Nutritional Value and Quality Characteristics of Cookies Prepared from Partial or Complete Substitution of Wheat Flour

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Abstract: Effects of wheat flour substitution using buckwheat flour of levels vary from 0 to 100% (in the purpose of antioxidant enrichment and to create a new developed product with a different nutritional and aromatic profile) on dough physical properties and dynamic rheology, cookie physical properties, nutritional value and aromatic compounds profile were studied. Dough with the buckwheat incorporated flour showed lower hardness and higher stickiness. Dynamic rheology properties of buckwheat substituted cookie dough, determined as a profile of G', G'' and δ were different compared to those of control samples. Moisture contents and water activity of buckwheat cookie samples were higher compared to control cookies. Spread ratios of control cookies were lower (4.63), than that of the buckwheat cookie samples,60% substitution level showed the highest value (5.4),and control samples still lower than that of the 100% buckwheat cookie sample (5.1). Buckwheat cookies were darker than wheat cookies. Antioxidant properties of buckwheat cookies when measured by both TPC and DPPH were higher than antioxidant properties of wheat cookies. Buckwheat cookies had a different aromatic compounds profile with a good overall acceptability.

Keywords: Wheat Substitution, Cookies, Anti-Oxidant, Aromatic profile, Dynamic Rheology and Buckwheat.

INTRODUCTION

Egypt have always faced problems with the sufficiency of wheat flour for the bread making and other uses, that is why many researchers have made trials to increase the production of wheat flour or even other cereal or non-cereal sources to substitute wheat flour to solve the problem (Watzke, 1998; Ammar *et al.,* 2009).

Antioxidant enriched foods are getting higher importance as it is nutritionally more healthy and different in taste (Abdel-Samie *et al.,* 2010). Antioxidant compounds are therapeutic agents against diseases involving radical damage; It inhibits lipid peroxidation in food products which could also improve food quality and safety (Dietrych-Szostak and Oleszek, 1999). A diet rich in fruits, vegetables and minimally refined cereals "which are considered as a main Antioxidant sources" is associated with lower incidence of illnesses such as coronary heart disease, some forms of cancer and neurodegenerative ailments (Stangeland *et al.,* 2009).

Buckwheat (*Fagopyrium esculentum Moench*) belongs to the Polygonaceae family. It is considered as a valuable additive for functional food products, successfully replaces rice or potatoes in the main menus of many countries (Dietrych-Szostak and Oleszek, 1999). Buckwheat leaves and young parts of the plant are consumed in some countries as a vegetable. Green flour, obtained by milling of the dried plants, is used as a natural food colorant (Kalinova *et al.,* 2006). Antioxidant activities of buckwheat extracts were shown to be high even comparing to those of synthetic antioxidants (Sun and Ho, 2005). Compared to oats and barley regarding its antioxidant it was found that buckwheat had higher antioxidant activity. Buckwheat seeds and leaves were proved to be suitable food component with antioxidant effect (Holasova *et al.,* 2002). The dietary and health value of phenolics, especially rutin, in buckwheat seeds and flour were shown to be high, while the high rutin yield in the leaves could effectively explain the therapeutic effects of leaf/herb extracts (Quettier-Deleu, *et al.,* 2000).

Six flavonoids have been isolated and identified in buckwheat grain (rutin, orientin, vitexin, quercetin, isovitexin, and isoorientin) (Dietrych-Szostak and Oleszek, 1999). Phenolic compounds in buckwheat contained catechin and epicatechin compounds (Watanabe and Ayugase, 2009). Vitamin E and squalene were also detected in buckwheat seeds and leaves extracts (Kalinova, *et al.,* 2006). From the water-soluble extracts of buckwheat, Guo, *et al.,* (2007) isolated a novel antitumor (against human mammary cancer protein, coded as TBWSP31. Nephrectomized rats given buckwheat extract showed improvement in renal function, as indicated by decreased serum level of creatinine, with a significant decrease in the level of methyl guanidine, a uremic toxin produced from creatinine in the presence of hydroxyl radical (Yokozawa, *et al.,* 2002). Buckwheat concentrate was found to be an effective source of D-CI "a chemically synthesized anti-hyperglycemic compound, and a component of an insulin mediator" for lowering serum glucose concentrations in rats and therefore may be useful in the treatment of diabetes (Kawa, *et al.,* 2003).

Buckwheat was used to substitute 15% of wheat flour to make buckwheat enhanced breads and it was moderately acceptable by panelists (Lin, *et al.,* 2009).

The aims of our research were to prepare better cookies with higher nutritional value and different flavor, through using buckwheat flour. It was also aimed to investigate the impact of wheat flour substitution using buckwheat flour on cookies nutritional, physical and sensory characteristics.

MATERIALS AND METHODS

Materials:

Wheat flour "11.2% protein low-gluten" was purchased from local market of zagazig city, Egypt.

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Buckwheat flour “10.69% protein” was obtained from Tian Xiang Ye Tian, Xiangyetian Food Co., LTD, Chifeng City, Inner Mongolia Province, China. Sugar, shortening, salt and baking soda were obtained from the local markets of Zagazig city, Egypt.

Chemicals:

Chemicals were of analytical grade and were purchased from El-Gumhorya Company except reagents including Diphenyl-picrylhydrazyl (DPPH), Folin-Ciocalteu (2N) were purchased from Sigma-Aldrich (Germany).

Methods:

Moisture:

contents of flour and cookie samples were determined according to the AACC 44-15A method (AACC, 2002) using the one stage method because moisture contents of prepared cookies did not exceed 13%.

Preparation of cookies:

Cookies were prepared according to the **AACC 10-50 D** method (1999),With minor modification as we did not add dextrose solution “a browning aid reagent” because buckwheat is darker than wheat flour. Wheat flour of the base formula was substituted for buckwheat flour according to the flour blends substituting systems shown in Table.1.

Table (1): Wheat and buckwheat flours blends used to prepare buckwheat cookies

Sample number	Wheat flour %	Buckwheat flour %
Control	100	0
BW^{*}_{10}	90	10
BW_{20}	80	20
BW_{30}	70	30
BW_{40}	60	40
BW_{50}	50	50
BW_{60}	40	60
BW_{70}	30	70
BW_{80}	20	80
BW_{90}	10	90
BW_{100}	0	100

*Buckwheat

Dough characteristics:

Dough hardness and stickiness of base formulated dough and buckwheat cookie dough were measured using Texture Analyzer TAXT2I (Stable Micro Systems Ltd., Surrey, UK). Force in compression mode was used under the following test conditions, 5 kg load cell, cylindrical probe (25 mm diameter), 2.0 mm/s pre-test speeds, with a 1.0 mm/s test speed and 10 mm/s post-test speed. Dough pieces of 7 mm thickness were precisely centered on the texture analyzer stage and compressed by the probe which contacted the dough to a 5mm distance. A positive peak value was taken as a measure for dough hardness, while the negative peak value indicated dough stickiness (Pareyt, *et al.,* 2008).

Dynamic rheology properties of cookie dough samples prepared using different wheat and buckwheat blends were tested using a controlled stress direct strain and controlled rate Rheometer (TA, AR-G2 Rheometer. New Castle, DE, USA). Oscillatory dynamic rheological measurement was performed, with a frequency sweep test at 40 °C with two serrated plates of a 40 mm diameter to prevent slippage during testing (plate to plate Geometry). Also, the edges of cookie dough samples were covered by the machine’s cover to prevent the samples dehydration through moisture loss. G’, G’’, and tan (δ) were measured over a frequency range of 0.01–20 Hz at a 1.5% strain.

Quality attributes of cookie:

Color was analyzed for the values “L*, a* and b*” using a Hunter lab (Ultra Scan Pro, INC, Made in Japan). L* value representing lightness (brightness), a* value redness to greenness (where +a* indicates redness while -a* indicates greenness) and b* value yellowness to blueness (+b* is yellowness while -b* is blueness). Chroma meter was calibrated between every two samples using a white-colored calibration plate with a serial number “USP1166” and color values (L*=57.36, a*= -21.38, b*=11.36).

Physical properties of different cookie samples (base formula, buckwheat substituted cookies) including thickness, diameter and spread ratios were measured according to the **AACC 10-50D** method (AACC, 2002). After 30 min of removing the cookies from the oven, six cookies were laid edge-to-edge and measured for diameter using a scale, cookies were rotated 90° and re-measured for diameter again, and average of two measurements was taken and divided by 6 to get the diameter of the single cookie sample. Same number of cookies (6) was put on top of another and was measured using a caliper, then rearranged again and re-measured for thickness and average of the two values were taken and divided by 6 to get the thickness of a single cookie sample. Spread ratio was the ratio of diameter divided by thickness. Cookie moisture content was determined according to the AACC 44-15A (AACC, 2002).

Texture properties, determined as Breaking Forces of cookie samples (base formula, buckwheat substituted cookies), were evaluated according to our previous study (Abdel-Samie, *et al.* 2010) with a minor modification following to the recommendations of the equipment’s guide. Three-point bend test was carried out using a Texture Analyzer (TATX2) Stable Microsystem, Surrey, Mono Research, to evaluate the peak breaking force (kg) of cookies using the “force-in-compression system” and a return to start cycle. A knife edge probe with a two beams stage with a 5 mm distance between the two beams was used. Pre-test speed was 1mm/s, test speed was 3 mm/s post-test speed was 10 mm/s and a distance of 5 mm. trigger force was 20g. Cookie hardness was also determined using the same equipment but with a cylinder probe of 25 mm diameter, pre-test speed was 2.5 mm/s, test-speed was 2 mm/s and post-speed was 10 mm/s with a 5 mm distance and a 20 g trigger force.

Antioxidant Capacity of Prepared Cookies:

Extraction: The cookie samples were finely grinded in a laboratory blade mill to pass through a 1.0

mm screen. One gram of cookie powder was defatted using 100ml n-hexane in a soxhelt apparatus to allow refluxing for two hours to remove fats from the cookie samples powder. Defatted powder was then extracted using 50mL of 80% methanol at room temperature for 1h with continuous stirring using an orbital shaker. Extracts were filtered and stored at -20ºC until further analysis for antioxidant determination (Chan, *et al.,* 2008).

Total phenolic contents (TPC) of the extracts of cookie samples were determined using the Folin-Ciocalteu method as described by (Emmons *et al.,* 1999). Four milliliters of distilled water were mixed with 500 µL saturated sodium carbonate, 250 µL of sample extract and 250 µL of Folin-Ciocalteu reagent diluted with water (1:1 v:v). The mixture was allowed to stand at room temperature for 25 min, centrifuged for 10 min at 5,000 xg at room temperature, and the absorbance at 725 nm was determined. Results were expressed as mg Gallic acid equivalents (GAE) per 100 gram of sample (mg GAE/100g)

Antioxidant Activity by Free-Radical-Scavenging Activity

DPPH (1,1-diphenyl-2-picrylhydrazyl radical) was used to determine the scavenging activity of the extracts of cookie samples (control and buckwheat cookies) as described by (Tepe, *et al.,* 2005), with slight modifications. A 2-mL aliquot of extract was added to 2mL of DPPH solution (200 µM in methanol). The mixture was shaken vigorously and incubated at room temperature in the dark for 30 min. The absorbance of the mixture was determined at 517 nm using a spectrophotometer (model 721E, Shanghai Spectrum Instrument Co. Ltd., China). The antioxidant activity was calculated according the following formula:

$$AO\% = \frac{A_{DPPH} - A_{sample}}{A_{DPPH}} \times 100$$

Where AO is the antioxidant activity, A_{DPPH} is the absorption of the DPPH solution, and A_{sample} is the absorption of the extract.

Aromatic compounds:

Aromatic compounds profile of all prepared cookies using; wheat, wheat buckwheat blends and buckwheat cookie samples were analyzed using SPME-GC by determining the volatile compounds of crashed cookie samples. Cookie samples were cut into small pieces. Five grams of cookie sample pieces were precisely weighted and were put in 15mL sample bottles occupying 3/5 of the bottle. Samples were reconditioned in a thermostatic water bath at 60℃ with the maturing extraction head covering the bottle for 40min headspace extraction. SPME fibers were made back to the needle by using the handle and extract the needle to inject the sample. Volatile compounds were analyzed. Chromatograph condition were DB-WA X122-7032 AOYJ (30m×0.25mm，0.25µm); flow of carrier gas was a certain flow of 0.8ml/min；heating procedure was to start heating on a temperature of 40℃, keep on 40℃ temperature for 3.5min, heat to 90℃ at the rate of 5℃/min, then heat to 220℃ at the rate of 12℃/min and keep temperature on 220℃ for 7min. Mass spectra condition were as the following: lionization way EI, the temperature of sample injecting hole 250℃, electron energy 70eV, emission current 200µA, collecting way is full scan, mass range of collecting is 33～495amu.

Sensory-evaluation test was carried out by 25 panelists, who were asked to evaluate the prepared cookies for color, texture, flavor, aroma and over-all acceptability on a nine-point hedonic scale, according to the following scoring system: 1- dislike extremely; 5- neither like nor dislike; and 9- like extremely. Sensory evaluation of cookies provides a practical and rapid test of quality in the absence of direct methods to measure taste and aroma. The results obtained from the sensory-evaluation test enable the evaluation of food and help to judge consumer acceptance without following detailed chemical or microbiological methods.

Statistical analysis:

SPSS (version 17.0) software was used to perform the statistical analysis. One way ANOVA (analysis of variance) was performed and significant differences was considered at the level of $p \leq 0.05$. Duncan's multiple-range test was used to differentiate between the mean values. Standard deviation was also calculated and presented after the mean values.

RESULTS AND DISCUSSIONS

Dough hardness and stickiness:

Fig.1. presents cookie dough hardness of control sample (100% wheat flour) and samples with the substitution of wheat flour using buckwheat flour at different substitution levels (0-100%) expressed as Kg forces. Dough hardness of samples prepared with the substitution of wheat flour using buckwheat flour was lower than that of control dough sample. Gradual dilution of wheat flour gluten with the gradual increase of buckwheat substitution percentages caused a weakness of the gluten network and gave the cookie dough lower hardness. Maximum dough hardness was displayed by control cookie dough sample with a hardness score of 3.1Kg, while minimum cookie dough hardness was scored when a 60% of wheat flour was substituted using buckwheat flour. Substitution of more than 60% of wheat flour using buckwheat flour increased the dough hardness again. The lower water absorption due to the absence of gluten in the buckwheat flour could be one of the main reasons of this phenomenon. Relative increase of the cookie dough hardness after substituting a 50% of wheat flour using buckwheat flour is referred to the higher starch contents in the buckwheat flour comparing to the wheat flour, buckwheat flour contain 65-75% of starch, mixed starch allowed dough hardness to increase because of the build-up structure of the starch.

Dough stickiness followed the same tendency of dough hardness changes as could be merged from Fig.1 which presented the dough stickiness (Kg) of cookie dough samples. All cookie dough samples stickiness were significantly ($P \leq 0.05$) lower than control cookie dough sample. Control dough stickiness was 0.91 Kg while the stickiness of 50% buckwheat substituted dough sample was 50% lower stickiness comparing to control dough sample with a stickiness score of 0.45 Kg. Stickiness of the 100% buckwheat cookie dough sample was 0.66 Kg.

Lower hardness and stickiness of buckwheat substituted cookie dough were due to the lower gluten and lower gliadins contents in the buckwheat flour comparing to wheat flour (Guo *et al.,* 2007), which caused a decrease in elasticity of the dough which caused a decrease of the dough hardness, while the decrease of gliadins was the reason of the decrease of adhesiveness which caused a decrease in stickiness of cookie dough samples with the substitution of wheat flour using buckwheat flour.

Dynamic rheological properties of cookie dough samples:

Dough dynamic rheological properties i.e. G', G" and δ showed significant variation within cookie dough prepared using different flour blends (wheat flour alone, wheat and buckwheat flour blends or buckwheat flour alone) when subjected to a frequency sweep test ranging from 0.1-20 Hz at 1.5 strain and at a fixed temperature 40°C (Fig.2. A-C). The storage dynamic modulus G' presents the energy stored in the raw materials and recovered from it per cycle and represents the elastic nature of the raw material, G" presents the loss modulus and presents the energy lost from the materials per cycle and it represents the viscous nature of the raw materials (Singh *et al.,* 2003).

Data of storage modulus showed gradual increase in G' in all prepared cookie dough samples with the increase of frequency during the dynamic rheology test protocol. Furthermore, substitution of wheat flour using buckwheat flour within all substitution levels gradually increased the increasing rate of G' as could be seen in fig. 2.A. G' start point also increased with the substitution of wheat flour using buckwheat flour Maximal G' was obtained within samples of 100% buckwheat flour cookie dough samples which scored 9350 and after passing the dynamic rheology test protocol, G' scored maximal value (17270), while control cookie dough samples scored minimal G' before passing the protocol with a score of (6309) and also scored the minimal score of G' after passing the test protocol (16720).

Same trends of change of G' were observed within the G'' results "Fig. 2.B." with a minimal scores for the control cookie dough samples before and after passing the dynamic rheology test protocol with a scores of "4386 and 15356" respectively, while 100% buckwheat flour cookie dough samples scored maximum G'' values before and after passing the dynamic rheology test protocol with scores "5930 and 14630" respectively.

G' and G'' changes were because of the different properties and natures and characteristics between buckwheat and wheat flours, especially differences in the protein quality and fibers, wheat flour contains more gluten compared to the buckwheat flour which could be considered as gluten-free flour, which significantly affected the dynamic rheological properties of different cookie dough samples with different substitution levels.

δ is a ratio relate G' to G'', and because both modulus had the same trends of change which increased with the increase of frequency through the frequency sweep test, δ did not show big changes within the same sample, but cookie dough samples prepared using wheat flout showed lower δ compared to buckwheat flour cookie dough samples "Fig. 2.C".

Spread ratios of cookie

Table 2 presents the spread ratio of cookie samples prepared using the base formula (control sample without any wheat flour substitution) and the buckwheat flour substituted cookies of different substitution levels (10-100%). Spread ratios of cookie samples depended on gluten contents of flour; high gluten content in the flour absorb water to build a gluten network which retain components and build a structure leading to less spread ratio; on the other hand, substitution of wheat flour with a gluten free flour "buckwheat flour" results in an increase of spread ratios of the prepared cookies. Spread ratio of control cookie sample was 4.63 and that was lower than all other prepared cookies. Maximal spread ratio was (5.38) obtained by the 60% wheat flour substituted using buckwheat flour. Gradual decrease of wheat flour with the gradual increase of buckwheat flour caused a weak structure of cookie samples and that caused a more spread ratios comparing to the control cookie samples. This finding is confirmed by the study of (Pareyt *et al.,* 2008) who found that cookie prepared with lower gluten formula gave the highest spread ratios.

Water activity of cookies:

Water activity of cookie samples prepared without and with the wheat flour substitution using buckwheat flour is shown in Fig.3.a. Results showed that increase of substitution level by buckwheat flour increased the water activity of cookie powder. Control cookie samples had a water activity of 0.49 which was the minimal score, while water activity of buckwheat substituted cookie samples were higher than control sample, with a maximal water activity obtained in the maximum buckwheat substitution level (100%) with a water activity of 0.56%. Higher water activity in the buckwheat added cookie samples is duo to the higher fiber contents in buckwheat flour (Lin, *et al.,* 2009) cause the retention of more water in the cookies.

Moisture content of cookies

Moisture contents of prepared cookie samples of base formula (control sample) and also with the buckwheat substitution of different levels (10-100%) are presented in Fig.3.b. Moisture of control cookies was 7.4% which was the minimal score comparing to other cookie samples prepared using buckwheat flour. Gradual increase of buckwheat substitution level resulted in a significant increase of moisture contents, with a maximal score obtained in the 100% buckwheat cookie samples (8.9%) which was 20% higher than control cookie sample. Higher moisture content is due to the higher fiber contents of buckwheat flour. These results are in agreement with these obtained by (Lin, et al., 2009) who reported a higher moisture contents of buckwheat bread compared to wheat bread.

Breaking forces of prepared cookies

Breaking forces of cookie samples prepared using all formulas, wheat flour, wheat buckwheat flour blends of different substitution percentages, and buckwheat flour cookies determined using the texture analyzer (TATX2) Stable Microsystem, Surrey, Mono Research are presented in Table.2. Gradual decrease of wheat flour in the cookie formula decreased the cookie breaking force from 8455g in the control cookie samples to reach the minimal value in the 60% wheat flour substituted using buckwheat flour with a breaking force of 5040g, which is 40% less than the control treatment, without significant differences with the 50% and 70% of wheat flour substitution. Less breaking force of the 50, 60 and 70% wheat flour substituted cookie samples is due to the lower gluten contents of buckwheat flour comparing to the gluten contents of wheat flour (Kreft, Fabjan et al. 2006). Higher substitution levels of buckwheat flour increased cookies breaking force again to reach 7466g. Relative increase of the cookies breaking forces is referred to the higher starch contents in the buckwheat flour comparing to the wheat flour. Buckwheat flour contains 65-75% of starch (Choi and Ma 2007). Gelatinized starch after cookies baking allowed breaking force to increase because of the build-up structure of the gelatinized starch. Breaking force of the 100% buckwheat cookie samples was 7466g which is 12% less than breaking force of the control sample.

Cookie color

Color values of prepared cookies are shown in Table.2. Color was analyzed as three values, L*, a* and b*. Table.2. shows a gradual decrease of L* values with the gradual increase in substitution level of wheat flour by buckwheat flour. Lightness of control cookie samples was 61.65 while substitution of 100% of wheat flour using buckwheat flour decreased L* value by 16% compared to the control sample cookies with a score of 51.56. It could be noticed that, substituting up to 50% wheat flour using buckwheat flour did not change L* value significantly ($P \leq 0.05$), but substituting more than 60% gave a significant differences of L* values. Same trend of L* values changes was observed in a* values (Table.1). Statistically, cookie samples with a 50% wheat flour substituted using buckwheat flour was same to control cookie, while substitution of 60% or more of wheat flour using buckwheat flour significantly increased the a* values ($P \leq 0.05$). a* value of control cookie sample was 10.17, while the 100% substituted cookies (buckwheat cookie samples) was 21% higher than control cookie samples with a score of 12.28. Effects of the substitution of wheat flour using buckwheat flour on cookie color was mainly reflected on the b* values, as it could be seen in Table. 2. It indicated that substitution of more than 20% of wheat four using buckwheat flour decreased the b* values significantly ($P \leq 0.05$). b* values of control cookie samples was 35.1, substitution of 100% wheat flour using buckwheat flour decreased b* values by 19% with a b* value of 38.4. Concluding that buckwheat cookie samples were darker than wheat cookies, gradual increase of buckwheat gave higher redness and less yellowness cookie samples.

Sensory evaluation

The sensory characteristics of cookies prepared using the substitution of wheat flour using buckwheat flour of different levels were conducted to determine the acceptability of the product. Cookie samples were evaluated for surface, color, surface appearance, texture, taste, flavor and overall quality on a 9-point hedonic scale, Over-All acceptability scores are presented in Fig. 4. Over-All acceptability scores of cookies prepared using up to 60% of buckwheat were not significantly different compared to the control cookies while 70% substitution of wheat flour using buckwheat flour or more were significantly affected the over-all acceptability comparing to control cookies. Substitution of 10, 20 and 30% of wheat flour using buckwheat flour in the preparation of cookies increased the over-all acceptability significantly from 8.4 in control cookies to 8.44, 8.76 and 8.64 in 10, 20 and 30% substituted cookies respectively. 100% buckwheat cookies with the minimum over-all acceptability score was 6.24 which is still accepted to consumer and this score means that cookies with 100% buckwheat and 0% of wheat flour was slightly liked, and that gives the buckwheat flour great chance to be used in the substitution of wheat flour to prepare cookies and maybe other products.

Higher moisture contents and higher water activity of buckwheat substituted cookie samples were reflected on two parameters, first is cookie hardness and breaking forces and also were noticed by the consumer when a sensory evaluation was applied to test consumer's acceptability of cookie samples prepared using buckwheat flour as blend with wheat flour of different ratios or alone. Gradual increase of buckwheat gave higher redness and less yellowness cookie samples, which was reflected to the less preferred color scores when cookie samples were evaluated by panelists.

TPC of cookie samples

TPC of cookie samples, and its relationship to the substitution of wheat flour using buckwheat flour is presented as a linear relationship between the substitution% and TPC in Fig.5.A. Data show that TPC of prepared cookies followed the buckwheat substitution% linearly with R^2 of 0.93. Control sample without any wheat flour substituted had the lowest TPC value among other samples with a 110 mg GAE/100g, while substitution of wheat flour using buckwheat flour gradually increased the TPC and reached its maximal value 230.66 mg GAE/100g when cookies were prepared using a 100% of buckwheat flour. These results are in accordance with the study of (Lin *et al.,* 2009) who prepared an antioxidant enrichment of bread when a 25 % buckwheat flour together with wheat flour was used.

DPPH scavenging activities of cookies

Antioxidant properties of cookie samples determined using DPPH scavenging activity, followed the same trends of TPC properties of cookies as was noticed in Fig.5.B. DPPH scavenging activities of buckwheat cookies were higher than that of control cookie samples prepared without the addition of buckwheat flour. Control cookie samples scavenged 33% of the DPPH free radical and that was the minimal DPPH scavenging activity among all tested cookie samples. Gradual increase of buckwheat flour caused a highly significant increase of DPPH scavenging activity which was 85% correlated to the substitution percentage of buckwheat flour instead of wheat flour in the prepared cookies. Maximal DPPH scavenging activity was scored by the maximal buckwheat flour substituted cookies (100%), DPPH scavenging activity of 100% substituted buckwheat cookies was 85%. Higher scavenging activity of buckwheat substituted cookies is duo to the higher scavenging activity of buckwheat flour comparing to wheat flour.

Antioxidant properties of buckwheat cookies measured using both TPC and DPPH scavenging activities assays was correlated to the substitution percentages of wheat flour using the buckwheat flour. Buckwheat flour was reported to be higher antioxidant activity comparing to wheat flour

Aromatic compounds profile of cookie volatile compounds

Aromatic compounds data of all cookie samples; wheat flour, wheat-buckwheat flours blends of different levels and buckwheat flour are presented in Table.3. It was noted that many volatile compounds decreased with the decrease of wheat flour level in the cookie formula, those decreased compounds were as following: Trans-1,3-diacetoxy-1-propene, Levulinic acid, Toluene, 2-n-pentylfuran, 1-hydroxy-2-butanone, nitrohexane, 2-methyl-butyl acetate, 2-cyclopentene-1,4-dione, 2-(2-ethoxyethoxy)ethanol, 2-decenal, 2-undecenal, 2(5H)-furanone, 2,4-decadienal, 2,4-decadienal, and 2-ethyl-3-hydroxyhexyl ester of 2-methyl-propionic. Those volatile compounds started to decrease with the decrease of wheat flour; interestingly those compounds totally disappeared in the buckwheat cookie samples with the absence of wheat flour in the cookie formula. While a group of other volatile compounds were not found in the control cookies which formulated of 100% wheat flour without any buckwheat flour, those compounds are: Butanal, 2-methyl, Ethanol, Ethyl butyrate, dl-limonene, Pentyl alcohol, dimethylnitrosamine, 6-methyl-5-hepten-2-one, 4-dimethylamino-pyridine, 4-nitrophthalamide, n-decaldehyde, 2-nonenal, Octilin, and Delta lauro-lactone. These differences of volatile compounds, both cases; new compounds appeared or compounds disappearedwas the reason of the different flavor and aroma of cookie samples prepared using different flour blends or streams. Further determinations and studies of aromatic compounds and relation to the sensory evaluation are needed.

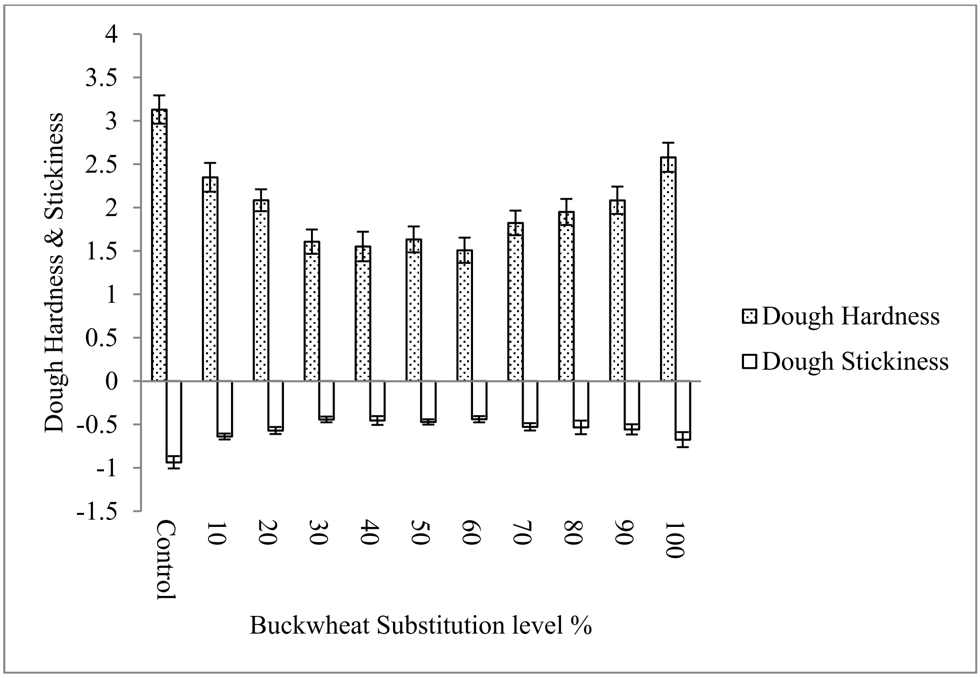

Fig. (1): Effect of wheat flour substitution using buckwheat flour on cookie dough hardness and stickiness

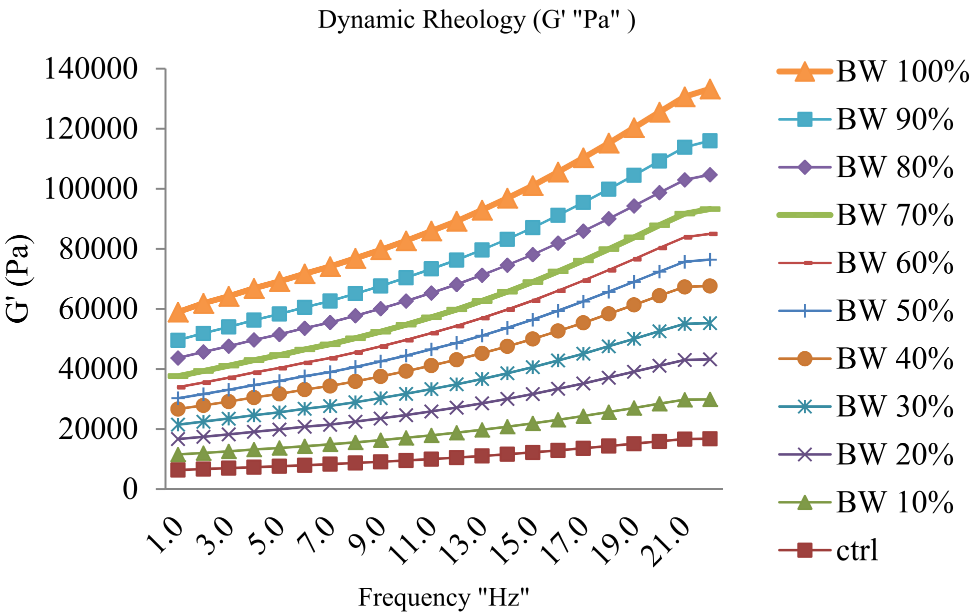

Fig. (2 A.): Effect of wheat flour substitution using buckwheat flour on dynamic rheology (G') of cookie dough samples

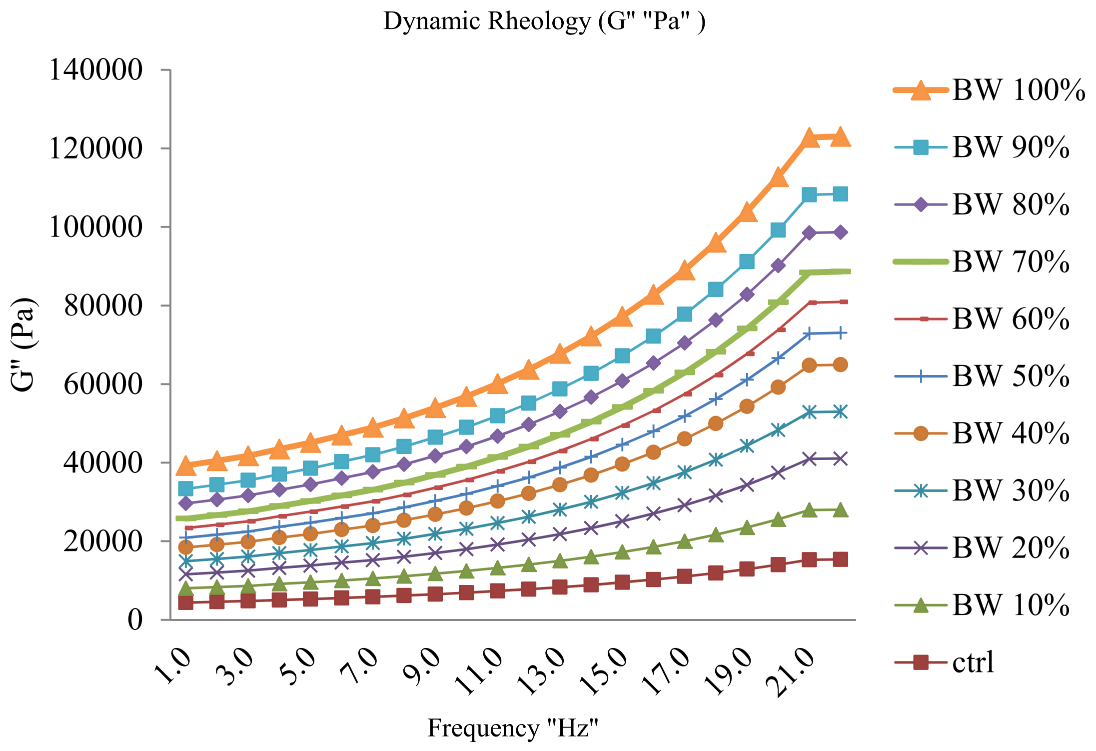

Fig. (2.B.): Effect of wheat flour substitution using buckwheat flour on dynamic rheology"G'' of cookie dough samples.

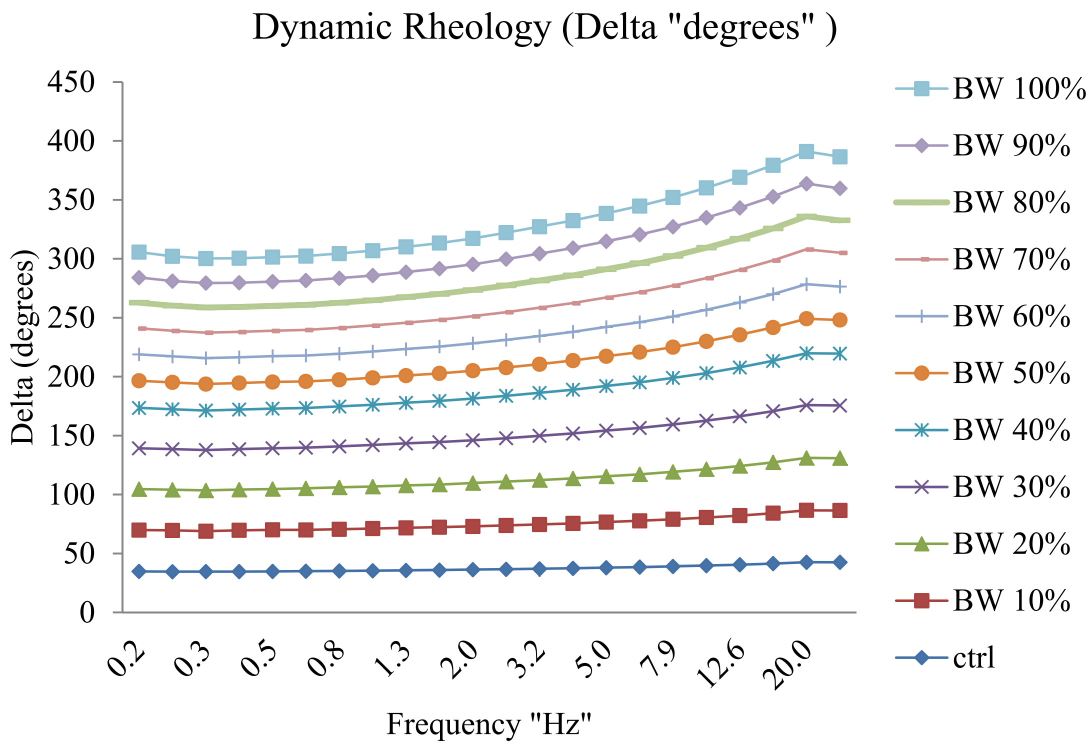

Fig. (2.C.): Effect of wheat flour substitution using buckwheat flour on dynamic rheology (delta) of cookie dough samples

Table (2): Effect of Wheat flour substitution using buckwheat flour on some physical properties of cookie samples including spread ratio, breaking forces and color values

Treatment			Spread ratio	Breaking forces (Kg)	Color		
Wheat%	**BW*%**	**Code**			**L***	**a***	**b***
100	0	Ctrl	4.63±0.07	8.46±0.36	61.65±1.13	10.17±0.53	35.10±1.37
90	10	BW10	4.90±0.05	7.98±0.27	61.13±1.90	10.53±0.38	33.11±0.76
80	20	BW20	5.12±0.05	7.42±0.29	60.30±0.92	10.99±0.81	32.36±1.66
70	30	BW30	5.26±0.06	6.83±0.26	60.46±2.20	11.16±0.55	30.62±1.24
60	40	BW40	5.29±0.06	6.12±0.21	60.08±1.89	11.24±0.57	29.82±1.37
50	50	BW50	5.39±0.05	5.68±0.36	58.98±1.76	11.66±0.86	29.70±0.53
40	60	BW60	5.38±0.06	5.04±0.24	58.79±1.32	11.69±0.69	29.73±1.13
30	70	BW70	5.32±0.04	5.38±0.23	57.62±2.20	11.96±0.42	29.51±0.95
20	80	BW80	5.19±0.05	6.10±0.21	56.88±1.42	11.99±0.89	29.10±1.10
10	90	BW90	5.11±0.05	6.59±0.36	54.29±1.63	12.08±0.81	29.03±0.58
0	100	BW100	5.09±0.07	7.47±0.28	51.56±1.49	12.28±0.94	28.40±1.09

* Buckwheat

Table (3): Effect of wheat flour substitution using buckwheat flour on aromatic compounds profile of prepared cookies

Compound	Formula	Retention time	Sample				
			Ctrl cookie	Buckwheat cookie samples			
				BW 10%	BW 60%	BW 70%	BW 100%
Acetone	C3H6O	2.62	4.51	4.48	5.17	5.27	6.23
Butanal, 2-methyl	C5H10O	3.81	-	-	-	0.67	0.74
Ethanol	C2H6O	4.28	-	0.39	0.68	1.04	1.19
Trans-1,3-diacetoxy-1-propene	C7H10O4	4.34	1.16	-	-	-	-
Levulinic acid	C5H8O3	4.35	1.2	0.71	-	-	-
2,3-butanedione	C4H6O2	5.13	4.94	7.22	4.36	6.22	5.94
Ethyl butyrate	C6H12O2	6.59	-	-	0.60	0.75	1.06
Toluene	C7H8	6.60	0.64	0.40	-	-	-
2,3-pentanedione	C5H8O2	7.23	0.75	1.02	1.21	1.33	1.51
n-hexanal	C6H12O	7.78	2.44	3.76	3.94	4.12	4.24
1-methoxy-2-propanol	C4H10O2	9.12	0.87	0.82	3.15	4.18	9.82
3-methyldecane	C11H24	9.59	0.38	0.47	0.50	0.58	0.71
n-heptaldehyde	C7H14O	10.26	0.59	0.82	1.02	1.26	1.41
dl-limonene	C10H16	10.52	-	-	1.75	2.31	5.68
n-dodecane	C12H26	10.60	1.17	1.11	-	-	-
p-diazine	C4H4N2	10.79	0.40	0.44	0.39	0.37	0.35
2-n-pentylfuran	C9H14O	11.15	0.42	0.39	0.33	-	-
Pentyl alcohol	C5H12O	11.54	-	0.33	0.44	0.49	0.5
methylpyrazine	C5H6N2	11.76	2.12	2.18	1.97	1.97	1.51
2,2,4,6,6-pentamethylheptane	C12H26	11.89	1.11	0.66	1.28	1.24	1.25
2,2,11,11-tetramethyldodecane	C16H34	12.03	2.42	2.60	2.59	2.42	2.26
dimethylnitrosamine	C2H6N2O	12.26	-	-	9.31	9.49	10.64
Acetol	C3H6O2	12.28	11.67	11.55	10.83	10.11	10.01
2-heptenal	C7H12O	12.63	0.54	0.59	0.40	0.57	0.80
2,6-dimethylpyrazine	C6H8N2	12.75	0.40	0.44	0.68	0.44	0.43
6-methyl-5-hepten-2-one	C8H14O	12.81	-	-	-	-	0.35
n-hexanol	C6H14O	13.05	0.35	0.44	0.65	1.05	1.43
1-hydroxy-2-butanone	C4H8O2	13.32	1.88	1.53	0.84	0.65	-
4-dimethylamino-pyridine	C7H10N2	13.82	-	-	0.45	0.58	0.68
Ethyl caprylate	C10H20O2	14.10	13.17	13.48	13.34	13.17	13.89
Ethylic acid	C2H4O2	14.24	2.58	3.12	4.15	3.66	4.91
furfural	C5H4O2	14.44	5.44	4.64	4.95	4.61	5.01
4-nitrophthalamide	C8H7N3O4	14.65	-	-	-	-	0.41
nitrohexane	C6H13NO2	14.88	0.92	0.95	0.94	-	-
n-decaldehyde	C10H20O	14.88	-	-	-	-	0.56
Ketone, 2-furyl methyl	C6H6O2	14.95	1.33	0.90	0.52	0.45	0.46
Artificial almond oil	C7H6O	15.19	0.49	0.51	0.59	0.58	0.63
2-methyl-butyl acetate	C7H14O2	15.33	0.90	0.67	-	-	-
2-nonenal	C9H16O	15.33	-	0.47	0.61	0.64	1.05
Octilin	C8H18O	15.51	-	-	0.30	0.36	0.45
2-cyclopentene-1,4-dione	C5H4O2	15.87	0.53	0.38	-	-	-
2-hendecanone	C11H22O	15.99	0.67	0.52	0.49	0.71	0.63
2-(2-ethoxyethoxy)ethanol	C6H14O3	16.23	2.61	2.92	4.44	2.00	
Butyric acid	C4H8O2	16.23	-	-	-		0.97
Ethyl decanoate	C12H24O2	16.38	2.65	2.34	2.13	2.43	2.42
2-decenal	C10H18O	16.48	0.40	0.31	-	-	-
Furfuryl alcohol	C5H6O2	16.58	14.50	10.94	5.58	3.36	1.42
Salicylaldehyde	C7H6O2	16.89	-	-	0.53	0.66	0.99
Isobornylisovalerate	C11H20O4	17.41	0.43	0.40	0.40	0.45	0.56
2-undecenal	C11H20O	17.57	0.37	0.17	-	-	-
2(5H)-furanone	C4H4O2	17.64	0.89	0.69	0.45	-	-
2,4-decadienal	C10H16O	18.14	0.33	-	-	-	-
Lauric acid, ethyl ester	C14H28O2	18.36	-	0.32	0.33	0.36	0.39
2,4-decadienal	C10H16O	18.37	0.33	-	-	-	-
2-ethyl-3-hydroxyhexyl ester of 2-methyl-propionic acid	C12H24O3	18.62	0.46	0.39	-	-	-
Benzenemethanol	C7H8O	18.77	-	-	0.31	0.38	0.46
4-hydroxynonanoic acid lactone	C9H16O2	20.16	4.15	4.17	4.24	4.25	4.95
2H-pyran-2-one,6-butyltetrahydro-	C9H16O2	20.63	0.40	0.45	0.60	0.60	0.70
Delta.decalactone	C10H18O2	21.54	0.89	0.96	1.05	1.05	1.25
4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	C6H8O4	22.04	0.74	0.98	1.75	1.78	1.91
Delta.laurolactone	C12H22O2	23.48	-	-	-	-	0.34

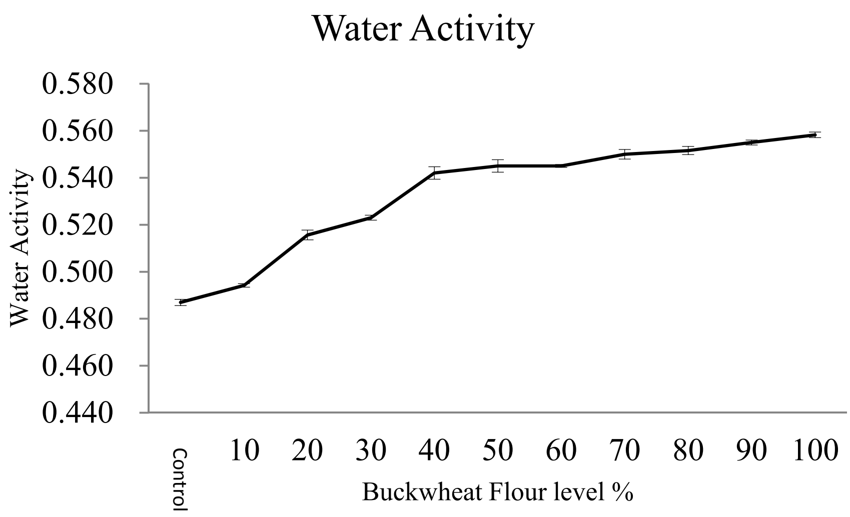

Fig. (3.A.): Effects of wheat flour substitution using buckwheat flour on water activity of cookie samples

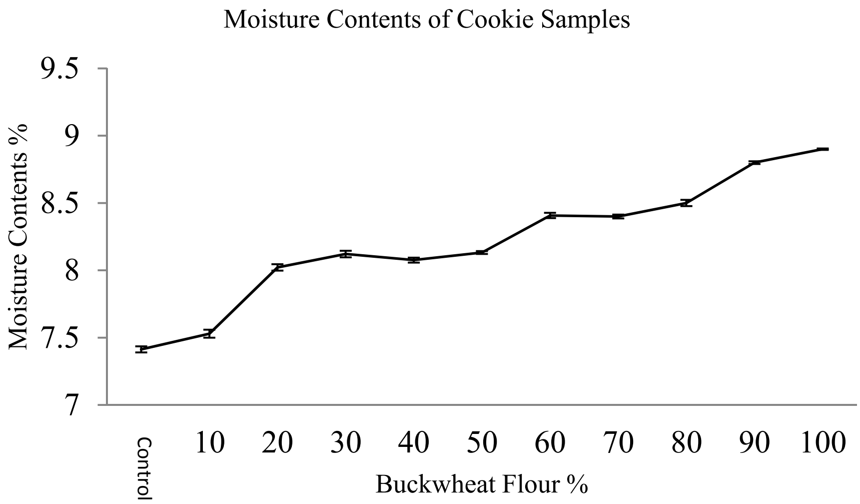

Fig. (3.B.): Effects of wheat flour substitution using buckwheat flour on moisture contents of cookie samples

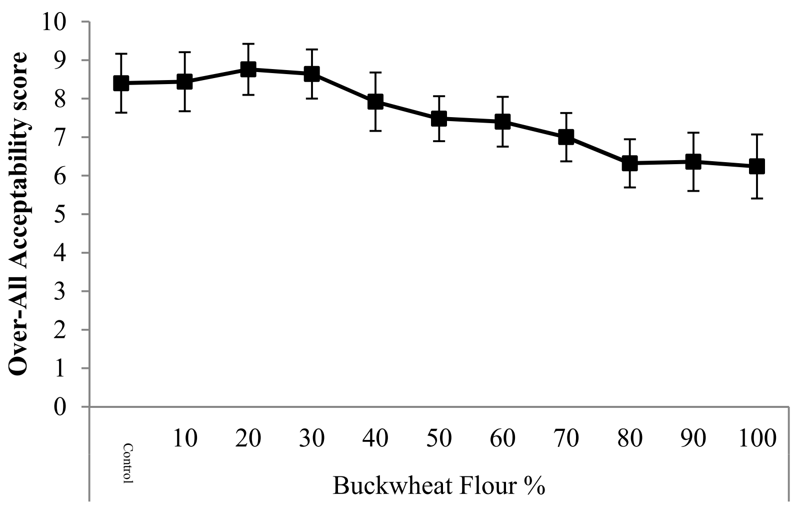

Fig. (4): Effect of wheat flour substitution using buckwheat flour on the sensory evaluation (Over all acceptability score).

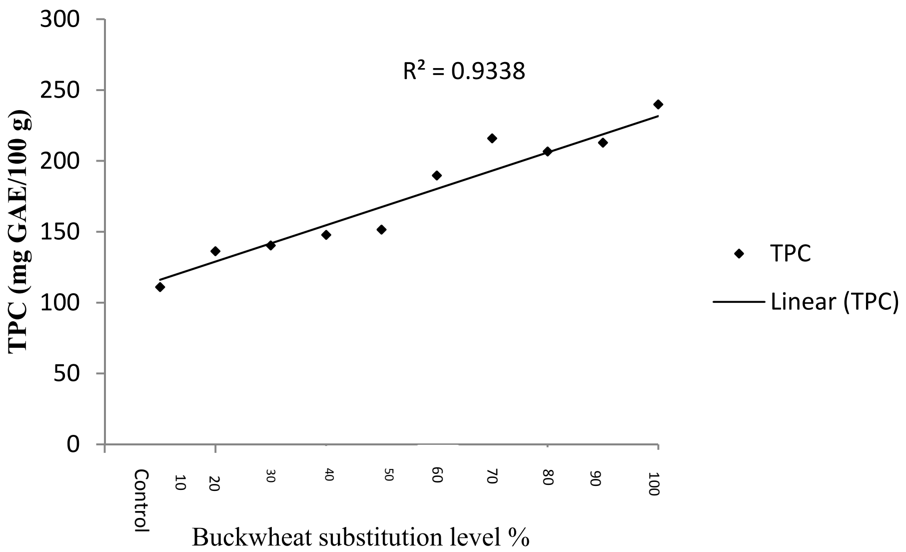

Fig. (5.A.): Linear relation between the increase of the wheat flour substitution using buckwheat flour and TPC of cookie samples

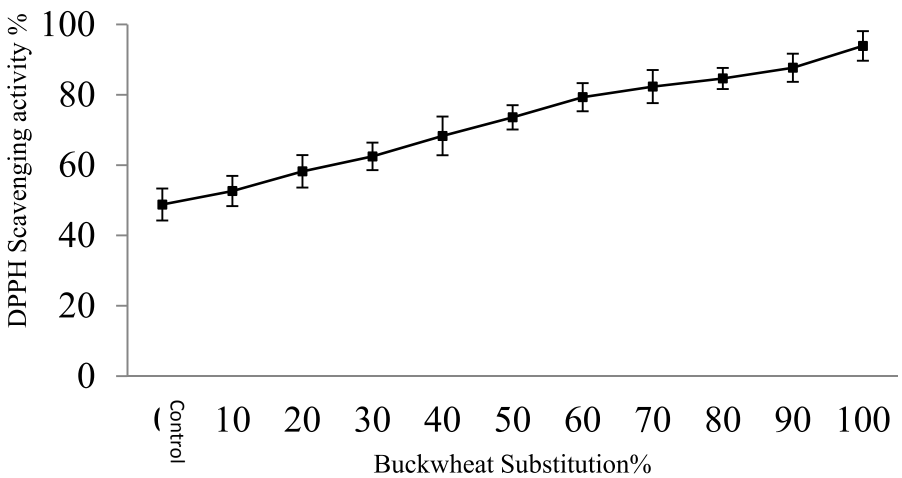

Fig. (5.B.): DPPH scavenging activity of cookie prepared using different wheat flour substitution percentages using buckwheat flour.

CONCLUSION

Substitution of wheat flour using buckwheat either partially or complete, enriched the nutritional value of cookies and created a different aromatic profile with a non-significantly difference in sensory attributes, gives a possibility of gluten-free or lower gluten products with a higher antioxidant, higher nutritional value cookies and open a way towards new products using Buckwheat.

REFERENCES

AACC. (2002). Approved Methods of Analysis, Methods 10-50D, 44-15 and 46-12. AACC International: St. Paul, MN. .

AACC. (1999). Approved Methods of the American Association of Cereal Chemists. AACC International: St. Paul, MN. .

Abdel-Samie, M. A.-S., J. Wan , W. Huang, O. K. ChungandB. Xu (2010). Effects of Cumin and Ginger as Antioxidants on Dough Mixing Properties and Cookie Quality. Cereal Chemistry, 87(5), 454-460. doi: 10.1094/cchem-01-10-0012

Ammar, M. S., A. E.Hegazy andS. H. Bedeir (2009). Using of Taro Flour as Partial Substitute of Wheat Flour in Bread Making. World Journal of Dairy & Food Sciences, 4(2), 94-99.

Chan, E. W. C., Y. Y. Lim, L. F. Wong, F. S. Lianto, S. K. Wong, K. K. Lim, C. E. Joe, & T. Y. Lim (2008). Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species. *Food Chemistry, 109*(3), 477-483.

Choi, S. M., & C. Y. Ma, (2007). Structural characterization of globulin from common buckwheat (Fagopyrum esculentum Moench) using circular dichroism and Raman spectroscopy. *Food Chemistry, 102*(1), 150-160.

Dietrych-Szostak, D. and W. Oleszek (1999). Effect of Processing on the Flavonoid Content in Buckwheat (Fagopyrum esculentum Mo1ench) Grain. Journal of Agricultural and Food Chemistry, 47, 4384-4387.

Emmons, C. L., D. M. Peterson, & G. L. Paul, (1999). Antioxidant Capacity of Oat (Avena sativa L.) Extracts. 2. In Vitro Antioxidant Activity and Contents of Phenolic and Tocol Antioxidants. *Journal of Agricultural and Food Chemistry, 47*(12), 4894-4898.

Guo, X., K. Zhu, H. Zhang and H. Yao (2007). Purification and Characterization of the Antitumor Protein from Chinese Tartary Buckwheat (Fagopyrum tataricum Gaertn.)Water-Soluble Extracts. J. Agric. Food Chem., 55,6958-6961.

Holasova, M., V. Fiedlerova, H. Smrcinova, M. Orsak, J. Lachman andS.Vavreinova (2002). Buckwheat-the source of antioxidant activity in functional foods. Food Research International, 35(2-3), 207-211.

HU, C. and D. D. KITTS (2000). Studies on the Antioxidant Activity of Echinacea Root Extract. Journal of Agricultural and Food Chemistry, 48, 1466-1472.

Kalinova, J., J. Triska andN. Vrchotova (2006). Distribution of Vitamin E, Squalene, Epicatechin, and Rutin in Common Buckwheat Plants (Fagopyrum esculentum Moench). J. Agric. Food Chem. , 54 5330-5335.

Kawa, J. m., C. g. Taylor andR. Przybylski (2003). Buckwheat Concentrate Reduces Serum Glucose in Streptozotocin-Diabetic Rats. J. Agric. Food Chem. 517287-7291.

Kreft, I., N. Fabjan andK. Yasumoto (2006). Rutin content in buckwheat (Fagopyrum esculentum Moench) food materials and products. Food Chemistry, 98(3), 508-512. doi: 10.1016/j.foodchem.2005.05.081

Lin, L.-Y., H.-M. Liu, Y.W. Yu,S. D. Lin and J.L. Mau (2009). Quality and antioxidant property of buckwheat enhanced wheat bread. Food Chemistry, 112(4), 987-991.

Pareyt, B., E. Wilderjans, H. Goesaert, K. Brijs andJ. A. Delcour (2008). The role of gluten in a sugar-snap cookie system: A model approach based on gluten-starch blends. Journal of Cereal Science, 48(3), 863-869.

Quettier-Deleu, C., B. Gressier, J. Vasseur, T. Dine, C. Brunet, M. Luyckx and F. Trotin (2000). Phenolic compounds and antioxidant activities of buckwheat (Fagopyrum esculentum Moench) hulls and flour. Journal of Ethnopharmacology, 72(1-2), 35-42.

Singh, J., N. Singh, T. R. Sharma andS. K. Saxena (2003). Physicochemical, rheological and cookie making properties of corn and potato flours. Food Chemistry, 83, 387-393

Stangeland, T., S. F. Remberg, & K. A. Lye, (2009). Total antioxidant activity in 35 Ugandan fruits and vegetables. *Food Chemistry, 113*(1), 85-91.

Sun, T. and C.T. Ho (2005). Antioxidant activities of buckwheat extracts. Food Chemistry, 90(4), 743-749.

Tepe, B., M. Sokmen, H. A. Akpulat, & A. Sokmen, (2005). In vitro antioxidant activities of the methanol extracts of four Helichrysum species from Turkey. *Food Chemistry, 90*(4), 685-689.

Watanabe, M. andJ. Ayugase (2009). Chiral Separation of Catechins in Buckwheat Groats and the Effects of Phenolic Compounds in Mice Subjected to Restraint Stress. Journal of Agrical and Food Chemistry, 57, 6438-6442.

Watzke, H. J. (1998). Impact of processing on bioavailability examples of minerals in foods. Trends in Food Science & Technology, 9(8–9), 320-327.

Yokozawa, T., H. Y. Kim, G. i. Nonaka, andK. Kosuna (2002). Buckwheat extract inhibits progression of renal failure. J. Agric. Food chem. , 50, 3341-3345

القيمة الغذائية و خصائص جودة الكوكيز المجهزة من الاستبدال الكلي أو الجزئي لدقيق القمح

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فى هذا البحث تمت دراسة تأثير استبدال دقيق القمح بدقيق الحنطة السوداء (بمستويات تتباين من الصفر و حتى الاحلال الكلي بهدف زيادة مضادات الاكسدة و بغرض خلق منتج جديد ذوخواص تغذويةونكهة ممزية) على الخصائص الريولوجيبة الديناميكية و الفيزيائية للعجين و ايضا تأثير الاستبدال على الخصائص الفيزيائية و التغذوية والتركيبة الاروماتية للكوكيز. وأظهرت النتائج أن عجينة الكوكيز المصنوعة بواسطة الحنطة السوداء كانت اقل صلابة و اكثر التصاقا مقارنة بالعجينة المقارنة، كما أعطت عجينة الحنطة السوداء قيما مختلفة من حيث الخصائص الريولوجليه الديناميكية G', G'' and δ. اما من حيث خصائص الكوكيز المصنوعة بالحنطة السوداء فقد احتوت على محتوى رطوبى ودرجة نشاط مائى اكثر من المعاملة المقارنة، كما اظهرت نسبة افتراش اكبر من المعاملة المقارنة، البالغة 4,63 للمعاملة المقارنة بينما كانت 5.4 في حالة استبدال 60% من الدقيق بالحنطة بينما كانت الكوكيز المعدة باستخدام 100% دقيق حنطة سوداء اقل في الافتراش من 60% استبدال و لكنها ايضا كانت اكبر افتراشا من المعاملة المقارنة حيث بلغ افتراشها 5.1. لونيا كانت الكوكيز المعدة بدقيق الحنطة السوداء اغمق. و من حيث الخواصالمضادةللاكسدة فقد كانت الكوكيز المعدة بواسطة الحنطة السوداء اغنى من كوكيز القمح عند مقارنتها بمحتواها من الفينولات و بطريقةDPPH. أخيرا اظهرت الكوكيز المصنوعة بواسطة الاستبدال الكلي للقمح بالحنطة السوداء اظهرت تركيبة مختلفة عن المعاملة المقارنة مع الاحتفاظ بالقبول عند تقييمها حسيا.