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Nutritional Evaluation of Biscuit Fortified with Psyllium Husk, Oat Flour and Sweet Lupine Powder

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The investigation's aim to produce biscuits with important nutritional value, physical attributes, and sensory characteristics using psyllium husk flour (PHF), wheat flour (WF), oat flour (OF), and sweet lupine powder (SLP). The materials used in this investigation were OF, SLP, and PHF and WF in addition to additional components to making biscuits. The obtained data showed that chemical composition of crude protein, fat and ash in OF, and SLP were higher than those of WF. The chemical composition of the raw materials and biscuit formulas was analyzed, and the results showed that all formulas made with OF, SLP, PHF, and WF had higher crude protein, fat, ash, and fiber contents than formulas made with WF alone. The well-blended combination of supplements produced biscuits with good color, taste, odor, and over acceptability. The color measurement of supplemented biscuits was higher, with higher energy percentages coming from ash, protein, and

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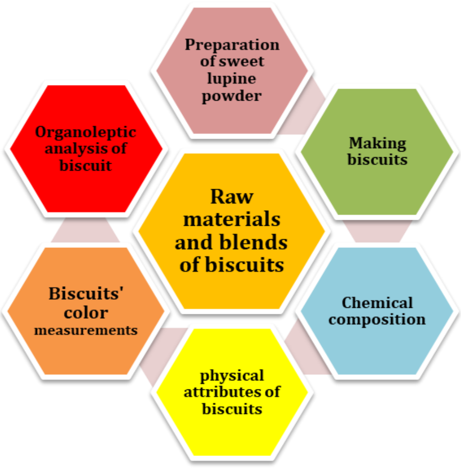
fiber. The findings demonstrated that the formulations made with OF, SLP, and PHF such as (B2, B3, and B4) had more width and volume than the control batch (B1). With rise in metabolism and nutrient related disorders like obesity, CVD, diabetes etc., effective approaches are necessary to overcome them. Therefore, the study recommend consumption biscuits made from replacing 4% PHF, 10% SLP and 5% OF with 100g of WF.

Graphic Abstract:



Keywords: Psyllium husk flour; oat flour; sweet lupine powder; wheat flour; biscuit.

1. INTRODUCTION

Internationally, nutritionists, food scientists, and medical professionals have begun to recognize the relationship between diet and disease. Incorporating whole grains, legumes, fruits, and vegetables into the diet is advised to attain and sustain optimal health by providing adequate amounts of dietary fiber, minerals, vitamins, and other health-promoting phytochemicals [1-2].

Due to their high protein, mineral, fiber, and vitamin content, legumes have been shown to have a positive impact on human lipid profiles [3]. The only other grain legume high in protein that also has low iso-flavons is lupin. Although over 300 species of lupins have been identified, only five of them are grown. The sweet white lupin (SWL), which is most frequently found in countries of the Mediterranean such as Egypt, Portugal, Greece, and Italy, is one of the most significant species [4].

Psyllium was initially collected from some wild species before it was introduced to India by Muslims for therapeutic purposes. The crust, seed, and whole plant are used term in psyllium. Regarded as a beneficial supplier of both soluble and insoluble fiber, compared with oat bran, it has about eight times the amount of soluble material. The plant's diet fibers can be utilized to make low-calorie foods since they have medicinal qualities [5]. Fibers, especially viscous dietary fibers, are useful for human health and can help prevent and treat chronic illnesses [6].

Psyllium husk (*Plantago ovata Forssk*.) is a dietary fiber that is highly compacted, soluble (70 g/100 g), and has a high capacity to bind water (2-3 g/g), resulting in the formation of a complex and stiff gel [7]. Psyllium husk, the gel-forming part of the fiber, is not fermented and is what gives this fiber its laxative, glycemic-controlling, and cholesterol-lowering qualities [8-9]. By grinding the seed, the outer layer, or husk, can be extracted, yielding 10–25% of the weight of the dried seed. Considering its chemical composition, the husk that is generated includes 84.98% of total carbohydrates, 4.07% ash and 0.94% protein [10]. The culinary, pharmaceutical, and cosmetic industries all employ psyllium husk. Ice cream, quick drinks, and breakfast cereals are among the foods that contain it, along with bakery goods like bread, cakes, and biscuits that have different functional and health characteristics [11].

Given their many health advantages, oats (*Avena sativa L.*) are a popular functional cereal grain. Oats have an intriguing nutritional composition that includes vitamins, soluble fiber, unsaturated fats, and high-quality protein [12]. Oats (*Avena sativa L.*) have gained attention due to their many nutritional and health benefits [13]. Nevertheless, because of the delicate structure of the kernels and the entire grain distribution of lipids, it is challenging to separate the endosperm, germ, and bran during milling [14], [15-16]. Typically, oats are processed into whole grains and served as porridge, flakes, or cereal for breakfast. They can also be pounded into flour and rolled into flakes.

Interest in sweet lupine seeds is always rising because of how versatile they are in culinary preparation and the increasing awareness of their health advantages. Even though there are other lupin species that are consumed, this evaluation will only look at white lupin because that is the only species for which biological activity data is currently available. In the Mediterranean region, white lupin has been a staple diet for humans for many years due to limited nutritional options. Both have low amounts of easily absorbed carbohydrates and high levels of dietary fiber and protein. Numerous bioactive substances, including 35–40 gram of protein per 100 gram of dry weight, are found in lupin seeds [17].

There are several real-world uses for Lupinus metabolic sweet in bread recipes. Lupine flour's higher protein content than wheat flour makes it possible to create bread recipes that are more nutritious while retaining other desired qualities [18]. One of the most important edible grains in the world is wheat, or Triticum aestivum [19]. Among all crops, wheat has the highest production, making it one of the most significant in the world. This is due to its exceptional ability to adapt to different environmental circumstances and its distinct qualities, which allow it to be processed into a variety of food goods [20]. One of the world's oldest and most significant staple food crops is wheat (*Triticum aestivum* L.) [21]. [22] studied that the approximate worldwide wheat production for the 2011–2012 season was 699.4 million metric tons. Carbohydrates are high in wheat.

Due to its excellent nutritional, sensory, and textural qualities, ready-to-eat convenience, and affordability, biscuits have long been one of the most well-liked and enticing food products [23]. Biscuits are one of the most important and popular bakery products in many countries. Although they are low in fiber, vitamins, and minerals, they are high in calories, fat, and carbohydrates, making them sufficiently nutrient-dense to be utilized daily.

Three main ingredients make up biscuits, which are classified as products in the miscellaneous food category: flour, fat, and sugar [24].

The aim of this study is to prepare biscuits with high nutritional value and sensory properties by replacing part of the WF with OF, SLP, and PHF. Furthermore, the enhanced sensory quality mixes of the biscuits as well as the chemical, physical, and color parameters were assessed. One of the possible effects of this study was that eating a small amount of biscuits is enough to provide a person with the protein necessary for growth, while causing a state of satiety for persons as a result of the presence of PHF, which is rich in fiber, but it should not exceed 6% because it absorbs a large amount of water so that the body does not become dehydrated.

2. MATERIALS AND METHODS

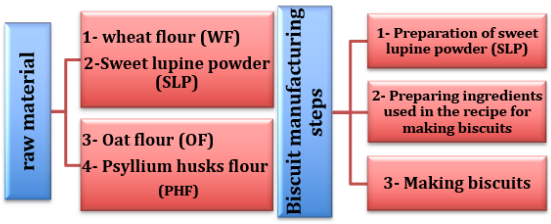


Fig. 1. Steps for preparing and manufacturing blends biscuits

2.1 Materials

Wheat flour 72% extraction (*Triticum aestivum*) acquired from Tanta City, Egypt's Delta Middle and West Milling Company.

Fig. 2. wheat field

Source:(https://th.bing.com/th/id/OIP.5nHIA6VDwwKVdYmw8_e0JQHaC2?pid=ImgDet&w=84&h=84&c=7&dpr=1.3)

- Sweet lupine powder (*Lupinus angustifolius*) purchased from local market Kafr El-Sheikh City, Egypt.

Fig. 3. Sweet lupine powder
Source: (https://www.foodingredientsfirst.com/news/ck-ingredients-introduces-australian-lupin-kernel-flour-to-food-industry-in-north-america.html)

Oat flour (*Avena sativa L.*) acquired from the Kafr El-Sheikh City, Egypt, local market.

Fig. 4. Oat flour
Source: (https://shamsagar.com/product/oats-atta/)

- Psyllium husks flour.

Fig 5. Psyllium husks (*Plantago ovata Forssk*.)
Source: (http://kadampsyllium.blogspot.ro/)

- Other ingredients baking powder, sugar and butter purchased from local market Kafr El-Sheikh City, Egypt.

2.2 Methods

2.2.1 Preparation of sweet lupine powder

After being free of impurities, sweet lupine seeds were thoroughly cleansed, rinsed with tap water, steeped in water for a whole day, and then carefully dehulled by hand before being baked at 60 degrees Celsius. In accordance with [25], the dried lupine seeds were crushed into powder.

2.2.2 Preparation of treatments

A pretest experiment was conducted to ascertain the optimal mixture ratio of the recommended raw materials selected for this investigation, as indicated in Table 1. One of the possible effects of this study was that eating a small amount of biscuit is enough to provide a person with the protein necessary for growth, while causing a state of satiety because of the presence of PHF, which is rich in fiber.

2.2.3 Making biscuits

In the Food Technology Institute's Agric. Research Centre lab, the biscuits were made. Table 2 listed the ingredients necessary to manufacture biscuits. Some modifications were made to the recipes outlined by [26] for making biscuits.

2.2.4 Preparation of biscuits blends in the laboratory

To make biscuits, one minute was spent creaming butter and sugar in a mixer. A whip was used to beat the eggs, and vanilla was added. The egg-vanilla mixture was combined with sugar-butter creamed and thoroughly beaten at low speed for 5 minutes. The dry ingredients (baking powder and wheat flour or blends) were combined, beaten constantly until the mixture was smooth, and then the resulting dough was allowed to rest for 15 minutes.

Using a guide roll, the dough was rolled out onto a cookie sheet. After cutting the dough into circles that were 5 cm in diameter and 0.3 cm thick, they were placed on a plate that had been oiled. The baking procedure took place in an oven that was heated electrically to 170°C for 12 to 15 minutes. Prior to sensory evaluation, biscuits were allowed to cool for one hour at room temperature after baking [27].

2.2.5 Chemical composition

The process outlined in [28] was used to determine crude protein (official method no. 950.36) and crude fiber (official method no. 950.37).

Table 1. The suggested blends used for preparing biscuits

Treatments	Blend composition
Control Blend (B1)	100%Wheat flour (72% extraction) (WF)
Blend (B2)	83%Wheat flour (72% extraction) (WF)+10% Sweet lupine powder (SLP)+ 5%Oat flour (OF) + 2%Psyllium husks flour (PHF).
Blend (B3)	81%Wheat flour (72% extraction) (WF) + 10%Sweet lupine powder (SLP) + 5%Oat flour (OF) + 4%Psyllium husks flour (PHF).
Blend (B4)	79%Wheat flour (72% extraction) (WF) + 10%Sweet lupine powder (SLP) + 5%Oat flour (OF) + 6%Psyllium husks flour (PHF).

WF = Wheat Flour SLP = Sweet Lupine Powder OF = Oat Flour PHF = Psyllium Husks Flour

Table 2. Ingredients used in the recipe for making biscuits

Components	WF (gm)	SLP (gm)	OF (gm)	PHF (gm)	Egg (gm)	Sugar (gm)	Butter (gm)	Baking powder (gm)	Vanillin (gm)
B1	100	**	**	**	24	30	22	1.5	1
B2	83	10	5	2	24	30	22	1.5	1
B3	81	10	5	4	24	30	22	1.5	1
B4	79	10	5	6	24	30	22	15	1

WF = Wheat Flour SLP = Sweet Lupine Powder OF = Oat Flour PHF = Psyllium Husks Flour

In accordance with the official procedures of the [29], the ash content (oven at 550–600 °C) and lipids (Soxhlet technique) were assessed. We computed the amount of carbohydrates via difference. Difference (100 - crude protein + ash + ether extract) was used to calculate the total carbohydrate content (on a dry weight basis) in the methods outlined by [28].

The Atwater formula was used to get the energy value (on a dry weight basis) and the formula is as follows: energy (kcal/100 g) = (4.1 × % protein) + (9.1 × % fat) + (4.1 × % carbohydrates). The estimated energy value was calculated using [30].

2.2.6 The physical attributes of biscuits

Physical characteristics such as width, length, thickness, and spread ratio were measured for both the control and the samples using the following prescription, which was computed using the method [31]. Biscuits length and width (cm). Biscuits' thickness (cm). Spread ratio = width ⁄ thickness. Using a computerized weighing balance, the average weight of four individual biscuits was used to determine the weight of the biscuits. Volume of biscuits was measured using width (W), length (L) and thickness (T) using the following formula: Volume (cm^3) = T x W x L

2.2.7 Color measurements

Using a handheld Chroma meter, the exterior color of the biscuit was measured in accordance with the procedure described by [32]. The Minolta CR-A70 (Konica Minolta Co., Ltd., Tokyo, Japan) was used to examine the color characteristics of GA-AOE films. The following was how the results were displayed straight from the machine's screen: *a** values demonstrated color transfers from green to red, *b** values showed color shifts from blue to yellow, and *L** values showed changes from darkness to lightness.

2.2.8 Sensory evaluation of produced biscuits

Prepared biscuits by using recommended blends were assessed for sensory characteristics by 20 panelists from the staff of crops technology Research, sakha, Dep., Agric. Res. Center, Giza. The scoring scheme was established as stated by [33]. as follows appearance (10), color (15), crispiness (15), hardness (15), taste (15), odor (20) and the overall score 100 degrees.

2.2.9 Texture profile analysis of biscuits

Texture profile analysis was conducted by Brookfiled CT3 Texture Analyzer No. M08-372-C0113 (version2.1, 1000gram unit). Hardness of samples was automatically recorded by computer software (TA-CT-PRO software). According to [29] the samples were compressed twice to 40% deformation trigger load 5 N, and test speed-2 mm/s. The experiments were conducted under ambient conditions.

2.2.10 Analytical statistics

The SPSS 16.0 program was used to analyze expository data. Expressive insights were used to resolve means and standard deviations. Analyses comparing samples were settled by looking into single-direction variation (ANOVA) and multiple range tests, Statistical significance was defined at $P \le 0.05$ [34].

3. RESULTS AND DISCUSSION

3.1 Chemical Composition of Raw Materials (% on dry weight basis)

Table 3 presents the results of the proximate analysis of WF, OF, SLP and PHF. Table 3 showed that OF contains were 12.94% protein, 6.83% fat, 7.98% fiber, 1.85% ash and 70.38% available carbohydrates, respectively, SLP were 38.33% protein, 9.34% fat, 10.09% fiber, 3.15% ash and 39.08% available carbohydrates, respectively. The PHF were 1.52% protein, 0.09% fat, 21.03% fiber, 3.85% ash and 73.49% available carbohydrates, respectively.

Table 3 presents the results of the proximate analysis of WF were 11.41% protein, 1.06% fat, 0.54% fiber, 0.44% ash and 86.53% available carbohydrates, respectively on dry weight basis. These results are nearly in agreement with [35] reported that the dry weight basis chemical analysis of the WF 72% extraction to contain 12.30% protein, 1.90% crude lipid, 0.54% ash, 84.44% available carbohydrates, 0.82% crude fiber, and 413.92 Kcal per 100 g caloric value.

The results indicated that the energy values in WF, OF, SLP and PHF were 411.26, 403.83, 402.41 and 308.42 Kcal, respectively on dry weight basis. These findings are nearly in agreement with [36] reported that the dry weight basis chemical analysis of the WF 72% extraction and Psyllium flour. Found to contain 11.81 and 16.40% protein, 0.75 and 5.40% crude ether extract, 0.45 and 3.70% ash, 86.97 and 74.50% available carbohydrates, 0.84 and 26.50% crude fiber, 0.35 and 0.49% soluble fiber, 0.49 and 20.50% insoluble fiber, and 398.5 and 306.20 Kcal per 100 gm for caloric value, respectively, were the contents of WF 72% extraction and psyllium.

3.2 Proximate Analysis for Biscuit Blends (% according to dry weight)

Table 4 lists the biscuits' chemical makeup. containing OF, SLP and PHF discovered the approximate composition of biscuit samples made by replacing in the blend (2) 17% (10% SLP + 5% OF + 2% PHF), blend (3) 19% (10% SLP + 5% OF + 4% PHF) and blend (4) 21% (10% SLP + 5% OF + 6% PHF) of WF with OF, SLP and PHF as opposed to the control biscuit. Findings revealed that decreased in the amount of accessible carbohydrates when OF content rises, SLP and PHF were seen. This could be because OF has a limited amount of readily available carbohydrates, SLP and PHF compared to WF.

Table 3. Composition analysis of raw materials (on dry weight basis %)

Materials	Composition analysis of raw materials					
	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	* Available carbohydrates (%)	Energy value (Kcal.)
WF	11.41^{c} ± 0.01	1.06^{c} 0.01	0.54^{d} ± 0.01	0.44^{d} ± 0.01	86.53^{a} ± 0.06	411.26^{a} ± 0.05
OF	12.94^{b} ± 0.01	6.83^{b} 0.01	7.98^{c} ± 0.01	1.85^{c} ± 0.01	70.38^{c} ± 0.08	403.83^{b} ± 0.05
SLP	38.33^{a} ± 0.01	9.34^{a} 0.01	10.09^{b} ± 0.01	3.15^{b} ± 0.01	39.08^{d} ± 0.05	402.41^{c} 0.03
PHF	1.52^{d} ± 0.01	0.09^{d} 0.01	21.03^{a} ± 0.01	3.85^{a} 0.01	73.49^{b} ± 0.06	308.42^{d} 0.05

WF = Wheat Flour SLP = Sweet Lupine Powder OF = Oat Flour PHF = Psyllium Husks Flour
-Means with different letter in the same column are significantly different at ($p \le 0.05$).
-Each value was an average of three determinations ± there are a difference between Average and standard deviation.
** Available carbohydrates % = 100 - (crude fat + ash + crude protein + crude fiber)*

Table 4. Composition analysis for different blends biscuits (on dry weight basis %)

Biscuit blends	Composition analysis of raw materials					
	Protein (%)	**Fat (%)**	**Fiber (%)**	**Ash (%)**	*** Available carbohydrates (%)**	**Energy value (Kcal.)**
(B1)	10.58[d] ± 0.01	25.45[c] ± 0.01	0.36[d] ± 0.01	0.61[d] ± 0.01	62.98[a] ± 0.06	533.25[a] 0.04
(B2)	12.26[a] ± 0.01	26.18[a] ± 0.01	1.51[c] ± 0.01	0.89[c] ± 0.01	59.15[b] ± 0.06	531.04[b] 0.05
(B3)	12.13[b] 0.01	26.16[ab] ± 0.01	1.79[b] ± 0.01	0.93[b] ± 0.01	58.97[c] ± 0.06	529.63[c] 0.04
(B4)	12.01[c] ± 0.01	26.15[b] ± 0.01	2.06[a] ± 0.01	0.97[a] ± 0.01	58.81[d] ± 0.06	528.31[d] 0.04

-Means with different letter in the same column are significantly different at ($p \leq 0.05$)
-Each value was an average of three determinations ± there are a difference between Average and standard deviation
** Available carbohydrates % = 100 – (crude fat + ash + crude protein + crude fiber)*

As a notice in Table 4 were increased percentage of protein in blends (2), (3) and (4) results to substituting SLP and OF compared with blend (1) but the percentage of protein decreased in blends (3) and (4) compared with blend (2) results to increased substituting PHF.

The results in Table 4 showed that the chemical composition of the biscuits blends percentage of protein were increased in B2, B3 and B4 compared to B1, but the lowest protein content and the highest fiber content were B4 due to the high percentage of replacement of PHF.

Additionally, the results in this Table 4 show that progressively raising the mixing level SLP, OF and PHF utilizing WF in blends (2, 3 and 4) caused the nutritional value of the biscuits to increase dramatically, even though the levels of ash and fat were significantly lower. This study supports that of [37], who discovered that biscuits made with psyllium seed flour rose in crude ether extract, crude fiber, and ash to varying extents (0, 5, 10, and 20% of psyllium seeds). On the other hand, calories values and available carbohydrates decreased, due to increased percentage of PHF.

3.3 Physical Characteristics for Biscuit Blends

The physical characteristics of biscuits made with WF, OF, SLP, and PHF at varying percentages (17, 19, 21%). It was discovered that the sample with 21% OF, SLP, and PHF had the lowest weight (9.29g) because of adding PHF by a percentage of 6%, while the samples with 17% blend (11.77 and 10.69g) and the control sample (B1) had the highest weight.

When using additional combinations instead of the standard blend, biscuits' physical qualities are enhanced. It is noted that the width, Thickness, and Volume of the biscuits increased in blends (B2, B3 and B4) with the decrease in the weight of the biscuits compared with blend control (B1). The data in the Table 4 shows that the quality of biscuits is improved by increasing the addition of PHF, as the best biscuit blends were blend (B4) following blend (B3) and blend (B2) compared with blend (B1).

In comparison to the standard blend, the addition combinations blends increase the biscuits' physical characteristics. It is noted that the width, Thickness, and Volume of the biscuits increased in blends (B2, B3 and B4) with the decrease in the weight of the biscuits compared with blend control (B1). The data in the Table 4 shows that the quality of biscuits is improved by increasing the addition of PHF, as the best biscuit blends were blend (B4) following blend (B3) and blend (B2) compared with blend (B1).

These results disagree with those obtained by [38] Physical properties of wheat-oat biscuits from WF (72% ext.) fortified with OF at different levels (20, 40, 60, 80, and 100%) were noted for the volume. The sample using 100% oat flour yielded the lowest volume (41 cm3), while the control sample containing 100% WF had the maximum volume (50 cm3). Additionally, it was found that the specific volume declined steadily as the amount OF increased. The sample containing 100% OF had the lowest specific volume, while the control sample had the highest specific volume (2.38 cm^3/g).

Table 5. Physical characteristics of biscuit

Biscuit blends	Physical properties of biscuit					
	Weight (g)	Length (cm)	Width (cm)	Thickness (cm)	Spread ratio (%)	Volume (cm^3)
(B1)	11.77^{a} ± 0.01	9.05^{a} ± 0.01	2.55^{b} 0.05	0.73^{d} 0.05	3.49^{a} ± 0.01	16.95^{b} ± 0.02
(B2)	10.69^{ab} ± 0.01	8.58^{ab} ± 0.01	2.67^{a} 0.05	0.81^{bc} 0.05	3.35^{ab} ± 0.02	18.37^{ab} ± 0.02
(B3)	10.31^{ab} ± 0.01	7.98^{d} 0.01	2.67^{a} 0.05	0.85^{ab} 0.05	3.14^{b} ± 0.02	18.11^{ab} ± 0.01
(B4)	9.29^{b} ± 0.01	8.47^{bc} 0.01	2.71^{a} 0.01	0.88^{a} 0.05	3.07^{c} ± 0.02	20.22^{a} ± 0.02

-Means with different letter in the same column are significantly different at ($p \leq 0.05$)
-Each value was an average of three determinations ± there are a difference between Average and standard deviation

Table 6. Color characteristics of biscuit

Biscuit blends	Color parameters of biscuit		
	Lightness (L^*)	Redness (a^*)	Yellowness (b^*)
(B1)	63.29^{a} ± 0.02	7.56^{b} ± 0.01	30.93^{b} ± 0.02
(B2)	61.35^{a} ± 0.03	7.87^{b} ± 0.01	34.39^{a} ± 0.03
(B3)	63.54^{a} ± 0.02	9.67^{a} ± 0.01	34.51^{a} ± 0.03
(B4)	63.32^{a} ± 0.01	10.14^{a} ± 0.01	35.53^{a} 0.04

-Means with different letter in the same column are significantly different at ($p \leq 0.05$)
-Each value was an average of three determinations ± there are a difference between Average and standard deviation

3.4 Color Analysis of Biscuit Blends

One of the most significant sensory characteristics that directly influences a product's consumer preference is color. To get the attention of customers, bakery products should receive extra attention. After evaluation, the color parameters (L^*, a^*, and b^*) of the biscuit are displayed in Table 6. The whiteness (L^*) scale ranges from 0 black to 100 white; the a^* and b^* scales go from a negative value (green hue) to a positive value (red hue) and negative blue to positive yellow, respectively.

One of the first things that affects a consumer's decision is the product's color. The Maillard reaction was used to make the color of the blended biscuits during the final baking step [26]. The acceptability of biscuit blends was significantly influenced by color. Table 6 displays the L^*, a^* and b^* values for biscuit blends made from WF supplementation percentages.

As notice from the result in the Table 6 were 63.29 7.56 and 30.93 brightness (L^*), redness (a^*), and yellowness (b^*) in the blend (1) biscuit (control) and decreased lightness (L^*) and redness (a^*) but increased yellowness (b^*) were 61.35, 7.87 and 34.39 in mixture blend (2) biscuit because of adding SLP. Data in Table 6 It was explained that with an increase in the percentage of PHF, both lightness (L^*) and redness (a^*) but increased yellowness (b^*) increased in blends 3 and 4 biscuits were (63.54 and 63.32), (9.67 and 10.14) and (34.51 and 35.53), respectively as a result to increased percentage of PHF.

Psyllium husks were darker than WF (72% extraction) and mixture from WF (72% extraction) biscuits with OF where lightness (L^*) and yellowness (b^*) decreased but redness (a^*) increased as rate of PHF used in mixture increased. There were two reasons why biscuits enhanced with PHF, SLP, and OF had different colors. The first and most noticeable was the psyllium husk flour's color, which had a greyish tint and significantly influenced the dough's and the loaves' overall color. The panelists noted this as well. Conversely, a comparison of the chemical makeup of psyllium husk flour and wheat flour revealed that the latter had a larger protein level than the former, and this difference was found to have a major impact on the Maillard reaction during baking [36].

3.5 Evaluation of Biscuit Mixtures' Sensory Qualities and General Acceptability

Table 7 lists the biscuits' sensory characteristics. It was demonstrated that the biscuits with OF, SLP, and PHF in ratios of 17, 19, and 21% underwent a sensory evaluation that looked at color, odor, taste, crispy texture, and overall acceptability. The results demonstrated that when WF was supplemented with OF, SLP, and PHF, the sensory scores of colors in blends B1 and B2 were significantly lower than those of the control, with B3 recording the highest value was 13.71.

The sensory scores of the control cookies were 8.45, 12.33, 12.33, 12.87, 13.17, 12.33, and 85.01 for looks, hardness, thickness, odor, taste, crispness, and overall acceptability. It was found that the samples containing 80 and 60% OF had the highest odor values (7.83 and 7.67), while the sample containing 100% OF had the lowest value (5.73) and the sample containing 20% OF had the lowest value (5.63). The addition of lupin flour increased the cookies' color sensory scores. As the amount of lupin flour substituted grew, so did the color score of the biscuits. Other research has shown that adding lupin to various foods improves their color in comparable ways. Up to 30% more lupin flour added to cookies resulted in an improvement in color [39].

These results agree with those obtained by [40], who added OF for biscuits in varying amounts. They discovered that the control sample had the lowest value (19.2) while the samples containing 10, 20, and 30% oat flour had the greatest value (19.8). The surface color values of the control sample and samples with varying amounts of oat flour did not differ significantly. The sample that contained 10% OF had the lowest taste value (18.8). The control sample and the other samples containing OF 0, 10, 20, 30, 40, and 50% did not differ in terms of general acceptability.

The results in Table 7 show that, given B3, the greatest values for appearance, color, hardness, thickness, crispness, odor, and overall acceptability were, in that order, 8.75, 13.71, 13.67, 13.58, 13.29, 13.17, and 89.25. Our sensory evaluation results led us to the conclusion that OF, SLP, and PHF can be used in place of wheat flour up to 19% to make healthy and nutritious biscuits without compromising the biscuits' overall acceptability.

Table 7. Sensory evaluation for different biscuit blends

Sensory evaluation	Biscuit blends			
	(B1)	(B2)	(B3)	(B4)
Appearances (10)	8.45[a] ± 0.07	8.62[a] ± 0.08	8.75[b] ± 0.07	8.37[b] ± 0.06
Color (15)	13.41[a] ± 0.08	13.13[a] ± 0.09	13.71[a] ± 0.07	13.08[a] ± 0.03
Thickness (15)	12.42[a] ± 0.22	12.71[ab] ± 0.31	13.67[a] ± 0.21	12.79[a] ± 0.21
Crispness (15)	12.33[a] ± 0.55	12.45[a] ± 0.52	13.58[a] ± 0.44	13.29[a] ± 0.42
Hardness (15)	12.33[a] ± 0.44	12.46[a] ± 0.53	13.29[a] ± 0.43	13.21[a] ± 0.45
Taste (15)	13.17[a] ± 0.34	12.87[a] ± 0.44	13.08[a] ± 0.54	12.42[a] ± 0.45
Odor (15)	12.87[a] ± 0.44	11.71[a] ± 0.37	13.17[a] ± 0.56	12.21[ab] ± 0.61
Overall acceptability (100)	85.01[a] ± 0.92	84.08[a] ± 0.81	89.25[a] ± 0.81	85.37[a] ± 0.78

-Means with different letter in the same row are significantly different at ($p \leq 0.05$)
-Each value was an average of 20 determinations ± there are a difference between Average and standard deviation

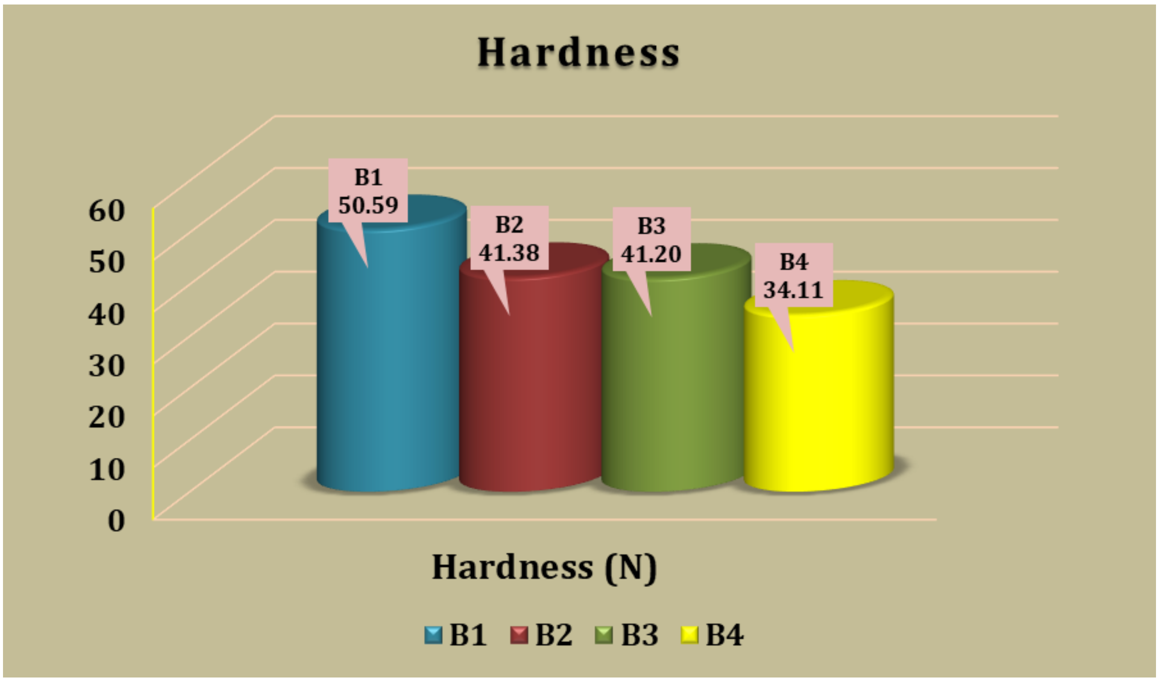


Fig. 6. Hardness of biscuit blends

Data in Fig. 2 presented the hardness of biscuit blends. A decrease in hardness from 50.59 newton in B1 100% WF to 34.11 newton in B4 21% (10% SLP + 5% OF + 6% PHF). These results are due to an increasing PHF ratio in biscuit blend (4). These results are consistent with [41], as the percentage of WF decreases and the percentage of PHF increases, the percentage of gluten decreases, leading to a weakening of the gluten network, and thus a decrease in the hardness value. It is well acknowledged that texture has a significant role in customer acceptance. Due to its tight link with human perception of freshness [42] stated that hardness is the most important factor in assessing baked products. This work confirms the great importance of applied science in bakery products [43-54].

4. CONCLUSION

The overall findings suggested that the chemical analysis, sensory characteristics, physical attributes, and color parameters of the biscuits produced were improved by partially replacing WF with OF, SLP, and PHF.

The nutritional content of the biscuit formula is increased by adding OF, SLP, and PHF, while maintaining the quality of the biscuits produced. Organoleptic characteristics revealed that the biscuits enhanced with PHF, SLP, and OF were acceptable and differed significantly from the control biscuit in terms of appearance, color, thickness, crispiness, taste, and odor. Still, it could make some high-quality bakery goods that are suitable for people or consumers using PHF, SLP, OF, and WF.

One of the possible effects of this study was that eating a small amount of biscuits is enough to provide a person with the protein necessary for growth, while causing a state of satiety as a result of the presence of PHF, which is rich in fiber, but it should not exceed 6% because it absorbs a large amount of water so that the body does not become dehydrated.

DISCLAIMER

The products utilized in this study are typical and widely used in our nation and field of study. There isn't a single conflict of interest between the product creators and authors because our goal isn't to utilize these goods as a means of pursuing legal action, but rather to further knowledge. Furthermore, the research was supported by the writers' own personal funds rather than by the producing corporation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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