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Assessment of Gross Chemical Composition, Mineral Composition, Vitamin Composition and Amino Acids Composition of Wheat Biscuits and Wheat Germ Fortified Biscuits

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Abstract

Wheat germ is reckoned valuable healthful functional food. The present investigation was performed to assess nutritional status of wheat biscuits and wheat germ fortified biscuits. Study included determination of gross chemical composition, caloric value, minerals (Mn, Ca, Fe, Cu, P, Na and K), vitamins (C, Folic acid, A, and E), and amino acid composition of wheat biscuits and 15%, 20% wheat germ fortified biscuits. Likewise physical and sensory characteristics of studied biscuits were assessed. The data revealed that 20% wheat germ fortified biscuits proved to be nutritious functional healthful food. It improved both physical, sensory characteristics and recorded the highest crude protein (12.20%), crude fiber (2%), and the least fat (9.63%), moisture (3.01%), and caloric value (436.31 Kcal/100g). While it recorded the highest Mn and Cu contents as well as increased vitamins C, Folic acid, A, and E. Besides, 20% wheat germ fortified biscuits increased all the eight essential amino acids contents resulting in an improvement of the nutritive value of wheat biscuits. Therefore it could be recommended for caloric reduced diets for obese and overweight persons. Likewise, it should be increasing interest as an ingredient in the industry as functional and healthy foods formulations as biscuits, bread and cakes.

Keywords

Wheat Biscuits, 15%, 20% Fortified Wheat Biscuits, Gross Chemical Composition, Minerals, Vitamins, Amino Acids Caloric Value, Physical, Sensory Characteristics

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1. Introduction

Wheat germ constitutes about 2.5% - 3% of the wheat seed and is reckoned valuable healthful functional food [1]-[5]. The mean proximate chemical composition of wheat germ was: 10.80%, 26.50%, 8.56% and 4.18% for moisture, crude protein, crude fat and ash content; respectively, on dry basis [6] [7]. While [8] reported that wheat germ contained approximately 10% - 15% lipids, 26% - 35% proteins, 17% sugars, 1.5% - 4.5% fibre and 4% minerals, as well as significant quantities of bioactive compounds, such as tocopherols (300 - 740 mg/kg DM), phytosterols (24 - 50 mg/kg), policosanols (10 mg/kg), carotenoids (4 - 18 mg/kg), thiamin (15 - 23 mg/kg) and riboflavin (6 - 10 mg/kg). [9] stated that the raw wheat germ contained 11% moisture, 31.4% crude protein, 18.5% dietary fibre and 7% fat.

On the other hand, [6] found that the mean mineral composition of wheat germ was: 365.1 + 7.21, 0.6 + 0.03, 9.45 + 0.35, 1365.1 + 21.35, 310.3 + 7.49, 13.0 + 1.41, 775.2 + 7.35 and 9.05 + 0.07 (mg/100g) for Ca, Cu, Fe, K, Mg, Mn, P and Zn contents, respectively (on dry basis). While, [5] reported that the mean mineral composition of raw wheat germ was: 9.07, 11.24, 1.59, 17.38, 312, 100, 70, 440, 705, 344, 300 (mg/100g) for Fe, Mn, Cu, Zn, Mg, Ca, Na, K, P, S and Se contents, respectively.

On the other hand, wheat germ contained high vitamin, dietary fibre contents and a low fat content [10]. While, [11] found that the mean vitamins of wheat germ were (2.00 ± 0.042); (0.22 ± 0.036) and (7.40 ± 0.35) mg/100g for thiamine, riboflavin and niacin contents, respectively. [12] [13] outlined that the wheat germ is the nutritionally richest part of the wheat seed. It is one of the few plant parts in nature in which the entire vitamin B-complex is found. [5] reported that the raw wheat germ contained 10343.23 IU/100g (vitamin A); 1312 IU/100g (vitamin E); and 98.45 mg/100g (vitamin C).

Furthermore, [14] [15] identified that the mean essential amino acid profile of defatted wheat germ was: (2.92, 1.73), (6.64, 1.11), (6.69, 2.32), (1.64, 0.25), (4.06, 1.04), (4.50, 0.93), (1.15, 0.20), and (4.53, 1.40) (g/100g) for isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. While, [5] found that the raw wheat germ contained the essential amino acids: 4.06, 10.47, 10.26, 2.08, 5.03, 2.54, 1.80; and 6.21 (g/100g) for isoleucine, leucine, lysine, Methionine, phenylalanine, threonine, tryptophan and valine.

The fortification of bakery products and bakers confectionery with wheat germ, *i.e*. bread, toast bread, biscuits, and cakes were reported by several authors, *i.e*. [2] [16]-[27].

This investigation was designed to produce fortified wheat biscuits with wheat germ, which has better nutritional value, available and relatively cheap and does not require any preparation efforts before using. The objectives of this investigation were to study the gross chemical composition, caloric value, the mineral composition, the vitamin composition, the amino acid composition as well as physical and sensory quality attributes of wheat biscuits and wheat germ fortified biscuits.

2. Materials and Methods

2.1. Materials

5 kg wheat flour 72% extraction hard red winter and 3 kg wheat germ were obtained from El-Haram Milling Company, Faesal, Giza in December 2014. Sugar powder, powdered milk, butter, sodium chloride, ammonium bicarbonate, sodium bicarbonate and baking powder were purchased from Cairo local market in December 2014.

Both wheat flour and wheat germ were kept in glass containers at 4˚C in the refrigerator till the analysis.

2.2. Technological Process

2.2.1. Biscuit Formula and Ingredients

Control biscuit dough was prepared according to the formula presented in **Table 1**, [28]. The supplemented biscuits with wheat germ were prepared using the same formula except for replacing the wheat flour with 15% and 20% of wheat germ.

2.2.2. Dough Preparation

Powdered sugar and butter were creamed in Braun Mixer with a flat beater for 2 minutes at 5 rpm. Water containing sodium chloride, ammonium bicarbonate, powdered milk, sodium bicarbonate and baking powder were added to the cream and mixed for 5 minutes at 125 rpm to obtain a homogenous cream. Thereafter the flour was

Table 1. Wheat flour biscuits formula*.

Ingredients	Gram
Wheat flour (72% extraction rate)	100
Powdered sugar	20.00
Sodium chloride	0.50
Powdered milk	10.00
Butter	40.00
Ammonium bicarbonate	1.00
Sodium bicarbonate	0.50
Baking powder	0.50
Water	25.00

*[28].

added slowly to the above cream and was mixed for 2 minutes at 60 rpm to obtain biscuit dough [29].

2.2.3. Preparation of Biscuits

The dough was sheeted to thickness of about 3 mm using Atlas Brand Rolling Machine. The sheeted dough was cut into round shape using a 45 mm diameter cutter and baked on an alluminium tray in an electric oven at 180˚C for 6 minutes. The biscuit was cooled for 30 minutes, packed in polyethylene bags stored under desiccation [30] [31].

2.2.4. Preparation of Different Blends of Biscuits

Blends of biscuits:

Blends of biscuits were prepared using wheat flour 72% extraction rate as control or those which were substituted with 15% and 20% wheat germ.

3. Methods

3.1. Physical Valuation of Biscuits

Biscuit were evaluated for height (cm), width (cm), spread ratio and spread factor. Five biscuits were used for the evaluations from the three studied biscuits and averages were recorded. The spread ratio and spread factor were calculated according to [31] using the following equations:

$$\text{Spread ratio} = \frac{\text{Width}}{\text{Height}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

3.2. Sensory Evaluation of Biscuits

Sensory evaluation for the color, texture, taste, odor, and overall acceptability were done in order to determine consumer acceptability. A numerical hedonic scale ranging from 1 to 10 (1 is very bad and 10 for excellent) was used for sensory evaluation [32]. Ten experienced judges participated in the test.

3.3. Gross Chemical Composition

Moisture, protein, fat, crude fiber and ash were determined according to the methods described in [33].

Total carbohydrates content was calculated by difference (100—total gross chemical composition) on dry weight basis according to [33].

The caloric value was calculated according to the method of [34].

3.4. Mineral Composition

Total content of elements was carried out using a mixture of ($HClO_4/HNO_3$) according to (Inductive Coupled Plasma Emission Spectrometry). The elements Ca, Mn, Cu and Fe) were determined using ICP (ICAP6200) according to [35]. Sodium and potassium contents were estimated using Flame Photometry (Jenway PFP7) according to the procedure reported by [36]. Phosphorus was estimated using GBC Atomic Absorption 906A according to the procedure described in [37].

3.5. Vitamins Assay

Vitamin C was determined using Aglient HPLC (uv-vis) as described by [38]. Folic acid was determined using Surveyour HPLC ((PDA) as described by [39]. Vitamins A and E were determined using Schmidzua HPLC (PDA) as described by [40].

3.6. Amino Acids Composition

Acid hydrolysis was carried out according to the method of [41]. The dried and defatted grinding sample (Ca. 0.2 g) was hydrolyzed with 6N HCl (10 ml) in sealed tube, heated in an oven at 110˚C for 24 hours. The resulting solution was completed to 25 ml with de-ionized water. After filtration, 5 ml of hydrolyzate was evaporated until to be free from HCl vapor.

Then the residue was dissolved in diluting citrate buffer (pH 2.2). The system used for the analysis was High Performance Amino Acid Analyzer, Model: Ingos AAA400.

3.7. Tryptophan Determination

Tryptophan was determined by the colormetric method using UV-1601PC, Shimadzu. UV-Visible spectrophotometer (550 µm) according to the method described by [42].

4. Results and Discussion

4.1. Physical Characteristic of Biscuits

Wheat germ had been considered as a functional food supplement in several bakery products. The mean values of physical characteristics of wheat biscuits and fortified wheat biscuits are presented in **Table 2** and **Figures 1-3**.

The data recorded a gradual increment of spread ratio of both 15% and 20% wheat germ fortified biscuits ranging from 7.50 to 7.87; respectively. Considering the spread factor of control biscuits (100% wheat flour 72% extraction ratio biscuits) as 100, results given in **Table 2** indicated that it increased to 109 and 114 for 15% and 20% wheat germ fortified biscuits; respectively.

4.2. Sensory Characteristics of Biscuits

The sensory characteristics of the studied wheat biscuits as influenced by incorporation of 15% and 20% wheat germ are outlined in **Table 3**. The data revealed that both fortified wheat biscuits with 15% and 20% wheat

Table 2. Physical characteristics of 100% wheat flour 72% extraction biscuits (control) and wheat flour biscuits supplemented with 15% and 20% wheat germ.

Biscuit samples	Width[a] (cm)	Thickness[b] (cm)	Spread ratio[c]	Spread factor[d]
100% wheat flour-72% extraction biscuits (control)	5.5	0.8	6.87	100.00
15% fortified wheat biscuits with wheat germ	6.0	0.8	7.50	109.00
20% fortified wheat biscuits with wheat germ	6.3	0.8	7.87	11400

[a]Width of 5 biscuits in series; [b]Thickness of 5 biscuits in series; [c]Width/thickness; [d] $\frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$.

Figure 1. 100% wheat flour-72% extraction biscuits.

Figure 2. 15% wheat germ fortified wheat biscuits.

Figure 3. 20% wheat germ fortified wheat biscuits.

Table 3. Sensory characteristics of 100% wheat flour 72% extraction biscuits (control) and wheat flour biscuits supplemented with 15% and 20% wheat germ*.

Biscuits samples	Color	Texture	Taste	Odor	Overall acceptability
100% wheat flour-72% extraction biscuits (control)	7.00	7.50	7.50	8.00	7.50
15% fortified wheat biscuits with wheat germ	8.00	8.20	7.80	8.20	7.90
20% fortified wheat biscuits with wheat germ	8.00	8.30	800	7.20	8.20

*Mean of ten replicates.

germ improved all studied sensory characteristics. However, the best scores were recorded for 20% wheat germ fortified biscuits. Such data are in good agreement with [19] [23]-[25] findings.

4.3. Gross Chemical Composition of Biscuits

The mean value of gross chemical composition and caloric value of wheat biscuits and fortified wheat biscuits with 15% and 20% are given in **Table 4**. The data revealed that incorporation of 15% wheat germ in wheat flour biscuits increased crude protein, fat and crude fiber as well as moisture contents and caloric value. However, such supplementation decreased carbohydrates content. While, 20% wheat germ supplemented wheat biscuits recorded the highest crude protein (12.20%), crude fiber (2%) and the least fat (9.63%), moisture contents (3.01%) and caloric value (436.31 K Cal/100g) as well. Such data are in good accordance with [22]-[43] findings.

4.4. Minerals Composition of Biscuits

The mean values of minerals composition of wheat biscuits and 15%, 20% wheat germ fortified biscuits are outlined in **Table 5**. The data revealed that 15% wheat germ supplemented wheat biscuits had the highest Ca, Fe, P, Na and K contents; respectively. Meanwhile, 20% wheat germ supplemented wheat biscuits had the highest Mn and Cu contents, respectively. Such data coincide with [24] [25] [44]-[48] findings.

4.5. Vitamins Content of Biscuits

The data outlined in **Table 6** represented the mean values of vitamins content in wheat biscuits and 15%, 20% wheat germ fortified biscuits. The data revealed that 15% wheat germ fortified biscuits increased vitamin C and vitamin E contents. While, 20% wheat germ increased all studied vitamins, *i.e.*, C, Folic acid, A and E contents than that of wheat biscuits. Such data are in agreement with [43] [49]-[51] findings.

4.6. Amino Acids Content of Biscuits

The amino acid composition data of wheat biscuits and 15%, 20% wheat germ fortified biscuits are presented in **Table 7**. The outlined data revealed that 15% wheat germ fortified biscuits increased isoleucine, lysine, and phenylalanine contents. While, 20% wheat germ fortified biscuits increased all the eight essential amino acids contents, resulting in an improvement of the nutritive value of wheat biscuits. The data are in good agreement

Table 4. Gross chemical composition and caloric value of wheat flour biscuits and 15%, 20% wheat germ flour fortified wheat biscuits (on dry weight basis)*.

Biscuit's samples	Moisture	Ash	Protein	Fat	Crude fiber	Total carbohydrates	Caloric value Kc/100g
Wheat flour biscuits (72% extraction rate)	3.75	0.95	9.11	11.75	1.00	77.19	450.95
15% wheat germ flour fortified wheat flour biscuits	6.50	0.96	10.25	13.12	2.00	73.67	453.76
20% wheat germ flour fortified wheat flour biscuits	3.01	0.96	12.20	9.63	2.00	75.21	436.31

*Mean of three replicates.

Table 5. Mineral content of wheat flour biscuits and 15%, 20% wheat germ flour fortified wheat flour biscuits on dry basis*.

Biscuit's samples	Mn mg/kg	Ca mg/kg	Fe mg/kg	Cu mg/kg	P mg/kg	Na mg/kg	K mg/kg
Wheat flour biscuits (72% extraction rate)	5.79	1635	173.05	0.00	1299.78	6073	2756
15% wheat germ flour fortified wheat flour biscuits	40.18	1773	226.65	0.27	2923.24	6563	6290
20% wheat germ flour fortified wheat flour biscuits	48.31	1406	122.05	0.85	2667.73	5000	6200

*Mean of three replicates.

Table 6. Vitamin content of wheat flour biscuits and 15%, 20% wheat germ flour fortified wheat flour biscuits on dry weight basis*.

Biscuit's samples	Vitamin C mg/100g	Folic acid mg/100g	Vitamin A mg/100g	Vitamin E mg/100g
Wheat flour biscuits (72% extraction rate)	0.00	0.071	1354	4.00
15% wheat germ flour fortified wheat flour biscuits	2.3	0.067	1155.30	4.60
20% wheat germ flour fortified wheat flour biscuits	1.9	0.080	1454	5.70

*Mean of three replicates.

Table 7. Amino acid composition of wheat flour biscuits and 15%, 20% wheat germ flour fortified wheat flour biscuits g/100g protein of dry weight basis.

Biscuit's samples	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Tryptophan	Valine
Wheat flour biscuits (72% extraction)	0.67	5.24	1.17	0.96	1.02	0.67	0.48	3.58
15% wheat germ flour fortified wheat flour biscuits	0.76	5.22	2.01	0.92	1.20	1.12	0.50	3.36
20% wheat germ flour fortified wheat flour biscuits	0.80	6.04	2.76	0.99	1.28	1.21	0.56	3.80

with [22] [46] [47] [52]-[54] findings.

5. Conclusion

In conclusion, 20% wheat germ fortified biscuits proved to be nutritious functional and healthful food. Moreover, it could be recommended for caloric reduced diets for obese and over-weight persons. Likewise, it should be increasing interest as an ingredient in the food industry such as functional and healthy foods formulations as biscuits, bread, and cakes.

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