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Nutritive Value of Biscuits Prepared by Incorporating some Oil Seeds Flour

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Abstract

To ready and evaluate a healthy biscuit as functional food, three varieties of fortified oil crop seeds, i.e., sesame seeds (S), peanut seeds (P), and whole sunflower seeds (SF), were employed in several models of three formulations to fortify all-purpose wheat flour (WF). The results of the sensory evaluation revealed that the combination biscuits fortified with the ingredients S1 (70%WF+30%S), P1 (70%WF+30%P), PS (60%WF+20%P+20%S) as a double mixture, and PSSF (50%WF+20%P+20%S+10%SF) as a multimode had a high degree of preference sensory evaluation; thus, they were selected for a chemical evaluation. The findings of the chemical analysis demonstrated that all varied types of fortified biscuits had a higher protein, ash, crude fiber, fat, and total calorie content but lower carbohydrate content than control biscuits. S1 and PSSF combination samples had significantly ($p<0.05$) higher mineral content, total essential amino acids, biological value, protein efficiency ratio, and total monounsaturated fatty acids when compared with the control. Peanut biscuits (P1) had the lowest water activity content, and the specific volume recorded decreased significantly for all types of fortified sweet biscuits. Additionally, the PSSF sample recorded the lowest hardness value and the highest redness (a*) value. All enriched biscuits exceeded the recommended dietary requirements for a previously investigated nutrient for adolescents. Hence, it is advisable to incorporate the examined nutritional sources into bakery products to produce healthy items with elevated biological values owing to their rich nutrient composition.
Keywords: Sesame; Peanut; Sunflower, Nutritional value; Adolescence; Biscuit

1. Introduction

Functional foods impart or deliver additional health-related functions over basic nutrition [1]. The correction of nutritional deficiencies in children spatially macro and micronutrients may have beneficial effects on present and future physical and mental health [2]. The mineral element calcium is most abundant in the human body. The bones and teeth contain the largest portion (99 %) of calcium, which, together with phosphorus, gives them rigidity [3]. Through direct cell-to-cell contact or secretory proteins, osteoblasts and osteoclasts communicate to control cellular activity, survival, and differentiation [4]. Maternal human immune deficiency virus infection and low bone mineral density in children and adolescents may increase their risk of fragility fractures compared to their uninfected peers [5]. The family of wheat (*Triticum aestivum, L.*) is Poaceae. Lysine is a limited amino acid in wheat flour and abundant in protein-fortified foods derived from plant sources. For developing nations, using composite flours has a few benefits, including 1) saving hard currency, 2) promoting high-yielding native plant species, 3) improving the availability of protein for human nutrition, and 4) improving the total utilization of domestic agriculture production [6].

The family of sesame seeds (*Sesamum indicum*) is Pedaliaceae. It was discovered that the overall mineral, calcium, magnesium, and iron content of cookies increased when sesame seed flour was substituted for wheat flour at five, ten, fifteen, and twenty percent; this was in comparison to the control group [7]. Mansour et al. [8] discovered that calcium and vitamin D deficiency had different effects on developing and mature ones in female albino rats and that a distinct sesame component protected osteoporotic bone. Moreover, Yasmeen et al. [9] showed that greater calcium is a key bone mineral, reducing osteoclast and raising osteoblast pathway in bone development. Yang et al. [10] illustrated that natural lignin from sesame oil had a therapeutic impact on inhibiting the production of osteoclasts and bone resorption.

Peanut (*Arachis hypogaea*) seeds (Fabaceae family) showed that peanut sprout water extract and soy saponin could protect against bone disorders, including bone enhancement [11]. Mani et al. [12] discovered that ground nut oil-infused composites have a considerable impact on fiber shape, wet ability, and mineral deposition, demonstrating their adaptability for bone regeneration. Yuan et al. [13] reported that the calcium involved in peptides from sunflower and peanut seeds could effectively increase bone mass, structure, and Ca bioavailability. Regarding boosting calcium absorption (peanut peptide-Ca, sunflower seed peptide-Ca) in addition to high Zn bioavailability in peanuts (Arachis hypogaea L.), Singh et al. [14] demonstrated that peanuts have valuable zinc and iron contents. Moreover, magnesium, potassium, and calcium are abundant in kernels, contributing to a decrease in Zn and Fe binding with phytic acid, increasing their availability for human consumption.

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The family of sunflowers *(Helianthus annus)* is Asteraceae. Man et al. [15] found it acceptable to substitute wheat flour with sunflower seed flour at levels of (0%, 15%, 25%, and 35%), with supplementation and anti-inflammatory effects as well as a possible therapeutic agent to defend skeletal muscle dysfunction. The animals were fed meals containing polyunsaturated fatty acids, such as sunflower oil or fish oil, which reduced alveolar bone loss with increased age [16]. Choi [17] suggested that sunflower seeds might prevent bone weakness and inflamed bone disorders by enhancing osteoblast function. Germination is key to plant growth. Catabolic and anabolic mechanisms in the plant's life cycle may increase seed therapeutic potential [18]. Germination reduces protease inhibitors, making protein digestible [19]. Non germinated seeds had far more fats than 48-hour germinated [20]. The increased levels of total phenolic, melatonin, and total isoflavone contents during the sprouting process are the key reasons why sunflower sprouts have greater antioxidant activity than sunflower seeds [21].

Due to their high eating quality and extended shelf life, biscuits are rapidly gaining popularity and are one of the most consumed snacks in the world. Most bakery products, including cookies, are manufactured with refined flour [6,7,22]. Biscuit formulas with improved efficacy and nutritional value result from changes to the basic recipe and adding additives, such as fat and fibers, replacers, and grains other than wheat [6,7]. Therefore, the purpose of this study is to construct an appropriate high-nutrition-value product (biscuits) using three types of oil crop seeds (sesame, peanut, and sunflower) to fortify wheat flour (F) to prevent osteoporosis.

This study was conducted to investigate the salvations and osteoporosis protection problems conducted by enrichment fortification of bakery products with seeds of oil crops.

2. Materials and Methods

This study was conducted at the Bread and Pastries Research Technology Laboratory, Food Technology Research Institute, Agriculture Research Center, Giza, Egypt.

2.1 Materials

Wheat flour was obtained from Al Ddoha Company, Egypt. Sesame seeds (Shandawel 3 variety), peanut seeds (Giza 6 variety), and sunflower seeds (Sakha 53 variety) were obtained from the Agricultural Research Center (Field Crops Research Institute), Giza, Egypt.

Fresh eggs, corn oil, baking powder, vanilla, and powdered sugar were obtained from the local market. Egypt's El-Gomhoriah and Middle East companies supplied all the chemicals utilized in this process.

2.2 Methods

2.2.1 Preparation of roasted sesame seed flour

The whole sesame seeds were prepared based on the method described by Elleuch et al. [23]; only seeds that were not damaged were sieved to remove stone and dust, Sieving, humidification, washing with water, spinning. In aluminum dishes, whole sesame seeds were stacked in a single layer before being placed in an electric forced-air oven. Drying was conducted in an oven at 120 ˚C for one hour. After roasting, the seeds were left to cool to room temperature before being crushed using an electric mixer (MIENTA super blender) (Model BL-721) and sieved through a 280 µm sieve. The sieved flour was then placed in an airtight container and refrigerated at -18 °C until usage.

2.2.2 Preparation of roasted peanut seeds flour

Kernel peanut seeds were prepared according to the method described by Aljuhaimi and Özcan [24]. Approximately 1 kilogram of entire seed kernels was evenly dispersed in a layer on the plates and roasted at 120 °C for fifteen minutes. Before examination, the heated sample was cooled to room temperature, hulls were removed, and seeds were crushed into a powder using a grinder. The roasted seeds were sieved and packaged in polyethylene sample bags and stored at -18 °C until needed.

2.2.3 Preparation of sprout whole seeds roasted sunflower flour

Sunflower seeds germinated according to the method described by Aishwarya and Anisha [25]. Whole seeds (free of insects and illnesses) were then properly washed with running water to remove extraneous particles and dust. Then, they were soaked for 3–4 hours and let to germinate in the air, then drained (in a colander) to get rid of the water, dried (in a dehydrator at 115°C for 6–8 hours), ground (in a food processor), passed through a 280 µm sieve, and finally stored (in polythene bags) at -18 °C until needed.

2.2.4 Preparation of different types of biscuits

The biscuits were carefully made in the Lab of the Pastries and Bread Research Department, Food Technology Research Institute, Agricultural Research Center. Table (1) lists the ingredients necessary to prepare biscuits with a few modifications using Wade's [26] method.

Table (1): The ingredients listed in the formula for sweet biscuits.

Ingredients	Amount(g)
Wheat flour (all-purpose)	100
Corn oil	22
Sugar (Powder)	30
Egg (Fresh)	24
Baking powder	2.5
Vanillin	1

2.2.5 Treatment

As shown in Table (2) and Figure (1), a preliminary test was performed to find the most favorable combination ratio of the selected raw materials, as suggested in this investigation.

For biscuit preparation, sugar-corn oil was creamed and added to the egg-vanilla mixture, which was then beaten at a low speed for 15 minutes. After that, the dry ingredients, such as wheat flour or baking powder, were added gradually and stirred until the dough achieved a smooth consistency.

Finally, the ball of dough was allowed to rest for 15 minutes. Using a guide roll, the dough was spread on a baking sheet. The dough was divided into circles (5cm in diameter and 0.3 cm thick). It was placed in a well-greased dish and then baked in an electrically heated oven at 170 °C for 12 to 15 minutes. One hour was given for biscuits to cool at ambient temperature after baking before sensory evaluation.

Table (2). Blends components that are used to make sweet biscuits.

Treatments		Blends composition	Symbol
Control		100% Wheat	Con.
Single mixes	1	70% Wheat +30% sesame	S1
	2	70% Wheat +30% Peanut	P1
	3	70% Wheat +30% sunflower	SF1
Double mixes	4	60% Wheat +20% peanut +20% sesame seed	PS
	5	60% wheat +20% sesame +20% sunflower seed	SSF
	6	60% wheat +20% sunflower seed +20% peanut seed	SFP
Multi mixes	7	50% wheat +20% peanut seed +20% sesame seed +10 sunflower seed.	PSSF
	8	50% wheat +20% sesame seed +20% sunflower seed +10% peanut seed.	SSFP
	9	50% wheat + + 20% sunflower seed +20%Peanut seed 10% sesame seed.	SFPS

2.2.6 Sensory characteristics of sweet biscuits

The characteristics of biscuits' aroma, texture, and flavor were evaluated using the approach of Sai Manohar and Haridas Rao [27] by a panel of ten expert judges (from the Food Technology Research Institute) assigning points for different quality characteristics, including general appearance (20), taste (20), odor (20), color (20), crispiness (20) and total score (100).

The average of the total score was converted to a descriptive category (acceptance) as follows: "Very good" 90 – 100, "Good" 80 – 89, "Satisfactory" 70 – 79 and "Questionable" less than 70.

2.2.7 Chemical analysis

- Moisture contents for raw materials and sweet biscuits were determined as the method described by Latimer AOAC 934.01 [28], using the conventional oven (Ctra Km: 585.1, Barcelona, Spain).
- Crude fat gross determined as the method described by Latimer AOAC 2003.06 [28], using Soxhlet Extractor model-2045 Foss.
- Crude protein was determined as the method described by AOAC [28] No 988.05, using the Kjeldahl method. (Crude protein content percent per weight = total nitrogen * 6.25 for peanut and composite flour and total nitrogen *5.4 for others.

Crude protein %= Kjeldahl N% x F →Equation (1)

- Crude fiber was determined as the method described by AOAC [28] by using Fibertech model 2023 Foss.
- Available carbohydrate content was calculated according to Fraser and Holmes [29] as follows:

Available carbohydrates (g/100g) (on a dry basis) =100 – (Ash +Fat +Protein + Fiber →Equation (2)

-The total energy of pan bread was calculated According to Passmore et al. [30] following:

Total energy (K. Cal/100g) equals 4 (% carbohydrate+% protein) + 9 (% fat) →Equation (3)

- Minerals content (Ca, P, Fe, Mg, Mn, K, Na, Zn and Cu) was determined as a method described by AOAC [28], using Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer.

Amino acids were measured according to the method described by AOAC [28] official method No.994.12 using Automatic Amino Acid Analyzer AAA400, INGOS Ltd.

- Protein Efficiency Ratio (PER) was estimated using the equation reported by Alsmeyer et al. [31] as follows:

PER= 0.684 +0.456 (leucine) - 0.047 (proline). (g/100 g protein) →Equation (4)

- Biological value (BV) was calculated using the equations suggested by Block and Mitchell [32]

BV= 49.9+ 10.53 PER →Equation (5)

- Fatty acid was determined as the method described by IUPAC [33] by using a Gas chromatography spectrometer (Thermo Scientific, Austin, TX, USA)
- Water activity (a_w) evaluated at 25°C by using a Decagon Aqua lab Meter Series 3TE (Pullman, WA, USA). All samples for sweet biscuits were broken into small pieces at the same moment before the water activity assessment. The measurements were performed in triplicate according to Shahidi et al. [34].

2.2.8 Properties of biscuits:

To determine the average diameter and thickness of five biscuits, Sai Manohar and Rao [27] conducted measurements in millimeters. The volume was determined through the displacement method using rape seed. The specific volume was determined by dividing the volume (cm3) by the weight of the biscuit (g).

- Spread Ratio $= \frac{\text{Diameter}}{Thickness}$ → Equation (6)
- Spread Factor = $\frac{\text{Spread ratio of the sample}}{\text{Spread ratio of the control}} \text{ X } 100$ → Equation (7)

2.2.9 Texture profile analysis of sweet biscuits

The texture profile of sweet biscuits was assessed using a Brookfield CT3 Texture Analyzer, specifically the model with operating instructions manual No. M08-372-C0113 (manufactured by Stable Micro Systems in the United States). The measurement focused on determining the hardness (expressed in Newtons) of the biscuit samples. The test was of the compression type, with a target compression distance of 5.0mm. The hold time during compression was set to 0 seconds. The trigger load applied during the test was 5.00 N (Newton). The compression speed used was 2.00 mm/s, while the return speed was set to 2mm/s per cycle. In addition, the pretest speed before compression was set to 2 mm/s. The experimental setup consisted of a probe with the designation TA-PFS-C, a fixture identified as TA-RT-KIT, and a load cell capable of measuring up to 10000g to measure hardness, adhesiveness, and fracture ability parameters. The experiments were conducted under ambient conditions Bourne et al.[35].

2.2.10 Determination of color attribute of biscuit

The method outlined by Mc Gurie [36] was employed to measure the external color of the products; values of $L*$, $a*$, and $b*$ were determined using a handheld Chromameter (model CR-400, Konica Minolta, Japan). The coordinates pinpoint the measured color in a three-dimensional color space by averaging the color of three biscuits per treatment.

2.2.11 Recommended dietary allowances %

Recommended dietary allowances % (RDA), from the Dietary Reference Intakes, according to the Food and Nutrition Board [37], was calculated as follows:

RDA% $= \frac{\text{Value in nutrient in sample of biscuitx100}}{\text{RDA for the same nutrient}}$ → Equation (8)

2.2.12 Statistical analysis

The sensory evaluations, chemical composition, and physical attributes data were analyzed with the statistical software SAS [38], utilizing the least significant difference value (LSD) at a 5% probability level.

3. Results and Discussion

3.1 Sensory evaluation of preliminary all types of sweet biscuits:

Sensory testing can help identify the imperative sensory characteristics driving acceptability. It can be useful to discover target consumers and assess innovative ideas. Sensory evaluation ensured that substandard food products (bread and bakery products) were not released to the market [39] before a preliminary experiment was conducted to find the ideal proportions of the proposed raw materials used for this investigation.

Due to the effect of all sensory features, the overall acceptability of producing sweet biscuits was rated from 90 to 100 degrees as "very good", and below 70 degrees was "questionable".

The results of the sensory assessment of single mixtures from the indicated materials did not produce a statistically significant difference ($p>0.05$). Table (3) and Fig (1) reveal that samples S1 and P1 did not differ significantly from the control biscuit and yet received extremely high scores.

Regarding the production of sweet biscuits fortified with oil crop seeds, double mixed biscuits indicated that the sample PS was not statistically different ($p>0.05$) from the control biscuit and had a very good acceptable score. Multimode mixed biscuits highlighted that sample PSSF had no significant differences compared to the control. Thus, these prior levels with particularly good acceptability were chosen for evaluation in this work. These results corresponded well with those published by Kishor et al. [40] for fortifying biscuits with sesame and Ojo and Omolade [22] for fortifying with peanut seeds while Man et al. [15] and Grasso et al. [6] for fortifying with sunflower seeds.

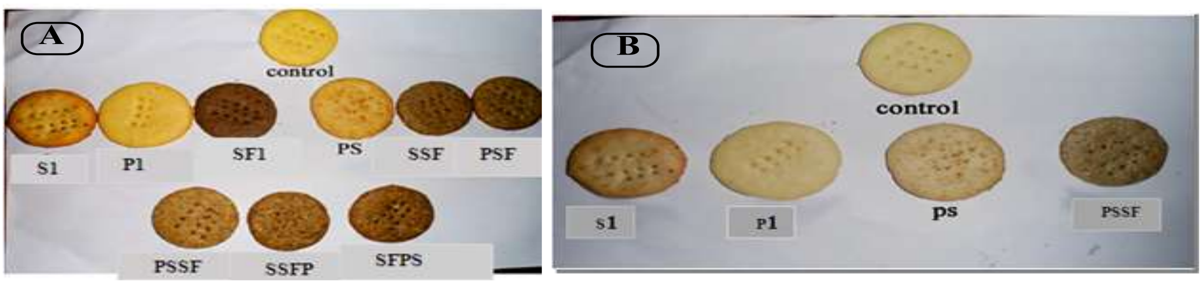

Fig. (1): (**A**) Sweet biscuit fortified with single, double and triple mixed levels of different seeds of oil crops (according to Table 1). (B Selected Sweet biscuit fortified with single, double and triple mixed levels of different seeds of oil crops. Control = 100% wheat flour; S1 =70% wheat flour +30% sesame seeds flour; P1 =70% wheat flour +30% peanut seeds flour; PS = 60% wheat flour + 20% peanut +20% sesame seeds flour; PSSF =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sunflower seeds.

Table (3): Sensory evaluation of different sweet biscuits

Treatments	General appearance (20)	Odor (20)	Taste (20)	Crispiness (20)	Color (20)	Total score (100)	Acceptance
Fortified with a single level of different seeds of oil crops.							
Control (100%WF)	19.10[a] ±0.99	18.70[a] ±1.25	18.90[a] ±1.10	18.50[a] ±0.97	19.20[a] ±0.79	94.40[a] ±3.63	V
P1 (70%WF +30%P)	18.60[ab] ±1.65	18.30[a] ±1.57	18.20[ab] ±1.69	18.40[a] ±1.35	19.20[a] ±1.32	92.70[a] ±5.95	V
S1 (70%WF +30%S)	17.50[bc] ±1.18	18.60[a] ±1.35	18.20[ab] ±1.40	19.20[a] ±1.03	19.40[a] ±2.27	92.90[a] ±3.93	V
SF1 (70%WF+30%SF)	16.90 [c]±2.03	18.00[a] ±1.83	17.20[b] ±2.70	18.10[a] ±2.08	16.60[b] ±1.90	86.80[b] ±9.25	G
LSD at 5%	1.38	1.37	1.65	1.30	1.51	5.54	--
Fortified with double mixed same levels of different seeds of oil crops							
Control (100%WF)	19.10[a] ±0.99	18.70[a] ±1.25	18.90[a] ±1.10	18.50[a] ±0.97	19.20[a] ±0.79	94.40[a] ±3.63	V
PS (60%WF+20%P+20%S)	17.50[ab] ±2.17	18.00[a] ±1.94	18.10[ab] ±2.64	18.70[a] ±1.70	17.70[ab] ±2.06	90.10[ab] ±8.98	V
SSF (60%WF+20%S+20%SF)	16.30[b] ±2.63	17.80[a] ±1.55	17.30[ab] ±1.89	18.50[a] ±1.43	16.30[bc] ±2.63	86.30[b] ±7.35	G
PSF (60%WF +20%P+20%SF)	16.00[b] ±2.67	17.90[a] ±1.52	16.90[b] ±1.60	17.70[a] ±1.64	15.60[c] ±2.59	84.30[b] ±6.50	G
LSD at 5%	2.01	1.44	1.72	1.33	1.95	6.25	--
Fortified with triple mixed levels of different seeds of oil crops							
Control (100%WF)	19.10[a] ±0.99	18.70[a] ±1.25	18.90[a] ±1.10	18.50[a] ±0.97	19.20[a] ±0.79	94.40[a] ±3.63	V
PSSF (50%WF+20%P+20%S+10%SF)	18.00[ab] ±1.70	18.70[a] ±1.70	18.60[ab] ±1.65	18.70[a] ±1.64	17.60[ab] ±2.07	91.60[ab] ±7.75	V
SSFP (50%WF+20%S+20%SF+10%p)	17.40[b] ±1.35	17.70[a] ±1.89	17.70[ab] ±2.11	18.30[ab] ±1.34	16.30[b] ±2.67	87.40[bc] ±8.11	G
SFPs (50%WF+20%SF+20%P+10%S)	17.30[b] ±1.42	17.30[a] ±2.16	17.20[b] ±1.99	17.00[b] ±2.16	15.90[b] ±2.85	84.70[c] ±9.19	G
LSD at 5%	1.26	1.63	1.59	1.44	2.03	6.78	--

*Data represents as mean ±SD. Each value within the same column followed by the same letter is not considered significantly different at $P \leq 0.05$.
*90-100 is very good (V); 80-89is good (G); 70-79 is satisfactory (S); less than 70 is questionable (Q).
***WF**= wheat flour; **S1**= roasted sesame seeds flour; **P**1=roasted peanut seeds flour; **SF**= sprout whole sunflower seeds flour.

3.2 Chemical composition of raw materials and produced biscuits:

Table (4) and Fig (2) show the chemical composition of raw materials. It can be observed that all-purpose wheat flour had the highest levels of moisture and carbohydrate11.03 and 84.15 %, but the lowest levels of the remaining parameters (protein 12.60 %, crude fat2.34%, ash 0.56%, crude fibre 0.43%, and energy 407.26 Kcal/100g). Sesame seeds contained the highest values of ash (4.65%), followed by whole sunflower seeds (3.04%) and peanut seeds (2.47%). Peanut seeds contained the highest value of protein (27.19%), fat (54.6%), and energy (619.81 k.cal/100g). Moreover, whole sunflower seeds recorded the highest value of crude fibre (23.60%), which was comparable with sesame seeds (23.41%), followed by peanut seeds (10.93%) on a dry weight base compared with wheat flour (0.43%). Our results agreed with Olagunju and Ifesan [41], who recorded 52.70% fat and 5.83% ash content in raw sesame seeds. However, they differed in terms of protein (26.23%), fiber (3.56%), and carbohydrates (9.77%). According to Tenyang et al. [42], white roasted sesame seed has an ash content of 3.18% and a protein content of 15.60%. However, there are variances in the amounts of crude fat, fiber, and carbohydrate (62.04, 5.07, and 11.57%, respectively). This finding is comparable to that of De Lamo and Gómez [43], who demonstrated sunflower carbohydrate content of 24.07% but differences in protein 19.33%, lipid 49.8%, fiber 9%, and energy value of 582 kcal/100g. Our results matched the findings of Mohamed [44], who measured the moisture (6.57%), protein (25.42%), fat (50.64%), and ash (2.05%) content of groundnut, but different in fibre (0.83%) and carbohydrates (14.41%), and nearly to sesame seed in fat

(49.55%), ash (2.37%), and protein (21.81%); however, contrasts in moisture (6.79%), fibre (8.52%) and carbohydrates (10.94%) compared with wheat which contains around 11.90% moisture,1.01% fat, 0.60% ash, 10.75% protein and 0.72% fibre, but differences in carbohydrates (75%).On the other hand, the present study agreed with Tenyang et al. [45], who noticed changes in lipids (55.28%), protein (22.07%), fibre (4.04%), and carbohydrate (14.42%) but not in moisture (2.32%) and ash (3.95%) in roasted sunflower seeds at 120°C/30 min.

Table (4): Proximate composition of raw materials and selected sweet biscuits on dry weight base

Samples	Parameters							
	Moisture	Dry matter	Crude Protein	Crude fat	Ash	Crude fibre	Available carbohydrates	Energy Kcal/100g
Raw materials: Wheat flour (WF), sesame (S), peanut (P) and sunflower (SF)								
WF	$11.03^{a}\pm0.35$	$88.14^{d}\pm0.17$	$12.60^{d}\pm0.23$	$2.34^{d}\pm0.07$	$0.56^{d}\pm0.07$	$0.43^{c}\pm0.02$	$84.15^{a}\pm0.31$	$407.26^{d}\pm0.15$
S	$3.78^{c}\pm0.22$	$96.22^{b}\pm0.22$	$18.63^{b}\pm0.21$	$51.56^{b}\pm0.42$	$4.65^{a}\pm0.01$	$23.41^{a}\pm0.10$	$1.75^{d}\pm0.13$	$545.54^{b}\pm2.44$
P	$2.88^{d}\pm0.07$	$97.13^{a}\pm0.07$	$27.19^{a}\pm0.09$	$54.67^{a}\pm0.03$	$2.47^{c}\pm0.01$	$10.93^{b}\pm0.09$	$4.76^{c}\pm0.09$	$619.81^{a}\pm0.15$
SF	$5.45^{b}\pm0.21$	$94.56^{c}\pm0.21$	$14.11^{c}\pm0.40$	$36.89^{c}\pm0.11$	$3.04^{b}\pm0.04$	$23.60^{a}\pm0.27$	$22.35^{b}\pm0.27$	$477.89^{c}\pm1.47$
Fortified biscuits								
Cont	$3.30\ ^{b}\pm0.05$	$96.70^{c}\pm0.05$	$8.80^{d}\pm0.35$	$18.34^{e}\pm0.54$	$1.53^{d}\pm0.07$	$0.26^{d}\pm0.05$	$71.00^{a}\pm0.06$	$485.06^{d}\pm3.07$
S1	$3.47^{b}\pm0.09$	$96.54^{c}\pm0.09$	$11.24^{b}\pm0.16$	$27.62^{c}\pm0.30$	$2.48^{a}\pm0.08$	$3.27^{bc}\pm0.92$	$55.46^{c}\pm0.39$	$515.30^{c}\pm4.82$
P1	$2.93^{c}\pm0.01$	$97.08^{b}\pm0.01$	$12.56^{a}\pm0.50$	$27.88^{c}\pm0.02$	$1.94^{c}\pm0.19$	$1.98^{c}\pm0.25$	$55.65^{c}\pm0.57$	$523.70^{bc}\pm0.17$
PS	$2.98^{c}\pm0.19$	$97.01^{b}\pm0.19$	$12.71^{a}\pm0.14$	$31.00^{b}\pm0.23$	$2.24^{ab}\pm0.10$	$3.21\ ^{bc}\pm1.44$	$50.85^{d}\pm1.70$	$533.11^{ab}\pm4.34$
PSSF	$3.91^{a}\pm0.08$	$96.09^{d}\pm0.08$	$13.08^{a}\pm0.20$	$34.06^{a}\pm1.16$	$2.47\ ^{a}\pm0.16$	$5.01^{a}\pm1.13$	$45.39^{e}\pm0.07$	$540.40^{a}\pm10.94$

*Data represents as mean ±SD. Each value within the same row followed by the same letter is not considered significantly different at $P \leq 0.05$.

***WF**= wheat flour; **S1**= roasted sesame seeds flour; **P**1=roasted peanut seeds flour; **SF**= sprout whole sunflower seeds flour.

*__Cont__ = (control)100% wheat flour; **S**1 =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% peanut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sun flower seeds.

To ensure the consumer's health, safety, and well-being, it is essential to have a thorough understanding of the chemical composition of food [46].

The chemical alterations in chosen sweet biscuits according to the addition of various suggested raw materials were analyzed, and the acquired results demonstrated significant (*p<0.05*) increases in protein, fat, and fibre (Table (6)). The protein content started from 11.24% in the S1 sample to

13.08% in the PSSF sample, compared to 8.80% in the control sample. In addition, the fat content varied from 27.62% in the S1 sample to 34.06% in the PSSF sample, compared to 18.32% in the control sample. On the other hand, the ash content was determined to obtain mineral details.

In the current investigation, there was little significant difference in the fortified samples (1.94% (P1 sample) and 2.48% (S1 sample) compared to 1.54% for the control).

Compared to the control sample, which contained 0.26% crude fibre, the various samples' crude fibre contents ranged from 3.27% for the S1 sample to 5.01% for the PSSF sample. Regarding available carbohydrates, the results ranged from 45.39% in the PSSF sample to 55.65% in the P1 sample, compared to 71% in the control. The total energy levels ranged from 515.30 Kcal/100g in the S1 sample to 540.40 Kcal/100g in the PSSF sample, compared to 485.06 Kcal/100g in the control; variation in values was due to the various nutritional values of the raw materials employed. Lipids, protein, and glucose give energy and supply important nutrients for regular physiological activities such as fat storage and muscle development [47]. Due to their high vitamin content, peanuts have been utilized to prevent osteoporosis in most developing countries. These results were consistent with Olagunju and Ifesan [41] for biscuits fortified with sesame seeds and with Ojo & Omolade [22] for biscuits fortified with peanut butter. Our outcomes were the same trend as Kishor et al. [40]. The improved nutritional content of the biscuit resulted from using wheat flour and sesame seed in varying proportions. Our results were comparable to those of Labuckas et al. [48], who discovered that cookies made from defatted peanut flour included three times higher protein and nine times higher fibre than cookies made with wheat flour. Also, the present result was high protein values in biscuits supported with oil seeds, which increased osteoblasts and decreased osteoclasts, meanwhile reducing osteoporosis disease in childhood and adolescent period [4].

3.3 Minerals composition of raw materials and selected sweet biscuits mg/100g on dry weight base

The most important minerals for children's physiological demands are Ca, Fe, Mg, and Zn. Their presence in raw materials is a core part of dietary mixes. For instance, Ca is combined with salts to strengthen teeth and bones. Fe is necessary for increasing the volume of blood and haemoglobin in children and adolescents. In comparison, Mg is valuable for cells because it motivates several metabolic processes. Zn acts as a complement of more than 20 metabolic enzymes. Furthermore, it enhances our immune systems, aids in wound healing, and is involved in building new cells [49].

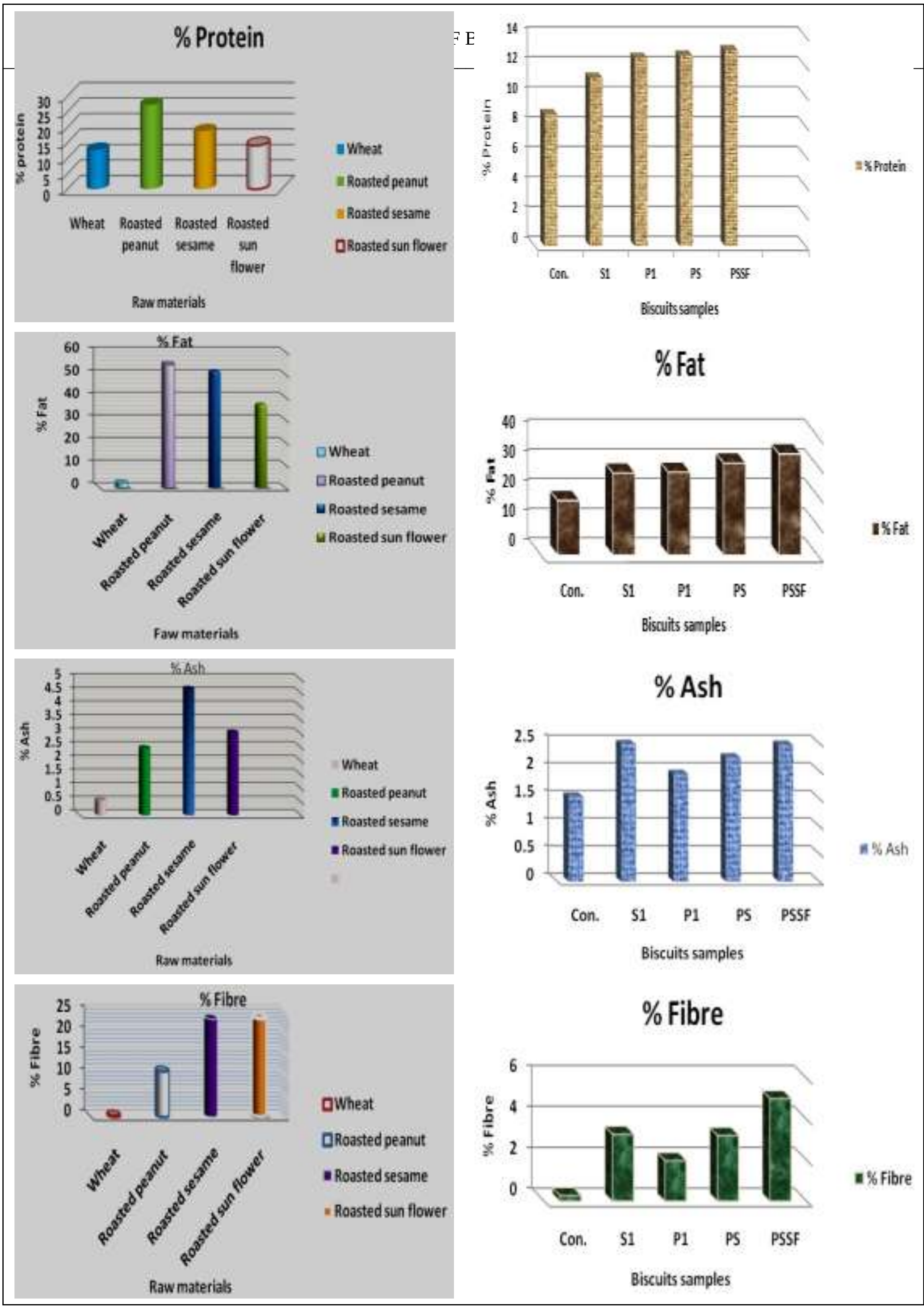

Fig. (2): Proximate composition of raw and selected sweet biscuits.

The data presented in Table (5) and Fig (3) showed significant ($p<0.05$) increases in the case of sesame seeds with high values of Ca, Fe, Mn, and Na (114.01, 2.37, 1.75, and 90.69mg/100g, respectively). Whole sunflower seeds had the highest P, Mg, K, and Zn (65.16, 30.73, 554.45, and 5 mg/100g, respectively). Furthermore, peanuts had the greatest Cu value (1.71mg/100g). In contrast, all-purpose wheat flour had the lowest value of these minerals (Ca 33.65, P 19.53, Fe 1.08, Zn 2.13, Mn 0.65, K 195.35, Na 40.76, Cu 0.13, and Mg 3.84 mg/100g, on dry weight base). These results were in agreement with de Lamo and Gómez [43], who found that Ca (33mg/100g), Fe (3.7mg/100g), and Zn (2. 96mg/100g), but higher than our results in Mg (117mg/100g), P (323 mg/100g), K (394 mg/100g) and sodium (3 mg/100g). These results agreement with the wheat flour findings of Alshehry [50]

Our observation was confirmed on sesame seeds (value of Fe 2.02 mg/100g) by Obeta et al. [51]. Mohamed [44] showed that the total minerals in sesame and groundnut were high, but the lowest value was in wheat. Consumption of sesame and flax seeds as a combination food carried out enhanced bone health and protected from osteoporotic diseases Yasmeen et al. [9]. Sesame content was higher in Zn (5.51 mg/100g), Mg (351.71 mg/100g), Ca (862.31 mg/100g), and P (380.70 mg/100g) but lower in K (385.68 mg/100g). Moreover, groundnut seeds increased in (Zn 5.31 mg/100g) and Fe (2.73 mg/100g), Mg (294.24 mg/100g), Ca (129.42 mg/100g), P (213.52 mg/100g), and K (868.71 mg/100g) compared with wheat flour which was similar in Ca (35.48 mg/100g), Fe (3.08 mg/100g) and Zn (2.07 mg/100g), but there were differences in Mg (130.18 mg/100g), P (321.75 mg/100g) and K (362.24 mg/100g). On the other hand, our data agreed with Muttagi and Joshi [52] regarding sunflower seed varieties. They found that ash rated (3.54%-3.92%), Ca (77.63-84.56 mg/100g), Fe (3.83-4.67 mg/100g), and Zn (3.77-4.0556 mg/100g), but not similar in P (640–67056 mg/100g). Furthermore, in comparison with groundnut seeds, it agrees in the case of ash 2.34%, Zn (2.98 mg/100g), and Fe (3.31 mg/100g), but different in Ca (60.79 mg/100g) and P (296.77 mg/100g).

Table (5): Minerals composition of raw materials and selected sweet biscuits mg/100g (on dry weight base).

Sample mg/100g	Constituents								
	Calcium	**Phosphor**	**Magnesium**	**Manganese**	**Iron**	**Potassium**	**Sodium**	**Zinc**	**Cupper**
Raw material: Wheat flour (WF), sesame (S), peanut (P) and sunflower (SF)									
WF	$33.65^{d}\pm$ 0.65	$19.53^{c}\pm$ 1.08	$3.84^{c}\pm$ 0.399	$0.65^{b}\pm$ 0.0s	$1.08^{c}\pm$ 0.08	$192.35^{c}\pm$ 4.19	$40.76^{c}\pm$ 2.65	$2.13^{c}\pm$ 0.13	$0.13^{d}\pm$ 0.03
S	$114.01^{a}\pm$ 6.02	54.72b± 0.42	$30.2^{5\,a}\pm$ 1.33	$1.75^{a}\pm$ 0.45	$2.37^{a}\pm$ 0.56	$441.33^{c}\pm$ 9.51	$90.69^{a}\pm$ 9.66	4.50ab± 0.50	1.50b± 0.02
P	$95.53^{b}\pm$ 0.95	$48.31^{b}\pm$ 5.95	$19.94^{b}\pm$ 0.66	$1.56^{a}\pm$ 0.24	$1.46^{bc}\pm$ 0.14	$531.18^{b}\pm$ 2.55	$89.19^{a}\pm$ 3.27	$3.50^{b}\pm$ 0.50	$1.71^{a}\pm$ 0.04
SF	$69.60^{c}\pm$ 6.18	$65.16^{a}\pm$ 5.62	$30.73^{a}\pm$ 1.30	$1.40^{a}\pm$ 0.11	$1.67^{b}\pm$ 0.05	$554.45^{a}\pm$ 5.95	$65.53^{b}\pm$ 12.53	$5.00^{a}\pm$ 1.00	$0.42^{c}\pm$ 0.03
Fortified biscuits									
Control	$24.32^{d}\pm$ 2.47	$47.70^{c}\pm$ 6.54	$3.09^{b}\pm$ 0.75	$0.42^{c}\pm$ 0.06	$0.98^{c}\pm$ 0.02	$137.08^{d}\pm$ 7.81	$50.58^{ab}\pm$ 2.3	$1.41^{e}\pm$ 0.02	$0.07^{e}\pm$0. 01
S1	$40.02^{ab}\pm$ 3.51	$51.36^{bc}\pm$ 3.78	$4.87^{ab}\pm$ 0.67	$0.68^{a}\pm$ 0.10	$1.68^{a}\pm$ 0.34	$193.8^{8c}\pm$ 10.08	$60.65^{a}\pm$ 3.60	$1.75^{c}\pm$ 0.04	$0.28^{c}\pm$ 0.02
P1	$35.54^{bc}\pm$ 2.32	$46.08^{c}\pm$ 1.25	$5.66^{a}\pm$ 1.11	$0.51^{bc}\pm$ 0.03	$1.14^{bc}\pm$ 0.08	$195.43^{c}\pm$ 7.13	$52.33^{ab}\pm$ 9.53	$1.57^{d}\pm$ 0.03	$0.33^{b}\pm$ 0.02
PS	$41.84^{ab}\pm$ 0.88	$61.55^{ab}\pm$ 12.95	$4.54^{ab}\pm$ 0.14	$0.52^{b}\pm$ 0.04	$1.16^{bc}\pm$ 0.11	$265.60^{b}\pm$ 10.86	$57.21^{a}\pm$ 6.64	$1.81^{b}\pm$ 0.03	$0.41^{a}\pm$ 0.02
PSSF	$42.78^{a}\pm$ 7.99	$65.00^{a}\pm$ 5.58	$4.74^{ab}\pm$ 0.18	$0.61^{a}\pm$ 0.05	$1.29^{b}\pm$ 0.10	$296.78^{a}\pm$ 8.15	$59.08^{a}\pm$ 10.02	$1.90^{a}\pm$ 0.03	$0.42^{a}\pm$ 0.02

*Data represents as mean ±SD. Each value within the same row followed by the same letter is not considered significantly different at $P \leq 0.05$.

***WF**= wheat flour; **S1**= roasted sesame seeds flour; **P**1=roasted peanut seeds flour; **SF**= sprout whole sunflower seeds flour.

*__Control__ = 100% wheat flour; **S**1 =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% pea nut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sun flower seeds.

The results outcomes in Table (5) and Fig (3) might demonstrate a significant increase in the PSSF sample where it had the highest value of Ca, P, Mn, K, Zn, and Cu (42.68, 65.00, 0.61, 296.78, 1.90, and 0.42mg/100g, respectively). The highest values of Mg and Fe were observed in the S1 sample (4.87 and 1.68 mg/100g, respectively). Furthermore, all samples had no significant differences in Na value compared with the control.

In contrast, the control sample had the lowest value for most minerals such as Ca, P, Mg, Mn, Fe, K, Na, Zn, and Cu (24.32, 47.70, 3.09, 0.42, 0.98, 137.08, 50.58, 1.41, and 0.07 mg/100g, respectively).

Data showed that all types of biscuit samples had high calcium and phosphor values compared with the control; thus will be carrying out improved bone mass in children and adolescents when consuming these types of bakery products [3,13,53].

Also, biscuits supplemented with sesame, peanut and whole sunflower seeds recorded high amount of calcium, which protects bone health as well as avoids osteoporosis [7,12,54,55].

Also, increased potassium levels could be an added advantage to the product as potassium is an important mineral in maintaining osmotic pressure and acid-base balance; sodium is an important mineral that helps control body water and regulate thirst. Zinc is essential for numerous biological processes, including reproduction, glucose regulation, and stress management. These results agreed with a previous study that reported that biscuits (wheat flour substituted with sesame, cumin, and Moringa) were a reliable source of bio-accessible minerals (Ca and Zn). They might help improve the mineral profiles of diets [56].

Moreover, our results agreed with Salem et al. [57], where cake samples created by adding sunflower seeds to wheat flour contained significantly more zinc, potassium, iron, manganese, and magnesium than the control sample. Peanut flour is a rich source of micronutrients for a healthy supply of nutrients for human growth and development [58].

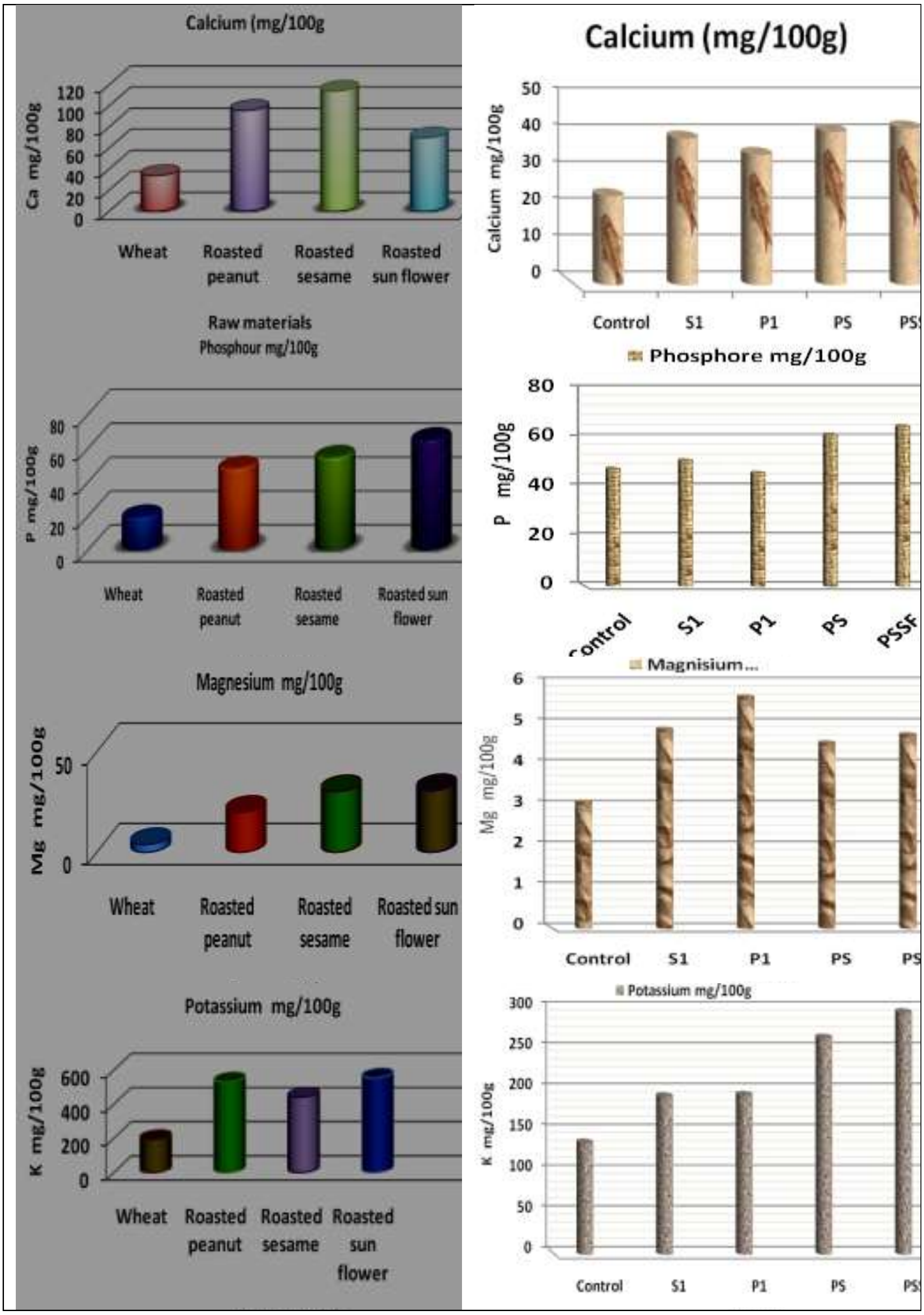

Fig. (3): Minerals composition of raw materials and selected sweet biscuits.

3.4. Amino acid content of fortified biscuits

The amino acid composition of a protein is a determining factor in its overall quality. The human body endogenously synthesizes non-essential amino acids which are not deemed necessary to be obtained through dietary sources. However, the necessary amino acids are extremely important from a nutritional standpoint because the body cannot produce them and must thus be supplemented in the food [59]. The necessary amino acid content, protein efficiency ratio (PER), and biological value (BV) are methods of assessing protein quality. In comparison to the control biscuits (Table 6 and Fig 4), the fortified biscuit samples exhibited higher quantities of leucine, lysine, threonine, and histidine, along with total essential amino acids (total EAA) and additional amino acids, such as arginine and aspartic acid, as indicated in Table 6.

Table (6): Amino Acids composition (g A.A /100g protein) of selected sweet biscuits

Amino Acids	Biscuits					
	Control	**S1**	**P1**	**PS**	**PSSF**	**FAO/WHO Pattern (1991)**
Essential Amino Acids (EAA)						Adult
Histidine	2.18	2.36	2.38	2.33	2.28	1.6
Lysine	2.95	3.22	3.45	3.31	3.36	1.6
Isoleucine	3.89	3.87	3.96	3.43	3.84	1.3
Leucine	7.00	7.31	7.26	7.23	7.20	1.9
Methionine	1.71	1.61	1.07	1.35	1.56	--
Cysteine	1.71	1.82	1.79	1.72	1.92	--
Phenylalanine	5.27	5.05	5.24	5.27	5.28	--
Tyrosine	3.89	3.87	3.93	4.05	4.20	--
Threonine	3.27	3.65	3.33	3.56	3..60	0.9
Valine	4.51	4.51	4.40	4.17	4.56	1.3
***Tryptophan**	--	--	--	--	--	0.5
Total (without histidine)	34.20	34.91	34.43	34.09	35.52	11.1
Total EAA	36.38	37.27	36.81	36.42	37.80	12.7
Non-Essential Amino Acids (NEAA)						
Arginine	4.36	7.63	7.73	8.46	8.76	--
Aspartic acid	5.29	6.88	8.69	8.21	8.76	--
Serine	5.45	5.26	5.11	5.52	5.04	--
Glutamic acid	30.68	26.56	25.83	25.15	23.88	--
Proline	10.43	7.85	7.38	7.11	6.60	--
Glycine	3.58	4.19	4.37	4.77	4.80	--
Alanine	3.73	4.30	4.04	4.28	4.32	--
Total NEAA	63.52	62.67	63.15	63.50	62.16	--
Total AA	99.90	99.94	99.96	99.92	99.96	--
PER	3.39	3.65	3.65	3.65	3.66	--
BV	85.60	88.34	88.34	88.34	88.44	--

***Control** = 100% wheat flour; **S**1 =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% peanut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sun flower seeds.
* **PER=** protein efficiency ratio**, BV=** biological value.

Furthermore, proline and total non-essential amino acids (total NEAA) were elevated in unfortified biscuits. All fortified biscuits had a greater PER and BV than unfortified biscuits.

The PSSF sample had the highest levels of total EAA, PER, and BV compared to the control and other fortified biscuits. Our results agreed with literature [60] which, aproved that sunflower seed peptide and peanut peptide could promote Ca transport in Caco-2 cells without affecting cell

permeability. Consequently, the PSSF sample and S1 are appropriate for newborns, children, and teenagers [13,60]. It has been known for a long time that low protein or amino acid intake weakens immune function and usually leads to infectious diseases [61]. Available in PSSF samples biscuits in peanut and sunflower seeds protein peptide chains related to calcium without cells harmful carried out enhanced bone content as well as avoid from osteoporotic disuse.

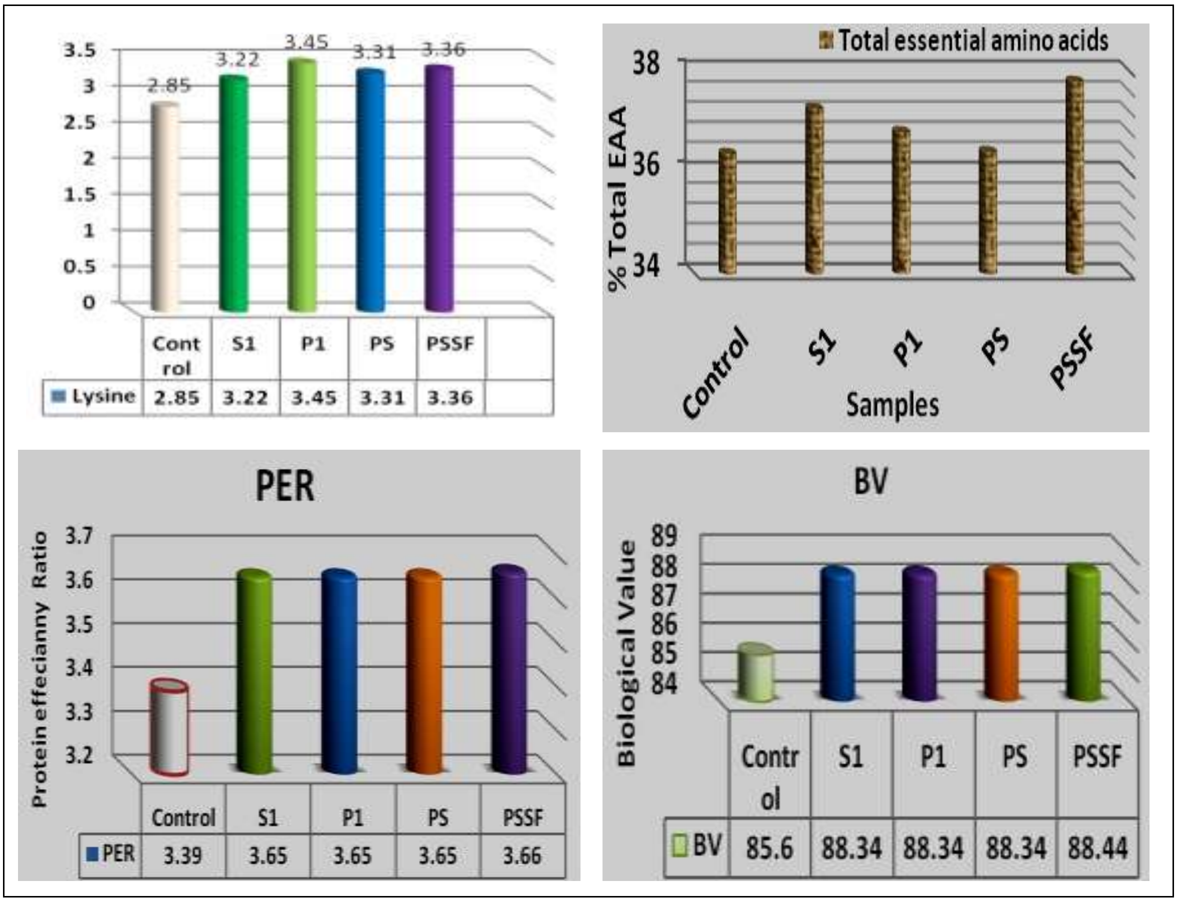

Fig.(4): Amino Acids composition (g A.A /100g protein) of selected sweet biscuits

3.5. Fatty acids composition of selected sweet biscuits

The composition of fatty acids in the final biscuits is shown in Table (7) and Fig (5). The results determined that palmitic acid was the predominant saturated fatty acid (SFA) in all oil samples of biscuits. S1 and PSSF samples contained fewer saturated fatty acids than the control and others.

Oleic acid was more abundant than monounsaturated fatty acids (MUFA). Compared to the control sample, all enriched biscuit samples showed higher levels of total TMUFA and lower levels of total polyunsaturated fatty acid (TPUFA).

Our result was in agreement with [62],who showed the detection of corn oil in adulterated sesame oil, as well as increased palmitic, linoleic, and linolenic acids as the mixed rate of corn oil was increased, whereas decreased stearic and oleic acids.

The S1 sample has the greatest total unsaturated fatty acid content (84.41%), followed by PSSF (84.32%) when compared to the control (84.23%) and other samples**.** In addition, our findings agreed with Al-Bachir [63], who stated that sesame, sunflower, and peanut seed oils were of the unsaturated type and could be categorized as belonging to the oleic C18:1-linoleic acid 18:2 group.

Peanut oil has a lower linoleic value than corn oil [64], demonstrating our results. It has provided cardiovascular protection for high-risk people [65]. Low consumption of saturated fat and an enhanced ratio of unsaturated to saturated fatty acids are related to a reduced risk of coronary heart disease and metabolic bone disease in humans [66].

Dou et al. [67] stated that n-3 PUFAs could slightly enhance bone mineral density. Inhibiting the production of osteoclasts and bone resorption caused lignin from sesame oil, which has a therapeutic effect on osteoporosis disease Cai et al. [68];Yang et al. [10], which is available in PSSF and S1 biscuits samples. Decreased alveolar bone loss with increased age when unsaturated fatty acids sunflower oil consumption which available in it [16].

Table (7): Fatty acids composition (% oils of the sample) extracted from fortified biscuits

Fatty Acids	Biscuit's samples				
	Control	S1	P1	PS	PSSF
Saturated Fatty Acids (SFA)					
C14:0 Myristic acid	0.05	0.04	0.05	0.06	0.05
C16:0 Palmitic acid	13.29	11.74	12.86	12.07	11.40
C17:0 Margaric acid	0.03	0.07	0.07	0.07	0.07
C18:0 Stearic acid	1.94	3.16	2.14	2.82	2.88
C20:0Arachidic acid	0.34	0.44	0.70	0.61	0.58
C22:0 Behenic acid	0.12	0.14	1.06	0.88	0.70
Total saturated fatty Acids (TSFA)	15.77	15.59	16.88	16.51	15.68
Monounsaturated Fatty Acids (MUFA)					
C16:1Palmitooleic acid	0.24	0.28	0.27	0.25	0.25
C17:1 Heptadeccunoic acid	0.04	0.04	0.04	0.04	0.04
C18:1 Oleic acid	29.46	34.46	34.77	35.34	33.37
C20:1 Gad oleic acid	0.27	0.25	0.56	0.44	0.43
Total Monounsaturated fatty Acids (TMUFA)	30.01	35.03	35.64	36.07	34.09
Polyunsaturated Fatty Acids (PUFA)					
C18:2 linoleic acid	53.41	48.76	46.96	46.90	49.72
C18:3n-3 Linolenic acid	0.81	0.62	0.52	0.52	0.51
Total Polyunsaturated Fatty Acids (TPUFA)	54.22	49.38	47.48	47.42	50.23
Total Unsaturated Fatty Acids (TUFA)	84.23	84.41	83.12	83.49	84.32
Total Fatty Acids	100.00	100.00	100.00	100.00	100.00

*__Control__ = 100% wheat flour; **S**1 =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% peanut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sun flower seeds.

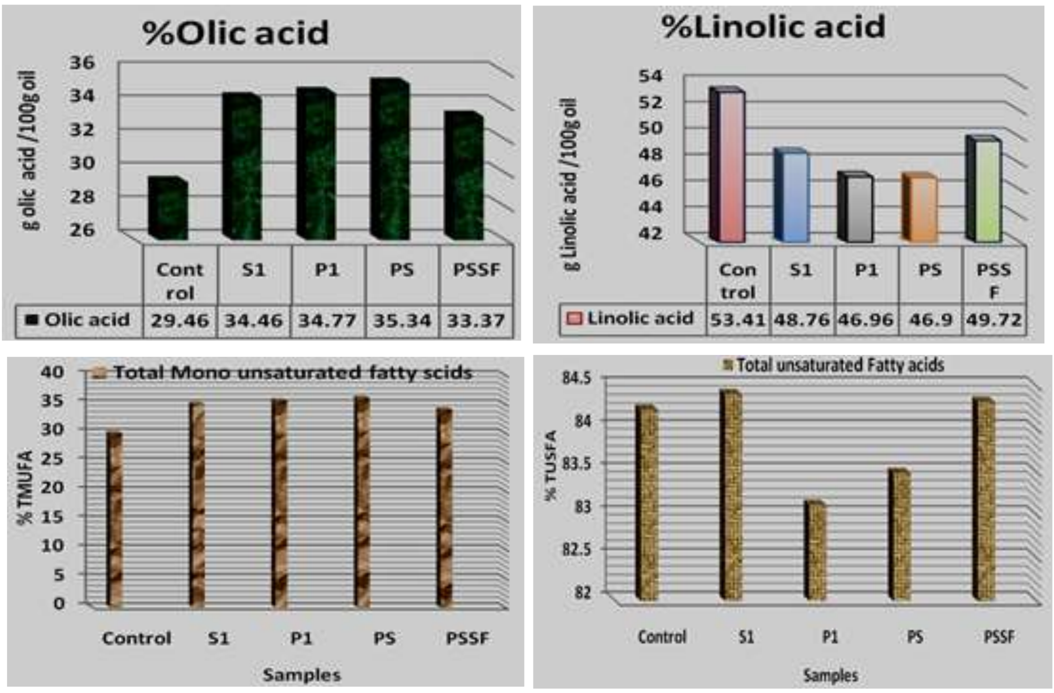

Fig. (5): Fatty acids composition of biscuits.

3.6 Moisture content, water activity, and physical properties of selected mixed sweet biscuits:

Water is an important substance in all foods, contributing to texture, structure stability, palatability, and overall quality. Its content is crucial
for controlling foodstuff's shelf life [69]. The need for a meaningful term to describe the behaviour of microorganisms in environments with reduced moisture helped establish water activity [54].

The data presented in Table 8 indicate a statistically significant decrease ($p<0.05$) in moisture content among the various samples, as evidenced by their crispiness. The moisture content varied from 1.99% for the PS sample to 4.08% for the S1 sample, compared to 4.73% for the control sample. This variation may be attributed to differences in water-holding ability and the composition of the different sample mixes.

Table (8): Moisture content, water activity and physical properties of selected mixed sweet biscuits

Parameters	Biscuit's samples					
	Con.	S1	P1	PS	PSSF	LSD at 5%
Moisture (%)	4.73[a] ±0.17	4.08[ab] ±1.36	3.07[bc] ±0.63	1.99[c] ±0.80	3.13[bc] ±0.05	**1.51**
Water activity After baking (a_w)	0.24[c] ±0.01	0.30[a] ±0.01	0.23[c] ±0.00	0.27[b] ±0.00	0.26[b] ±0.01	0.01
Diameter (mm)	41.75[c] ±1.25	44.90[b] ±0.10	47.40[a] ±0.40	47.15[a] ±0.15	45.75[b] ±0.25	**1.10**
Thickness (mm)	7.00[a] ±0.50	7.00[a] ±0.50	5.13[b] ±0.13	7.15[a] ±0.85	6.65[a] ±0.15	**0.91**
Spread ratio (%)	6.01[b] ±0.61	6.45[b] ±0.45	9.19[a] ±0.18	6.70[b] ±0.82	6.89[b] ±0.20	**0.93**
Spread factor	100.00[b] ±0.00	109.11[ab] ±18.48	155.8[a] ±18.23	111.16[b] ±2.26	115.42[ab] ±8.47	**22.29**
Wight (g)	4.53[bc] ±0.30	5.21[ab] ±0.08	4.43 ±0.48	5.57[a] ±0.36	5.27[a] ±0.54	**0.70**
volume (cm^3)	27. 33[a] ±0.38	26.13[ab] ±0.88	25.13[b] ±0.13	21.88[c] ±0.63	22.75[c] ±1.01	**1.24**
Specific volume (cm^3/g)	6.11[a] ±0.46	5.02[bc] ±0.25	5.74[ab] ±0.65	3.96[d] ±0.37	4.23[cd] ±0.54	**0.86**

Values are mean ±SD. Each value with the same row followed by the same letters is not significantly different at a level of 0.05.
Control= 100% wheat flour. **S1**=70% wheat flour+30%sesame seeds flour.
P1=70% wheat flour+30%peanut seeds flour. **PS** = 60% wheat flour+20% peanut seeds flour + 20% sesame seeds flour. **PSSF**=500% wheat flour+20% peanut seeds flour + 20% sesame seeds flour+ 10% whole sunflower seeds flour.

On the other hand, water activity (a_w) in the S1 sample had the highest value (0.30) compared with all fortified sweet biscuit PS, PSSF, and P1 samples (0.27, 0.26, and 0.23, respectively) and the control (0.24). The drying procedure employed in making biscuits had a significant role in reducing water activity. In our case, the water activity measurements indicated that the readings fall within a safe range for maintaining the biscuit's quality. It fell under the required thresholds for bacterial growth (a_w > 0.91) and mold growth (a_w >0.81). Aside from its impact on microbial deterioration, water activity substantially influences the functionality of enzymes and vitamins in food products, as well as their sensory attributes, such as color, taste, and scent [54]. The value of moisture in the structure of biscuits and its distribution greatly affects the functionality and physical biscuit's characteristics [70]. Non-significant $p>0.05$ spread ratio values were found for all samples except the P1 sample (9.19%) compared with all other samples S1, PS, and PSSF (6.45,6.70 and 6.89%, respectively) and the control (6.01%).

Specific volumes for all types of fortified sweet biscuits decreased significantly and were recorded from 3.96cm^3/g for the PS sample to 5. 74 cm^3/g for the P1 sample compared with 6.11cm^3/g for the control. Our results aligned with Agrahar-Murugkar et al. [56], who recorded a high diameter value and spread ratio in sweet cookies supplemented with sesame seeds compared with control. Our results disagree with Dharsenda and Dabhi [71], who studied biscuits from wheat flour fortified with peanut milk residue flour. There were low widths and spread factors but high thickness compared with control biscuits.

3.7 Texture profile analysis of selected sweet biscuits:

Table (9) presents the textural parameters assessed from texture profile analysis (TPA) test curves results for the biscuits samples. Data showed that all samples had significantly decreased $p<0.05$, and lower hardness ranged from 48.94N for the P1 sample to 28.16N for the PS sample than the control 52.76N).

All samples recorded lower adhesiveness, ranging between the PSSF samples (0 mj) to the P1 sample (0.20mj) compared with the control (0.43 mj). On the other hand, the S1 sample recorded the highest value of resilience (0.27) compared with the control (0.03) and other samples P1, PS, and PSSF (0.01, 0.02, and 0.05, respectively).

All samples with less fracture ability ranged from 26.48N for the P sample to 11.50N for the PSSF sample compared with the control (52.76 N). Our results agree with Agrahar-Murugkar et al. [56], who reported that sesame sweet cookies' hardness was significantly lower than control sweet cookies**.** They matched the findings of Dharsenda and Dabhi [71], who studied that hardness value was significantly decreased upon wheat flour substitution of peanut milk residue flour compared with control biscuits.

Table (9): Texture profile analysis of selected sweet biscuits after baking

Parameters	Con.	Biscuits Fortified with				LSD at 5%
		S1	P1	PS	PSSF	
Hardness (N)	52.76ᵃ ±7.76	36.18ᵇ ±1.07	48.94ᵃ ±4.16	28.16ᶜ ±1.50	29.42ᵇᶜ ±3.29	7.79
Adhesiveness (mJ)	0.43ᵃ ±0.58	0.10ᵃ ±0.10	0.20ᵃ ±0.10	0.00ᵃ ±0.00	0.00ᵃ ±0.00	0.48
Resilience	0.03ᵇ ±0.03	0.27ᵃ ±0.06	0.01ᵇ ±0.01	0.02ᵇ ±0.02	0.05ᵇ ±0.01	0.06
Fracture ability (N) With 1% of load sensitive	52.76ᵃ ±7.76	17.21ᶜ ±2.77	26.48ᵇ ±2.46	17.67ᵇᶜ ±5.40	11.50ᶜ ±4.32	8.97

Values are mean ±SD. Each value with the same row followed by the same letters is not significantly different at a level of 0.05.
Control= 100% wheat flour. **S1**=70% wheat flour+30% sesame seeds flour.
P1=70% wheat flour+30%peanut seeds flour.
PS = 60% wheat flour+20% peanut seeds flour + 20% sesame seeds flour.
PSSF=500% wheat flour+20% peanut seeds flour + 20% sesame seeds flour+ 10%whole sunflower seeds flour.

3.8 Color measurements of selected mixed sweet biscuits:

The attribute of color holds significant importance in the field of food, as it plays a crucial influence on the sensory experience and consumer approval of distinct items. It is closely associated with the Maillard reaction (occurring between reducing sugars and amino acids during biscuit baking) [56].

The study examined the impact of fortifying various recommended raw materials on the external color variations of the resulting biscuits. The findings of this investigation are presented in Table (10).

It could be demonstrated that the PSSF sample had the highest values of redness α* (1.64). In contrast, the P1 sample recorded the lowest value (-2.77) compared with the control (-1.67).

The S1 sample had the highest values of yellowness (*b**), 33.34, compared with other samples, P1, PS, and PSSF, that recorded (30.17, 29.86, and 23.53, respectively) and control (31.98). The decreased significant ($p<0.05$) PSSF sample had the lowest value of (*L**) *Lightness,* 55.59, compared with other samples S1, P1, and PS (66.18, 73.75, and 69.54, respectively) and control 76.02.

The color intensity was related to many factors: The baking time of the dough, the contact and temperature in the baking plates, and the color formulation of raw material; thus, different colors were found by Agrahar-Murugkar et al. [56].

Our results agreed with Agrahar-Murugkar et al. [56], who found that cookies supplemented with sesame seeds recorded lower redness (*a**) and (*L**) but higher yellowness (*b**) as compared with the control.

Moreover, they matched Dauda et al. [72], who found that decreased (*a**) and (*b**) values with increased defatted groundnut paste levels in the biscuits but different in (*L**) value, which was increased compared with control. Our results agreed with [54], who stated that composite flour with increased sunflower meal levels led to increased redness (*a**) biscuits.

Table (10): Color measurements of selected mixes additives sweet biscuits.

Parameters	Control	S1	P1	PS	PSSF	LSD at 5%
L*(Lightness)**	76.02ᵃ ±0.88	66.18ᵈ ±0.95	73.75ᵇ ± 0.67	69.54ᶜ ±1.07	55.59ᵉ ±0.60	1.55
α* (Redness)	-1.67ᶜ ±0.16	-0.33ᵇ ±0.20	-2.77ᵈ ±0.13	-0.51ᵇ ±0.10	1.64ᵃ ±0.98	0.83
b* **(Yellowness)**	31.98ᵃᵇ ±0.34	33.34ᵃ ±2.58	30.17ᵃᵇ ±0.56	29.86ᵇ ±0.79	23.53ᶜ ±2.71	3.21

Values are mean ±SD. Each value with the same row followed by the same letters is not significantly different at a level of 0.05.
Control= 100% wheat flour. **S1**=70% wheat flour+30%sesame seeds flour.
P1=70% wheat flour+30%peanut seeds flour.
PS = 60% wheat flour+20% peanut seeds flour + 20% sesame seeds flour.
PSSF=500% wheat flour+20% peanut seeds flour + 20% sesame seeds flour+ 10%whole sunflower seeds flour.
L^*(lightness with L^*= 100 for lightness, and L^*= zero for darkness), a^* [(chromaticity on green (−) to red (+)], b^*[(chromaticity on a blue (−) to yellow (+)].

3.9. Percentages of the recommended dietary allowances

A meal per day or school day is significant from a nutritional, social, and educational perspective. Micronutrient deficits in teenagers can affect brain development, delay sexual maturity, and increase the risk of osteoporosis [73].

Adequate nutrient intake, particularly protein amount, protein quality, and micronutrients, promotes children's growth and lowers their disease risk [74].

It is important to find enriched micronutrient foods like nuts, which help children and adolescents grow during pre- and post-memepausal periods and improve their nutrition status [60]. Studying micronutrient status during adolescence has become a crucial area of concern.

The nutrition status may be significantly influenced by socioeconomic status [75]. Pan bread enrichment with sesame, peanut seed and sprouted sunflower seed separately by 30% could be recommended for adolescence and adults [76].

The ratios of RDA% derived from one hundred grams of the resulting biscuits for adolescents (males and females) are displayed in Table (11, 12). It can be seen that all values of RDA% for protein, fiber, energy, and minerals (i.e., calcium, magnesium, copper, iron, manganese, phosphor, zinc, and potassium) were elevated in all samples of fortified biscuits compared to the control one.

Table (11): Percentage of the RDA of some nutrients provided from 100g biscuit for adolescents male.

Age group	Nutrient	RDA*	% RDA from Biscuit samples**				
			Control	S1	P1	PS	PSSF
Male (14-18) years	Carbohydrate	130 (g/d)	54.62	42.66	42.81	39.12	34.88
	Protein	52 (g/d)	16.92	21.62	24.15	24.44	25.15
	Fiber	38 (g/d)	0.68	8.89	5.21	8.45	13.18
	Energy	3152 (Kcal/d)	15.39	16.34	16.63	16.91	17.15
	Ca	1300 (mg/d)	2.06	3.35	2.92	3.29	3.90
	Mg	410(mg/d)	0.94	1.35	1.65	1.14	1.20
	Cu	0.89 (mg/d)	8.99	33.71	39.33	49.44	49.44
	Fe	11 (mg/d)	9.09	18.27	11.00	11.55	12.55
	Mn	2.2 (mg/d)	19.09	31.36	25.00	23.64	29.09
	P	1250 (mg/d)	4.34	4.41	3.79	5.96	5.65
	Zn	9 (mg/d)	13	16.18	14.46	16.73	17.00
	K	4007(mg/d)	3.64	5.10	5.06	6.90	7.61

* According to Food and Nutrition Board reports by the National Academy of Sciences (2004), the recommended dietary allowances from the Dietary Reference Intakes**.**

** % RDA=Value of nutrient in the sample of biscuit × 100 / RDA for the same nutrient; **Control** = 100% wheat flour; **S1** =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% pea nut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sunflower seeds.

Table (12): Percentage of the RDA of some nutrients provided from 100g biscuit for adolescents female.

Age group	Nutrient	RDA*	% RDA from Biscuit samples**				
			Control	S1	P1	PS	PSSF
Female (14-18) years	Carbohydrate	130 (g/d)	54.62	42.66	42.81	39.12	34.88
	Protein	46 (g/d)	19.13	24.48	27.30	27.63	28.44
	Fiber	26 (g/d)	1.00	15.39	7.62	12.35	19.27
	Energy	2368 (Kcal/d)	20.48	21.75	22.13	22.51	22.81
	Ca	1300 (mg/d)	2.06	3.35	2.92	3.29	3.90
	Mg	360 (mg/d)	1.07	1.54	1.88	1.30	1.37
	Cu	0.89 (mg/d)	8.99	33.71	39.33	49.44	49.44
	Fe	15 mg/d	6.67	13.40	8.07	8.47	9.20
	Mn	1.6 (mg/d)	26.25	43.13	34.38	32.50	40.00
	P	1250 (mg/d)	4.34	4.41	3.79	5.96	5.65
	Zn	9 (mg/d)	15.89	19.78	17.67	20.44	20.78
	K	4007 (mg/d)	3.64	5.10	5.06	6.90	7.61

* According to Food and Nutrition Board reports by the National Academy of Sciences (2004), the recommended dietary allowances from the Dietary Reference Intakes**.**

** % RDA=Value of nutrient in the sample of biscuit × 100 / RDA for the same nutrient; **Control** = 100% wheat flour; **S1** =70% wheat flour +30% sesame seeds flour; **P1** =70% wheat flour +30% pea nut seeds flour; **PS** = 60% wheat flour + 20% peanut + 20% sesame seeds flour; **PSSF** =50% wheat flour +20% peanut + 20% sesame seeds flour + 10% whole sunflower seeds.

4. Conclusion

This study concluded that adding sesame, peanut and whole sunflower seed flour to wheat flour increased nutritional value and mineral and protein content. The best blend was found in the S1 sample (70% all-purpose wheat flour +30% sesame flour) and PSSF sample (50% all-purpose wheat flour +20% sesame seeds flour +20% peanut seeds flour +10% whole sunflower seeds flour). Newly prepared biscuits could be recommended for adolescents and adults to protect them from osteoporosis. In addition, it is easy to cook as a balanced nutritious meal.

Conflict of interest

The authors declared no conflict of interest.

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