

## Nutritional evaluation of biscuit fortified with psyllium husk, oat flour and sweet lupine powder

### Abstract

The investigation's aim is to produce biscuits with superior nutritional content, physical attributes, and sensory appeal using psyllium husk flour, wheat flour, oat flour, and sweet lupine powder. The materials used in this investigation were oat flour, sweet lupine powder, and psyllium husks flour and wheat flour in addition to additional elements that go into making biscuits.

The obtained data showed that chemical composition of crude protein, fat and ash in oat flour, and sweet lupine powder were higher than those of wheat flour. The chemical composition of the raw materials and biscuit formulas was analyzed, and the results showed that all formulas made with oat flour, sweet lupine powder, psyllium husks flour, and wheat flour had higher crude protein, fat, ash, and fiber contents than formulas made with wheat flour alone. The well-blended combination of supplements produced biscuits with great color, taste, odor, and over acceptability. The color were content of supplemented biscuits was higher, with higher energy percentages coming from ash, protein, and fiber. The findings demonstrated that the formulations made with oat flour, sweet lupine powder, and psyllium husk flour (B2, B3, and B4) had more width and volume than the control batch (B1). The great flavor, color, odor, and overall acceptance of the biscuits were produced using an applied physical technique utilizing a well-blended combination of supplements.

**Keywords:** Psyllium Husk, Oat flour, Sweet Lupine Seed, Wheat flour, Biscuit.

**Commented [UG1]:** You can write more generalized background. For e.g. substituting some high fiber flour for making biscuits instead of writing name for each component.

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## 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] and [2].

Due to their high protein, mineral, fibre, 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

(PS), 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] and [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] and [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 carbs and high levels of dietary fiber and protein. Numerous bioactive substances, including 35–40 grammes of protein per 100 grammes 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]. As per reference [22], 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

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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 purpose of this study was to develop practical biscuits using oat flour instead of wheat flour, sweet lupine powder, and psyllium husks because oat flour has exceptional nutritional value and health benefits. Furthermore, the enhanced sensory quality mixes of the biscuits as well as the chemical, physical, and color parameters were assessed.

## 2. Materials and Methods

### 2.1. Materials

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

Figure 1: wheat field.



Source:

([https://th.bing.com/th/id/OIP.5nHIA6VDwwKVdYmw8\\_e0JQHAc2?pid=ImgDet&w=84&h=84&c=7&dpr=1.3](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.

Figure 2: 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.

- Figure 3: Oat flour.



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**Commented [UG6]:** Overall, clear information is provided in the introduction. It would be better if you could also mention possible implications of your study.

Source: (<https://shamsagar.com/product/oats-atta/>)

- **Psyllium husks.**

Figure 4: 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 contaminants, 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 flour.

### 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.

**Table 1. The suggested blends used for preparing biscuits.**

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

### 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.

**Table 2. Ingredients used in the recipe for making biscuits**

<b>Ingredients</b>	<b>Amount</b>
Wheat flour (72% extraction)	100 (g)
Egg	24 (g)
Sugar	30 (g)
Butter	22 (g)
Baking powder	1.5 (g)
Vanillin	1 (g)

#### **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 five 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 fifteen 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).

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 accordance with [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 × % carbs). The projected 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]. Cookie 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<sup>3</sup>) = T x W x L .

#### **2.2.7. Biscuits' 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. Organoleptic analysis of the biscuit

various combinations Ten panelists assessed the organoleptic properties of biscuit samples, including color, thickness, crispiness, taste, and odor, using the methodology outlined by [33].

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### 2.2.9. 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  $P \leq 0.05$  [34].

## 3- Results and discussions

### 3.1. Chemical composition for raw materials (% on dry weight basis).

The chemical composition of wheat flour, oat flour, sweet lupine powder and psyllium husks in Table 3. Regarding Table 3 protein ratios in oat flour and sweet lupine powder were increased to 12.94 and 38.33%, respectively. wheat flour and psyllium husks were 11.41 and 1.52%, respectively.

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The results indicated that the ratio of fat in oat flour was 6.83%, sweet lupine powder was 9.34%, wheat flour was 1.06% and psyllium husks was 0.09% (on dry weight basis).

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

Composition analysis of raw materials						
Materials	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	*Carbohydrates (%)	Energy value (Kcal.)
Wheat flour72%	11.41 <sup>c</sup> ± 0.01	1.06 <sup>c</sup> 0.01	0.54 <sup>d</sup> ± 0.01	0.44 <sup>d</sup> ± 0.01	86.53 <sup>a</sup> ± 0.06	411.26 <sup>a</sup> ± 0.05
Oat Flour	12.94 <sup>b</sup> ± 0.01	6.83 <sup>b</sup> 0.01	7.98 <sup>c</sup> ± 0.01	1.85 <sup>c</sup> ± 0.01	70.38 <sup>c</sup> ± 0.08	403.83 <sup>b</sup> ± 0.05
Sweet lupin powder	38.33 <sup>a</sup> ± 0.01	9.34 <sup>a</sup> 0.01	10.09 <sup>b</sup> ± 0.01	3.15 <sup>b</sup> ± 0.01	39.08 <sup>d</sup> ± 0.05	402.41 <sup>c</sup> 0.03
Psyllium husks	1.52 <sup>d</sup> ± 0.01	0.09 <sup>d</sup> 0.01	21.03 <sup>a</sup> ± 0.01	3.85 <sup>a</sup> 0.01	73.49 <sup>b</sup> ± 0.06	308.42 <sup>d</sup> 0.05

-Means with different letter in the same row 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.

\*Carbohydrates % =  $100 - (\text{crude fat} + \text{ash} + \text{crude protein} + \text{crude fiber})$ .

From the same table the estimated ratio of fiber and ash in oat flour were 7.98 and 1.85%, the sweet lupine powder was 10.09 and 3.15% and wheat flour was 0.54 and 0.44%, respectively but these ratios were increased to in psyllium husks to 21.03 and 3.85%, respectively on a dry basis.

Regarding to Table 3 the carbohydrates and energy value in oat flour were 70.38% and 403.83 Kcal, sweet lupine powder was 39.08% and 402.41 Kcal, psyllium husks were 73.49% and 308.42 Kcal and wheat flour were 86.53% and 411.26 Kcal, respectively on dry weight basis. These findings are nearly in agreement with [35] reported that the dry weight basis chemical analysis of the WF 72% extraction and PSF. 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% total 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 – 100 g for caloric value, respectively, were the contents of WF 72% extraction and psyllium.

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Commented [UG12]: This is confusing. You don't have to repeat the information provided in the table. You can just compare the composition of your ingredient. For e.g. sweet lupin had the highest protein content among all the ingredients used.

### 3.2. Proximate analysis for biscuit blends (% according to dry weight).

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

As a notice in Table 4 were increased ratios of protein in blends (2), (3) and (4) results to substituting sweet lupine powder and oat flour compared with blend (1) but the ratios of protein decreased in blends (3) and (4) compared with blend (2) results to increased substituting psyllium husks.

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

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

-Means with different letter in the same row are significantly different at ( $p \leq 0.05$ ).

**Commented [UG13]:** Please explain the basis by which different formulation were made. Why was only the percentage of psyllium husk changed and not oat flour or lupine powder.

**Commented [UG14]:** Sentences are not clear and lot of grammatical errors. It's difficult to understand what you are trying to say.

-Each value was an average of three determinations ± there are a difference between Average and standard deviation.

\*Carbohydrates % = 100 – (crude fat + ash + crude protein + crude fiber).

Additionally, the results in this Table show that progressively raising the mixing level sweet lupine powder, oat flour and psyllium husks utilizing wheat flour in blends (2, 3 and 4) caused the nutritional value of the biscuits to increase dramatically, even though the levels of protein, ash, fat, and fiber were significantly lower. This study supports that of [36], who discovered that biscuits made with psyllium seed flour rose in crude ether extract, crude fiber, and ash to varying degrees (0, 5, 10, and 20% of psyllium). On the other hand, the amount of calories and accessible carbs decreased.

**Commented [UG15]:** In B2, B3 and B4, only the percentage of psyllium husk was increased. This should be taken into consideration while discussing the results.

### 3.3. Physical characteristics for biscuit blends.

The physical characteristics of biscuits made with wheat flour, oat flour, sweet lupine powder, and psyllium husks at varying percentages (17, 19, 21%). It was discovered that the sample with 21% oat flour, sweet lupine powder, and psyllium husks had the lowest weight (9.29g) because of adding psyllium husks by a ratio 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 shows that the quality of biscuits is improved by increasing the addition of psyllium husk, as the best biscuit blends were blend (B4) following blend (B3) and blend (B2) compared with blend (B1).

**Table 5. Physical characteristics of biscuit**

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

-Means with different letter in the same row are significantly different at ( $p \leq 0.05$ ).

-Each value was an average of three determinations  $\pm$  there are a difference between Average and standard deviation.

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 shows that the quality of biscuits is improved by increasing the addition of psyllium husk, 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 [37] Physical properties of wheat-oat biscuits from wheat flour (72% ext.) fortified with oat flour 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 cm<sup>3</sup>), while the control sample containing 100% wheat flour had the maximum volume (50 cm<sup>3</sup>). Additionally, it was found that the specific volume declined steadily as the amount of oat flour increased. The sample containing 100% oat flour had the lowest specific volume, while the control sample had the highest specific volume (2.38 cm<sup>3</sup>/g).

### 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 samples were 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.

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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 wheat flour supplementation ratios.

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 sweet lupine powder. Data in table (6) It was explained that with an increase in the percentage of psyllium husk, 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 ratio of Psyllium husks.

**Table 6. Color characteristics of biscuit**

Biscuit blends	Color parameters of biscuit		
	Lightness ( $L^*$ )	Redness ( $a^*$ )	Yellowness ( $b^*$ )
Biscuit (control)	63.29 <sup>a</sup>	7.56 <sup>b</sup>	30.93 <sup>b</sup>
(B1)	± 0.02	± 0.01	± 0.02
Biscuit	61.35 <sup>a</sup>	7.87 <sup>b</sup>	34.39 <sup>a</sup>
(B2)	± 0.03	± 0.01	± 0.03
Biscuit	63.54 <sup>a</sup>	9.67 <sup>a</sup>	34.51 <sup>a</sup>

<b>(B3)</b>	± 0.02	± 0.01	± 0.03
<b>Biscuit</b>	63.32 <sup>a</sup>	10.14 <sup>a</sup>	35.53 <sup>a</sup>
<b>(B4)</b>	± 0.01	± 0.01	0.04

-Means with different letter in the same row 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.

Psyllium husks were darker than wheat flour (72% extraction) and mixture from wheat flour (72% extraction) biscuits with Oat flour where lightness ( $L^*$ ) and yellowness ( $b^*$ ) decreased but redness ( $a^*$ ) increased as rate of Psyllium husks used in mixture increased. There were two reasons why biscuits enhanced with psyllium husk flour, sweet lupine powder, and oat flour 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 [35].

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### 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 oat flour, sweet lupine powder, and psyllium husks 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 wheat flour was supplemented with oat flour, sweet lupine powder, and psyllium husks, the sensory scores of colors in blends 1 (B1) and 2 (B2) were significantly lower than those of the control, with blend 3 (B3) recording the highest value of 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% oat flour had the highest odor values (7.83 and 7.67), while the sample containing 100% oat flour had the lowest value (5.73) and the sample containing 20% oat flour 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 [38].

These results agree with those obtained by [39], who added oat flour to 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% oat flour had the lowest taste value (18.8). The control sample and the other samples containing oat flour 0, 10, 20, 30, 40, and 50% did not differ in terms of general acceptability.

**Table 7. Sensory evaluation for different biscuit blends.**

Sensory evaluation	Biscuit blends			
	Biscuit (B1)	Biscuit (B2)	Biscuit (B3)	Biscuit (B4)
Appearances (10)	8.45 <sup>a</sup> ± 0.07	8.62 <sup>a</sup> ± 0.08	8.75 <sup>b</sup> ± 0.07	8.37 <sup>b</sup> ± 0.06
Color (15)	13.41 <sup>a</sup> ± 0.08	13.13 <sup>a</sup> ± 0.09	13.71 <sup>a</sup> ± 0.07	13.08 <sup>a</sup> ± 0.03
Thickness (15)	12.42 <sup>a</sup> ± 0.22	12.71 <sup>ab</sup> ± 0.31	13.67 <sup>a</sup> ± 0.21	12.79 <sup>a</sup> ± 0.21

<b>Crispness (15)</b>	12.33 <sup>a</sup> ± 0.55	12.45 <sup>a</sup> ± 0.52	13.58 <sup>a</sup> ± 0.44	13.29 <sup>a</sup> ± 0.42
<b>Hardness (15)</b>	12.33 <sup>a</sup> ± 0.44	12.46 <sup>a</sup> ± 0.53	13.29 <sup>a</sup> ± 0.43	13.21 <sup>a</sup> ± 0.45
<b>Taste (15)</b>	13.17 <sup>a</sup> ± 0.34	12.87 <sup>a</sup> ± 0.44	13.08 <sup>a</sup> ± 0.54	12.42 <sup>a</sup> ± 0.45
<b>Odor (15)</b>	12.87 <sup>a</sup> ± 0.44	11.71 <sup>a</sup> ± 0.37	13.17 <sup>a</sup> ± 0.56	12.21 <sup>ab</sup> ± 0.61
<b>Overall acceptability (100)</b>	85.01 <sup>a</sup> ± 0.92	84.08 <sup>a</sup> ± 0.81	89.25 <sup>a</sup> ± 0.81	85.37 <sup>a</sup> ± 0.78

-Means with different letter in the same row 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.

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 oat flour, sweet lupine powder, and psyllium husks can be used in place of wheat flour up to 19% to make healthy and nutritious biscuits without compromising the biscuits' overall attractiveness.

#### 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 wheat flour with oat flour, sweet lupine powder, and psyllium husk flour.

The nutritional content of the biscuit formula is increased by adding oat flour, sweet lupine powder, and psyllium husk flour, while maintaining the quality of the biscuits produced. Organoleptic characteristics revealed that the biscuits enhanced with psyllium husk flour, sweet lupine powder, and oat flour were acceptable and differed significantly from the control group in terms of appearance, color, thickness, crispness, taste, and odour. Still, it

**Commented [UG18]:** Overall, needs a serious revision in writing. There are lot of sentence errors. You do not need to repeat the information provided on the table, instead just compare the findings between different samples and relate with the past work.

could make some high-quality bakery goods that are suitable for people or consumers using psyllium husk flour, sweet lupine powder, oat flour, and wheat flour.

## 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.

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**Commented [UG19]:** What did you conclude after increasing the percentage psyllium husk in the blend. Higher the better? Or something else.

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