

## Development and characterization of high nutritional value snack bar as a complementary source of nutrients in supporting the growth of pregnant women: chemical, physical, and sensory properties

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### Abstract

Developing high nutritional value pregnant bar products as a source of different nutrients to support daily-consumed poor is considered a practical goal to increase pregnant crucial nutrient intake. This research aims to develop high nutritional snack bar as a complementary to support the nutrient requirements in pregnant women using a mixture of grains (chickpea and quinoa flours) along with wheat flour in addition to chia seeds, inulin, moringa leaves powder, anise, mastic and stevia. This study was conducted in two stages. Seven treatments of quinoa and chickpea flour levels in the ratio of (1:2) with wheat flour were produced. Proximate analysis, physical properties, color analysis, and sensory evaluation test were determined. This highly nutritional snack bar has larger contents of protein, fiber, lipids, and ash, as well as lower amounts of moisture and carbohydrate content compared to wheat flour control. Moreover, physical properties: snack bar samples' weight, diameter and thickness decreased as the concentration of chickpea and quinoa flours increased. The results of the color analysis showed that there were significant differences in lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) values between the control and the seven snack bar treatments, which showed lower lightness ( $L^*$ ) and yellowness ( $b^*$ ) color values and higher redness ( $a^*$ ) color values. Regarding the sensory evaluation, the most accepted treatment was treatment 7, which had 47.5% wheat flour, 35% chickpea flour, and 17.5% quinoa flour. Developing a high-nutrient-value snack bar as a complementary source of nutrients to support and cover most pregnant women's nutrient requirements, maintaining necessary daily needs with controlled calorie intake and high quality and acceptability.

**Keywords:** anise; chia seeds; chickpea flour; ESHA's food processor; high nutritional snack bar; inulin; mastic; moringa leaves powder; nutrition analysis; pregnant women; quinoa flour; sensory evaluation; stevia

### Introduction

An adequate and balanced diet that provides all macronutrients and micronutrients needs in sufficient amounts is necessary to ensure a healthy pregnancy with a lower risk of related problems. It reduces inappropriate fetal

growth, congenital disorders, and chronic conditions for babies later in life (Kaiser *et al.*, 2008). Bawadi *et al.* (2010) studied the correlation between maternal diet and pregnancy outcomes in 700 pregnant women in Jordan and found that maternal macro and micronutrient intake directly affects pregnancy outcomes. Even

though numerous factors affect maternal intake, pregnant women are required to change their daily eating habits in order to follow a healthier diet to fulfill their needs; this includes making new, healthier food choices when it comes to shopping and preparing meals and snacks (Fowles *et al.*, 2008). Recently, eating habits in Arab countries, including Jordan, have become similar to those of Western countries: food is mostly low in fiber and high in fat, sugar, and salt, a fact confirmed by (Musaiger *et al.*, 2015), who studied the impact of diet on obesity in Jordanian females at universities. Moreover, available snacks are not formulated to meet the specific nutrient requirements of pregnant women, especially in food cravings related to undesirable excessive weight gain during pregnancy (Blau *et al.*, 2020). Instead, they usually have high energy, fat, and sugar (Rush *et al.*, 2016). Snack bars are usually made using a base of grains or protein and enriched with a wide range of nutrient-rich ingredients, vitamins, minerals, and herbs (Constantin *et al.*, 2018). The main basic ingredient in cereal products is wheat flour, the powder from grinding grains (Milling) (Lin *et al.*, 2019). Mainly, wheat flour comprises starch, water, and protein, along with a small number of lipids and polysaccharides, especially arabinoxylans (AX) (Goesaert *et al.*, 2005). Chickpea (*Cicer arietinum L.*) mainly consists of polysaccharides (starch) characterized by a high amount of amylose, resulting in a lower glycemic index due to retrogradation. Also, it has protein, fibers, vitamins, minerals, and phytochemicals, including flavonoids, phenolic acids, and carotenoids (Kaur and Prasad, 2021). It is an important crop because it is an excellent source of proteins, carbohydrates, fibers, vitamins, and minerals, including iron, calcium, and folic acid (Jukanti *et al.*, 2012; Rachwa-Rosiak *et al.*, 2015; Jamieson *et al.*, 2020). Its low glycemic response makes it an excellent option to maintain a normal blood glucose level (Zafar *et al.*, 2020). Moses *et al.* (2006) conducted a trial on 62 women to study the impact of low glycemic index versus the normal diet on pregnancy outcomes. The researchers found that a diet with low glycemic index foods positively affects pregnancy outcomes. Quinoa (*Chenopodium quinoa Willd.*) is considered a pseudocereal since its seeds are identified as starchy dicotyledonous (James, 2009). In addition, quinoa is a treasure of nutrients since it is rich in carbohydrates, protein, fat, and fiber and has large amounts of iron and calcium compared to other cereals (Bhathal *et al.*, 2015) along with vitamins B, vitamin A, and C (Montemurro *et al.*, 2019). (Thejasri *et al.*, 2017) defined quinoa as the only plant supplying the body with all essential amino acids. Ibrahim (2015) studied the effect of replacement wheat flour with quinoa flour on rats fed over 10 days with an iron-deficient diet, followed by treatment with quinoa and wheat flour biscuits for 20 days, recording lab tests in both stages, then compared to control rats fed on wheat flour biscuit. In order to

prepare therapeutic biscuits to help raise awareness of the importance of nutritional status and mineral deficiencies, such as anemia, which is high in preschool children and pregnant women, as WHO stated. The study revealed that rates fed with quinoa and wheat flour biscuits showed higher serum iron levels, hemoglobin, hematocrit, and mineral content of the liver, such as iron, zinc, and calcium, compared to the rats fed only on wheat flour biscuits. Chia seeds (*Salviae hispanicae semen*) consist of protein, fiber, Polyunsaturated fatty acids, vitamins, and phenolic compounds, such as phenolic acids and flavonoids (Motyka *et al.*, 2022). So, it is a supplement and a functional food since it is an excellent source of protein, fibers, and fat, especially unsaturated fatty acids (De Falco *et al.*, 2017). Most oils in chia seeds are PUFAs, including linoleic and alpha-linolenic acids (Ashura *et al.*, 2021). Which is crucial to ensure healthy pregnancy outcomes. The need for Omega-3 fatty acids increases during pregnancy to ensure healthy pregnancy outcomes. Some researchers studied the effect of Omega-3 supplementation on postpartum depression (PPD) and found that supplementing pregnant women with Omega-3 fatty acids could reduce the risk of PPD (Hsu *et al.*, 2018). Moringa is a common Moringaceae family tree that grows in tropical climates such as India, Asia, and Africa (Vergara-Jimenez *et al.*, 2017). Moringa oleifera consists of several compounds with rhamnase sugar, isothiocyanates, glucosinolates, vitamins, minerals, and carotenoids (Fahey, 2005). Moringa is a good source of proteins, fibers, calcium, iron, vitamin C, vitamin A, and magnesium (Sanbou *et al.*, 2001; Raja *et al.*, 2016). Hadju *et al.* (2020) studied the effect of moringa powder and honey on pregnancy outcomes and compared the result to the supplementation of iron and folic acid over 2 to 3 months. The study revealed that honey and moringa leaves powder positively affect fetal birth weight, maternal hemoglobin, and weight gain and decrease oxidative stress in maternal and fetal bodies. Inulin is an oligo and polysaccharide with fructose units attached by glycosidic bonds, which allow it to resist digestive enzymes in the abdomen (Ahmed and Rashid, 2019). It is a dietary fiber found mainly in garlic, chicory, asparagus roots, Jerusalem artichoke, and other foods, including onion, leek, banana, and wheat (Mensink *et al.*, 2015). In addition, inulin is one of the most important prebiotics (Kolida *et al.*, 2002), which improves the gut's good bacteria and prevents severe constipation (De Vrese, 2009; Wan *et al.*, 2020). Miao *et al.* (2021) studied the effect of inulin on glucose tolerance during pregnancy on 6-7-week-old mice over seven weeks of treatment of inulin. The study revealed that inulin treatment improved fat and glucose metabolism along with the reduction of fasting blood glucose, leading to the improvement of glucose tolerance in pregnant mice. Anise from the Apiaceae family is a well-known herb that mainly grows in Mediterranean countries as

well as in western Asia. The spice comes from ripping and drying the aniseed fruit, which has an aromatic and sweet taste. It is commonly added to preserve and enhance the flavor of several recipes, such as pudding, desserts, and bakery products, and can work as an antioxidant, too (Singletary, 2022). The seeds of anise (*Pimpinella anisum* L.) consist of reducing sugars, fatty acids, amino acids, and phenolic components (Topčagić *et al.*, 2022). Eid and Jaradat (2020) studied the reasons for herbal usage during pregnancy and lactation in 350 Palestinian women. They found that anise is the third plant commonly used during pregnancy and reported that it is safe to use and can help with sleep problems and the flu. Mastic gum combines phytochemical and phenolic components (Tabanca *et al.*, 2020). Also, it is a resin from a mastic tree with a family known as Anacardiaceae. It is grown mostly in the Mediterranean region and has anti-inflammatory, antioxidant, and antimicrobial properties (Dragović *et al.*, 2020). Moreover, Abdolhosseini *et al.* (2017) stated that mastic (*Pistacia lentiscus* Linn.) could be successfully used to treat nausea and vomiting during pregnancy since it improves the appetite and reduces the inflammation of the abdomen with no side effects as long as it is used with the right appropriate dosage. Stevia (*Stevia rebaudiana*) is a herb derived from a plant family called Asteraceae and is mainly used as a sugar substitute. Stevia leaves have several glycosides, such as rebaudiosides and stevioside (Gupta *et al.*, 2013). Maslova *et al.* (2015) conducted a study in Denmark on 46262 women to study the correlation between pregnancy weight gain and increased sugar consumption and protein to carbohydrate rate. This study showed a great linkage between additional sugar intake and increased gestational weight gain. Hence, stevia can be an excellent sugar substitute. Therefore, the main goal of this research is to develop a high nutritional value snack bar as a complementary source of nutrients to support and cover most of the pregnant women's nutrient requirements that maintain necessary daily needs with high quality and acceptability by using a mixture of grains (chickpea and quinoa flours) along with wheat flour in addition to chia seeds, inulin, moringa leaves powder, Anise, Mastic, and Stevia.

## Materials and Methods

### Flour

All-purpose wheat flour (zero) with Extraction rate (ER)= 75% and Ash content = (0.55%) was acquired from Modern Flour Mills and Macaroni Factories Company, Amman, Jordan. Chickpea and quinoa flours were obtained from Red Mill in bags weighing 454 g and 510 g, respectively. These flours were stored at room temperature 25 °C until analysis.

### Other snack bar ingredients

Moringa Leaves Powder was acquired from Durrat AL-Manal for Development and Training (DMDT), a nonprofit company in Jordan. Meanwhile, inulin was obtained from NOW Foods Industry, Bloomingdale, Illinois. Stevia, Ghee (clarified butter fat), milk, salt (Sodium chloride), Anise, Mastic gum, Vanilla (*Vanilla planifolia*), a Leavening Agent (baking powder), and chia seeds were purchased from a local market in Irbid, Jordan.

### Snack bar preparation

Snack bar preparation processes were done at the Food Processing Factory- Department of Bakeries and Dessert at Jordan University of Science and Technology (Irbid, Jordan) using the method reported by Rahmi *et al.* (2021) with some modifications, such as the type of flours, fat and sugar that had been used and the removal of maltodextrin and egg in the dough. Several steps were followed to produce the snack bar, including mixing, baking, and cutting, as shown in Figure 1.

### Mixing

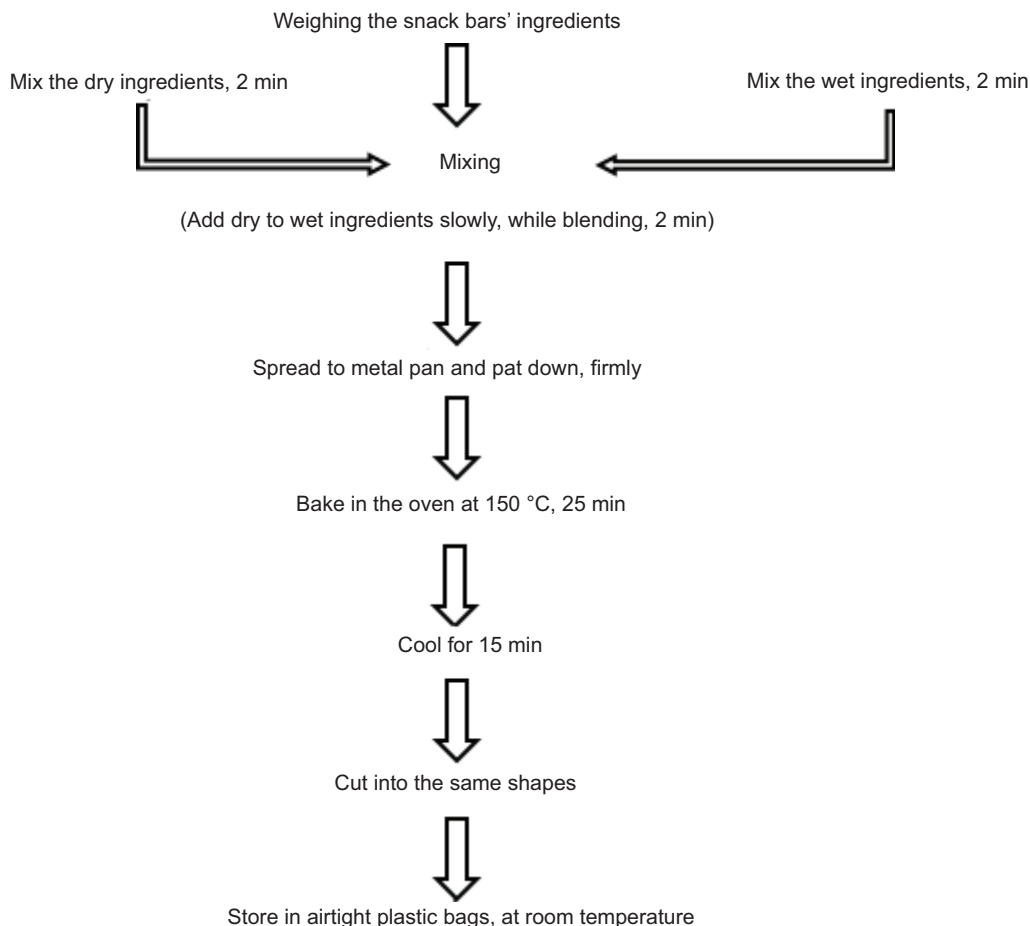
Dry ingredients were weighed and mixed using a Kitchen Aid mixer at speed two for 2 minutes for a mixture of desirable consistency. Then, liquid ingredients were mixed for 2 minutes separately. Finally, dry ingredients were added slowly and mixed with liquid ingredients for about two minutes at speed two to obtain a proper smooth dough.

### Baking and cutting

The dough was spread in a prepared pan and patted down firmly to ensure the same thickness throughout. Next, it was baked at 150 °C for about 25 minutes and allowed to cool at room temperature. The samples were then cut into the same rectangle-shaped snack bar and stored in airtight plastic bags until evaluated.

### Preliminary Work

In order to determine the optimal formula of the snack bar control in terms of taste, texture, color, and aroma, preliminary trials were done in two stages using 100% wheat flour. The first stage was determining the exact amounts of the control essential ingredients. The second stage was conducted to find the exact amount of inulin, moringa, and chia seeds, and the most acceptable sample was sample 2,



**Figure 1.** Preparation steps used to produce snack bars.

as shown in Table 1 and Figure 2. Lastly, the control snack bar ingredients were set, as shown in Table 2.

**Snack bar treatment formulation**

Seven formulations of quinoa and chickpea blends were used in the snack bar preparation according to the ratio of (1:2) and wheat flour, as shown in Table 3 and Figure 3.

**Chemical analysis**

Raw flour and snack bar formulas were examined for moisture, ash, protein, lipid, and fiber contents according to AACC methods (AACC., 2000). The carbohydrate content was calculated by the difference of the other tests as 100 - (moisture + ash + protein + lipid + fiber) (Gbenga-Fabusiwa et al., 2018).

**Moisture content**

The moisture content of the snack bar formulas and raw flour was measured according to the American

**Table 1.** Percent of inulin, moringa powder, and chia seeds used in preliminary work.

Ingredient	Sample 1	Sample 2	Sample 3
Inulin	1.6%	5%	10%
Moringa powder	1.6%	5%	10%
Chia seeds	1.6%	5%	10%



**Figure 2.** Stage 2 of preliminary work: snack bars with different percentages of inulin, moringa, and chia seeds from three trials, where sample 1: 1.6%, sample 2: 5%, and sample 3: 10% of wheat flour weight.

Association of Cereal Chemists approved method No.44-15A (AACC, 2000). Moisture content was determined by weight loss after drying in the oven (Memmert model 500, West Germany) at 105 °C.

### Ash content

The ash content of the snack bar samples and all flours was determined based on the American Association of Cereal

Chemists approved method No.08-01 (AACC, 2000). The process was carried out by burning a fixed amount (3g) of the sample in crucibles at 550 °C until the grey color appeared. Next, the ash content was allowed to cool and then weighed. The ash content was set as the difference in weight between empty and ash-containing crucibles.

### Protein content

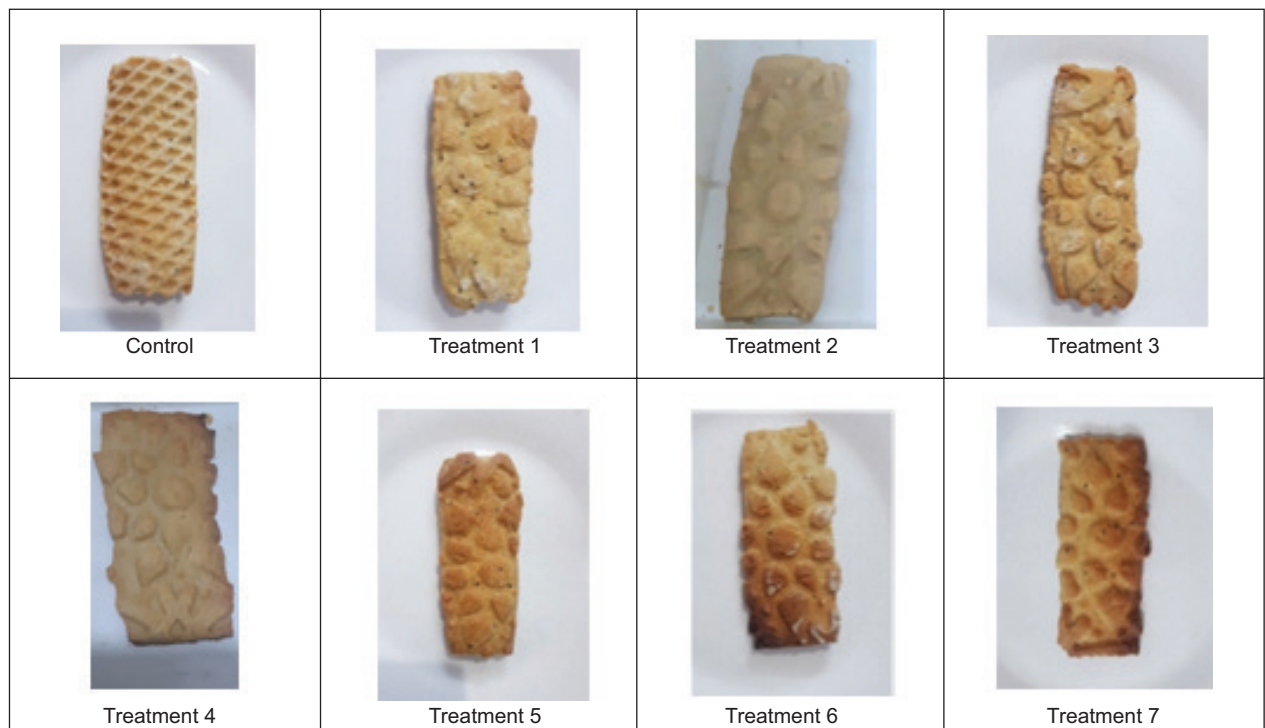
The protein content of the flours and the snack bar formulas were determined via Kjeldtech Apparatus (Technick GmbH D-40599, Behr Labor, Germany) based on Kjeldhal's as reported by the American Association of

**Table 2. Control snack bar ingredients.**

Ingredients	%
Wheat flour	88.09
Fat (ghee)	7.2
Stevia sugar	2.8
Milk	13.9
Sodium chloride (salt)	0.73
Baking powder	0.73
Vanilla extract	0.36
Anise	0.73
Mastic	0.36
Inulin	0.057
Chia seeds	0.057
Moringa	0.057
Total	115

**Table 3. Percent of flour mixture used for snack bar treatments.**

Treatment number	Wheat flour (%)	Quinoa flour (%)	Chickpea flour (%)
Control	100	0	0
1	92.5	2.5	5
2	85	5	10
3	77.5	7.5	15
4	70	10	20
5	62.5	12.5	25
6	55	15	30
7	47.5	17.5	35



**Figure 3. The developed snack bars and the control.**



Cereal Chemists approved method 46-10 (AACC, 2000). Crude protein percentage (CP %) was determined by multiplying the nitrogen percentage by 5.7 for wheat flour and the nitrogen percentage by 6.25 for the other treatment flours and snack bar formulas (Priatama and Nuraeni, 2019).

### Lipid content

The lipid content of the raw flour and snack bar formulas was measured using the Soxhlet method (HT2 1045 Extraction Unit, Hoganas, Sweden), as stated by the American Association of Cereal Chemists approved method No. 30-10 (AACC, 2000). This method uses petroleum ether as a solvent for 4 hours, after which the extracted content cools to room temperature.

### Crude fiber

Crude fiber content was achieved using two (1.25%) solutions, including sulphuric acid and sodium hydroxide. Following the American Association of Cereal Chemists approved method No. 32-10 (AACC, 2000).

### Carbohydrate content

The carbohydrate content of snack bar treatments and all raw flours was calculated by difference, which yielded  $100 - (\text{moisture} + \text{ash} + \text{protein} + \text{lipid} + \text{fiber})$ .

### Physical Analysis

Thickness, Diameter, and Spread ratio were carried out according to the AACC method (10-50D); the weight of snack bar samples was estimated using an electronic balance (Jayasena and Nasar-Abbas, 2011). This test was duplicated for accuracy, and the average value was obtained for every parameter.

#### Diameter

The use of a right-angle ruler measured the snack bar's diameter. This ruler was put on the side of the snack bar, and the measure was reported in centimeters based on (AACC, 2000) 10-50D.

#### Weight

The weight of snack bar samples was estimated using an electronic balance and recorded in grams.

#### Thickness

The total height of the snack bar was determined using a ruler. The ruler was positioned from the head of the snack bar to the bottom, and the measurements were reported in centimeters according to the method of AACC (2000) 10-50D.

#### Spread ratio (SR)

The spread ratio was determined by dividing the diameter value (width) by the thickness value of snack bar treatments, which was also used by Akubor and Ukwuru (Akubor and Ukwuru, 2003). The values of the spread ratio were yielded using the following equation:  $SR = D / T$ .

#### Snack bar color

The color of snack bar samples was measured using a Minolta colorimeter CR-300 (Ramsey, N.J., U.S.A) and recorded in the  $L^*a^*b$  color system. This system contains a lightness component ( $L^*$ ) and two chromatic components: a refers to (+a) redness to (-a) greenness, and b refers to (+b) yellowness to (-b) blueness as compared to a standard white calibration plate. White standard's values were  $L = 97.1$ ,  $a = +0.13$ ,  $b = +1.88$ . The color measurement was taken from two different sides. This experiment was done in triplicate then the final results were averaged (Rasulu and Juharnib, 2021).

#### Sensory evaluation of the snack bar

A sensory evaluation test was conducted to evaluate the acceptability and quality of the snack bar treatments and the control during seven test sessions. The sample population consisted of students from Jordan University of Science and Technology at Jordan University of Science and Technology laboratories. Sixty students were included in this study from both genders, all of different ages and cultures. The researcher instructed and explained the process for all consumers using standard product evaluation criteria. Snack bar treatments were tested for the overall impression, texture, color, hardness, flavor, and aftertaste on a seven-point hedonic scale ranging from 7 = like significantly to 1 = dislike highly. Water was offered between every session, and dry snack bar treatments were to decrease any error during the test. Each sample was cut to almost one centimeter and was labeled according to the sensory evaluation standard procedure (Momanyi *et al.*, 2020; Aljanada., 2022).

## Nutritional analysis

The food processor nutrition analysis software (ESHA Food Processor, version 10.6.3.0) was used to determine the nutritional composition of the high-nutrient snack bar for pregnant women (T7) and wheat flour snack bar (control) compared to the Dietary Reference Intakes (DRI) of pregnant women and food labels.

## Statistical analysis

Six different bars were evaluated and compared to one another in addition to the control. All physical, chemical, color, and sensory data were analyzed using Statistical Package for the Social Sciences (SPSS). The analysis of variance (ANOVA) and least significant difference (DMRT) were used to determine the significance of the effects at  $p$ -value  $\leq 0.05$  among treatments.

## Results and Discussion

### Chemical analysis

The proximate analysis results for raw wheat, chickpea, and quinoa flours are shown in Table 4. The chickpea and quinoa flours had higher amounts of protein (22.40 and 15.01% respectively), ash (2.80 and 3.40%, respectively), lipid (6.71 and 7.00%, respectively), and fiber (5.41 and 6.80%, respectively) than wheat flour. In comparison, wheat flour contained higher carbohydrate levels (74.90%). It has been reported that chickpea and quinoa flours had higher protein, ash, lipid, and fiber levels and lower carbohydrate content than wheat flour in past studies (Rababah *et al.*, 2006; Daraz *et al.*, 2020), while wheat flour contained (72.5%) carbohydrate content (Doxastakis *et al.*, 2002), which is in accordance to the results of this study.

**Table 4.** The percentages of moisture, ash, protein, lipid, carbohydrate, and fiber in wheat, chickpea, and quinoa flours.

	Chickpea flour	Quinoa flour	Wheat flour
Moisture%	10.30 $\pm$ 0.01 <sup>b</sup>	9.61 $\pm$ 0.01 <sup>c</sup>	11.90 $\pm$ 0.01 <sup>a</sup>
Ash%	2.80 $\pm$ 0.01 <sup>b</sup>	3.40 $\pm$ 0.00 <sup>a</sup>	0.50 $\pm$ 0.01 <sup>c</sup>
Protein%	22.40 $\pm$ 0.01 <sup>a</sup>	15.01 $\pm$ 0.01 <sup>b</sup>	10.31 $\pm$ 0.00 <sup>c</sup>
Lipid%	6.71 $\pm$ 0.01 <sup>b</sup>	7.00 $\pm$ 0.01 <sup>a</sup>	1.01 $\pm$ 0.01 <sup>c</sup>
Carbohydrate%	52.40 $\pm$ 0.01 <sup>c</sup>	64.16 $\pm$ 0.01 <sup>b</sup>	74.90 $\pm$ 0.01 <sup>a</sup>
Fiber%	5.41 $\pm$ 0.01 <sup>b</sup>	6.80 $\pm$ 0.01 <sup>a</sup>	1.40 $\pm$ 0.01 <sup>c</sup>

<sup>a,b,c</sup>Means within the same row with different superscripts are significantly different ( $P < 0.05$ ).

The Proximate analysis results for the control and snack bar treatments are shown in Table 5. Snack bar treatments were significantly higher in protein, ash, lipid, and fiber and lower in moisture and carbohydrate contents than wheat flour control. The moisture content reduction could be because chickpea and quinoa flour have lower moisture content than wheat flour (Gomez *et al.*, 2008; Chopra *et al.*, 2018). There is another reason for reducing the moisture content of snack bar treatments. As the amount of fiber and protein in the raw flour increases, water absorption (water holding capacity) increases, leading to a lower moisture content of the final product (Alrayyes, 2018). Chickpea and quinoa flour contain more fibers and proteins than wheat flour (Jagannadham *et al.*, 2014; Iglesias-Puig *et al.*, 2015). This finding agrees with past studies that developed chickpea muffins and quinoa cookies and found that moisture content decreased in treatments compared with wheat flour control (Al-Rubai, 2016; Bhathal and Kaur, 2018). Ash content was also increased mainly due to the high mineral content of chickpeas, including iron, calcium, magnesium, and zinc (Man., 2015). Furthermore, quinoa flour contains many minerals, providing sufficient potassium, calcium, and magnesium (Mohammed *et al.*, 2019). This result is in parallel with past studies that reported that ash content along with minerals content increased with the addition of chickpea flour in bread development (Man, 2015) and quinoa flour in the preparation of cookies as well (Daraz *et al.*, 2020) when compared to wheat flour control. The protein content of snack bar treatments increased with increasing chickpea and quinoa flours since they contain high protein levels, and wheat or cereal contains lysine, which is a limiting amino acid. In contrast, chickpea or legume contains another limiting amino acid, methionine. This combination of wheat and chickpeas in the same product enhances protein quality (Goni and Valentin, 2003). This result is similar to other studies that mentioned that using chickpea flour had significantly increased protein content in developed biscuits (Yadav *et al.*, 2012), and higher protein content was reported with the addition of quinoa to prepare cookies compared to wheat flour control (Chopra *et al.*, 2018). Similarly, the lipid content of treatments increased by increasing chickpea and quinoa flour levels, which agrees with past studies that stated that the lipid levels increased with the addition of chickpea (Man *et al.*, 2015) and quinoa flours (Bhathal and Kaur, 2018) compared to the wheat flour control. The carbohydrate content significantly decreased in each treatment, comparable to other studies, which mentioned a remarkable decrease in the carbohydrate content of muffin treatment made with chickpea flour and dry milk compared to wheat flour control (Al-Rubai, 2016). Besides, it was found that the carbohydrate content of biscuits made with quinoa flour decreased compared to the control (Makpoul and Ibrahim, 2015). On the other hand, the fiber content

**Table 5.** The percentages of protein, fiber, carbohydrate, fat, ash and moisture in the control and snack bar treatments.

Treatment	Protein %	Fiber %	Carbohydrate %	Fat %	Ash %	Moisture %
Control	10.29 ± 0.01 <sup>h</sup>	1.40 ± 0.01 <sup>h</sup>	74.90 ± 0.00 <sup>a</sup>	1.01 ± 0.00 <sup>h</sup>	0.50 ± 0.00 <sup>h</sup>	11.91 ± 0.01 <sup>a</sup>
T1	11.03 ± 0.00 <sup>g</sup>	1.74 ± 0.01 <sup>g</sup>	73.51 ± 0.01 <sup>b</sup>	1.44 ± 0.01 <sup>g</sup>	0.68 ± 0.01 <sup>g</sup>	11.61 ± 0.01 <sup>b</sup>
T2	11.74 ± 0.01 <sup>f</sup>	2.06 ± 0.01 <sup>f</sup>	72.11 ± 0.00 <sup>c</sup>	1.86 ± 0.01 <sup>f</sup>	0.87 ± 0.02 <sup>f</sup>	11.33 ± 0.01 <sup>c</sup>
T3	12.47 ± 0.00 <sup>e</sup>	2.40 ± 0.00 <sup>e</sup>	70.71 ± 0.01 <sup>d</sup>	2.31 ± 0.01 <sup>e</sup>	1.05 ± 0.01 <sup>e</sup>	11.04 ± 0.01 <sup>d</sup>
T4	13.18 ± 0.01 <sup>d</sup>	2.73 ± 0.01 <sup>d</sup>	69.33 ± 0.01 <sup>e</sup>	2.74 ± 0.02 <sup>d</sup>	1.25 ± 0.02 <sup>d</sup>	10.75 ± 0.01 <sup>e</sup>
T5	13.90 ± 0.01 <sup>c</sup>	3.07 ± 0.00 <sup>c</sup>	67.92 ± 0.01 <sup>f</sup>	3.17 ± 0.00 <sup>c</sup>	1.43 ± 0.02 <sup>c</sup>	10.47 ± 0.01 <sup>f</sup>
T6	14.64 ± 0.01 <sup>b</sup>	3.41 ± 0.00 <sup>b</sup>	66.54 ± 0.01 <sup>g</sup>	3.61 ± 0.01 <sup>b</sup>	1.63 ± 0.02 <sup>b</sup>	10.17 ± 0.00 <sup>g</sup>
T7	15.35 ± 0.01 <sup>a</sup>	3.75 ± 0.01 <sup>a</sup>	65.15 ± 0.01 <sup>h</sup>	4.04 ± 0.01 <sup>a</sup>	1.81 ± 0.01 <sup>a</sup>	9.88 ± 0.01 <sup>h</sup>

<sup>a,b,c,d,e,f,g,h</sup>Means within the same column with different superscripts are significantly different (P<0.05)—control: 100% wheat flour. T1 presents treatments: 92.5: 2.5: 5, T2: 85: 5: 10, T3: 77.5: 7.5: 15, T4: 70: 10: 20, T5: 62.5: 12.5: 25, T6: 55: 15: 30 and T7: 47.5: 17.5: 35 as % of wheat flour, quinoa flour and chickpea flour.

of snack bars increased by increasing both quinoa and chickpea flour. This result agrees with other past studies, where findings showed that cookies made with quinoa flour had higher fiber content than the 100% wheat flour control (Daraz *et al.*, 2020) and showed higher fiber content in cookies samples made with chickpea, kidney bean, and wheat flours compared to wheat flour cookies (Sibian and Riar, 2020).

### Physical analysis

The results for the physical characteristics of both the control and high-nutritional snack bar treatments are shown in Table 6. Results revealed that the weight of samples decreased as the percentages of chickpea and quinoa flours increased, which is parallel with a past study that reported that the weight values of biscuits decreased as percentages of chickpea and plantain flours increased (Yadav, 2012). These findings are possibly due to chickpea flour's lower oil absorption capacity (OAC). Similarly, results showed that the diameter, thickness, and spread ratio (SR) of snack bar samples decreased as the concentration of both chickpea and quinoa flours increased, except for treatment 4, which had a higher SR score, which could be due to the flours particle interactions. These results also agreed with a previous study, which found that biscuits prepared with isolated soy protein, broad bean, and chickpea flours showed lower diameter and thickness values (spread ratio) as these blends increased (Rababah *et al.*, 2006). This can be due to enhancing hydrophilic areas competing for the dough's free-water molecules.

### Snack bar color

Color properties of the product are essential since they can significantly affect consumer acceptability (Gupta

*et al.*, 2019). The product's color can give an idea about the cooking degree and reactions throughout the extrusion phase, such as the Maillard reaction and caramelization (Altan *et al.*, 2008). The results of the color analysis showed that there were significant differences (P<0.05) in lightness (L\*), redness (a\*), and yellowness (b\*) values between the control and the seven snack bar treatments. Figure 4 shows a reduction in (L\*) and (b\*) values and an increase in (a\*) values. This decrease in (L\*) and increase in (a\*) color values might be due to the increased amount of proteins, which results in more interaction between reducing sugars and amino acids through baking (Maillard reaction), which leads to a product with a darker color (Gupta *et al.*, 2019; Rababah *et al.*, 2006). Similarly, it was reported lower lightness (L\*) and yellowness (b\*) color values of a snack prepared from a mix of chickpeas, barely in addition to lettuce seeds, as the percentages of both chickpeas and barely increased (Twfik *et al.*, 2008). Moreover, these results also agree with results obtained by another researcher who stated that cake and cookies prepared with quinoa flour showed darker color as the (L\*) color values decreased (Lorenz and Coulter, 1991).

### Sensory evaluation of the snack bar

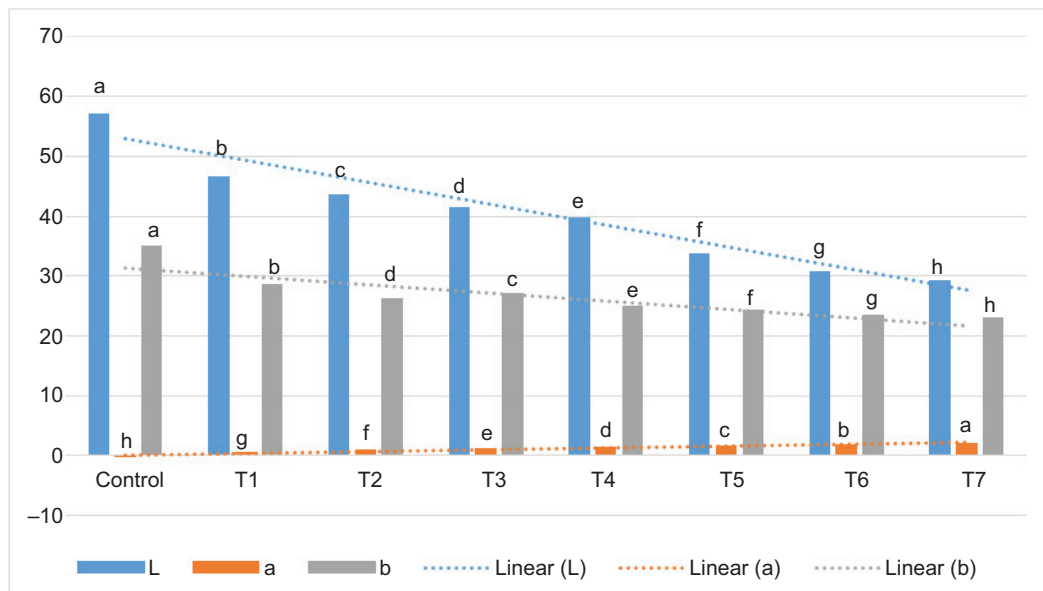
Hedonic scale results play an essential role in consumer decision about the product by determining acceptance degree, so it is vital that the sensory attributes of the supplemented snack stay acceptable compared to the control and the available snacks in the markets (Man *et al.*, 2015). The sensory evaluation results, which were performed for six different aspects of treatments, including overall impression, flavor, texture, hardness, color, and aftertaste, are shown in Figure 5. Results revealed that values of overall impression, flavor, texture, hardness, and aftertaste increased as the percentage of chickpea and quinoa flours increased. The overall impression of



**Table 6.** The control and snack bar treatments' mean weight, thickness, and diameter values.

Treatment	Weight (grams)	Diameter (cm)	Thickness (cm)	Spread Ratio
Control	45.0 ± 0.0 <sup>a</sup>	12.3 ± 0.25 <sup>a</sup>	1.45 ± .05 <sup>a</sup>	8.48 <sup>b</sup>
T1	40.5 ± 0.5 <sup>b</sup>	11.3 ± 0.25 <sup>b</sup>	1.35 ± .05 <sup>a,b</sup>	8.37 <sup>c,d,e</sup>
T2	38.5 ± 0.5 <sup>c</sup>	10.8 ± 0.25 <sup>b,c</sup>	1.30 ± .10 <sup>a,b,c</sup>	8.3 <sup>f</sup>
T3	36.5 ± 0.5 <sup>d</sup>	10.3 ± 0.25 <sup>c,d</sup>	1.25 ± .05 <sup>a,b,c,d</sup>	8.24 <sup>e</sup>
T4	35.5 ± 0.5 <sup>d,e</sup>	9.8 ± 0.25 <sup>d,e</sup>	1.15 ± .05 <sup>b,c,d,e</sup>	8.52 <sup>a</sup>
T5	34.5 ± 0.5 <sup>e,f</sup>	9.0 ± 0.50 <sup>e,f</sup>	1.10 ± .10 <sup>c,d,e</sup>	8.18 <sup>g</sup>
T6	33.5 ± 0.5 <sup>f</sup>	8.8 ± 0.25 <sup>f</sup>	1.05 ± .05 <sup>d,e</sup>	8.38 <sup>c,d</sup>
T7	31.0 ± 1.0 <sup>g</sup>	8.3 ± 0.25 <sup>f</sup>	1.00 ± .00 <sup>e</sup>	8.3 <sup>f</sup>

<sup>a,b,c,d,e,f,g</sup>Means within the same column with different superscripts are significantly different (P<0.05). Control: 100% wheat flour, Treatments are presented by T1: 92.5: 2.5: 5, T2: 85: 5: 10, T3: 77.5: 7.5: 15, T4: 70: 10: 20, T5: 62.5: 12.5: 25, T6: 55: 15: 30 and T7: 47.5: 17.5: 35 as % of wheat flour, quinoa flour and chickpea flour.



**Figure 4.** The mean values of lightness (L\*), redness (a\*), and yellowness (b\*) of the control and snack bar treatments. <sup>a,b,c,d,e,f,g,h</sup>Means within the same column with different superscripts are significantly different (P<0.05). Control: 100% wheat flour, Treatments are presented by T1: 92.5: 2.5: 5, T2: 85: 5: 10, T3: 77.5: 7.5: 15, T4: 70: 10: 20, T5: 62.5: 12.5: 25, T6: 55: 15: 30 and T7: 47.5: 17.5: 35 as % of wheat flour, quinoa flour, and chickpea flour.

treatments increased, which can be explained by the fact that the overall appearance is one of the first important factors for consumers to determine product acceptability (Lorenz and Coulter, 1991). This result is in agreement with various researchers who developed chickpea chips and quinoa products and reported an increase in overall impression scores as the amount of chickpea and quinoa flours increased compared to the control (Rababah *et al.*, 2012; Bhathal and Kaur, 2018). The supplemented snack bar treatments received high flavor scores compared to the 100% wheat flour control. This result could be due to consumers' individual preferences. This result agrees with past studies in which one prepared quinoa bread with

different levels and stated that all the levels' tastes were accepted and pleasant, and the most acceptable treatment was at 20% level (Stikic *et al.*, 2012). The other one developed cookies with different levels of chickpea flour and reported that the consumers, even more, accepted the chickpea-supplemented cookies more than the controls. The chickpea flour addition was more accepted at levels 20-40% in wheat flour samples (Yamsaengsung *et al.*, 2012), similar to the percentages used in this study for both the quinoa and chickpea flours. Moreover, the texture score also increased as the chickpea and quinoa contents increased. It was also found that the texture scores increased as the amount of chickpea flour

increased and produced more acceptable cookies, up to 75% of chickpea flour (Torra *et al.*, 2021). Similar texture results were found by replacing wheat flour with quinoa flour to prepare several products, including pop-ups and cookies (Bhathal and Kaur, 2018). Regarding the hardness score of the sample, it increased along with increasing the chickpea and quinoa flour levels. This result could be due to increased flours with high amounts of protein, leading to increased water absorption to ensure a proper dough. The hardness score result is similar to past researchers' results, who prepared cookies with mung bean and chickpea flours and found that chickpea cookies had the highest hardness scores compared to mung bean treatment and wheat flour control (Noor *et al.*, 2012). It was also found that the hardness score of bread samples increased as the amounts of quinoa and chickpea flours increased in comparison to 100% rice flour control (Buresova *et al.*, 2017). The aftertaste attribute has high scores in sensory evaluation could be due to the beany taste that felt after consuming legumes- bakery products (Ouazib *et al.*, 2016). Similarly, it was found that an addition of 35% chickpea flour resulted in cookies with high aftertaste scores and accepted more than the wheat flour control (Torra *et al.*, 2021). However, the color results showed opposite findings than other sensory attributes, which revealed that as the chickpea and quinoa contents increased, the color score decreased, resulting in a darker color. This dark color could be due to the high protein levels in the dough that lead to more reducing sugars and amino acid interactions in baking,

which is known as the Maillard reaction (Gupta *et al.*, 2019). The color score results are compatible with other researchers who developed chickpea biscuits, cookies, and corn snacks and reported lower color scores as the chickpea flour levels increased (Dhankhar *et al.*, 2021; Vasan *et al.*, 2017; Shah *et al.*, 2017) respectively). In addition, it was found that as the amounts of chia seeds and quinoa flour increased, the color score decreased, which produced darker color cookies (Goyat *et al.*, 2018). Similarly, increasing the chickpea flour, the past study revealed a darker color cookie (Sibian and Riar., 2020). This issue can be solved by the addition of pigments, such as titanium dioxide in order to lighten the color of the final product (Krahl *et al.*, 2016). The previous results show the linear relationship between the protein, fiber, and overall Acceptability (Figure 6). Where the overall acceptability of the snack bar increased as the amount of protein and fiber increased, which gave an indicator of good product quality. This result is due to the increased quinoa and chickpea flours and the high inulin content in the snack bar.

#### Nutritional analysis of the snack bar

Figure 7 shows that the food label of the high nutritional snack bar (T7) differs from the wheat flour control, where the high nutritional snack bar had higher protein, fiber, and iron content and lower carbohydrate content than the control while sharing approximately the same

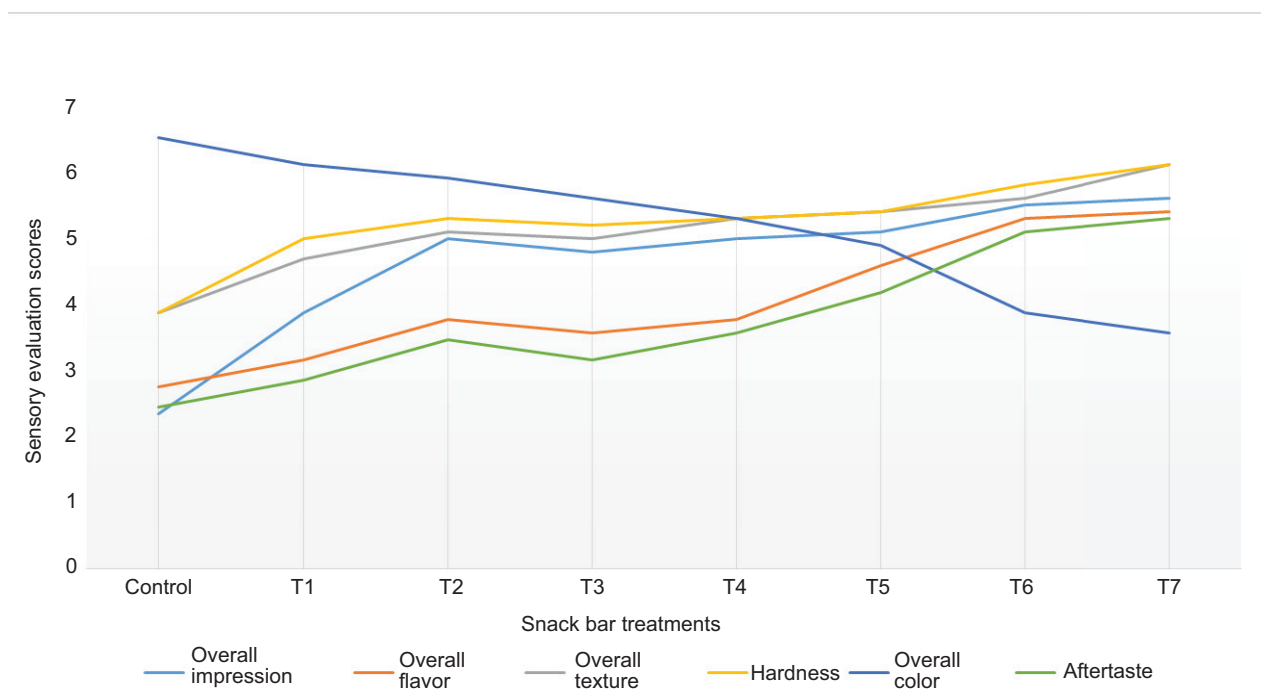


Figure 5. Sensory evaluation of snack bars.



**Table 7.** Nutrient content of both the control and treatment 7 with each other and with the Dietary Reference Intakes (DRIs) for pregnant women in different age groups, (Group 1) 19–30 years; (Group 2) 31 to 50 years.

Basic Component	Control			High Nutritional Snack Bar (T7)			DRI for Pregnant Women	
	Per serving (45g)	% for (Group 1)	% for (Group 2)	Per serving (45g)	% for (Group 1)	% for (Group 2)	19–30 years (Group 1)	31–50 years (Group 2)
Calories (Kcal)	173.23	7.17	7.56	181.90	7.53	7.94	2416.36	2291.98
Carbohydrate (g)	30.81	9.27	9.77	28.47	8.57	9.03	332.25	315.15
Fat (g)	3.38	4.49	4.73	4.35	5.78	6.10	75.18	71.31
Protein (g)	7.05	7.66	7.66	7.96	8.64	8.64	92.10	92.10
Fiber (g)	0.94	2.78	2.93	2.70	7.99	8.43	33.83	32.09
Iron (mg)	1.21	4.46	4.46	1.57	5.80	5.80	27.00	27.00
Calcium (mg)	80.17	8.02	8.02	87.78	8.78	8.78	1000.00	1000.00
Folate (mcg)	0.03	0.01	0.01	52.73	8.79	8.79	600.00	600.00

calories and calcium content. Moreover, as shown in Table 7, when comparing the nutrient content of both the control and treatment 7 with each other and with the Dietary Reference Intakes (DRIs) for pregnant women in different age groups, we conclude that treatment 7 could provide pregnant women with higher amount of calories, fat, protein, fiber, iron, calcium, and folate than control. In comparison, it provided lower carbohydrate content than wheat flour control.

## Conclusions

From the results of this study, we conclude that it is possible to produce a highly nutritional, great quality snack bar as a complementary source of nutrients that can provide pregnant women with some of their necessary daily with larger contents of protein and fiber as well as lower amounts of carbohydrate compared to wheat flour control, which makes it a great nutrient supporter for women who attempt to fulfill their needs and control their weight at the same time during pregnancy. The most accepted and recommended treatment through sensory evaluation was treatment 7, which had 47.5% wheat flour, 35% chickpea flour, and 17.5% quinoa flour.

## Future Directions

It is essential to conduct future studies in this field that focus on determining snack bars' amino acids, fatty acids profiles, vitamins, and minerals contents, as well as the shelf life evaluation. In addition, improve the final product color by the addition of food pigments in order to enhance the overall acceptability. Also, determine the snack bar texture by the texture analyzer machine. Moreover, examine the biological effect of this high nutritional snack bar on pregnant rats and record the results with various lab tests.

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