* (2010), Ribeiro *et al. (2008);* Moreira et al. (2011) and Jozinovic et al (2012).

Table 4: Total phenolic contents and antioxidant activity of mixtures of wheat flour with chestnut flour before and after biscuit process

Samples	**Total phenols* (µg/g)**	**Antioxidant activity**	
		DPPH scavenging capacity (µmole/g)	**ABTS scavenging capacity (µmole/g)**
Raw materials			
WF	501 ± 25.5	4.17 ± 0.17	8.3 ± 0.31
CNF	3778 ± 0.154	37.50 ± 0.96	72.35 ± 0. 65
WF: CNF (90:10)	827± 0.27	7.75 ±0.078	15.42 ± 0.022
WF: CNF (80:20)	1213 ± 0.36	10.84 ± 0.007	21.13 ± 0.040
WF: CNF (70:30)	1503 ± 0.04	13.81 ± 0.072	28.19 ± 0.032
Biscuit			
Control (100% WF)	490 ± 0.21	3.74 ± 0.059	7.35 ± 0.013
WF: CNF (90:10)	801 ± 0.29	6.78 ± 0.070	14.22 ± 0.027
WF: CN (F 80:20	1190 ± 0.25	9.25 ± 0.000	20.17 ± 0.028
WF: CNF (70:30)	1480 ± 0.11	12.21± 0.017	27.11 ± 0.004

* Total phenolic as gallic acid equivalent (µg/g).

THERMAL PROPERTIES OF WF AND CNF

Thermal properties of WF and CNF (gelatinization properties) are presented in Table 5. Where, thermal properties of starch granules (WF or CNF) when heated in excess of water undergo significant structural and morphological changes including starch swelling due to water absorption, loss of crystallinity due to the amylopectin double helix dissociation and amylose leaching to the water phase. These set of changes are generally refereed as starch gelatinization, and occur in a temperature range dependent on the starch botanical origin (Charles, 2004; Liu, 2005). Onset (T0) and peak (Tp) Temperatures of WF were 58.79 and 62.66°C, while it was slightly decreased to 57.1 and 61.9°C in CNF, respectively. Also, there were slight differences between conclusion of WF (67.02°C) and CNF (67.9°C). Such findings were agreed with Correia *et al*., (2012); Yang *et al*., (2010); Yoo *et al*. (2012) and Zhang *et al*.(2011).

Table 5: Thermal properties of WF and CNF

Flours	**T0**	**Tp**	**Tc**	**ΔT(°C)**	**Δ*H* gel**
WF	58.79	62.66	67.02	8.23	1
CNF	57.1	61.9	67.9	10.0	9.6

To: onset temperature, Tp: peak temperature, Te: end temperature, ΔT: Te-To and ΔHG: The enthalpy of the transition

RHEOLOGICAL PROPERTIES OF DOUGH

Table (6) shows the effect of adding CNF at three levels (10, 20, and 30%) to WF on the rheological properties of dough as evaluated by a farinograph. The water absorption was found to be 56.5% in WF, while it increased in mixture of WF and CNF with an increase in replacement rate, which may be due to the higher fiber and starch contents contributed from CNF (Stefano *et al*., 2012). Similar results were reported by (Hussein *et al*., 2010), who reported that water absorption increased as Doum Fruit flour level increased in blends, which might be due to the high fiber content of Doum Fruit flour. Fiber is characterized by its high water holding capacity as reported by Holloway & Grieg (1984). The same trend was also observed in the arrival time and dough development time. General incorporation of high fiber materials in dough altered dough development, consequently dough development time increased as CNF level increased. Similar findings were reported by Hussein *et al*. (2010). Dough stability decreased from 9 to 5 minutes as CNF level increased, while weakening increased from 90 to 130 BU and mixing tolerance index increased from 40 to 65 BU which is due to dilution of gluten protein from wheat flour with the increase fiber content from CNF. This may also be due to the interaction between fibrous materials and gluten, which affects the dough mixing properties as reported by Peymanpour *et al*. (2012).

Table 6: Farinograph parameters of dough prepared from different formulas.

Samples	Water absorption (%)	Arrival time (min)	Dough development time (min)	Stability time (min)	Weakening (BU)	Mixing tolerance index (BU)
WF (72%)	56.5	1.5	2.5	9.0	90	40
90%WF+10% CNF	60	2.0	3.0	7.5	110	50
80%WF+20% CNF	65	2.5	4.0	6.0	120	60
70%WF+30% CNF	69	3.0	4.5	5.0	130	65

RAPID VISCO-ANALYZER (RVA) CHARACTERISTICS OF WF AND CNF DOUGH

Rapid Visco-Analyzer peaks of WF and their blends with CNF at several levels (10, 20 and 30%) and their pasting properties are summarized in Table 7. The obtained data showed that, by adding CNF to WF led to decreased Peak Viscosity, Trough (cP), Breakdown (cP), Setback (cP), Final viscosity (cP), and Peak Time (min) while Pasting Temperature (˚C) increased. The peak viscosity indicates the water holding capacity of starch and refers to the maximum viscosity reached during the heating and holding cycle. It can be affected by the molecular structure of amylopectin (Shibanuma *et al.*, 1996), starch, water concentration, lipids, residual proteins (Whistler *et al.*, 1997), granule size (Fortuna *et al.*, 2000) , and instrument operating conditions (Batey et al., 2000). Pasting properties of starch are affected by amylose and lipid contents and by branch chain-length distribution of amylopectin. Amylopectin contributes to swelling of starch granules and pasting, whereas amylose and lipids inhibit the swelling (Tester & Morrison, 1990, Durgadevi and Nazni, 2012). Furthermore, the amylopectin chain-length and amylose molecular size produce synergistic effects on the viscosity of starch pastes (Jane *et.al.,*, 1992).

Table 7: Pasting profile of WF and their blends with flours CNF

Samples	Peak 1	Trough	Breakdown	Final Visc.	Setback	Peak Time	Pasting
Control (100% WF)	2651	1568	1083	3128	1554	6.20	68.65
90%WF+10% CNF	2036	1173	863	2436	1263	6.13	86.30
80%WF+20% CNF	1576	897	679	1917	1020	5.93	86.30
70%WF+30% CNF	1386	763	623	1665	902	5.80	86.35

COLOR ATTRIBUTES OF RAW MATERIALS AND BISCUITS

Color is one of the most important sensory attribute that affect directly the consumer preference of any product. Special attention should be given to bakery products to attract the consumer attention. The color parameters (L*, a* & b*) of raw materials and biscuit samples were evaluated and presented in Table 8. Scale range of whiteness (L*) is from 0 black to 100 white; a* scale extends from a negative value (green hue) to a positive value (red hue) and b* scale from negative blue to positive yellow. Chestnut flour (CNF) was darker than WF and mixture from WF and CNF, where lightness (L^*) decreased but redness (a^*) and yellowness (b^*) increased as rate of CNF used in mixture increased. All formulas caused a noticeable darker color for the crust of biscuits (L* and b* values were decreased) and the redness (a values) of crust were increased as a result of CNF addition compared to control sample (100% WF). Saturation and hue values increased when chestnut flour was added.

Table 8: Hunter color values of raw materials and surface of biscuits from WF and CNF

Samples	L*	a*	b*	a/b	Δ E	Hue	Saturation
Raw materials							
WF 72%	92.33 ± 0.8	0.45 ± 0.2	9.53 ± 0.1	0.047 ± 0.2	92.82 ± 0.2	24.23 ± 0.1	9.54 ± 0.3
CNF	78.83 ± 0.7	2.56 ± 0.0	11.27 ± 0.4	0.23 ± 0.6	79.67 ± 0.9	68.66 ± 0.5	11.56 ± 0.2
Biscuits from WF and CNF							
Control (100% WF)	67.60 ± 0.3	9.02 ± 0.1	23.94 ± 0.5	0.38 ± 0.3	72.28 ± 0.7	83.67 ± 0.3	25.58 ± 0.1
90%WF+10% CNF	59.88 ± 0.2	9.99 ± 0.3	23.02 ± 0.2	0.43 ± 0.5	64.93 ± 0.5	84.28 ± 0.2	25.09 ± 0.5
80%WF+20% CNF	54.81 ± 0.1	10.95 ± 0.2	21.01 ± 0.3	0.52 ± 0.2	59.71 ± 0.3	84.78 ± 0.7	23.69 ± 0.4
70%WF+30% CNF	46.93 ± 0.2	11.85 ± 0.1	18.74 ± 0.6	0.63 ± 0.1	51.90 ± 0.4	85.18 ± 0.1	22.17 ± 0.2

BAKING QUALITY OF BISCUITS

Table 9 shows baking quality of biscuits as affected by CNF addition. Biscuit height and volume were increased as a result of CNF addition, while the diameter and spread ratio slightly decreased. The increase of the biscuit specific volume was more pronounced when CNF was added at levels of 10%, 20% and 30%; consequently increasing the level of CNF in biscuit decreased its baking quality. Also, this result agreed with El-Shebini *et al*. (2013) who stated that the addition of doum fruit flour to wheat flour led to increase the volume of biscuit.

Table 9: Effect of adding CNF to WF on baking quality of biscuits

Samples	Diameter (cm)	Height (cm)	Spread ratio (diam./ht.)	Weight (g)	Volume (cc)	Specific volume (cc/g)
Control (100% WF)	6.2±0.09	1.10± 0.11	5.64±0.05	25.29±0.09	49.86±0.19	1.97±0.1
90%WF+10% CNF	5.8± 0.11	1.20± 0.09	4.83±0.03	25.76±0.07	51.70±0.17	2.01±0.2
80%WF+20% CNF	5.5± 0.19	1.30± 0.06	4.23±0.01	26.16±0.03	52.16±0.13	1.99±0.3
70%WF+30% CNF	5.2± 0.12	1.35± 0.07	3.85±0.02	26.80±0.04	53.75±0.11	2.01±0.1

SENSORY EVALUATION

The effects of adding CNF to WF on the sensory properties of biscuits were evaluated and presented in Table 10. The obtained results indicated that, increasing CNF levels in biscuit led to decrease the sensory scores of color and texture but in the same time, taste was increased and odor, appearance, and overall acceptability not affected significantly.

Table 10: Effect of adding CNF to WF on sensory properties of biscuits

Samples	Color (10)	Texture (10)	Odor (10)	Taste (10)	Appearance (10)	Overall acceptability (10)
Control	8.5^{a}±0.85	8.8^{a}±1.28	8.5 ±0.92	8.2^{b} ± 1.03	8.6±0.89	8.5±0.89
90%WF + 10% CNF	8.1 ^{ab} ±0.37	7.9^{ab}±0.87	8.7 ±0.57	8.5^{b} ± 1.75	8.8±0.52	8.4 ±0.67
80%WF + 20% CNF	7.7^{b}±0.79	7.5^{ab}±1.85	9.2±0.63	8.9^{ab} ±1.01	9.0±0.47	8.5 ±0.71
70%WF + 30% CNF	7.4 ^{b} ±1.38	7.1^{b}±1.97	9.5±0.74	9.6^{a} ± 0.88	9.3±0.99	8.6 ±0.57
LSD at 0.05	0.97	1.03	NS	1.11	NS	NS

CONCLUSION

From the obtained results, it could be concluded that chestnut flour could be used with wheat flour to prepare biscuit characterized with its good sensorial properties, higher nutritive value and healthy (a good source of essential unsaturated fatty acids, fiber, minerals, polyphenolic compounds and antioxidants).

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