Nutritional value, sensory properties, and rheological changes of fortified wheat flour with flaxseed and chickpea flours: Application in toast bread and cookies

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Abstract:

Recently, attention has increased to the production of functional foods using natural sources and bioactive compounds to enhance the functional characteristics of food products. Therefore, the current study aims to strengthen wheat flour (WF72%) with different levels of flaxseed flour (FF) and chickpea flour (CHF) by 20–30% and use it in the production of toast bread and cookies. The results clarified that the chemical composition of FF recorded the highest content of fat (36.78%), ash (4.02%), and fiber (4.36%), while CHF showed the highest values of protein (22.03%) in comparison to WF (control). Adding FF or CHF at different concentrations to WF leads to an increased content of protein, fiber, and ash in composite flours. Also, the fat content of composite flours increased with an increase in FF levels. FF has the significant highest in antioxidant activity, total flavonoids (TFC), total phenols (TPC), and antioxidant capacity. In terms of rheological properties, during the mixing stage in all cases, an increase was observed in the water absorption; arrival time and behavior of dough development, while a decrease in stability time compares WF. Texture and overall acceptance of toast bread and cookies were also improved at a level of 20% replacement, although the sensory scores showed a decreasing trend with increased addition. It can be recommended that replacing white bread with bread fortified with flaxseed and chickpea flours, could positively impact its technological, nutritional, and functional properties.

Keywords:

Bakery products – antioxidants – functional- legume -flaxseeds flour- physiological taste assessment.

Introduction

Food products produced from composite flour have similar properties to those made from whole-wheat flour. Composite flour is created to have specific nutrient and functional properties and is obtained from cereals as a source of protein with or without wheat flour **(Noorfarahzilah *et al.*, 2014).** Wheat bread is a cheap staple diet, but its low amount of lysine and other important amino acids is a significant nutritional drawback. Legumes are considered an environmentally sustainable protein source with the ability to increase the nutritional value of breads **(Srivastava and Chakraborty, 2018).** Also, most cookies are manufactured with wheat flour, which is low in some major nutrients and amino acids; they can be fortified to increase their nutritional value with a variety of fiber- and protein-rich ingredients **(Kaur *et al.*, 2019).**

Legumes have a high concentration of bioactive chemicals such as fibers and essential amino acids, which may supplement some nutritional and functional qualities and/or inadequacies of a cereal-based diet. Adding legume flour to wheat bread merits special consideration **(Rizzello *et al.*, 2014)**. Chickpeas are regarded as a wholesome, nutrient-dense food that has a high protein level and is rich in fiber, vitamins, minerals, and vital amino acids **(Milán-Carrillo *et al.*, 2007; Jukanti *et al.*, 2012 and Capurso et al., 2018)**. Chickpea flour has no effect on the texture of food products made with it; it has improved health benefits. The amount of carbohydrates and fat in food products can be greatly reduced by a slight addition of this flour, while the amount of protein, fiber, and mineral elements increases. Chickpeas and their protein may reduce the amount of acrylamide that forms in baked goods made with wheat flour **(Rachwa-Rosiak *et al.*, 2015).** Flaxseeds (*Linum usitatissimum L.)* are a plentiful source of nutritional and bioactive substances (protein, oil, mucilage and lignans), and vitamins, minerals, and antioxidants may be partially responsible for the health advantages. One of the crucial phytochemicals found in foods made from plants is phenol, so numerous products are now offered in a variety of forms on the market **(Wang *et al.*, 2017 and Campos-Vega *et al.*, 2020)**. So, The main object of current study is the production of bread fortified with natural different levels of FF and CHF and evaluating the chemical composition, rheological behavior, sensory attributes and functional of toast bread and cookies compared with ordinary bread.

Materials and Methods

Materials

Flaxseeds, chickpeas, wheat flour (72%) yeast, eggs, sugar, butter, vanilla, baking soda, milk, and chocolate the main ingredients used in this study were obtained from a local market in Minia City, Minia Governorate, Egypt.

Reagents and chemicals

All solvents and chemicals were obtained from El-Gomhoryia Company for chemicals, medical instruments and trading drugs in Cairo, Egypt.

Methods

Preparation flaxseed and chickpea flours

According to **Marpalle *et al*., (2014),** flaxseeds were roasted in a skillet at 80 to 90 °C for ten minutes, and then flaxseed flour was made using a laboratory grinder (Toshiba ElAraby, Egypt) and sieved. Chickpea flours were processed according to **Costa *et al.* (2020),** by submerging them in water (3 parts water to 1 part grain) for 12 hours, drying them at 180 °C for 1 hour in an electric oven, then pulverizing and sieving them through a mesh size of 10 to become fine flour. All flour samples were filled and kept in glass jars at 4°C until they were analyzed, and products prepared**.**

Preparation of flour blending

Flaxseed flour and chickpea flour at levels of 20 and 30% have been mixed with wheat flour. The flour blends were then maintained in the refrigerator in an airtight container for further process analysis and product preparation after being individually packaged in sealed polyethylene bags.

Photo (1): Flaxseeds flour

Photo (2): Chickpea flour

Preparation of toast bread

According to **Nassef *et al.*, (2023),** make toast bread with a few adjustments, as stated in Table (A). Combine the ingredients (butter, sugar, salt, and yeast) with the flour; gradually add the water and milk; and then knead the dough for 5 to 10 minutes, or until it is soft and smooth. The dough should be covered and placed in a sizable bowl with plastic wrap, where it should rise for about 55 minutes or until puffy. Mold is used to contain the dough. 30 minutes were spent resting the dough, followed by 30 minutes of baking at 180°C, air cooling, and storage in polyethylene bags for sensory characteristics.

Table (A): Formula of toast bread

Samples / Ingredients	WF 100%	FF 20%	FF 30%	CHF 20%	CHF 30%
WF	440 g	352 g	308 g	352 g	308 g
FF	___	88 g	132 g	___	___
CHF	___	___	___	88 g	132 g
Butter	42 g	42 g	42 g	42 g	42 g
Salt	6 g	6 g	6 g	6 g	6 g
sugar	22 g	22 g	22 g	22 g	22 g
Moist Yeast	7 g	7 g	7 g	7 g	7 g
Water(ml)	174	174	174	174	174
Milk (ml)	125	125	125	125	125

Preparation of cookies

Cookies were made according to **Mohibbullah *et al.*, (2023)** method with a few adjustments, as stated in Table (B). To prepare the dough, the butter was combined with the powdered sugar, followed by the eggs, vanilla, flour, salt, and baking soda. The dough was then formed using gloves and chocolate chips, baked for 20 minutes at 170°C, allowed to cool naturally, and then placed in polyethylene bags for use in sensory testing.

Table (B): The Formula of cookies

Samples / Ingredients (g)	WF 100%	FF 20%	FF 30%	CHF 20%	CHF 30%
WF	200	160	140	160	140
FF	___	40	60	___	___
CHF	___	___	___	40	60
Butter	100	100	100	100	100
Salt	0.5	0.5	0.5	0.5	0.5
Backing soda	5	5	5	5	5
Vanilla	3	3	3	3	3
Powder Sugar	160	160	160	160	160
Chocolate chips	100	100	100	100	100
Egg	1	1	1	1	1

Chemical properties

Fiber, ash, moisture, protein, and fat contents were determined according to **A.O.A.C: (2012)**; carbohydrate content was calculated as follows:

Carbohydrate (%) = 100 – (fat % + moisture% + fiber % + ash % +protein %).

Energy (kcal) = 4 (g carbohydrate) +4 (g protein) + 9 (g fat).

Determination of total flavonoids, total phenolic content, antioxidant activity and total antioxidant capacity

Abu Bakar *et al.*, (2009) colorimetric method was used to determine the total flavonoids for WF, CHF and FF. Total phenol content is determined according to **Musa *et al.*, (2011)** by using the Folin-Ciocalteu reagent. Antioxidant activity was calculated by **Oms-Oliu *et al.*, (2009).**

The 2, 2- diphenyl -1 picrylhydrazyl (DPPH) radical scavenging ability was performed, the antioxidant ability was calculated using the following equation:

$$AA\% = \frac{Abs_{DPPH} - Abs_{sample} \times 100}{Abs_{DPPH}}$$

Where:

AA: antioxidant ability.

Abs $_{DPPH}$: absorbance of DPPH- free radical solution in methanol.

Abs $_{sample}$: absorbance of DPPH- free radical solution mixed with sample extract.

The determination of total antioxidant activity was done as per the phospho-molybdenum method with some modifications **Kanika *et al*., (2015).**

Determination of rheological dough

According to **A.A.C.C, (1969)** methods were tested for farinograph and extensograph for WF and composite flours with a mix of FF and CHF at different levels of 20 and 30%. The following equation was used to calculate absorption values:

$$\textbf{Absorption \%} = (x + y - 300) / 3$$

Wherever:

x: ml of water needed to generate the curve with maximum matchmaking entered on 500 BU. Line.

y: flour grams equal to 300 g of 14 percent moisture foundation.

The extensograph test effects were determined as extensibility, resistance to extension and energy (region under curve, cm^2).

Evaluation of sensory properties of toast bread and cookies

30 panelists, comprising faculty, postgraduates, and students from the Faculty of Specific Education at Minia University in Egypt, participated in the sensory evaluation. Each participant received five randomly coded samples of each product on a round glass plate. The products (toast and cookies) were created with composite wheat flour and a mix of flaxseed and chickpea flour (20 and 30%). A 10-point scale was used to evaluate the odor, taste, texture, overall acceptability, and color of the samples. To rinse the samples in between, water was provided.

Ethical Approval

Experiments, especially the sensory evaluations for this study were approved by the Ethics Committee of Scientific Research, Faculty of Specific Education, Minia University.

Statistical Analysis

Using the General Linear Model software as a statistical analysis method we analyzed data **(SAS, 2003)** and used double range tests to compare the average **(Duncan, 1955)**.

Result and Discussion

Chemical analysis and nutritional value of wheat, flaxseeds, and chickpea flour

The proximate composition of WF, FF, and CHF are presented in Table (1). The results clarified that the protein content of WF, FF and CHF were 10.75, 20.50 and 22.03 %, respectively, while the moisture content varied from 10.21, 2.39 and 10.65% for FF, CHF and WF, respectively. Also, our findings show that the fat content of samples varies between 37.98% for FF, 7.25% for CHF, and 1.56% for WF, respectively. Carbohydrate content for FF, CHF, and WF was 22.93, 65.26, and 76.33%, respectively. The content of ash varies between 0.59, 2.03 and 4.02 %) for WF, CHF, and FF, respectively. And fiber was 0.15, 1.04, and 4.36 %) in WF, CHF and FF respectively.

FF had the highest content of fat (37.98%), ash (4.02%) and fiber (4.36%). **Lu *et al.*, (2020)** indicated that chickpeas are a good source of protein, which could be used as a functional food fortification in food industry applications. Our results agreed with **Man *et al.*, (2021) who** reported that the content of protein, ash and carbohydrate in flaxseed flour was (21, 1.77 and 21.76%) respectively. **Karwasra *et al.*, (2021)** revealed that wheat flour contains 11.7% protein, which is lower than flaxseed flour's protein of 20.06% and confirmed that FF contains the highest amount of fat and ash than WF.

Table (1): Proximate chemical content of WF, FF and CHF

Chemical Composition $g.100g^{-1}$	WF	FF	CHF
Moisture	10.65 ± 0.09 ^{a}	10.21± 0.11^{a}	2.39± 0.39^{b}
Protein	10.75±0.55 ^{C}	20.50±0.56^{b}	22.03±0.05^{a}
Fat	1.56±0.34^{C}	37.98±0.14^{a}	7.25±0.12^{b}
Fiber	0.15±0.04^{C}	4.36±0.36^{a}	1.04±0.7^{b}
Ash	0.59±0.02^{C}	4.02±0.01^{a}	2.03±0.01^{b}
Carbohydrates	76.33±0.27^{a}	22.93±0.19^{C}	65.26±0.38^{b}

Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at p<0.05.

CHF showed the highest value of protein (22.03%) in comparison to WF. **Gonzales *et al*., (2016)** explained that legumes contain three times as much dietary fiber as wheat flour. The data were nearly identical to the results provided by **Ouazib *et al*., (2016)** who reported that chickpea content in protein, carbohydrate, fat, and ash was about 21.44, 66.49, 6.85 and 3.07%, respectively. **Hamid and El-Shimy, (2013)** explained that the protein and fat content of chickpea flour were 22.82 and 7.03%, respectively. Also, the results are similar to those by **Mohammed *et al***., **(2014)** who revealed that chickpea flour contained 21.9% protein and 6.3% fat, respectively.

Chemical analysis and nutritional value of wheat flour mixed with flaxseeds and chickpea flour.

The effect of the incorporation of different ratios of legume flours on the chemical properties of wheat flour is discussed in Table (2). Our findings demonstrated that substituting flaxseeds and chickpea flour for wheat flour increased the nutritional content. CHF 30 had the highest value of protein (14.13%). **Hefnawy *et al*., (2012)** reported that composite flours made from wheat and chickpea flour showed high protein content. On the other hand, the moisture content of composite flours decreased when the ratio of FF and CHF increased. WF100 was observed to have the highest moisture content (10.65%) and the lowest for CHF30 (8.17), which means it is highly affected by the blending of chickpea flour, which could be due to a reduction in the moisture content of legumes in composite flours **(Kaushal *et al*., 2012).**

Flaxseed flour was found to be a good source of fat, so the addition of 20 and 30% caused an increase in the level of fat to (8.84 and 12.48%) respectively, while the WF100 content was 1.56%. Our results agree with **Kaur *et al*., (2017)** who reported that the fat content of composite flours increased with increased levels of FF replacement.

Table (2): Proximate chemical content of WF mixed with FF and CHF at levels 20 and 30%

Chemical Composition (g.100g)$^{-1}$	WF 100%	FF		CHF	
		FF 20%	FF 30%	CHF 20%	CHF 30%
Moisture	10.65 ±0.09[a]	10.56 ±0.48[a]	10.52 ±0.03[a]	9.0 ±0.05[b]	8.17 ±0.08[c]
Protein	10.75 ±0.55[c]	12.70 ±0.54[b]	13.67 ±0.54[ab]	13 ±0.42 [ab]	14.13 ±0.37[a]
Fat	1.56 ±0.034[e]	8.84 ±0.25[b]	12.48 ±0.20[a]	2.7 ±0.25[d]	3.27 ±0.20[c]
Fiber	0.15 ±0.04[d]	1.00 ±0.11[b]	1.40 ±0.13 [a]	0.33 ±0.05[cd]	0.42 ±0.05[c]
Ash	0.59 ±0.02[e]	1.27 ±0.01[b]	1.61 ±0.01 [a]	0.87 ±0.01[d]	1.02 ±0.01[c]
Carbohydrates	76.33 ±0.28[a]	65.64 ±0.25[d]	60.31 ±0.24[e]	74.11 ±0.23[b]	73.01 ±0.21[c]

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%).
Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at $p<0.05$.

The results from Table (2) demonstrated that substituting flaxseed and chickpea flour for wheat flour increased the fiber and ash content in composite flour samples. FF 30 had the highest values of fiber and ash (1.40 and 1.61%). Results agreed with **Rochfort and Panozz, (2007) who** studied the possibility of enriching cereal flour with legume flour sources, adding FF or CHF at different concentrations to WF caused an increase in the fiber and ash content of the composite flour; and **Kaur *et al.*, (2017)** confirmed that FF contains high fiber and ash. On the contrary, the results showed that the carbohydrate content of compound flour decreased as the proportion of other flours increased; the highest percentage of carbohydrates was in WF100 (76.33%) and the least was in FF30 (60.31%), which is because of the high content of wheat flour from carbohydrates.

Nutritional evaluation of WF, FF and CHF

The nutritional evaluation of **WF, FF and CHF** are investigated in Table (3). The data presented showed that the energy (Kcal/100g) in FF, CHF and WF was 515.52, 414.43 and 362.33%, respectively. FF has the highest energy content (515.52 Kcal/100g) when compared with WF and CHF. Our findings agree with **Prajapati *et al.*, (2016)** who reported that the energy content of flaxseeds was 566.27 kcal/100g. And **Wood and Grusak, (2007)** found that the energy content of chickpea types varied from 334 to 446 Kcal/100g, which resembles our results (414.43 Kcal/100g) for energy. CHF was ranked second in energy content after FF compared to WF. **World Health Organization, (2003)** advised consuming energy foods such as chickpeas, which contain a high content of non-starch polysaccharides.

Table (3): Nutritional evaluation of WF, FF and CHF

RDA (1989)	Chemical composition	WF	FF	CHF
2900 Kcal	Energy (Kcal/100g)	362.33±1.89[c]	515.52±2.69[a]	414.43±2.12[b]
	* G.D.R. (g)	800.38±4.17[a]	562.53±2.95[c]	699.76±3.61[b]
	**P.S./ 100 g	12.49± 0.06[c]	17.77±0.11[a]	14.29±0.09[b]
63 g	Total protein (g/100g)	10.75±0.55[c]	20.50±0.56[b]	22.03±0.05[a]
	*G.D.R. (g)	587.69±28.93[a]	307.56±8.39[b]	286.01±0.62[c]
	**P.S./ 100 g	17.05±0.87[c]	32.53±1.09[b]	34.95±0.95[a]
Dry matter (%)		89.35±0.09[b]	89.79±0.11[b]	97.61±0.40[a]

Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at p<0.05.
* G.D.R. (g): Grams ingested to meet an adult man's recommended daily allowance (RDA) (1989
** P.S. /100 (%): Percentage of adult man RDA satisfaction when consuming 100g powders of (wheat, flaxseed, and chickpea flour).

From the results in Table (3), it was noticed that the gram daily required obtaining the RDA of energy varied between 800.38, 699.76, and 562.53g for WF, CHF, and FF, respectively. Also, results clarified that when consuming 100g powders of WF, FF, and CHF, they will cover (12.49, 17.77, and 14.29 %) respectively, of the recommended daily allowance (RDA) of man in energy**.** As well as the GDR (g) of WF, CHF, and FF to obtain the RDA of protein varied between 587.69, 286.01 and 307.55g, respectively; and taking 100g the powders of WF, FF and CHF will cover 17.05, 32.53 and 34.95% of the RDA of man in protein. **Jain, (2023)** reported that flaxseeds have a high physiological energy value, low carbohydrate content and a high percentage of proteins, fiber, calcium, iron, and phosphorus. **Kohajdová *et al*., (2011)** explained that chickpea flour has a high content of fat, protein, and ash in comparison to wheat flour.

Nutritional evaluation of WF mixed with FF and CHF at levels (20, 30%)

The effect of the incorporation of different ratios of flours on the nutritional evaluation properties of composite flours is shown in Table (4). Results clarified that the energy content of composite flours increased with an increase in the ratio of other flours compared to WF100. The highest energy content was observed for FF30 (408.29 Kcal/100g) and the lowest for WF100 (362.33 Kcal/100g), which means the blending of flaxseed flour is highly affected by increased energy.

GDR (g) for energy varied from 729.03 to 800.38% depending upon the energy content of each blending proportion. So, the percentage of adult man RDA satisfaction when consuming 100g powders of composite flours consisting of wheat, flaxseed, and chickpea differs according to energy content; P.S./100g for energy was 12.49, 13.28, 13.71, 12.81, and 12.98% for WF, FF20, FF 30, CHF 20, and CHF 30 respectively.

Table (4): Nutritional evaluation of WF mixed with FF and CHF at level (20 and30%)

RDA (1989)	Chemical composition	WF 100%	FF		CHF	
			FF 20%	FF 30%	CHF 20%	CHF30 %
2900 Kcal	**Energy (Kcal/100g)**	362.33 ±1.89e	392.97 ±1.01b	408.29 ±0.59a	372.75 ±1.2d	377.96 ±0.90c
	*** G.D.R. (g)**	800.38 ±4.17^{a}	752.81 ±2.78^{d}	729.03 ±2.09^{e}	780.25 ±2.81^{b}	770.19 ±2.18^{c}
	****P.S./ 100 g**	12.49 ±0.06^{e}	13.28 ±0.10^{b}	13.71 ±0.04^{a}	12.81 ±0.04^{d}	12.98 ±0.03^{c}
63 g	**Total protein (g/100g)**	10.75 ± 0.55^{cd}	12.70 ±0.5b^{c}	13.67 ±0.54^{ab}	13.00 ±0.42^{ab}	14.13 ±0.37^{a}
	***G.D.R. (g)**	587.7 ±28.93^{a}	531.67 ±24.66^{b}	503.65 ±22.53^{b}	527.39 ±23.03^{b}	497.22 ±20.07^{b}
	****P.S./ 100 g**	17.05 ±0.87^{b}	18.87 ±0.95^{ab}	19.89 ±0.92^{a}	18.99 ±0.85^{ab}	20.14 ±0.85^{a}
Dry matter (%)		89.35 ±0.09^{c}	89.44 ±0.05^{c}	89.48 ±0.03^{c}	91.00 ±0.05^{b}	91.83 ±0.08^{a}

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%).
Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at $p<0.05$.
* G.D.R. (g): Grams ingested to meet an adult man's recommended daily allowance (RDA) (1989
** P.S. /100 (%): Percentage of adult man RDA satisfaction when consuming 100g powders of (wheat, flaxseed, and chickpea flour).

The protein content of composite flours ranged from 12.70 to 14.13 g/100g compared to WF protein content (10.75%), depending upon the blending proportions. The results clarified that the protein content of composite flours increased with an increase in the ratio of other flours compared to WF. The highest protein content was observed for CHF30 (14.13 g/100g) and the lowest for WF100 (10.75 g/100 g), which means the blending of CHF greatly increased the nutritional value of WF. GDR for protein varied from 497.22 % to 587.7% depending upon the protein content of each of the blending proportions. The lowest GDR for protein obtained by CHF30 was (497.22 g), followed by FF 30 (503.65g). It is clear from our previous results in Table (4) that the use of CHF and FF for raising protein and energy content in food products could prevent malnutrition diseases. Our results agreed with **Man *et al*., (2015) and Lu *et al*., (2020) who** confirmed that a chickpea is considered a functional food and useful source of dietary protein because of its high nutritional value and excellent balance of essential amino acids.

Total phenolics, flavonoid, antioxidant activity and antioxidant capacity of WF, FF and CHF

Phenolic acids and flavonoids are the main bioactive phenolic chemicals found in legumes and play important roles; also, polyphenols are known to be the most abundant antioxidants, found largely in plant-based food **(Thabtia *et al*., 2012; Singh *et al*., 2017 and Samtiya *et al*., 2020).** The data in Table (5) shows the total phenolic content of the varied samples studied (WF, FF, and CHF). Total phenolics were 95.63, 357.16 and 122.57 (mg GAE /100g) in WF, FF and CHF respectively. Our results disagree with those obtained by **Pourabedin *et al*., (2017**) who reported that the total phenol content in FF was 56.92 mg/100g, and **Kaur *et al*., (2017)** found that the total phenol content in FF was 91.8 mg/100g.

Total flavonoids content was 92.90, 191.97 and 106.50 mg quercetin /100g in WF, FF and CHF respectively. By comparing WF and based on the obtained results, there are observed significant differences ($P<0.5$) between WF and (FF, CHF) in terms of flavonoid content. WF showed a lower flavonoid content (92.90 mg quercetin /100 g), while FF showed a higher content (191.97 mg quercetin /100g). This result confirmed that FF has the highest content of total phenolics and flavonoids compared to WF and CHF. Flaxseed has an excellent nutritional profile and antioxidants **(Kaur and Kaur, 2018)**. Our results differed from those by **Anwar and Przybylski, (2012)** who found that the total flavonoid content of FF was (20–60 mg quercetin/100g). **Johnsson *et al*., (2002)** reported that the total flavonoid content of flaxseeds ranges from 35 to 71 mg quercetin/100g.This difference in results can be due to the different types of samples and methods for extraction and analysis.

Table (5): Total phenols, flavonoids, antioxidant activity and antioxidant capacity of WF, FF and CHF

Parameters	WF	FF	CHF
Total phenolics content (TPC) (mg GAE/100g)	95.63 ±0.17[c]	357.16 ±6.67[a]	122.57 ±3.85[b]
Total flavonoids (mg quercetin /100g)	92.90 ±2.2[c]	191.97 ±2.97 [a]	106.50 ±5.55[b]
Antioxidant activity (AA %)	51.87 ±1.59c	83.42 ±1.23 [a]	79.56 ±0.96[b]
Total antioxidant capacity(TAC)	67.15 ±0.70[c]	239.72 ±3.30 [a]	138.25 ±3.76[b]

Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at p<0.05.

Flavonoids and phenolics are examples of phytochemicals that have a variety of biological effects, especially antioxidant activity, and have health benefits to reduce the risk of diseases linked to oxidative stress, such as anti-inflammatory and anti-carcinogenic properties **(Fidrianny *et al*., 2014; Tan and Norhaizan, 2017 and Ravichanthiran *et al*., 2018)**. The quantity and antioxidant activity of phenols, which define how well phenolic compounds can avoid oxidative injury, increase as a result of reactions between antioxidant chemicals and pro-oxidants (**Briante *et al*., 2003 and Villaño *et al*., 2005**). According to **Barreria *et al*., (2008**), polyphenolic chemicals found in plants, such as flavonoids and phenolics, which are crucial in neutralizing free radicals, are the primary cause of the antioxidant activity in plants.

Results in Table (5) indicated that WF, FF and CHF had higher levels of phenolic compounds (95.63 to 357.16%) and flavonoids (92.90 to 191.97%), have antioxidant activities and antioxidant capacity that could be capable of scavenging free radicals. **Shan *et al*., (2005)** confirmed the high positive correlation between antioxidant activity and total phenolic content.

FF had the highest values of antioxidant activities and antioxidant capacity, followed by CHF, while WF showed the lowest values of AA% and TPC. That high value of antioxidant activity in FF could be because flaxseeds contain ferulic acids, *p*-coumaric, caffeic, flavonoids and other phenolic compounds (**Gai *et al.*, 2023).** Also, chickpeas contained a variation in total phenolics and antioxidant activity **(Heiras-Palazuelos *et al.*, 2013);** with the major phenolic subclasses being iso-flavonoids and flavanol's, which enhanced the scavenging of free radicals **(Pannala *et al.*, 2001 and Mekky *et al.*, (2015).** Our results were agreeable **Kaur and Kaur, (2018)** revealed that the DPPH of flaxseed flour was 72.84% and that of wheat flour was 7.82%. **Sahu *et al.*, (2014)** reported that chickpea had a radical scavenging activity value ranging from 36.2 to 49.5% and total amino acid were strongly linked with total flavonoid and total phenol**.**

Total phenolics, flavonoids, antioxidant activity and antioxidant capacity of WF mixed with FF and CHF at levels (20 and 30%)

The content of phenols, flavonoids, antioxidant activity and antioxidant capacity were measured in WF which was replaced by FF, CHF at different levels (20 and 30%) were present in Table (6).

-Total phenol content

The results show that the total phenol content of composite flours increased with the increase in ratio of other flours; TPC ranged from 95.63 to 174.1 mg GAE/100g depending upon the blending proportions. The addition of FF30% led to an increase in TPC nearly twice compared to WF**. Pourabedin *et al.*, (2017)** confirmed that phenolic compounds were increased in bread samples with an increased FF ratio.

-Total flavonoids content

The total flavonoid content of different flour samples ranged from 92.9 to 122.63 mg quercetin /100g. From Table (6), the maximum was in FF30 (122.63 mg quercetin/100 g), whereas WF100 had the lowest value of total flavonoids content (92.9 mg quercetin/100g). The TFC of blended flour increased with the addition of FF.

- Antioxidant activity and total antioxidant capacity

Concerning the antioxidant activity value, it ranged from 51.87 to 61.33%. FF 30 recorded the highest score of AA (61.33%), followed by CHF 30 (60.17%), while WF was replaced by 20 CHF and 20 FF and recorded values of 58.17 and 57.4%, respectively; WF 100 had the lowest AA value (51.87%).

Also, the total antioxidant capacity (TAC) value ranged from 67.15 to 118.9%. FF 30 recorded the highest score of TAC (118.9%), while WF, replaced by 20 and 30% CHF recorded the lowest values (81.37 and 88.48%) respectively. This ability is due to the high content of these samples in phenolic compounds such as phenols and flavonoids. **Cameron and Hosseinian, (2013)** confirmed that flaxseed has health benefits because flaxseed is considered an excellent source of antioxidants such as phenolics. Phytochemicals present antioxidant activity by donating hydrogen and producing stable intermediate radicals **(Samtiya *et al.*, 2020).**

Table (6): Total phenols, flavonoids, antioxidant activity and antioxidant capacity of WF mixed with FF and CHF at levels (20 and 30%)

Parameters	WF 100%	FF		CHF	
		20%	30 %	20%	30 %
Total phenols (mg GAE/100g)	95.63 ±0.20^{e}	147.9 ±1.47^{b}	174.1 ±2.30^{a}	101 ±1.09^{d}	103.7 ±1.55^{c}
Total Flavonoids (mg quercetin /100g)	92.9 ±2.70^{c}	112.72 ±7.58^{b}	122.63 ±10.2^{a}	95.56 ±3.19^{c}	96.98 ±3.47^{c}
Antioxidant activity (AA %)	51.86 ±1.30^{c}	58.17 ±1.43^{b}	61.33 ±1.38^{a}	57.4 ±1.29^{ab}	60.17 ±1.17^{ab}
Total Antioxidant capacity	67.15 ±0.85^{c}	101.7 ±1.18^{b}	118.9 ±1.49^{a}	81.37 ±1.62^{d}	88.48 ±2.00^{c}

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%).
Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same row are significant at p<0.05.

Farinograph parameters

In food manufacturing, the rheological characteristics of dough are necessary, and it is known that the water absorption capacity of flours, which varies among different flour sources, influences the rheological behavior of dough, and the quality attributes of final goods are greatly influenced by the water absorption capacity of flours, which varies among different flour sources **(Barak *et al*., 2013 and Yazar *et al*., 2017).** The effect of the addition of FF and CHF on the rheological behavior of WF measured by Brabender is presented in Table (7). During the mixing stage, in all cases, an increase was observed in the water absorption, arrival time, stability time and behavior of dough development.

-Water absorption

Water absorption is an index of baking quality and refers to the potential of protein molecules to absorb water **(Van Lill *et al*., 1995)**. In addition, **Vizitiu and Danviu, (2011)** found that the gluten strength, starch, and protein content of flour increase water absorption. The highest increase in water absorption was found in FF 20 and FF 30% (66.0 and 70.0%), respectively. This is due to the increased content of protein (20.5%) and fiber (4.36%) in flaxseed flour compared to WF100. Our results agreed with **Xu *et al*., (2014) and Mostafa *et al*., (2019)** who confirmed that the mixture of wheat flour and flaxseed flour leads to an increase in dough absorption of water compared to the control sample. According to the current findings, samples supplemented with CHF absorbed water slightly more readily than wheat flour. This increase may be due to chickpea flour's better water-holding ability (**Sulieman *et al*., 2013).** Results agreed with **Zafar *et al*., (2020)** who explained that the lowest value with the highest replacement of WF with CHF at different levels (10, 20, 30 and 40%) and **Hefnawy *et al*., (2012)** reported that increasing the levels of chickpea flour, showed an increase in water absorption in the dough.

Sulieman *et al*., (2013) and Gadallah, (2017) explained that water absorption in dough was gradually increased with level of chickpea flour replaced (5- 20%), which was due to the increase in protein content of blended flour. **Shahzadi *et al.*, (2005)** confirmed enhanced water holding capacity because of the protein content and increase in pentosans (ribose and deoxyribose).

-Dough development and arrival time

Data in Table (7) and Figure (1) show that the highest dough development time observed was in CHF30 (7.0 min), followed by FF30 and CHF20 (5.5 min). FF30 and CHF30 had the highest dough arrival time values (5.0 and 4.5 min) respectively, compared to all cases.

This finding was consistent with studies from **Pourabedin *et al.*, (2017)** which showed that samples containing FF showed a significantly ($p<0.05$) increased dough development time compared to the control sample. **Koca and Anil**, **(2007)** reported that the presence of gum in flaxseed led to a long development time in dough as a possible result of the difficult flaxseed fiber, wheat flour mixing process.

Table (7): Farinograph parameters of composite dough of WF fortified with FF and CHF at levels (20 and 30 %)

Parameters / Samples	Water absorption (%)	Arrival time (min)	Dough development (min)	Stability time (min)	Degree of softening
WF 100%	58.0 ^{e}	1.5 ^{e}	2.5 ^{d}	11.5 ^{a}	50 ^{e}
FF 20%	66.0 ^{b}	3.0^{c}	5.0 ^{c}	5.5 ^{d}	70 ^{c}
FF 30%	70.0 ^{a}	5.0 ^{a}	5.5 ^{b}	5.0 ^{e}	110 ^{a}
CHF 20%	59.5^{d}	2.5^{d}	5.5^{b}	8.0^{b}	60^{d}
CHF 30%	61.0^{c}	4.5^{b}	7.0^{a}	7.5^{c}	80^{b}

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%)
The values of various letters in the same column average at $p \leq 0.05$ stage is substantially different.

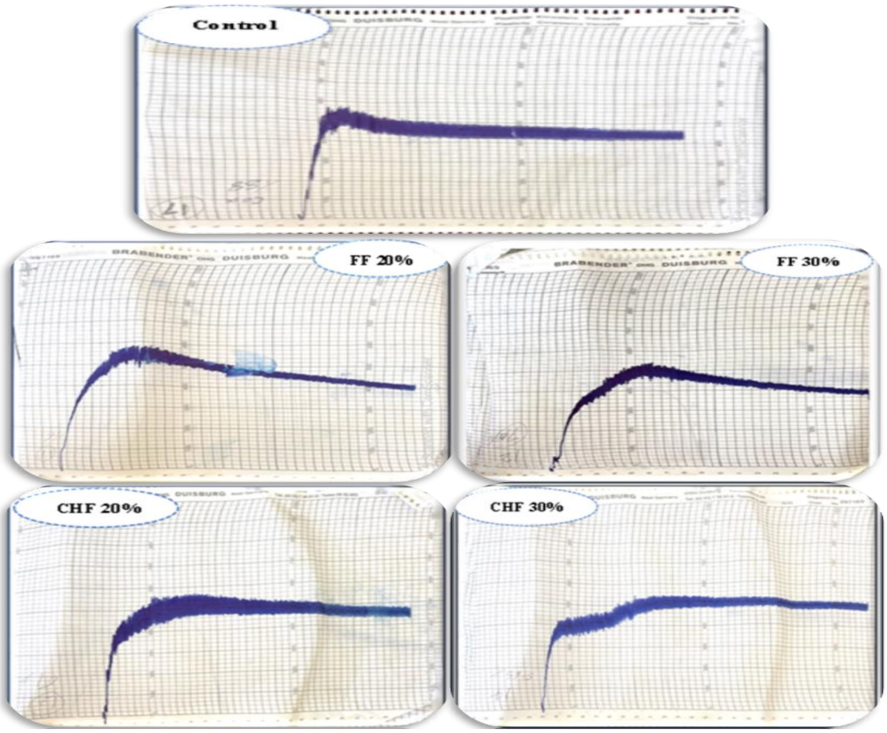

Figure (1): Effect of adding FF and CHF to WF on the farinograph parameters of dough.

-Dough stability time and degree of softening

The addition of legume flour to wheat flour makes the dough weaker and has been shown to enlarge the protein network and linearly dilute the covalently linked gluten network, resulting in the breakdown of the gluten mesh after the appropriate time **(Hefnawy *et al*., 2012 and Laleg *et al*., 2017)**. The reduced gluten content of the flour may be the cause of the observed weakening of the dough **(Barak *et al*., 2013**).

Data in Table (7) shows that dough stability time decreased markedly from 11.5 minutes for the WF100 blend to 5.0 minutes for the FF30 blend, indicating that flour has a limited tolerance for mixing. Results agreed with **Wandersleben *et al*., (2018)** who reported that FF has a large amount of dietary fiber (both soluble and insoluble), and it has been observed that adding FF can boost water absorption. It can also lengthen the development time (by more than double) and cut the stability time (by almost half). Also, **Pourabedin *et al*., (2017**) confirmed that the addition of flaxseed flour to the physico-chemical properties of bread toast has achieved changes in farinograph parameters. It increased the water absorption and development time of the dough and reduced its stability.

Also, results indicated that the degree of softening increased from 50 for the WF100 blend to 110 for the FF30 blend. **Göcmen *et al*., (2015**) explained that high-quality flour is characterized by a high-water absorption combined with a low degree of softening, whereas bad-quality flour is indicated by a high-water absorption paired with a high degree of softening. Thus, the obtained data shows that mixes of chickpea and flaxseed flour have less desirable rheological characterized.

Extensograph parameters

The extensograph measured elasticity, extensibility, proportional number, and energy. The dough's capacity to stretch means the dough's extensibility; it depends on the ratio of gliadin in the dough **(El–Safy, 2013).** Dough extensibility is a rheological property that forms even during dough mixing and its results help to determine dough rheological properties, the amounts of ingredients to obtain them, as well as the possibility of processing and baking. Dough extensibility doesn't depend only on the amount of gluten in the flour and its quality; it also depends on the amount of water added to the mixture **(Munteanu *et al*., 2019).**

Figure (2) shows the results of the extensograph analysis of WF, FF and CHF at different levels (20 and 30%). The energy value is an essential parameter in terms of the dough's resistance to processing; the gas holding capacity and fermentation tolerance of the dough increase when this value is higher. The results of the extensograph parameters presented in Table (8) showed a significant difference (P<0.05) had been decreased in energy from 65 cm_2 for WF100 to 40 cm_2 for FF 20 blend. Also, our results show the elasticity value in samples: the highest value was found in FF 30% (480 B.U), CHF 20 and 30% (440 and 450 B.U) respectively, while WF100 had the lowest elasticity value (430 B.U).

Table (8): Extensograph parameters of composite dough of WF fortified with FF and CHF at levels (20 and 30 %)

Parameters / Samples	Elasticity (B.U)	Extensibility (min)	Proportional number (P.N)	Energy (cm2)
WF 100%	430[d]	155 [a]	3.30 [e]	65 [a]
FF 20%	450[b]	135 [b]	3.43 [d]	45 [d]
FF 30%	480[a]	130[c]	3.66 [b]	40 [e]
CHF 20%	440[c]	120[d]	3.55 [c]	55 [b]
CHF 30%	450[b]	110[e]	3.71 [a]	50 [c]

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%)
The values of various letters in the same column average at $p \leq 0.05$ stage is substantially different.

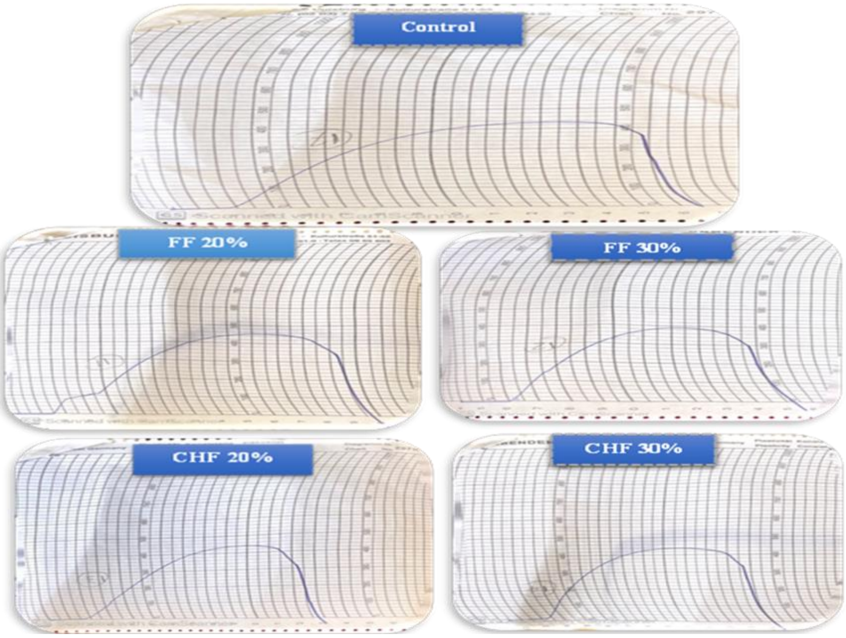

Figure (2): Effect of adding FF and CHF to WF on the extensograph parameters of dough.

Also, data in Table (8) showed the extensibility of control dough (WF) remained higher than that of FF and CHF dough at all replacement levels, as well as the resistance to extension of dough, which showed a significantly reduced reduction, and the induced strength reduction of dough became highly clear with the increasing of CHF and FF as a result of diluted wheat flour gluten by the addition of CHF and FF**. Liu *et al*., (2018)** reported that flaxseed flour contains more lipids, proteins, and fiber; these components can affect the formation of the gluten network by interacting with gluten and starch.

Sensory evaluation

Toast bread

The sensory evaluation of any food item is a fundamental step in the development of food products since it determines whether the product will be accepted or not. The influence of the addition of FF and CHF (20 and 30%) to WF was significant in terms of the sensory characteristics, including color, odor, taste, texture, and overall acceptability of the toast bread, as summarized in Table (9). A significant decrease ($P<0.05$) in all properties was observed in the presence of additional FF and CHF. Moreover, the increase level addition of FF and CHF to WF decreased in odor, taste, and overall acceptability compared to the WF sample.

The results showed a significant difference ($P \leq 0.05$) in the color of the toast bread replaced with 20 and 30% of FF and CHF (photo 3). The color of CHF20 had the highest score value (9.6) compared to all samples. The texture score value shows that is no significant difference ($P \leq 0.05$) between samples (FF30, CHF20 and CHF30), while the WF sample has the highest texture score value (9.55). The most significant and clear changes ($p\leq0.05$) in the flaxseed bakery products were a less soft texture with an increase in the level of replacement. The toast bread product with FF30 had the least value (8.8) in texture; this could be due to the level of substitution of flour incorporation used that affects the texture of the product.

For odor, data showed that the WF100 toast bread has the highest score value (9.6), while FF 20 and CHF 30 have the least score value (8.8). Also, the taste score value decreased in all samples compared to the WF100 sample (9.45). The overall acceptability of toast bread samples ranged from 8.92 to 9.47. WF100 had the highest value followed by FF 20 was (9.47 and 9.25), respectively. Although, the sensory scores of toasts followed a decreasing trend with the increased addition of mix, however, was reasonably good. **Hefnawy *et al*., (2012)** reported that the addition of 30% chickpea flour to the wheat flours led to improved rheological properties; control bread had the highest overall acceptability scores, followed by bread from mixture. And most people who have tried bread from chickpea–wheat flour mixes have found there appears to be a potential market for chickpea flour in bread making **(Mohammed *et al.*, 2012)**. **Sulieman *et al.*, (2013)** confirmed that addition of CHF to wheat flour improved the nutritional value of the bread produced. It also increased the score of essential amino acids, particularly (Lysine) in the bread, which was a deficiency in wheat bread.

Table (9): Sensory evaluation of toast bread and cookies prepared by WF replaced with FF and CHF at (20 and 30%)

Sensory properties	Color	Texture	Odor	Taste	Overall acceptability
Samples	Toast bread 				
WF 100%	9.50 ±0.67[a]	9.55 ±0.50[a]	9.6 ±0.58[a]	9.45 ±0.50[a]	9.47 ±0.58[a]
FF 20%	9.30 ±0.64[a]	9.20 ±0.75[ab]	8.8 ±0.4[b]	8.9 ±0.53[b]	9.25 ±0.70[ab]
FF 30%	8.85 ±0.57[b]	8.80 ±0.51[b]	9.00 ±0.84[b]	9.2 ±0.68[ab]	8.92 ±0.24[b]
CHF 20%	9.60 ±0.58[a]	9.00 ±0.84[b]	9.2 ±0.75[ab]	8.9 ±0.7[b]	8.95 ±0.59[b]
CHF 30%	9.20 ±0.75[ab]	8.92 ±1.03[b]	8.8 ±0.98[b]	8.92 ±0.98[b]	8.95 ±0.92[b]
Cookies 					
WF 100%	9.70 ±0.46[a]	9.60 ±0.58 [a]	9.78 ±0.41	9.90 ±0.3[a]	9.90 ±0.3 [a]
FF 20%	9.65 ±0.36[a]	9. 50 ±0. 5 [a]	9.75 ±0.43	9.55 ±0.67[b]	9.58 ±0.53[b]
FF 30%	9.32 ±0.73[b]	9.15 ±0.65 [b]	9.65 ±0.65	9.62 ±0.52[ab]	9.52 ±0.54 [b]
CHF 20%	9.70 ±0.46[a]	9.65 ±0.48 [a]	9.70 ±0.46	9.70 ±0.46[ab]	9.65 ±0.48 [ab]
CHF 30%	9.75 ±0.43[a]	9.80 ±0.4 [a]	9.80 ±0.4	9.80 ±0.4[ab]	9.75 ±0.43 [ab]

FF 20% = (WF 80% + FF 20%). FF 30%= (WF 70% + FF 30%).
CHF 20%= (WF 80% + CHF 20%). CHF 30%= (WF 70% + CHF 30%)
Values of three independent repeats (n=3) are expressed as the mean ± SD.
Values with different letters in the same column are significant at $p<0.05$.

Cookies

Fortification of cookies is a current development to enhance their nutritional and functional quality because many people eat cookies, which are typically high in calories, fat and carbohydrates but lacking in minerals, fiber, and vitamins **(Loza *et al.*, 2017).** Data in Table (9) shown a significant decrease (P<0.05) of all properties was observed in the presence of additional amounts of flaxseeds to wheat flour for produce cookies. Our data showed significant difference (P ≤ 0.05) in color between samples which ranged from 9.75 to 9.32 obtained in photos (4). The color of cookies with CHF30 was the highest score value (9.75) compared to all samples, while cookies with FF 30 % had less score value (9.32). Results were agreed with **Hamid and Shimy, (2013)** found that samples contain 10 to 20% CHF have high score of overall acceptability, color, taste and flavor of biscuits supplemented with chickpea.

The texture of cookies product shows that there is significant difference (P ≤ 0.05) between all samples. The texture ranged between (9.15 to 9.80); CHF30 had highest texture score value (9.80), while FF 30 had the lowest (9.15); this could be due to the level of substitution of flours incorporation used which affected on texture of the product, and could be due to the higher content of fibre in FF.

Our results agreed with data obtained by **Rajiv *et al.*, (2012)** who showed that the sensory characteristics of cookies especially (color, surface characteristics, texture, and mouth feel) were adversely affected beyond 15% level of FF. The cookies product with 20% FF had brownish color, hard texture and had the lowest total score, which increased hardness in texture of cookies lead to increase the level substitution of FF.

For odor, data present in Table (9) showed that the CHF30 cookies had the highest score value (9.8) followed by WF100 (9.78), while FF20 had the lowest score value (9.75). Also, the result shows that the taste score values was increase with the increase of the level of replacement of CHF but were still have less score value of taste compared to control sample.

Data in Table (9) were presented that WF100 had the highest value in overall acceptability was (9.9) followed by CHF30 was (9.75), respectively. Among the incorporated samples, cookies supplement with 30% FF had the lowest overall acceptability (9.52). Our results agreement with **Kaur *et al.*, (2017)** who explained that control sample had highest score for sensory panelists rated; followed by cookies containing FF 15%, the level of overall acceptability scores of substitutions was decrease with increase the level of replacement.

Man *et al.*, (2021) observed that samples containing FF had a decrease in sensory attributes as compared to the control and the overall appreciation of the biscuits shown didn't significant differences between samples in the aroma, hardness, appearance, chewiness, and taste. Also, **Hussain *et al.*, (2006)** studied the effect of adding flaxseed flour to wheat flour for prepared cookies; result observed that cookies prepared from whole wheat flour had a maximum score, while cookies prepared from 25 and 30% of FF had minimum scores of overall acceptability.

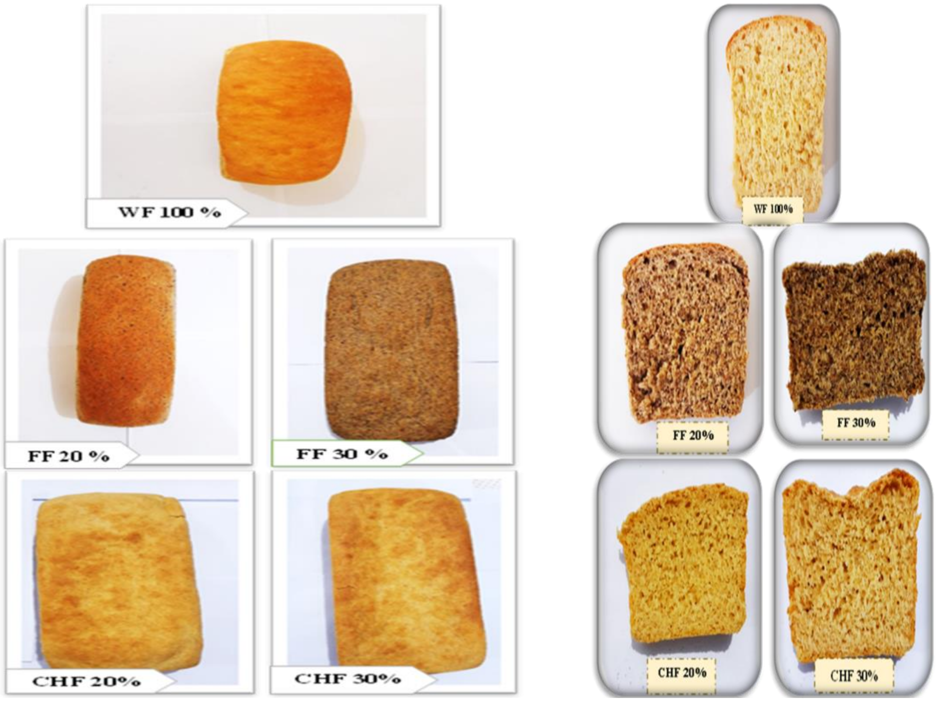

Photo (3): Toast bread prepared by WF replaced with different levels of FF, CHF (20 and 30%)

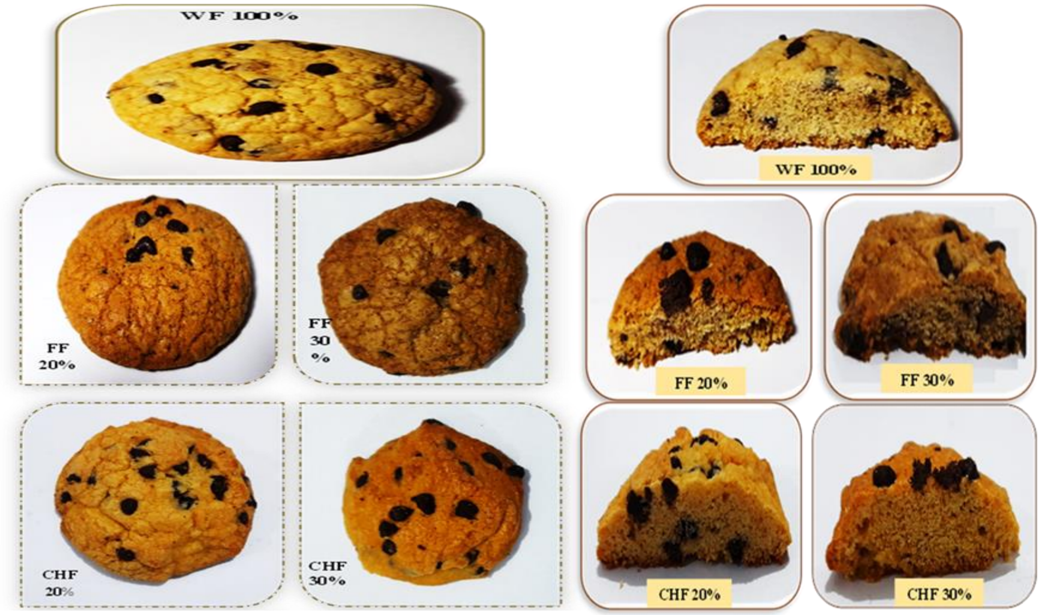

Photo (4): Cookies prepared by WF replaced with different levels of FF, CHF (20 and 30%)

Conclusions

These results indicate that the addition of natural sources of chickpeas and flaxseeds to bread and cookies, could positively impact to increase sources of protein and dietary fiber that improve the nutritional value of toast bread and cookies. Results found that the appropriate blend enhanced the influenced the dough's rheology and the sensory evaluation, most consumers accept bakery products, especially chickpea biscuits and cookies. So, this study recommends incorporating flaxseed and chickpea flour with wheat flour to enhance the nutritional quality, sensory and functional properties of bakery products.

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القيمة الغذائية،الخصائص الحسية والتغيرات الريولوجية لدقيق القمح المدعم بدقيق بذور الكتان والحمص: التطبيق في خبز التوست والكوكيز

المستخلص

حديثاً، زاد الاهتمام بإنتاج الأغذية الوظيفية باستخدام مصادر طبيعية ومركبات نشطة بيولوجيا لتعزيز الخصائص الوظيفية للمنتجات الغذائية. لذلك تهدف الدراسة الحالية إلى تدعيم دقيق القمح بمستويات مختلفة من دقيق بذور الكتان ودقيق الحمص بنسبة 20و30% واستخدامه في إنتاج خبز التوست والكوكيز الوظيفي، واسفرت نتائج الدراسة ان التركيب الكيميائي لدقيق بذور الكتان أعلى محتوى من الدهون (36,78%)، والرماد (4,02%)،والألياف (4,36%) ، بينما سجل دقيق الحمص أعلى قيم للبروتين (22,03%) مقارنة بدقيق القمح(الكنترول) . كما أدى إضافة دقيق بذور الكتان والحمص بتركيزات مختلفة الى دقيق القمح إلى زيادة محتوى البروتين والألياف والرماد كما زاد محتوى الدهن في الدقيق مع زيادة مستويات دقيق بذور الكتان، كما ظهر نتائج تحليل دقيق بذور الكتان انه يحتوي علي كمية مرتفعه من الفلافونويد، الفينولات الكلية، نشاط مضاد الأكسدة وقدرة مضادة للأكسدة. بالنسبة للخصائص الريولوجية، أظهرت نتائج معاملات الفارينوجراف خلال مرحلة الخلط زيادة في امتصاص الماء ووقت الوصول، زمن الثبات وسلوك تطور العجينة في انه يحتوي كمية جميع العينات مقارنة بدقيق القمح و أظهرت النتائج الحسية انخفاض معنوي مع زيادة الإضافة. أشارت هذه النتائج إلى إمكانية استخدام دقيق بذور الكتان ودقيق الحمص في إنتاج الخبز والبسكويت لتحسين الخصائص الوظيفية للمنتجات الغذائية. ويمكن التوصية باستبدال الخبز الأبيض بالخبز المدعم بدقيق الكتان والحمص، حيث يمكن أن يؤثر بشكل إيجابي على خصائصه التكنولوجية والغذائية والوظيفية .

الكلمات المفتاحية: منتجات المخابز الوظيفية – مضادات الأكسدة – البقوليات – دقيق بذور الكتان– التقييم الفسيولوجي والتذوقي.

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