Annals of Agric. Sci., Moshtohor **ISSN 1110-0419**
Vol. 60(1) (2022), 63 – 72 **https://assjm.journals.ekb.eg**

Physicochemical and Sensory Properties of Functional Biscuits Fortified With Oat Flour

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Abstract

This study aimed to produce functional biscuits from wheat flour (72% ext.) fortified with oat flour at different levels (20, 40, 60, 80, and100%). Physical, chemical and sensory evaluation of biscuits was performed. Oat flour had a high content of protein, ash, fat and fiber which were 13.45, 3.01, 8.91 and 7.69%, respectively. Oat flour was rich source of K, Ca, Mg, Na, Fe, Mn and Zn which were 367.0, 78.52, 118.0, 6.74, 18.30, 5.2 and 3.6 mg/100 g on dry weight, respectively. Results revealed that Faringraph and extensograph parameters showed that water absorption, dough weakening and arrival time increased as oat flour level increased in the blends. While dough stability, dough development time, extensibility, proportional number, energy and resistance to extension were decreased by adding oat flour to wheat flour at all levels replacement. Biscuit produced from wheat flour (72% ext.) with oat flour at different levels (0, 20, 40, 60, 80 and 100%) caused increase in crude protein, crude fat, ash, crude fiber contents from 12.87%, 14.28%, 0.63% and 3.39%, respectively for control treatment to 15.20%, 22.09%, 3.09% and 10.04%, respectively for treatment containing 100% oat flour. Highly acceptable biscuits could be obtained by substituting 80% oat flour in the wheat biscuits formulation.

Key words: Oat flour, wheat flour, macro and micro minerals, rheological properties, physical properties, biscuit, Sensory evaluation.

Introduction

Functional foods is a very popular term in the social and scientific media; consequently, food producers have invested resources in the development of processed foods that may provide added functional benefits to consumers' well-being (**Granato *et. al.*, 2020**). It contain biologically active ingredients associated with physiological health benefits for preventing and managing chronic diseases, such as type 2 diabetes mellitus (T2DM) (**Alkhatib *et. al.*, 2017**). So that , the trend has been to use functional foods.

Cereal grains provide half of the calories consumed by humans. In addition, they contain important compounds beneficial for health. During the last years, a broad spectrum of new cereal grain-derived products for dietary purposes emerged on the global food market. Special breeding programs aimed at cultivars utilizable for these new products have been launched for both the main sources of staple foods (such as rice, wheat, and maize) and other cereal crops (oat, barley, sorghum, millet, etc.) so that the development of a wide assortment of health-friendly dietary products contributing to the physical fitness of the human organism, (**Loskutov and khlestkina 2021**).

Oats like all other grain varieties, belongs to the Poaceae family, genus Avena species (*Avena sativa*). It is an annual grass grows for its seed that is believed to be Asiatic in origin and grown now in American and European countries, mainly Russia, Canada and United States of America. Oats are grown for use as grain as well as forage and fodder, straw for bedding, haylage, silage and chaff, (**Youssef, *et al.*, 2016**). Oats are one of the most nutritious grain cereals, high in protein and fiber. Oat protein is generally greater than that found in other cereal grains. It contains high amount of vitamins and minerals, (**Ahmad and Zaffar, 2014**).

Oats are an important source of nutrients; they contain protein, fat, digestible carbohydrates and dietary fiber espically beta-glucan fractions required for a balanced human diet, (**Fric *et al.*, 2011**). Likewise, oats were mainly used as feed for animals, but recent involved in many functional foods because its nutritional benefits have attracted attention from researchers worldwide and have resulted in the increased interest of food industry in using oats as food ingredient in various food products including infant foods, (**Santillana, *et al.*, 2021**), bread, (**Fraś, *et al.*, 2018**), oat milk, (**Deswal *et al.*, 2014**), beverages, (**Angelov *et al.*, 2018**), breakfast cereals, (**Decker *et al.*, 2014**), biscuits and cookies, (**Ballabio *et al.*, 2011**), granola bars and cereals, (**Aigster *et al.*, 2011**). Many positive effects of oats are associated with beta-glucan, due to its beneficial effect on serum cholesterol levels, and recently the European Food Safety Authority approved health claims for beta-glucan, (**Ciecierska, *et al.*, 2019**). However the dietary fiber content and nutritional value of oats are high. Oats contain many essential amino acids (isoleucine, leucine, lysine, methionine, cysteine, phenylalanine, threonine, tryptophan, and valine) necessary for human body, (**Youssef *et al.*, 2016**).

Biscuit is most popular bakery product worldwide. They have high content of carbohydrates, fat and calorie but low in fiber, vitamins, and mineral (**Amira *et al*., 2018)**.

Youssef *et al*., (2016) found that biscuits fortified with different levels (10, 20 and 30%) oat flours were evaluated for their chemical, physical and sensory evaluation. And highly acceptable biscuits could be obtained by incorporating 10% oat powders in the wheat biscuits formulation. **Zaki and Hussien, (2018)** reported that oat flour in the biscuit formulation was replaced at four levels, 25, 50, 75 and 100% with whole meal wheat flour (wmwf). Results revealed that, the chemical composition of oat flour and whole meal wheat flour resulted increase in fiber and ash contents and a decrease in protein and carbohydrate content compared to whole meal wheat flour. From these results showed that oat flour good source of fiber especially beta-glucan, protein, minerals, amino acids and fat.

The aim of this study was produce of functional biscuits using wheat flour fortified with oat flour at different levels. As well as assessing the rheological properties, physical, chemical characteristics and sensory quality of fortified biscuit.

Materials and methods

1.1. Materials and chemicals:-

Oat grains (*Avena sativa*) and wheat flour **(***Triticum aestevum*) **(**72% extraction rate**)** were purchased from El-Mokhtar Mill (Cairo governorate, Egypt) in season 2020. Sugar, corn oil, butter, fresh egg, dry milk powder, baking powder, salts and vanilla were obtained from local market at Giza, Egypt. All chemicals (hexan, acitic acid, methanol, toluene sulfuric acid, sodium hydroxide and salphate anhydride used on this study (analytical grades) were obtained from El-Gomhoria company.

1.2. Preparation of oat flour:

Oat grains were milled by Bühler mill and the produced oat flour was preserved in polyethylene bags until uses.

2.3. Preparation of biscuit samples:

The biscuit samples were prepared from wheat flour substituted by oat flour at different levels (20, 40, 60, 80 and 100%) as shown in (**Table 1**). The sugar 36 g and corn oil 25g were beat for 6 min in Hobart mixer (N-50) at 125 rpm to obtain creamy texture. Then wheat flour 100 g with baking powder 3g, milk powder 10g and salt 2g were added gradually to the previous mixture and mixed for 4 min at 61 rpm (speed 2) with adding 40-42 mL water according to Farinograph water absorption. The dough was sheeted to a thickness of 5 mm, cut using a circular mould into 55 mm diameter. Biscuits were baked for 15 min at 180±1°C in an electric oven with hot air. After baking, the biscuit samples were cooled at room temperature (25±1ºC) and then stored in tightly sealed polyethylene bags until the analysis.

Table 1. The recipe formulation of biscuits**.**

Ingredients (gm)	C	F1	F2	F3	F4	F5
Wheat flour	100	80	60	40	20	0.0
Oat flour	0.0	20	40	60	80	100
Milk	10	10	10	10	10	10
Corn oil	25	25	25	25	25	25
Sugar	36	36	36	36	36	36
Baking powder	3	3	3	3	3	3
Vanilia	0.1	0.1	0.1	0.1	0.1	0.1
Salt	2	2	2	2	2	2
Water	According to Farinograph water absorption					

C=100% Wheatflour, F1= 80% wheat flour + 20% oat flour, F2=60% wheat flour + 40% oat flour, F3= 40% wheat flour + 60% oat flour, F4 = 20% wheat flour + 80% oat flour, F5 =100% oat flour.

2.4. Determination of rheological properties:

Farinograph test was carried out to determine the water absorption, arrival time, dough development time, dough stability and degree of weakening according to the method described in **A.A.C.C. (2016).** Extensograph test was carried out to determine resistance to extension (BU), extensibility (mm), proportional number and energy (cm^2) according to the method described in **A.A.C.C (2016).**

2.5. Determination of Chemical Composition:

Moisture, crude protein, crude fat, ash and crude fiber contents were determined according to the methods described in the **AOAC (2012).** Available carbohydrate was calculated by difference. All determinations were performed in triplicates and the means were reported.

Total calories were calculated using the compositional data by the equation mentioned by **FAO and WHO (1974)** using the following equation:

E = 4 (Carbohydrate % + protein %) + 9 fat %.

Where: E **=** Energy as calories per 100gm sample.

Minerals: (Ca, Mg, Fe, Cu, Mn and Zn) were analyzed separately, using an atomic absorption spectrophotometer (Agilent technologies 4210 MP-AES) and (K and Na) by using Flame photometer .according to **AOAC (2012).**

2.6. Physical methods of biscuits.

Volume (cm^3) and weight (gm) of five biscuits samples of each treatment were recorded. Specific volume (cm^3/gm) was calculated by dividing of the volume to weight according to the method described in **A.A.C.C. (2016)**.

2.7. Texture profile analysis (TPA):

2.7.1. Texture Profile Analysis of biscuits:

Atexture analyzer (BROOKFIELD CT3 TEXTURE ANALYZER Operating Instructions Manual No. M08-372-C0113, Stable Micro Systems, USA) was used to measure the texture profile of biscuits in terms of hardness (N), Adhesiveness, Resilience and Fracturability at zero time and after 1 month, 2 month of storage. The experiments were conducted under ambient conditions.

2.8. Sensory evaluation of biscuits:

Sensory evaluation tests were performed according to **Galvez and Resurrecion (1990)** where ten trained panelists were asked to examine and score the different selected parameters of organoleptic properties for biscuit which was as follows: color (9), odor (9), taste (9), crispy (9), Overall Acceptability (9).

2.9. **Statistical analysis of data**:

The obtained data were statistically analyzed by least significant (L.S.D) at the 5% level of probability procedure according to **Snedecor and Cochran., (1980)** using version of costat 6.451.

Results and discussion

1.3. Farinograph characteristics of wheat flour-oat flour blends:

Data presented in Table (2) show the effect of substitution oat flour at five levels (20, 40, 60, 80 and 100%) to wheat flour on the rheological properties of flour as evaluated by farinograph. As shown in table (2), water absorption increased from 53.7% for control sample (100% wheat flour) to 59.10, 69.2, 76.5, 81.3 and 86.6% respectively as a result to the replace of oat flour to wheat flour. This finding could be attributed to the higher fiber content of oat flour. These results are in agreement with those obtained by **Zaki, and Hussien (2018)** who reported that absorption increase as oat flour level increased in dough. They added as the oat level in the flour increase, the time needed for the preparation of a good dough (dough development time) was decreased, due to a weaker formation of gluten matrix. Since pentosans and ß-glucans benefit from high water binding capacities, their presence in the oat flour caused higher water absorption capacities, for dough made of oat as part of the formula, in comparison with control.

Table 2. Farinograph characteristics of wheat flour-oat flour blends.

Samples	Farinograph paramters				
	Water absorption (%)	**Arrival time (min.)**	**Dough development time(min.)**	**Dough stability (min.)**	**Dough weakening (B.U)**
C	53.7	0.5	5.0	17.4	10
F1	59.1	1.0	4.5	14.0	20
F2	69.2	1.5	4.0	10.5	40
F3	76.5	2.0	3.5	6.0	60
F4	81.3	2.5	3.0	5.5	70
F5	86.6	2.5	3.0	5.0	90

C= 100% Wheat flour, F1= 80% wheat flour + 20% oat flour, F2 = 60% wheat flour+ 40 % oat flour, F3 = 40% wheat flour + 60% oat flour, F4 = 20% wheat flour + 80% oat flour, F5 = 100% oat flour.

Arrival time increased as oat flour level increased in dough. It recorded for wheat flour 0.5 min the lowest time to reach for replacement samples with 20, 40, 60, 80 and 100% oat flour to 1.0, 1.5, 2.0, 2.5, and 2.5 min, respectively. These results are in agreement with those obtained by **Zaki and Hussien, (2018)** which reported that arrival time (min) recorded for wheat flour 1.0 min the lowest time to reach for replacement samples with 25, 50, 75 and 100% to 1.5, 2.0, 2.5 and 3.0 min, respectively, **Abd El-Rasheed *et al*., (2015)** which reported that arrival time (min) of wheat and oats flour and its mixtures (75% wheat flour + 25% oat flour) recorded that 1.0, 3.5 and 1.5 min ,respectively.

From the obtained data, it could be noticed that the development time decreased as oat flour increased. When replacement of 0, 20, 40, 60, 80 and100% of oat flour in dough was recorded 5.0, 4.5, 4.0, 3.5, 3.0 and 3.0 min, respectively.

On the other hand, dough weakening were increased, while dough stability was decreased by adding oat flour to wheat flour at all levels replacement 0, 20, 40, 60, 80 and100% which recorded 17.4, 14.0, 10.5, 6.0, 5.5 and 5.0 min, respectively. These results are in agreement with those obtained by **Zaki and Hussien, (2018)** which reported that dough stability was decreased by adding oat flour to wheat flour at all levels replacement 25, 50, 75 and 100% which recorded 10, 5, 2 and 2 min, respectively. **El Shebini *et al.*, (2014)** showed that stability time decreased from control sample 18.0 min to 15.0 and 10.0 min for sample containing (75% WWF+25% OF) and (50% WWF+50% OF) , respectively.

From the obtained data, it observed that Dough weakening (B.U) for the control smaple recorded the lowest value 10 B.U and sample contain 20, 40, 60, 80 and 100% oat flour recorded 20, 40, 60, 70 and 90 B.U, respectively. These results are in agreement with those obtained by **Abd El-Rasheed *et al*., (2015)** who reported that Dough weakening (B.U) recorded the lowest value in control sample contian 100% wheat flour 40 B.U and value increased when replacement to oat flour 100% recorded 100 B.U **Zaki and Hussien, (2018)** reported that sample contain 100% oat flour 160 B.U of Dough weakening.

3.2. Extensograph characteristics of wheat flour - oat flour blends:

The results presented in Table (3) showed the effect of adding oat flour to wheat flour on extensograph parameters, Dough extensibility (E) (mm)**,** Resistance to extension (R) (B.U), Proportional number (R/E) and Dough energy (Cm^2) decreased as of level increased. That effect was related to the presence of fiber in oat flour that dilutes gluten content of dough.

It was found that Dough extensibility (E) (mm) decrease from control sample which recorded 180 (mm) and recorded with substitutions 20, 40, 60, 80 and 100% oat flour 140, 80, 50, 40 and 20 (mm), respectively. These results are in agreement with those obtained by **El Shebini *et al.*, (2014)** who reported respectively in sample contian (75%WF+25%OF) and (50%WF+50%OF), respectively.

From the obtained data, it could be noticed that the resistance to extension (R) recorded the highest value 588 B.U and at substitutions 20, 40, 60, 80 and 100%oat flour recorded 450, 240, 140, 90and 40B.U, respectively. These results are in agreement with those obtained by **El Shebini *et al.*, (2014)** who reported that the result in control sample for resistance to extension recorded 580B.U , 420B.U in sample contain (75% WF+25% OF) and 280B.U sample contain (50% WF+50% OF).

The results in table (3) indicated that the proportional number (R/E) decrease when increase substitutions with oat flour 0, 20, 40, 60,80 and 100% which recorded 3.27, 3.21, 3.00, 2.80, 2.25 and 2.00, respectively. These results are agreement with obtained by **El Shebini *et al.*, (2014)** who showed that proportional number of control sample contain 100%wheat flour, sample contain (75% WF+25% OF) oat flour and sample contain (50% WF+50% OF) recorded that 4.14, 3.82 and 3.5, respectively,

It was observed that Dough energy (Cm^2) decrease when increase substitutions with oat flour 0, 20, 40, 60, 80 and 100% which recorded that 65, 40, 15, 10, 5.0 and 1.5 cm^2, respectively.

Table3. Extensograph characteristics of wheat flour-oat flour blends.

Samples	**Extensograph paramters**			
	Dough extensibility (E) (mm)	**Resistance to extension (R) (B.U)**	**Proportional number (R/E)**	**Dough energy (Cm^2)**
C	180	588	3.27	65
F1	140	450	3.21	40
F2	80	240	3.00	15
F3	50	140	2.80	10
F4	40	90	2.25	5.0
F5	20	40	2.00	1.5

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.

3.3. Proximate chemical composition of wheat and Oat flours.

The chemical composition of wheat and oat flours was shown in Table (4). It was found that moisture, protein, ash, fat, fiber, and available carbohydrates were 9.97, 13.45, 3.01, 8.91, 7.69, and 66.94% for oat flour and 10.29, 11.12, 0.55, 1.10, 1.04, and 86.19% for the wheat flour, respectively. From the obtained results, it could be noticed that oat flour contained significantly higher amounts from protein, ash, crude fat and fiber contents than those of wheat flour, while wheat flour contained significantly higher amounts from moisture and available carbohydrate. The results demonstrated that oat flour is rich in protein, fiber, fat, and ash compared with wheat flour. Moreover, the oat flour well known as functional ingredients because high content in fiber. These results are in agreement with those obtained by **Youssef, *et al*., (2016)** who found that the chemical composition of oat flours contained

9.96% - 10.47% moisture, 11.61% -13.62% crude protein, 7.23% -8.92% Crude fat, 3.54% - 5.88% crude fiber, 2% -2.15% ash, and 69.435% - 75.625% available carbohydrates for red and common oat flours. **El-Qatey *et al*., (2018)** who showed that there were differences in the moisture and protein content, which were 9.51 and 12.92% for oat flour and 10.51 and 10.2 % for the wheat flour, respectively. The percentage of ash was 1.30 and 1.87% for wheat flour and Oat flour, respectively, where wheat flour showed the lowest percentage of ash due to lower extraction rates **(Chavan *et al.*, 1993)**. **Zaki and Hussien, (2018)** stated that protein content of raw materials were significantly different and showed 13.87% for oat flour and reached 14.66 for whole wheat flour. With respect to fat content oat flour was high in their fat content (6.85%) while whole meal wheat flour (2.88%). Data proved that carbohydrate content reached the maximum for whole meal wheat flour (77.29%) and the minimum for oat flour (66.46%)**.**

Table 4. Proximate chemical composition of wheat and oat flour (g/100 g on dry weight basis).

Composition	Wheat flour	Oat flour	LSD
Moisture	10.29 ^{a} ±0.72	9.97^{a}±0.87	1.81
Protein	11.12 ^{b} ±0.5	13.45^{a} ±0.45	1.079
Ash	0.55 ^{b} ±0.38	3.010^{a} ±0.41	0.91
Fat	1.100 ^{b} ±0.42	8.910^{a} ±0.99	1.72
Fiber	1.040 ^{b} ±0.89	7.690^{a} ±0.78	1.90
Available carbohydrates*	86.19^{a}	66.94^{b}	1.66

Means with the same latter in the same row are not significant different (p<0.05).
Mean of triplicate determination ± standard deviation.
*Available carbohydrates Calculated by difference.

Minerals composition of wheat and oat flours.

Minerals are necessary for a wide variety of metabolic and physiologic processes in the human body, including muscle contraction, enzyme activation, normal heart rhythm, bone health, nerve impulse conduction, oxygen transport, oxidative phosphorylation, antioxidant activity, immune function, and acid base balance of the blood. An adult needs around 350 mg Mg, 1000 mg Ca and 3000 mg K intake a day (**Eroglu Samur, 2012)**. Minerals composition of oats and wheat in table (5) as shown that oat flour was significantly higher k, ca, mg, iron and zn content. statistical analysis did not appear any significant differenece between two kinds of flows from Na, Cu and Mn contents. In contrast wheat flour had significantly content from potassium, calcium, magnesium, iron and and zinc 116.76, 20.07, 112.36, 1.13, and 1.07mg/100gm, respectively compared to oat flour which recorded 367, 78.52, 118, 18.3, and 3.6 mg/100gm, respectively. These results are in agreement with those obtained by **Levent, and Bilgiçli, (2012)** who reported that oat flour was relatively higher in calcium, copper, iron, magnesium, manganese, potassium and zinc 39.18, 0.41, 4.02, 137.11, 0.64, 295.30 and 2.42, respectively. While wheat flour was relatively lower which recorded that 24.0, 0.28, 1.21, 42.40, 0.42, 138.24 and 0.92 mg/100gm, respectively. **Youssef *et al.*, (2016)** showed that red oat flours were relatively higher in potassium, calcium, and iron 362, 71.71 and 24.21mg/100gm, respectively and lower in copper, sodium, zinc and manganese 1.20, 7.3, 3.62 and 3.66 mg/100gm, respectively compared with common oat higher in magnesium 120.67 mg/100mg and lower in iron 13.76 mg/100gm.

Table 5. Minerals cotent of wheat and oat flour (mg/100g on dry weight basis).

Minerals	Wheat flour	Oat flour	LSD at 0.05
K	116.76^{b}±1.25	367.0^{a}±1.18	2.75
Ca	20.07^{b}±1.84	78.52^{a}±1.62	3.93
Mg	112.36^{b}±0.47	118.0^{a}±2.12	3.48
Na	4.13^{a}±1.9	6.74^{a}±0.72	3.26
Fe	1.13^{b}±0.05	18.30^{a}±1.83	2.93
Cu	0.84^{a}±0.09	1.60^{a}±0.47	0.77
Mn	3.71^{a}±2.94	5.20^{a}±0.5	4.77
Zn	1.0700^{b}±0.33	3.60^{a}±0.63	1.14

Means with the same letter in the same row are not significant different (P<0.05).

3.4. Proximate Chemical composition of wheat-oat biscuits blends:

Proximate chemical composition of biscuits containing oat flour was showed in table (6). It was found that proximate composition of biscuit samples prepared by substituting 20%, 40%, 60%, 80% and 100% of wheat flour with oat flour compared to control biscuit. Results indicated that decrease in available carbohydrates with an increase in the level of oat flour was observed. This result may be due to low available carbohydrates content of oat flour compared to wheat flour. These results are agreement with those obtained by **Youssef *et al.*, (2016)** who stated that available carbohydrates content of biscuit was reduced from 75.9 to71.31% when wheat flour replaced with 10 to 30% red oat flour, respectively **Zaki, and Hussien (2018)** showed that available carbohydrates content of biscuit decreased from 64.53% in the control sample to 55.96% for biscuits containing 100% oat flour.

The results in Table (6) indicate that gradually increasing mixing level oat flour with wheat flour (20, 40, 60, 80 and 100%) led to significantly increase gradually the nutritional value of biscuits where protein, ash, fat and fiber ranged between (12.87-15.20%), (0.63-3.09%), (14.28- 22.09%) and (3.39- 10.04%), respectively, which were significantly lower in treatment (control), which its were significantly higher in F5 treatment (100% oat flour). **El-Qatey *et al*., (2018)** showed that increase in protein, ash, fat and fiber were observed in biscuits fortified with oats in a ratio of 10, 20, 30, 40 and 50% from 8.01 to 8.61%, 1.27 to 1.69%, 15.14 to15.66% and 3.43 to 4.87%, respectively.

Table 6. Chemical composition of wheat-oat biscuits blends (g/100gm on dry weight basis).

Samples	Moisture	Protein	Ash	Fat	Fiber	Available Carbohydrates	Energy
C	2.91^{a}±0.39	12.87^{b}±1.40	0.63^{c}±0.56	14.28 ^{d}±0.64	3.39^{d}±0.76	68.83^{a}±3.25	455.32
F1	3.14^{a}±1.36	13.34 ^{ab}±0.92	1.12^{c}±0.52	15.84^{cd}±1.47	4.72^{c}±0.8	64.98^{ab}±3.71	455.84
F2	3.33^{a}±0.87	13.80 ^{ab}±0.60	1.61 ^{bc}±0.40	17.40^{bcd}±0.7	6.05^{bc}±1.18	61.14^{bc}±2.88	456.36
F3	3.41^{a}±0.59	14.27^{ab} ±1.30	2.11 ^{abc}±0.58	18.97^{abc}±0.3	7.38^{b}±1.05	57.27^{dc}±3.23	456.89
F4	3.62^{a}±0.58	14.73^{ab}±0.83	2.60^{ab}±0.36	20.53^{ab}±1.6	8.71^{ab}±1.06	53.43^{de}±3.85	457.41
F5	3.75^{a}±0.38	15.20 ^{a}±1.30	3.09^{a}±0.45	22.09^{a}±0.60	10.04^{a}±0.700	49.58^{e}±3.05	457.93
LSD at 0.05	1.38	1.95	0.86	1.79	1.68	5.95	

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.
Means with the same letter in the same column are not significant different (P<0.05)

3.6. Minerals content of wheat-oat biscuits blends.

As shown in Table (7), the minerals content of wheat-oat biscuits blends was evaluated. The mineral content was increase significantly by increasing oat flour in biscuit compared to control sample. Therefore, the content of minerals increased in the biscuit by using substitutions of 0, 20, 40, 60, 80 and 100% oat flour as follows; Potassium (k) was 121.50, 166.81, 216.86, 266.90, 317.07 and 332.70 mg/100gm, respectively, Calcium (Ca) was 25.17, 31.76, 43.45, 55.14, 66.80 and 67.68 mg/100gm, respectively. Magnesium (Mg) was 95.20, 113.50, 114.47, 115.70, 116.87 and 116.9 mg/100gm, respectively, Sodium (Na) was 2.17, 4.52, 4.94, 5.31, 5.54 and 5.71 mg/100gm, respectively, Iron was (Fe) was 5.53, 4.56, 8.00, 11.43, 14.87 and 16.97 mg/100gm, respectively, Copper (Cu) was 0.45, 0.99, 1.14, 1.30, 1.41 and 1.45 mg/100gm, respectively. Manganese (Mn) was 1.13, 1.62, 2.52, 3.41, 4.31 and 4.70 mg/100gm, respectively, Zinc (Zn) was 0.98, 1.58, 2.08, 2.59, 3.09 and 3.10 mg/100gm, respectively. Therefore, attention has been paid to replacing wheat flour with oat flour in some bakery products due to the high nutritional value of oat flour and its containment of important minerals in high content compared to wheat flour such as potassium, calcium, manganese and iron, respectively (table 5).

Table 7. Minerals content of wheat oat biscuits blends (mg/100gm on dry weigh basis).

	Replacement (%)						
Minerals	**C**	**F1**	**F2**	**F3**	**F4**	**F5**	**LSD at 0.05**
K	121.50^{f}±1.50	166.81^{e}±1.01	216.86^{d}±0.74	266.90^{c}±0.60	317.07^{b}±0.43	332.70^{a}±0.70	1.59
Ca	25.17^{e}±1.83	31.76^{d} 1.04±	43.45^{c}±0.56	55.14^{b}±1.16	66.80^{a}±0.60	67.68^{a}±1.14	2.022
Mg	95.20^{d}±0.80	113.5^{c}±0.57	114.47^{bc}±1.60	115.70^{ab}±0.44	116.87^{a}±0.78	116.9^{a}±1.03	1.69
Na	2.17^{b}±1.03	4.52^{a}±0.60	4.94^{a}±0.18	5.31^{a}±0.78	5.54^{a}±0.54	5.71^{a}±1.17	1.40
Fe	5.53^{e}±0.67	4.56^{e}±0.63	8.00^{d}±1.12	11.43^{c}±0.77	14.87^{b}±1.05	16.97^{a}±1.49	1.78
Cu	0.45^{b}±0.16	0.99^{ab}±0.13	1.14^{ab}±0.39	1.30^{ab}±0.63	1.41^{a}±0.72	1.45^{a}±0.74	0.93
Mn	1.13^{e}±0.32	1.62^{de}±0.68	2.52^{cd}±0.59	3.41^{bc}±0.46	4.31^{ab}±0.69	4.70^{a}±0.43	0.97
Zn	0.98^{c}±0.14	1.58^{bc}±0.44	2.08^{abc}±0.92	2.59^{ab}±0.53	3.09^{a}±0.91	3.10^{a}±0.90	1.25

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.
Means with the same letter in the same row are not significant different (P<0.05)

3.7 Physical properties of wheat-oat biscuits blends:

Physical properties of wheat-oat biscuits blends**.**was shown in table (8). Biscuits produced from wheat flour with oat flour at different levels (0, 20, 40, 60, 80 and 100%). It found that the highest weight (28.22g) was obtained for the sample containing 100% oat flour, while the lowest weight was obtained for the control sample and sample containing 20% oat flour (21.00 and 21.95 g). Opposite trend was observed for the volume. Therefore, the highest volume (50cm^3) was obtained for the control sample with 100% wheat flour while the lowest volume was obtained for the sample containing 100% oat flour (41 cm^3). Also results observed that specific volume was decreased gradually by increasing oat flour level which the highest specific volume was obtained for the control sample (2.38 cm^3/g) and the lowest volume was obtained for sample containing 100% oat flour.

Table 8. Physical properties of biscuit samples containing different ratios of oat flour.

Samples	Weight (g)	Volume (cm^3)	specific volume (cm3/g)
C	21.00	50	2.38
F1	21.95	48.99	2.23
F2	24.50	47.00	1.92
F3	25.00	46.54	1.86
F4	26.10	45.00	1.72
F5	28.22	41	1.45

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.

3.8. Sensory properties of wheat-oat biscuits blends:

Effect of different contents of oat flour on sensory properties of biscuit are presented in Table (9). It was showed that the sensory evaluation included color, odor, taste, crispy and overall acceptability of biscuits containing oat flour ratios 20, 40, 60, 80 and 100% was performed and the results are found in Table (9). It was showed that increasing oat flour in biscuit led to significantly decrease the sensory scores of color. Significant differences ($P < 0.05$) in color were observed between control 8.50 and supplemented samples 20, 40, 60, 80 and 100% oat flour which were 7.83, 7.00, 6.50, 5.67 and 4.83, respectively. Such decrees of significantly the color score due to their dark nature of oat. The sensory scores of odor, taste crispy and overall acceptabiliy of control biscuits were 6, 6, 5.17 and 5.17, respectively. It observed that the highest value of odor 7.83, 7.67 given by incorporating of 80 and 60% oat flour, followed by a sample 100% oat flour with a value of 7.50 and the lowest value 5.83 was recorded by sample with 20% oat flour. The highest value of taste, crispy and overall acceptability 7.67, 7.67, and 7.33, respectively given by incorporating of 80% oat flour. Based on our results of sensory evaluation, we concluded that nutritious and healthy biscuits can be produced by substituting wheat flour up to 100% with oat flour without negative effect on the general acceptability of biscuits. These results are in agreement with those obtained by **El-Qatey *et al*., (2018)** who added oat flour in differend percentage to biscuits and they found that the lowest value of the control sample was 19.2 and the highest 19.8 in the samples containing the 10, 20 and 30% oat flour. There were no significant differences in surface color values in control sample and samples containing different percentages of oat flour. The highest value of taste 19.6 given by incorporating of 30 and 40% oat flour, followed by a sample 50% with a value of 19.5 and the lowest value 18.8 was recorded by sample with 10% oat flour. There was no difference in overall acceptability of the control sample and the other samples containing oat flour 0, 10, 20, 30, 40, and 50%, which recorded values of 96.5, 97.0, 97.2, 98.2, 98.2, and 98.4, respectively.

Table 9. Sensory properties of wheat-oat biscuits blends.

Sample	Color(9)	Odor(9)	Taste(9)	Crispy(9)	Overall acceptability(9)
C	8.50^a±0.50	6.00^c±0.50	6.00^c±0.50	5.17^c±0.29	5.17^b±0.29
F1	7.83^a±0.28	5.83^c±0.76	6.17^{bc}±0.76	5.83^{bc}±0.29	5.33^b±0.58
F2	7.00^b±0.50	6.83^{bc}±0.28	6.00^c±1.00	6.33^{abc}±0.58	6.00^{ab}±1.00
F3	6.50^b±0.50	7.67a±1.04	7.33^{ab}±0.57	6.67^{abc}±1.53	7.33^a±0.58
F4	5.67^c±0.29	7.83a±0.28	7.67^a±0.57	7.67^a±0.58	7.33^a±1.53
F5	4.83^d±0.29	7.50a±0.5	7.00^{abc}±0.50	7.33^{ab}±1.15	6.5^{ab}±0.50
LSD at 0.05	0.73	1.11	1.20	1.54	1.51

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.

WWF (wheat whole flour) OF(oat flour).
Means with the same letter in the same column are not significant different (P<0.05).

3.9. Textural profile analysis (TPA) of wheat-oat biscuits blends:

Table (10) presents texture analysis results for fresh, one month and 3 months stored samples. The effect of oat flour on facturability and hardness which increase during storage was very dependent on the high fiber in oat flour. The hardness recorded the lowest value in control sample in zero time, 1 month and 3months which were 32.00, 35.20 and 41.30, respectively. But recorded the highest value in sample contain 100% oat flour in zero time, 1 month and 3 months which were 58.71, 62.60 and 67.60, respectively. A decrease in Adhesiveness and Resilience values with ageing was observed in samples due to the increase in fiber in oats.

Table 10. Textural profile analysis (TPA) of wheat-oat biscuits blends.

Characteristics	Hardness			Adhesiveness			Resilience			Facturability		
Storage time	Zero	1mon	3mon	zero	1mon	3mon	Zero	1mon	3mon	Zero	1mon	3mon
C	32.00	35.20	41.30	0.41	4.51	15.9	0.29	0.25	0.20	63.70	66.50	72.80
F1	38.12	41.52	47.02	0.36	4.36	11.56	0.20	0.18	0.13	56.12	59.02	64.82
F2	42.95	46.00	51.60	0.30	4.20	11.20	0.17	0.13	0.08	51.20	55.13	61.23
F3	48.00	51.60	57.00	0.22	4.12	10.02	0.12	0.10	0.04	46.00	49.70	55.70
F4	56.50	59.12	64.50	0.15	3.25	8.97	0.09	0.05	0.03	40.56	44.60	50.20
F5	58.71	62.60	67.60	0.10	3.5	18.9	0.06	0.02	0.01	32.44	35.64	41.36

C=100%Wheat flour, F1=80%wheat flour+20%oat flour, F2=60%wheat flour+40%oat flour, F3=40%wheat flour+60%oat flour, F4=20%wheat flour+80%oat flour, F5=100%oat flour.

Conclusion

The oat flour has nutritional value due to its high levels of dietary fiber. The soluble fibers in particular are thought to exert a preventative role against heart disease, as they appear to have the ability to lower serum cholesterol. In the light of the above mentioned data, oat flour proved to have high levels of the minerals. Finally it could be stated that, oat flour has an increasing interest as they are important ingredients in the food industry such as functional and healthy foods formulations as biscuits, bread, and cakes.

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الخواص الفيزوكيميائية والحسية للبسكويت الوظيفي المدعم بدقيق الشوفان

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تهدف هذه الدراسة إلى إنتاج بسكويت صحي من دقيق القمح (استخلاص 72%). مدعم بمستويات مختلفة من دقيق الشوفان (20، 40، 60، 80, 100٪). تم التقييم الفيزيائي والكيميائي والحسي لمنتج البسكويت. الشوفان هو نوع من الحبوب يحتوي على العديد من المكونات ذات القيمة الغذائية العالية. أظهرت النتائج أن الشوفان يحتوي على نسبة عالية من البروتين والرماد والدهون والألياف (13.45، 3.01 ، 8.91 ، 7.69٪). دقيق الشوفان مصدر غني للعناصر المعدنية مثل البوتاسيوم والكالسيوم والماغنسيوم والصوديم والحديد و المنجنيز والزنك (367.0, 78.52 ,118.0 ,6.74 ,18.30 ,5.2 ,3.6 مجم/100جم على التوالى). تم التقييم الريولوجى والتركيب الكيميائي والمعادن والسعرات الحرارية لدقيق القمح والشوفان ومخاليطهم. أظهرت قراءات الفارينوجرام أن نسبة امتصاص الماء ودرجة ضعف العجين وزمن الوصول يزداد مع زيادة مستوى دقيق الشوفان في الخلطات. بينما ينخفض كل من زمن ثبات وتكوين العجين والمقاومة للتمدد والانسيابية والرقم النسبى والطاقة بإضافة دقيق الشوفان إلى دقيق القمح على جميع المستويات. تم استخدام البسكويت المحتوي على دقيق القمح فقط (استخلاص 72٪) كعينة (المقارنة) كنترول.

وكذلك تم تقييم البسكويت المنتج من دقيق القمح (استخلاص 72٪) والمستبدل بدقيق الشوفان بمستويات مختلفة (20 ، 40 ، 60 ، 80 ,100٪) حيث زادت نسبة كل من البروتين والدهن والرماد والالياف الخام من 12.87٪ و14.28٪ و 0.63٪ و 3.39٪ على التوالى للعينة الكنترول الى 15.20 % ,22.09% ,3.09% ,10.04% على التوالى للعينة المحتوية على دقيق الشوفان 100٪. يمكن الحصول على بسكويت مقبول للغاية عن طريق استبدال 80٪ من مسحوق الشوفان في تركيبة بسكويت القمح.

الكلمات الدالة: دقيق الشوفان ، دقيق القمح ، العناصرالمعدنية ، الخصائص الريولوجية ، الخصائص الفيزيائية ، البسكويت ، التقييم الحسي.