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EVALUATION OF SWEET LUPIN SEEDS FLOUR ADDITION ON PAN BREAD QUALITIES

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ABSTRACT

In this study, the addition of Sweet lupin seeds flour (SLSF) in different levels (5, 10 and 15%) to wheat flour (WF) was evaluated. Dough mixing properties, bread physical characteristics and sensory properties were investigated. Increasing SLSF level in the SLSF-WF composites led to an increased water absorption, dough development time, C4 and setback torque, while it decreased flour moisture, dough stability, C2, C3 and C5 when analyzed by Mixolab. The SLSF-WF composites produced darker bread, lower specific volume, and harder crumb. Higher antioxidant activities, higher protein and minerals contents were scored by pan bread containing SLSF. Bread samples enhanced with SLSF (5, 10 and 15%) were accepted by panelists for their aroma, crust and crumb color, texture, taste and overall-acceptability. The best acceptability of bread was obtained by addition of 5% SLSF even compared to control wheat bread.

Keywords: Bread enhancement, Sweet Lupin, Rheological properties.

INTRODUCTION

Lupin (*Lupinus spp*.) is a rich source of proteins, lipids, minerals, dietary fibres, vitamins, polyphenols, and bioactive peptides. Lupin contains higher protein content (28-48% according to species and cultivars), which is easily digestible by humans compared to that of other legumes proteins (Martinez-Villaluenga *et al*., 2009, Pastor-Cavada *et al*., 2009). Lupin seeds are rich in lysine and generally poor in the sulfur-containing amino acids such as methionine, cystein and threonine. Globulin was the main protein in sweet lupin seeds followed by albumins, glutelins and prolamines (Gulewicz *et al.* 2008). Lupin oil is a balanced fatty acid composition with total saturated fatty acids of about 10 % and total unsaturated fatty acids of 90%. Sweet lupin seeds have moderate oil content (about 8%), containing high concentration of oleic acid 46.28%, followed by linoleic acid 21.55%, linolenic acid 7.69%, and palmitic acid 7.39, with total tocopherol content of 184.70 mg/100g oil (Petterson, 2000, Sbihi *et al*., 2013). Lupin seeds flour is recently added to bakery products for its nutritional value and functional properties (Awad-Allah and Elkatry, 2013), its flour was incorporated in bread making as an ingredient because of its technological and functional properties (Guillamon *et al*., 2010). Consumption of lupine seeds-based diets reduces blood glucose, cholesterol, and triglycerides (Hall *et al.,* 2005, Chango *et al*., 1998).

Composite flours usage in bread making has recently gained a special great interest in purpose of using the special nutritional value of flours or powders other than wheat flour, or because of the shortage in wheat flour quantity (Eduardo, *et al.,* 2014). Wheat flours' key ingredient of quality is gluten, which is considered as “structural” protein in breadmaking with its properties of giving an extensible dough when hydrated and kneaded, with good gas holding properties, and a good crumb structure (Peighambardoust, *et al.,* 2011).

Wheat flour is rich in energy, dietary fiber, minerals, vitamins and many other bioactive compounds, and there is no other cereal flour could achieve its baking characteristics, but its flour protein is deficient in some essential amino acids including lysine and threonine. Wheat flour enhancement using protein-rich materials including cereal and non-cereal sources had been discussed by previous studies to increase its protein content, to improve the essential amino acid balance in the products, add more functional nutritional value of the resultant baked products, and to prevent worldwide protein-energy malnutrition. Consumer acceptability of the new developed products is an important issue of its success (Amir *et al*., 2013, Ogur, 2014).

This study aimed to investigate the evaluation of sweet lupine seeds flour addition to wheat flour in three different levels (5, 10 and 15%) on the flour mixing properties and quality characteristics of pan bread.

MATERIALS AND METHODS

Materials

Wheat flour (72% extraction), and other baking ingredients were purchased from local market of Zagazig city, Egypt. Sweet lupin seeds (*Lupinus albus*) were purchased from the Agricultural Research Center, Giza, Egypt.

Methods

Sweet Lupin Seeds Flour (SLSF) Preparation

Lupin seeds were cleaned, ground into powder using a Moulinex grinder (Moulinex, France), resultant sweet lupin seeds flour (SLSF) was then sieved through a 60 mesh screen to obtain fine powder and discard larger particles, then SLSF was kept under freezing at -18 °C in polyethylene bags until used.

Quality of Flour

Mixolab (Chopin, Tripette and Renaud, Villeneuve-la-Garenne, France) was used to analyze flour quality following the method reported by Jia *et al*. (2011). The measured Mixolab parameters were water absorption, dough development time, dough stability, C2-C5 torques and setback torque.

preparation of Bread

Pan bread was prepared according to the AACC official method 10-09 (AACC, 2002) with minor modifications. SLSF was added in 5%, 10% and 15% levels based on wheat flour weight. Water (600ml), salt (5gm), sugar (50gm), oil (40ml), fermented starter (150gm) and dry yeast (150gm) were all mixed in (Kenwood, Hampshire, UK) Major mixer, at medium speed for 2 min. Flour (1000gm) was then added and mixed at high speed for 6 min. After mixing, dough was divided into 750 g portions and put into 30 x 10 x 10 cm baking pans. Dough pieces on pans were rested in trays for 10 min at room temperature, covered by a plastic film to prevent moisture loss during proofing. Pans were placed in a thermostatically controlled proofing oven at 35°C and 95% relative humidity for 45 minutes for final proofing. Baking was performed in an electrical oven at 200°C for 30 minutes. Prepared bread samples were cooled to 25°C for 3 hours before use.

Sensory evaluation

Bread samples of all treatments (control sample and SLSF added samples) were evaluated for aroma, crust color, crumb color, texture, taste and overall acceptability according to (Lee and Choi, 2013). Bread slides were introduced to panelists (staff members of Food Science Department, Faculty of Agricultural, Zagazig University, Egypt) in random order, within 24 hours of bread preparation. Bread amples were evaluated using a 9-point hedonic scale, where (1=dislike the most, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9= like the most).

Physical properties

Specific Volume

Bread loaves volume was measured using (Tex-vol instrument BVM-L370). Specific volume of bread loaves was calculated from the ratio between volume and weight of the bread loaves (Sciarini *et al*., 2012).

Texture analysis of pan bread

Fresh bread loaves prepared without SLSF and with the addition of SLSF at 5, 10 and 15% levels were analyzed for texture parameters (hardness, stickiness, adhesiveness, chewiness, cohesiveness, gumminess, springiness and stringiness) following the methods of (O'Brien *et al*., 2000) with some modifications. Two bread slices of 12 mm height (24 mm total) was subjected to the Texture analyzer (TVT-300XP) to be evaluated for different texture parameters, two compression cycles with 5 seconds relaxation; the probe was a 35 mm cylindrical coded (P-Cy35S), compression cell 5 kg, pretest speed 5 mm/min, compression rate 40% of original height. Force in grams required to accomplish compression was recorded as hardness.

Color

The crust and crumb Color values of the bread samples (*L**, *a** and *b**) were measured using HunterLab color analyzer (Hunter Lab Color Flex EZ, USA), as described by Ishida and Steel (2014).

Proximate chemical composition of pan bread

Proximate chemical composition of crude SLSF powder and of produced bread samples were all determined. Moisture, ash contents and minerals contents were analyzed following to the Official Methods (AACC, 2002). Crude protein and Fiber percentages were both determined according to AOAC (2005).

Total carbohydrate was calculated by difference (100-moisture, protein, fat and ash). Total calories were calculated using the equation mentioned by FAO/WHO (1974). Where, energy (calories equal 4 for carbohydrate and protein and 9 for fat). All measurement was carried out in triplicates.

Antioxidant activity

Antioxidant properties including extraction, DPPH scavenging activity%, Total phenolic compounds (TPC) of wheat flour, SLSF, and bread samples of all treatments were determined according to Lilei et al. (2013).

Statistical analysis

SAS (V.9.2) software was used to analyze datafor the Analysis of variance (ANOVA). Differences between means were determined by the least significant difference (LSD) test, and significance was checked at $P<0.05$. All measurements were in triplicates and means of the three values was presented.

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RESULTS AND DISSCUSSION

Characteristics of Flour

Mixolab was used to describe dough behavior during mixing and heating in a single test, simulating the mixing and baking processes. The Mixolab parameters measured were as follows: dough consistency during mixing (C1), mixing stability, protein weakening as a function of mechanical work and temperature (C2), starch gelatinization (C3), amylase activity and hot gel stability (C4) and starch retrogradation in the cooling phase (C5). The obtained results from Mixolab data and curves were presented in details in Table 1 and Figure 1. Over all comparison between control dough (base formulated dough) and dough containing 5, 10 and 15% SLSf is presented in Figure 1. Protein quality could be calculated from the first stage of Mixolab curve as dough development time (DDT), dough stability and C2 value. DDT is the time to get the maximum torque of 1.1 Nm (C1) (Sedej *et al*., 2011).

Data in Table (1) showed that the moisture content ranged from 12.4% for the 15% SLSF to 13.6% for control wheat flour. Extraction rate of wheat flour affect its water absorption, protein (gluten) content, starch properties (damaged and gelatinized starch granules) and particle size of flour (Perten, 1990). Changes in pasting and mixing properties of lupin-wheat flour composites can be ascribed to lupin flour chemical composition, absence of gluten, different fiber composition. Water absorption of control wheat flour was 56%. Proportional addition of SLSF to wheat flour led to increase of its water absorption to reach maximal value of 57.8 in 15% SLSF. The flour which absorbs large amount of water usually preferred because it gives high yield of bread during baking process. Mis *et al*., 2012, reported an almost linear increase in water absorption with the use of carob fiber and whole oat meal, for their water holding ability which is related to their high fiber contents.

Dough development time (DDT) was ideal (1.4 minutes) in control flour (wheat flour with no SLSF added), while the addition of SLSF gradually increased DDT to reach its maximum at 4.07 minutes in the 15% SLSF. This might be due to the wheat gluten dilution as SLSF is a free gluten material, higher dough development time might also be due to the SLSF fiber composition and content compared to wheat flour. This is in agreement with results obtained by Doxastakis *et al*., (2002) and Sedej *et al*., (2011), who found that DDT increased when higher fiber compounds was added to bread formula.

Dough stability is the period of time in which the dough is able to withstand the applied deformation, subsequent decrease in torque value during further kneading and heating is a measure of protein weakening (Rosell *et al*., 2007). SLSF addition to wheat flour resulted in lower dough stability as it decreased from 8.3 minutes in control flour to reach 7.3, 6.28 and 5.17 minutes in the 5, 10 and 15% SLSF added to wheat flour, respectively. This could be attribute to the gluten dilution by the addition of the gluten free lupin powder.

Dough consistency is the minimum torque achieved by the dough after heating period which cause aggregation and denaturation of protein (C2). It was noticed that non diluted gluten of control wheat flour maintained dough consistency whereas the addition of SLSF decreased consistency of dough. Control sample had higher consistency (0.39 Nm) compared to substituted wheat flour samples. The increase of SLSF addition led to decrease the dough consistency (C2) to be 0.38, 0.32 and 0.29 Nm for 5, 10 and 15% SLSF, respectively. Antanas *et al*. (2013) found that the addition of different levels of triticale to whole-wheat flour lead to decreasing of C2.

Wheat flour contain more starch compared to flour samples, that gave control sample higher C3 value with a torque of 1.78 Nm, while it was 1.58Nm in the 15% SLSF. Decreased viscosity peak (C3) with less starch components addition was in line with those found by Hadnadev (2011), who found lower viscosity peak with lower starch contents.

By the end of the kneading and heating, dough reach a final torque which considered as an indicator on shelf life criteria as cooking stability could be related to the extended shelf life. C5 in control sample was 1.89 Nm, while SLSF added dough had lower C5 values (ranged from 1.66 to 1.81 Nm) which may give less bread firming during storage. Setback value (C5-C4) is taken as a final product quality attribute of bread as it gives an indication on bread staling during storage. Control wheat flour had the lowest setback value (0.49 Nm) while SLSF containing flour was lower in setback values (0.57, 0.59 and 0.65 respectively in L5, L10 and L15). This result could give a conclusion that the addition of SLSF to bread formula may prolong its shelf life and delay bread staling. These results are in accordance with those reported by Sedej, (2011) who found that buckwheat enhanced wheat bread had longer shelf life, lower bread staling and that was related to lower setback values.

Table 1. Rheological properties of wheat flour dough and SLSF substituted wheat flour dough measured by Mixolab.

Treatment	Flour moisture (%)	Water absorption (%)	Dough Stability (min)	C1 Min[2]	C2 (Nm)[3]	C3 (Nm)[4]	C4 (Nm)[5]	C5 (Nm)[6]	Setback (Nm)
Ctrl[7]	13.6 a	56.0 d	8.30 c	1.42 g	0.39 a	1.80 a	1.40 a	1.89 d	0.49 g
L5	13.2 b	56.8 c	7.30 e	3.62 f	0.38 b	1.70 b	1.22 b	1.81 e	0.57 f
L10	12.9 d	57.5 b	6.28 f	3.95 e	0.32 d	1.64 c	1.15 c	1.75 g	0.59 e
L15	12.4 f	57.8 a	5.17 g	4.07 d	0.29 e	1.58 e	1.10 d	1.66 f	0.65 d

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF
[1]= treatment,[2]= Time to reach dough development, [3]= Torque at the end of stage 2 in Mixolab curve, [4]= Torque at the end of stage 3 in Mixolab Curve, [5]= Torque at the end of stage 4 in Mixolab Curve, [6]= Torque at the end of stage 5 in Mixolab Curve, [7]= control.

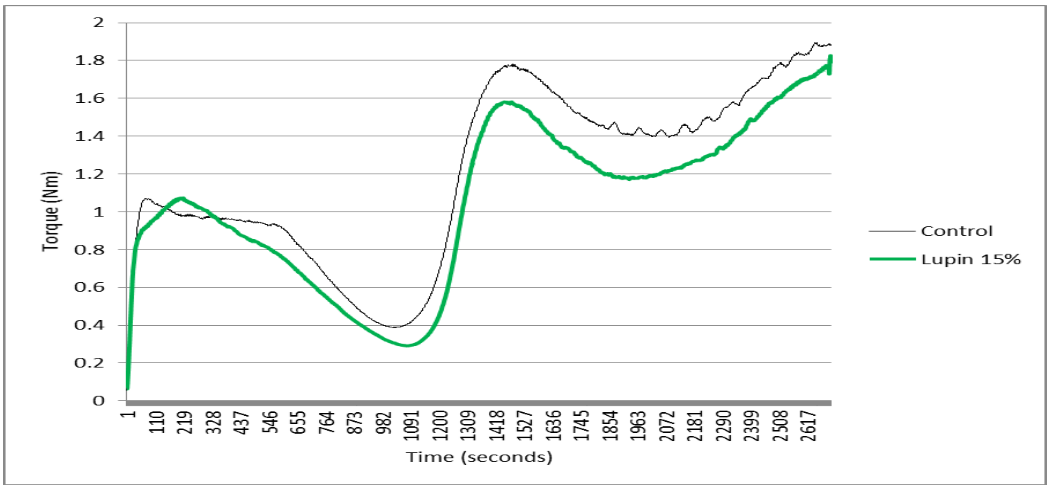

Fig. 1. Mixolab curve of control wheat flour and 15% SLSF

Sensory evaluation

Sensory evaluation of the breads samples of control and added SLSF including (aroma, crust color, crumb color, texture, taste and overall acceptability) is given in Table (2). From the data, it is clear that bread sample enhanced with 5% SLSF was the most acceptable and got the highest scores of aroma, taste and overall acceptability being 8.6, 8.8 and 8.8, respectively. The 10 and 15% added SLSF bread samples had scores less than these of the control and the 5% added SLSF bread samples but it was still accepted for consumer as all scores were over 6.

In SLSF fortified bread, the mean comparison of scores of different sensory attributes such as aroma, crust and crumb colors, taste and overall - acceptability were recorded and found to be non significant ($P \geq 0.05$) compared with control sample. These results are in harmony with those found by Lee and Choi (2013) who reported a decreased scores of sensory attributes with the addition of *Ecklonia cava* powder.

Table 2. Sensory evaluation of control and SLSF substituted pan bread

Treatment	Aroma (9)	Crust color (9)	Crumb color (9)	Texture (9)	Taste (9)	Overall acceptability (9)
Control	8.4 ab	8.6 a	8.6 a	8.4 a	8.2 ab	8.2 ab
L5	8.6 a	8.4 a	7.8 ab	8.2 a	8.8 a	8.8 a
L10	8.2 ab	8.0 a	7.8 ab	7.0 bc	8.6 a	7.8 b
L15	8.2 ab	7.8 ab	7.6 ab	6.4 cd	7.2 cd	7.6 b

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF

Physical properties of bread

Physical properties of bread samples (control and SLSF enhanced) are presented in Table (3). Highest specific volume (2.83 g/cm3) was that of control treatment, that might be because the gluten network was perfect comparing to the gluten network in the enhanced SLSF bread samples. The 15% SLSF had the lowest specific volume (2.64 g/cm3). A significant reduction in loaf volume was observed as the levels of SLSF increased. Lower specific volume values of the SLSF added bread may be due to the lower gluten in the additives which led to weaker gluten network and less gas trapping, which might be strongly related to higher bread hardness reported in the previously discussed bread texture (Dervas *et al*., 1999, Doxastakis *et al*., 2002).

Texture is a manifestation of the rheological properties of all food product, as a result, texture influence food processing, handling, shelf life stability and consumer acceptability (Agyare *et al*., 2005). Texture profile values of bread samples was presented in Table 3.

First compression peak force of the of the product or force required to compress food sample between the molars presents hardness, defined as force necessary to attain a given deformation (40%). Definitions of hardness simulates the first bite feeling in mouth. Data presented in table 3 showed that SLSF proportional addition to bread gradually increased its hardness values. Lowest hardness (6108 g) was scored by Control bread, while the addition of 5, 10 and 15 % of SLSF increased bread hardness to 6806, 7753 and 8211 g, respectively.

Lower bread loaves volume of SLSF enriched bread compared to the control made the bread structure more compressed, therefore it gave harder texture. These findings was in accordance with the discussion of Dervas *et al*. (1999); Doxastakis *et al*. (2002); Kohajdova *et al*., (2011) who mentioned that, smaller loaf volume was found to have a negative effect on its quality attributes, such as hardness, crumb grain and tenderness.

Hardness is the first positive peak force as bread resist compression by the probe exactly the same when it resist compression under teeth, while the negative peak simulate the stickiness or adhesiveness of bread samples to teeth. Adhesiveness is defined as the work necessary to overcome the attractive forces between the surface of the food and the surface of other materials with which the food comes into contact (e.g. tongue, teeth, palate), or the work required to pull food away from a surface. It was noticed that stickiness values had the same trends of hardness values. This is probably due to higher contents of protein in lupin comparing to wheat flour. Increased stickiness with increased protein contents were also reported by (Zhu *et al*., 2001) who found that, stickiness of steamed bread and dough were higher with the gradual increase of protein contents.

Gluten dilution with the SLSF addition caused lower active gluten network and a lower gas trapping within dough caused decreased the gas to volume ratio, that led to an increase in bread hardness. Increase of hardness through the compression and decreased trapping of gas and increased stickiness makes bread samples more chewable (Table 3).

Chewiness is the bread slice chewing ability; it can be calculated from gumminess and springiness multiple analyses by the Texture analysis software. Following the increased of both parameters gumminess and springiness, chewiness of bread samples enhanced with SLSF were higher than control samples. Control bread sample recorded the lowest chewiness value (1227 g), while 15% SLSF bread gave the highest value (2295 g) (Table 3).

Springiness measures the food structure recovery after its deformation in the first compression (Guine and Barroca, 2012). Springiness gradually increased with the addition of SLSF from 0.48 in control bread to 0.56 in the 15% SLSF enhanced bread. Cohesiveness and springiness values were also increased when SLSF was added to bread formula. These results comes in accordance with results of Onyango *et al*. (2015).

Table 3. Physical properties of control and SLSF enhanced pan bread

Treatment	Volume (cm^3)	Specific Volume (g/cm3)	Hardness (g)	Stickiness (g)	Adhesiveness	Chewiness (g)	Gumminess (g)	Springiness	Stringiness
Control	1892 a	2.83 a	6108 g	1511g	3502g	1227g	2634g	0.48 e	2.23 a
L5	1846 b	2.79 b	6806 f	1762 e	3805e	1541f	3026f	0.52 d	2.15 b
L10	1811 c	2.71 c	7753 d	2261 d	4094c	1991d	3794d	0.53 cd	2.04 e
L15	1788 d	2.64 d	8211 b	2405 b	4984a	2295b	4181b	0.56 b	2.03 e

L5:5% SLSF, L10:10% SLSF, L15: 15% SLSF

Color of bread

Color of bread is an important character that affects consumer preferences (Yoo *et al*., 2006). Crust color of bread is produced from Maillard and caramelization reactions during baking process (Jusoh *et al*., 2007). The SLSF used in this study is yellow color, thus, it was expected that the obtained bread supplemented with SLSF will have different color according to level of addition. Table 4 shows the crust and crumb color values for bread samples supplemented with SLSF. In general, *L** values (lightness) of crust are lower than its values in crumb due to the browning reaction in crust which give darker color. Bread sample supplemented with SLSF had higher *L** values for crust than control. Bread sample supplemented with 15% had the highest *L** value (48.6), while control sample had the lowest *L** value (38.1) for crust. As the level of SLSF increases the *L** values were significantly increased. The addition of SLSF led to slightly darker crumb (lower *L** values). Control sample had the highest whiteness index (WI) for crumb (64.44) than SLSF added samples. Bread samples supplemented with SLSF had significantly darker crumb color than control sample. Ballolli *et al.* (2014) observed similar results in the bread supplemented with foxtail millet. They found that bread crumb color was changed from white to dull yellowish with increased incorporation of millet flour.

Table 4. Color values of control and SLSF substituted pan bread

Sample	*L**	*a**	*b**	C*	WI	Δ E
			Crust color			
Control	38.1^g	10.7 a	15.3 f	18.7 f	35.3 g	0.00 g
L5	39.4^f	10.4 b	15.3 f	18.5 g	36.7 f	1.44 f
L10	42.3 e	10.2 c	16.5 e	19.5 d	39.1 e	4.51 e
L15	48.6 b	10.1 d	20.0 a	22.4 a	44.0 b	11.63 b
			Crumb color			
Control	70.3 a	-1 d	19.6 d	19.6 d	64.4 a	0.00 g
L5	69.1 b	-1.7 g	21.6 c	21.6 c	62.3 b	2.46 f
L10	68.1 c	-1.1 f	21.7 b	21.8 b	61.4 c	3.12 e
L15	67.8 d	-1.1 e	22.5 a	22.5 a	60.7 d	3.87 d

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF

The values of *a** which indicate the redness (+*a**) and greenness (-*a**) generally higher in crust than in crumb due to Maillard reaction during crust formation. There was gradual decrease in a values for bread crust with the increase levels of SLSF. Control bread had the highest red component *a** (10.73) while, bread supplemented with 15 % SLSF had the lowest a value (10.1) for crust (Table 4).

Higher incorporation of SLSF showed significantly increased in *b** values (yellowness) crust compared to control. Bread supplemented with SLSF had higher *b** values compared to the control with a score of 20. Feldheim (1991) and Biolley *et al.* (2000) stated that lupine flour causes a yellowness color due to the presence of fat-soluble pigments, primarily lutein and zeaxanthin.

Increasing the percentage of added SLSF to wheat flour led to slight increase of Chroma (C*) and color difference (Δ E) for crust in all fortified samples. Bread sample fortified with 15% SLSF had the highest C* for crust and crumb (22.4 and 22.5, respectively). The results are in harmony with those obtained by Abou-Zaid *et al*. (2012) and Ballolli *et al.* (2014).

Proximate chemical composition

Gross chemical composition of SLSF was determined and the results are listed in table (5). SLSF contains 8.90% moisture, 38.70% protein, 12.12% fat, 3.22% ash, 2.40% crude fiber and 34.67% carbohydrate.

Results in table 5 showed that moisture contents of enriched bread samples gradually decreased compared to the moisture contents of control sample (41.3%). The addition of SLSF decreased bread moisture contents to be 38.69, 37.61 and 36.04 % in the 5, 10 and 15% SLSF, respectively.

The addition of SLSF with its high protein contents comparing to wheat flour reflected the high content of protein in the prepared bread samples. Protein contents was in the range of 12.1% to 15.7% with lowest value for control and highest value for 15% added SLSF (table 5). SLSF addition to wheat flour was expected to increase protein content of produced bread, science they have high content of protein (38.70% and 33.45%, respectively). Similar findings were observed by Anton *et al*. (2008), who concluded that, the addition of bean flour to wheat flour increased protein contents of tortillas, since legumes are generally higher in protein contents comparing to cereals.

As could be shown from Table 6, a gradual increase in fat contents of bread samples was noticed with the addition of SLSF. Control bread contained 6.19% of fat while addition of 5, 10 and 15% SLSF increased fat contents to be 8.34, 8.72 and 9.50%, respectively.

Fiber contents of enriched bread samples were higher comparing to that of control bread samples, which contained 1.05%. SLSF gradually increased fiber contents to be 2.36, 3.01 and 3.47% by the addition of 5, 10 and 15% of SLSF. Increased fiber contents in SLSF enhanced bread samples is attributed to the higher fiber contents in crude materials (2.40%).

Control bread sample scored the minimum ash content (0.70%) comparing to those of SLSF enriched bread (0.95, 0.87 and 0.67 respectively for 5, 10 and 15% of SLSF addition to bread formula) (Table 5).

There were significant differences ($p<0.05$) among the bread samples in carbohydrate content. Control bread had the highest content of carbohydrate (38.65%), while the bread enhanced with 15% SLSF had the lowest carbohydrate content (34.72%). These results are closed to those found by Seleem and Omran (2014), who reported that addition of beans caused an increased in ash and fiber contents of prepared bread.

Table 5. Chemical composition of raw SLSF and prepared pan bread

Treatments		Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	*Carbohydrate (%)	Energy (KCal/100g)
Raw Materials	SLSF	8.9	38.7	12.12	3.22	2.4	34.7	402.7
Bread samples	Control	41.3 a	12.1 g	6.2 g	0.70 f	1.1 g	38.7 a	258.7 g
	L5	38.7 b	14.0 e	8.3 c	0.95 d	2.4 f	35.7 e	273.7 c
	L10	37.6 d	14.2 c	8.7 b	0.87 e	3.0 d	35.6 f	277.7 b
	L15	36.0 f	15.7 a	9.5 a	0.67 g	3.5 c	34.7 g	286.9 a

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF
***Carbohydrate was calculated by difference.**

Antioxidant activity

Total phenolic compounds (TPC) were 5.24 mg Gallic acid equivalent/ 100g (GAE/100g) in wheat flour, and 7.78 GAE/100g in the SLSF. DPPH scavenging activity of wheat flour was 64.3% and was 87.9% in the SLSF (Table 6).

Table 6: Antioxidant properties of raw materials and prepared pan bread

Treatment		TPC mg Gallic acid equivalent/g	DPPH Scavenging Activity %
Raw Materials	Wheat flour	5.24	64.3
	SLSF	7.78	87.9
Bread samples	Control	1.03 d	82.10 d
	L5	1.17 cd	85.80 c
	L10	1.36 b	87.90 b
	L15	1.43 a	91.17 a

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF

Control bread contained the lowest TPC content (1.03 mg GAE/100g) while, samples contained 5, 10 and 15% SLSF had higher TPC contents of 1.17, 1.36 and 1.43 GAE/100g bread, respectively. DPPH scavenging activity percentages of bread samples enhanced with SLSF had also higher DPPH scavenging percentages compared to control bread (85.8, 87.9 and 91.17 in 5, 10 and 15% added SLSF bread samples respectively) while control bread had the lowest value (82.1%). Similar results were found by Swieca *et al*. (2014) who concluded an antioxidant increase with the addition of coriander and quinoa leaves powder to the bread formula.

Minerals content

Minerals content of fortified bread samples are given in Table (7). The high contents of phosphorus, potassium, calcium and iron in the crude SLSF are the main reason of increasing these minerals in the fortified bread. Crude SLSF contained 6.42, 14.67, 1.62 and 0.078µg/g of phosphorus, potassium, calcium and iron, respectively.

Table 7: Minerals contents of raw SLSF and prepared pan bread

Treatment		P (µg/g)	K (µg/g)	Ca (µg/g)	Fe (µg/g)
Raw Materials	SLSF	6.42	14.67	1.62	0.078
Bread samples	Control	2.75 g	2.14 g	0.88 g	0.019 g
	L5	3.83 f	2.96 e	1.64 c	0.033 c
	L10	5.35 d	3.13 d	1.76 b	0.040 b
	L15	6.39 b	3.35 c	2.74 a	0.051 a

L5: 5% SLSF, L10: 10% SLSF, L15: 15% SLSF

Control bread had the lowest phosphorus content (2.75µg/g) while the highest content was observed in bread sample enhanced with 15% LSF (6.39µg/g). Similarly potassium contents with a minimal value of 2.1µg/g in control bread and maximal value of 3.35µg/g in 15% DRSF. Calcium content ranged between 2.74 and 0.88µg/g in 15% SLSF and control sample, respectively. An increase in iron was noticed when SLSF was added increasingly to the bread formula, as control sample bread contained 0.019µg/g of iron while 15% LSF contained 0.051µg/g.

CONCLUSION

Finally it can be concluded that, enrichment of wheat flour with SLSF increased water absorption and weakened the rheological properties of the dough though the dilution and the disturbance of the gluten network. The loaf volume significantly decreased which led to an increased bread hardness. Cohesiveness and springiness increased as SLSF increased. The addition of SLSF led to slightly darker crumb (lower *L** values) comparing to control. Bread sample enhanced with 5% SLSF was the most acceptable for consumer and got the highest scores of the most sensory attributes even when compared to control bread samples, all SLSF added bread samples of different addition levels were accepted to panelists. In conclusion, the 15% substitution level of wheat flour using SLSF could be used to prepare pan bread for its protein contents and high antioxidant activity, with good quality characteristics and consumer acceptability. The enhanced bread with SLSF had higher antioxidant activity, higher mineral contents (*i.e.* phosphorus, potassium, calcium and iron) than control as the crude SLSF had higher antioxidant activity and higher mineral contents than wheat flour.

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تقييم إضافة مسحوق بذور الترمس الحلو على خصائص خبز القالب

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تم دراسة تأثير إضافة مسحوق بذور الترمس الحلو لعمل خلطات مع دقيق القمح بمستويات (٥، ١٠، ١٥%) على كل من: خصائص العجن، الخصائص الفيزيائية، الخصائص الحسية والقيمة الغذائية للخبز. و قد أظهرت النتائج أن زيادة مستوى مسحوق بذور الترمس الحلو أدت الى زيادة كل من: امتصاص الماء، وقت تطور العجين، مدى مقاومة العجين في نهاية فترة العجن بينما أدت زيادة مسحوق بذور الترمس الحلو الى نقص كلا من: رطوبة الدقيق، ثبات العجين، **C4**، **C2, C3, C5** و هذا عند قياس خصائص العجن بواسطة الميكسولاب. أظهر الخبز المصنوع من خلطات مسحوق بذور الترمس الحلو مع دقيق القمح لونا اغمق، حجم نوعي اقل، سطح اصلب، وأظهرت زيادة نسبة مسحوق بذور الترمس الحلو في الخليط الى زيادة نوعية ملحوظة في كلا من مضادات الاكسدة، نسبة البروتين و العناصر المعدنية. كل عينات الخبز المنتجة باستخدام كل الخلطات سواء كانت المعاملة المقارنة او المضاف اليها نسب مسحوق بذور الترمس الحلو المختلفة (٥، ١٠ و ١٥%) كانت مقبولة للمستهلك وذلك عند تقييمها حسيا للرائحة، لون اللبابه و السطح، القوام، الطعم و درجة القبول الكلية. أحرز الخبز المصنوع من نسبة خلط ٥% مسحوق بذور الترمس الحلو مع دقيق القمح أفضل نتائج التقييم الحسي حتى عند مقارنتها بالمعاملة المقارنة.

الكلمات المفتاحية: تدعيم الخبز، الترمس الحلو، الخصائص الريولوجية**.**