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Preparation and Evaluation of Falafel Powder Free of Legumes

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ABSTRACT

The aim of the study is to produce a quick-to-prepare falafel powder that is free of legumes and has a high nutritional value, especially for those suffering from favism anemia, and it can be produced on a large commercial scale**.** By using carrots, vegetable leaves powder, and some grains (naked barley, grits wheat and broken rice). The chemical, minerals content, the antioxidant activity, total phenols, total flavonoid, soluble and insoluble dietary fibers were analyzed as raw materials. Sensory evaluation, physical properties and minerals content were determined and RDA was calculated for falafel free of legumes mixtures for age group (4-18 years). The data showed that grits wheat had higher in fibre and protein content (14.60% and 18.88%, respectively) than barley and broken rice. Vegetable leaves powder increased in the estimated minerals of iron, calcium, potassium, zinc, phenols, flavonoid, and antioxidant activity compared to other components. The data showed that the naked barley recording 7.05, followed by carrots at 6.35, grits at 5.6, and dried dill leaves at 5.12% for non-soluble dietary fibre content. Also, the results indicated that the second mixture which contained (42 % of naked barley and 40 % of grits wheat) had the best score (8.85) for sensory acceptability. The minerals of Fe, Ca, Zn, and K were found in much higher concentrations in the second mixture; their respective values were 3.31 and 51.33, 1.68, and 282.13 mg/100 g sample, although it was lower in oil absorption. It is recommended that falafel free of legumes mixes be produced for patients with favism due to their high nutritional value, sensory acceptance and widespread popularity.

1. Introduction

Falafel is one of the most popular foods consumed by the majority of the population in Egypt (Hussein, 1983). Vegetables are main ingredients in many recipes for fried foods. Falafel is among the most well-known fried veggies. A popular fast-food dish in the Middle East is falafel. It goes by several names, which vary depending on the place of origin. It is known in Egypt and Sudan as "*Ta'amiyya*"; it is a small fried balls made from faba beans and / or chickpeas (Abdullah 2015). It is considered a meal which is eaten at breakfast or dinner, especially in low-income families where it is consumed in large quantities because of its relatively low price and always available in addition to its distinctive taste (Amr and Abdulla 2003). The main constituent of Falafel is faba bean (*Vicia faba* L.) with variable amounts of onion, garlic and some vegetables such as Egyptian leek, herbs and parsley. Falafel is a vegetarian recipe which reflects its nutritious value as reported by Ismail and Kucukoner (2017). Barley (*Hordeum vulgare* L.) is the fourth most important cereal crop worldwide, after wheat, corn and rice; belonging to family Poaceae (Gramineae). Barley can substitute wheat in feeds as it contains more fibre and less protein. Barley is easily digestible (due to low gluten contents) and has superior nutritional qualities, high concentrations of lysine, thiamine and riboflavin (Marwat et al., 2012). Broken rice (*Oryza sativa* L) is a by-product during grain polishing from rice mills, which are the fragments of rice that are not completely broken. Deshelling is the first step in rice processing and yields brown rice then the polishing or whitening process.

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Some quality losses occur during milling which is the major problem of the rice industry as reported by Payman et al. (2006). It was estimated that around 9.7 million metric tons, or 36.6% of the broken rice globally in 2020, was used for animal feed and other non-human food uses (Childs 2020). This volume is enough to feed 158 million additional people yearly at the average global per-capita rate of 61.2 kg/year (Siebenmorgen et al., 1998). This represents a loss of food and inefficient use of production resources, equating to an estimated 3.2 million hectares of rice produced for non-human consumption because of poor perceived quality. On the other hand, apart from carrots roots being traditionally used in salad to prepare curries in India, these could commercially be converted into nutritionally rich processed products like juice, concentrate, dried powder, canned, preserve, candy and pickle as reported by Krishan et al. (2012). Faba beans contain toxic glycosides namely vicine and convicine, these toxic glycosides are the factors responsible for favism in humans particularly young males that have a deficiency of G6P Dactivity (Zam and Belal, 2020). Ahmed and Saad (2017) demonstrated that, despite blood transfusions, acute haemolytic crisis was the second most frequent reason for inpatient admissions at Cairo University's Paediatric Hospital. Ninety percent of individuals experiencing acute haemolytic crises were found to have a G6PD deficiency. The estimated prevalence of G6PD deficiency in Egypt is 5.9%, with the peaking of instances in this country occurring coincidentally with the growth season of beans. Favism, a prevalent form of acute haemolytic anaemia linked to G6PD deficiency that arises from faba bean consumption, is particularly common in children and youngsters (Ravikumar and Greenfield, 2020). According to Sintes et al. (2022), favism is most commonly diagnosed in children under the age of five. Adult diagnoses of favism are very rare, and this is especially true for the elderly. Favism is more life-threatening illness in children than in adults (Martínez et al., 2020). The prevalence of G6PD deficiency among Egyptian neonates is 8.9% (Abo El Fotoh and Rizk, 2016). Within six to twenty-four hours of consuming faba beans, a severe reaction known as favism occurs due to the extensive lysis of red blood cells (Siler et al., 2016). According to estimates, 26% of newborns and children in Egypt who suffer an acute haemolytic episode have favism (Pulkkinen et al., 2016). It is common among males between the ages 2 and 10 years (Ata et al., 2020). The aim of the study is to produce a quick-to-prepare falafel powder that is free of legumes and has a high nutritional value, especially for those suffering from favism anemia, and it can be produced on a large commercial scale.

2. Materials and Methods

Materials

Naked barely (Giza, 133), grits wheat, broken rice, carrots, dry garlic, dry onion, cumin, baking powder, coriander seeds, salt, parsley, leek, dill, coriander leaves, and sunflower oil (as frying) were purchased from a local market in Giza , Egypt.

Preparation of falafel free of legumes mixtures

The ingredients were prepared by cleaning and washing with running water all of the carrots, dill, leek, parsley, and green coriander well. Then, they were filtered from the water and dried in an air forced oven (Memmert, Schwabach, Germany) at a temperature of 45 degrees Celsius overnight. The dry ingredients (grits wheat, naked barley, carrots, dill, leek, parsley, and coriander) were ground separately in the factory mill bearing a brand name (Monolex mill, french) and each ingredient was packed separately until mixed and used. Dry ingredients were added individually: 1gm from dill, parsley, coriander, leeks powder and 2gm of ground cumin separately for each mixture. Also, 2gm of dried carrots powder, 1.5gm of salt, 5gm of dried onions, 2gm of dried garlic, 0.5gm of baking powder, and 1 gm from coriander seeds were added for 100gm mixture.

M1: consists of these previous ingredients with 42g naked barley and 40g broken rice.

M2 : consists of the previous fixed mixtures with 42 gm naked barley and 40gm grits wheat.

M3: consists of the previous fixed ingredients with

42 gm naked barley, 20 gm broken rice and 20 gm grits wheat.

M4: consists of the previous fixed ingredients with 27.66 gm naked barley, 26.67 gm broken rice and 27.67 gm grits wheat.

Then, the mixtures were packed in polypropylene bags and stored at room temperature (20±5 ˚C) for a period of three months in a dry place. The average relative humidity during storage period was 42%. These mentioned proportions were used based on previous experiments in which different proportions of naked barely, grits wheat, broken rice, vegetables leaves and carrots powder were used to prepare falafel free of legumes. These proportions were reached, which gave a cohesive falafel tablet that was good in terms of sensory and physical qualities.

Preparing the falafel free of legumes and frying

The falafel free of legumes prepared by mixing 100 g from mixture powder with 250 ml water, then waited for 20 minutes (to make the mixture absorb the water well) and mixed properly. Then the mixture was formed into tablet of the usual size for the consumer and fried in hot deep oil until it settled and reached the desired color.

Methods analytical

Moisture, ash, fibre, protein and fat on dry weight basis were estimated consistent with the methods of AOAC (2019). The percentage of total carbohydrate in the samples were calculated by difference as follow: Total carbohydrate = 100 (dry weight) - (protein + fat + ash). Mineral contents such as (iron (Fe), calcium (Ca), zinc (Zn) and potassium (K) were determined using a Pye Unicum SP1900 Atomic Absorption Spectroscopy Instrument (Perkin Elmer model 4100ZL, USA) ac-cording to the method described by AOAC (2019).

Determination of antioxidant activity

The antioxidant activity of the tested samples, based on the scavenging activity of the stable DPPH free radical was determined by the method described by Lee et al. (2004). Inhibition of DPPH free radical in percent (1nhibition %) was calculated from the equation:

Inhibition% = (Ac– As / Ac × 100)

Where: Ac is the absorbance of the control and As is the absorbance of the sample.

Determination of total phenolic content

Total phenolic content of different samples was determined using Folin -Ciocalteau reagent according to the method described by Maurya and Singh (2010). The results were expressed as of gallic acid mg /100g of weight sample.

Determination of total flavonoid

Total flavonoid content of the tested samples was determined according to the method described by Jia et al. (1999). The results were expressed as mg of quercetin/100 g sample of dry weight sample. Determination of soluble and insoluble dietary fibre content were estimated consistent with Prosky et al. (1984)

Physico-chemical analysis

Estimation of oil absorption for falafel free of legumes mixtures

The measurement of oil absorption was in accordance with Nurul et al. (2009).The falafel of free of legumes tablet sample was weighed before and after frying in hot oil at 180°C. Then, the falafel tablet sample was dried for an entire night at 105°C in an oven (Memmert, Schwabach, Germany). The percentage of oil absorption was calculated as follows:

$$\%\,Oil\ absorption = \frac{Weight\ of\ falafel\ after\ frying - Weight\ of\ falafel\ before\ frying}{Weight\ of\ falafel\ before\ frying} \times 100$$

Estimation of water absorption index (WAI) of falafel free of legumes mixtures

WAI was determined using the procedure outlined by Yagci and Gogus (2009) in triplicate. Using a vortex mixer, each 3g sample falafel was distributed in 30 ml of distilled water and mixed. This dispersion was left in a water bath heated at thirty degrees Celsius for 30 minutes.

The dispersion was then centrifuged using a centrifuge (Remi Instruments, Bombay, India) at 3000 rpm for 15 minutes, supernatant was poured into a petri- dish and dried at 110 ºC and weighed. Water absorption index (g gel/g sample) was calculated according to the following equation: [(weight of hydrate residue of sample) / dry weight of sample]× 100.

Sensory characteristics

The sensory characteristics of the falafel free of legumes samples were evaluated according to Abed El-Hakim et al. (2020) by 10 panellists from staff, employees and researchers of food Technology research Institute, kitchen unite experiment. Parameters were color, odor, appearance, taste, crispy, texture and the overall acceptability which were determined as the total mean score of all the sensory parameters. Sensory testing of the mixtures was conducted at the beginning of manufacturing and at the end of the storage period (three months).

Relative percentage of daily requirement protein, fibre and some minerals for falafel free of legumes mixtures compare with recommended dietary allowances for age group (4-18 years).

Statistical analysis

Statistical Analysis Software (SAS, 2003) was used to help with the data analysis for this investigation. The least significant difference test was used to evaluate a significant difference between the data means and standard deviation at a p-value ≤ 0.05.

3. Results and Discussion

Chemical composition of raw materials

Table 1 shows the results of the chemical composition and the presence of significant differences between the raw materials used in preparing falafel free of legumes. These materials include cereals, barley, broken rice and grits wheat. Vegetables used include carrots, parsley, coriander, leeks and dill leaves powder. A significant increase was observed in the moisture content of grains compared to vegetables, where moisture was recorded at 13.13, 12.56 and 11.90% in grits, broken rice and naked barley, respectively, while coriander and parsley leaves recorded 9.39% and 9.13%, respectively. The moisture in leeks was 7.87% and dill was 7.20%. The lowest in moisture was powdered carrots (6.0 %). At the same table, barley was significantly higher in ash (5.19%) compared to broken rice (0.75%) and grits (2.65%). There were no significant differences in ash among leaves vegetables, carrots powder was the lowest in ash content (1.10 %). Also, Table 1 showed that the grits was high in fibre and protein (14.60% and 18.88%), respectively, compared to barley and broken rice, followed by leeks in fibre (11.87%), then powdered coriander leaves (6.25%). Parsley recorded an increase in protein by (5.29%) compared to dill, coriander, and leeks. Powdered carrots was the lowest in protein content (0.95%). Broken rice had fat content (0.66%) and powdered carrots (0.60%) also decreased in their fat content. Carbohydrates increased significantly in carrots powder (97.35 %) as a result of its decrease in other ingredients. At the same time grits wheat decreased significantly in carbohydrate content as a result of its increase in protein. These results agreed with scientists El-Rehem and Ali (2013) who said that whilst the leaves are an excellent supply of ash and crude fibre, the seeds are a good source of fat and protein. Due to high digestibility, barley grains are fed to farm animals as a source of energy as well as protein, vitamins, and minerals (Blidere and Grunte, 2007).

Minerals content of the raw materials

The results showed a significant increase in the content of the mineral listed in Table 2 of the leafy vegetables used to produce falafel free of legumes compared to grains and carrots powder. The highest content (mg/100g sample) of potassium, calcium and zinc were in leek leaves powder, 1037.45, 1201.67 and 6.34, while the highest iron content was 6.92 in parsley leaves powder followed by leeks (5.95) then dill leaves powder (5.59) and coriander leaves powder (5.30). Parsley leaves powder contains calcium content 325.94 mg/100g sample followed by dill leaves powder which was 218 mg/100g. The results were consistent with Koca and Tasci (2016) found that leek eating can help create a well-balanced diet and that the vegetable's leaves

leaves are a significant source of potassium, calcium, and phosphorus. Leeks have also been shown to be an essential source of nutritional elements. The most valuable for their nutritional benefits are parsley and dill, according to Viškelis et al. (2012), mineral matter, ascorbic acid, and other biologically active components provide human dietary allowances with naturally occurring materials. For these reasons, investigations into this case are both important and beneficial.

Table 1. The proximate analysis of the raw materials (on dry weight basis)

Raw materials	Contents %					
	Moisture	Ash	Fibre	Protein	Fat	*Total carbohydrates
Naked barley	$11.90^c \pm 0.655$	$5.19^a \pm 0.569$	$7.48^c \pm 1.44$	$12.70^b \pm 1.61$	$2.20^a \pm 0.642$	$79.91^d \pm 0.63$
Broken rice	$12.56^b \pm 0.163$	$0.75^d \pm 0.115$	$0.90^g \pm 1.63$	$8.12^c \pm 0.954$	$0.66^d \pm 0.762$	$90.47^c \pm 0.123$
Grits wheat	$13.13^a \pm 0.45$	$2.65^b \pm 0.75$	$14.60^a \pm 1.04$	$18.88^a \pm 1.21$	$1.66^b \pm 0.231$	$76.81^e \pm 0.645$
Carrots powder	$6.00^f \pm 1.63$	$1.10^c \pm 0.985$	$2.60^f \pm 0.988$	$0.95^f \pm 1.63$	$0.60^d \pm 0.865$	$97.35^a \pm 0.614$
Parsley leaves powder	$9.13^d \pm 0.89$	$2.23^b \pm 1.63$	$4.10^e \pm 0.854$	$5.29^d \pm 1.56$	$1.14^c \pm 0.335$	$91.34^c \pm 0.74$
Coriander leaves powder	$9.39^d \pm 0.77$	$2.20^b \pm 1.48$	$6.25^d \pm 0.933$	$3.31^e \pm 1.112$	$1.50^c \pm 0.475$	$92.99^b \pm 0.356$
Leek leaves powder	$7.87^e \pm 0.98$	$2.45^b \pm 1.45$	$11.87^b \pm 0.987$	$3.24^e \pm 1.630$	$1.50^c \pm 0.476$	$92.81^b \pm 0.245$
Dill leaves powder	$7.20^e \pm 1.63$	$2.25^b \pm 0.256$	$2.10^f \pm 0.685$	$3.96^e \pm 1.513$	$1.54^c \pm 0.613$	$92.25^b \pm 0.478$

Mean values at same column with different letters are not significantly at . $p \leq 0.05$
* Total carbohydrates in the samples was calculated by difference

Table 2. Minerals content of the raw materials as (mg/100g sample)

Raw materials	Minerals content			
	K	Ca	Zn	Fe
Naked barley	$268.00^g \pm 0.623$	$28.64^g \pm 0.879$	$1.50^c \pm 0.245$	$1.56^d \pm 1.453$
Broken rice	$109.00^h \pm 1.123$	$7.00^h \pm 0.986$	$1.09^{cd} \pm 0.124$	$0.90^e \pm 0.714$
Grits wheat	$294.00^e \pm 1.456$	$45.00^e \pm 1.456$	$2.30^b \pm 1.63$	$4.90^c \pm 0.475$
Carrots powder	$145.00^f \pm 0.986$	$34.00^f \pm 0.879$	$0.07^f \pm 0.987$	$0.40^e \pm 0.112$
Parsley leaves powder	$466.10^d \pm 1.456$	$325.94^b \pm 0.877$	$1.64^c \pm 0.879$	$6.92^a \pm 0.122$
Coriander leaves powder	$546.20^c \pm 0.879$	$146.50^d \pm 0.564$	$0.68^e \pm 0.877$	$5.30^b \pm 0.879$
Leek leaves powder	$1037.45^a \pm 0.564$	$1201.67^a \pm 0.789$	$6.34^a \pm 0.789$	$5.95^b \pm 0.718$
Dill leaves powder	$785.00^b \pm 0.789$	$218.00^c \pm 1.63$	$0.91^d \pm 0.456$	$5.59^b \pm 0.142$

Mean values at same column with different letters are not significantly at $p \leq 0.05$

Determination of total, non soluble and soluble dietary fibre, antioxidant activity (%), total phenols and total flavonoid of raw materials

In the third Table, the results showed that there are significant differences between the raw samples tested, as the naked barley was significantly high in their total dietary fibre content, recording 12.07%. Also, the data showed that, dried dill leaves was significantly high in their total dietary fibre content was found 7.68%, followed by carrots powder and grits wheat (6.80%), then dried coriander leaves (5.60%), followed by dried parsley leaves was 3.87% and leeks was 3.14%, while broken rice was recorded the lowest value in the total dietary fibre 1.3%. The data in Table 3 showed clear significant differences between the samples in their non soluble dietary fibre content. Naked barely, grits wheat and carrots powder recorded a significant increase in non soluble dietary fibre, where naked barley recorded 7.05%, then powdered carrot 6.35**%**, and finally grits was 5.6**%**, and dried dill leaves was significantly high in insoluble dietary fibre 5.12%. Dried coriander leaves had the lowest value, 4.27%, parsley leaves was 2.79%, and leeks, 2.47%. Broken rice had a significantly lower value in nonsoluble dietary fibre (1.0%) compared to the other raw samples. The soluble fibre was recorded 2.56, 1.33, 1.08, and 0.67% in dill, coriander, parsley, and leeks dried leaves, respectively, in carrots powder was 0.45% and broken rice was 0.30%. The current results coincide with those of Krishan et al. (2012) who stated that carrots are one of the important root vegetables high in dietary fibre and bioactive compounds like carotenoids, along with notable amounts of a number of other useful ingredients with essential benefits for health. The consumption of carrots and its products is increasing steadily due to its recognition as an important source of natural antioxidants having anticancer activity. Antioxidant activity in Table 3 showed that the significant differences were found between the tested samples (dried vegetable leaves and grains), where dried dill, 78.51% parsley and coriander leaves recorded a significant increase in the estimated activity (66.98% and 65.91%, respectively) compared to dried leeks (46.45%) and dried carrots (46.21%). The results listed in the table were significantly higher in antioxidant activity in grits 11.80 %, broken rice 6.56%, than naked barley, the least active, 0.88 %. On the other hand, the results in Table 3 showed that the total phenols (mg gallic acid/100g sample) increased significantly in dried leek leaves (645.12), dried dill leaves was 503.12, dried carrots recorded 476.56, followed by dried coriander leaves was 345.63. Finally, dried parsley leaves was 334.91and the content of phenolics was high in naked barley 147.25 compared to broken rice, 21.24, and the lowest value was in grits, which was 7.88. The results for total flavonoid as mg quercetin /100g sample in Table 3 showed significant differences between the tested samples. The dried green leaves of leeks, dill, parsley, and coriander were characterized by their high content of total flavonoid, which were 255.67, 165.23, 156.58, and 145.23, respectively. While carrots powder recorded 66.25 and broken rice was 5.53, the lowest value for total flavonoid in grits was 2.11 and barley was 1.60. Our results were consistent with Aghili et al. (2012) reported that the vegetables are considered as a rich source of many antioxidants and nutrients that are essential for human health. Fresh leeks are a good source of flavonoids and glucosinolates in addition to numerous organosulfur components contributing to their rich flavor (Ozgur et al., 2011). Flavonoids are normal constituents of the human diet and are known for a variety of biological activities. In recent years, flavonoids have been used to improve the oxidative stability of foods (Morelo et al., 2019). Ullah et al. (2019) reported that flavonoids have numerous benefits. Health effects such as anticancer and antiobesity effects are beneficial against nicotine- related diseases. These data were compared with the published report of Suwannatrai et al. (2022) who researched that the TPC and TFC in roasted broken rice were found at an average of 20.40 ± 0.37 mg GAE g^{-1}crude extract and 4.58 ± 0.19 mg QE g^{-1} crude extract, respectively. Moreover, the sample has highly efficient antioxidants activity. Total phenolic and flavonoid content increases in dried spices (parsley, dill, leek, garlic, onion and carrots as found that by Priecina and Karklina (2014).

The proximate analysis of falafel free of legumes mixtures

Table 4 shows the chemical content of falafel free of legumes mixtures manufactured. The moisture was 8.57, 8.8, 9.2, and 9.7 % in the mixtures M1, M2, M3, and M4, respectively, and no significant differences appeared between the mixtures in their ash content. It was noted at the same table that there were slight significant differences between the mixtures in their fibre content, as the M2 mixture recorded a greater value of 9.41%, due to its high content of high-fibre grits (14.60 %), while the M1 mixture recorded a lower value of 3.81, and the M3 was 6.61 and M4 was 6.70 %. There was a significant difference in protein between the M2 mixture and other manufactured mixtures, as the protein for this mixture was 13.90 % and in M3 was 11.25% and M4 it was 11.41%, while the M1 mixture was the lowest value of protein content (9.12%). This is due to the presence of grits in the M4, M3 and M2 mixtures and the decrease in protein in the mixture. The first mixture contains broken rice that is low in protein and does not contain grits. There were no significant differences between the mixes in their fat content, and the fat content ranged from 1.14 1.69 % between the falafel free of legumes mixtures manufactured. There are slight significant differences between the mixes in their fat content

The fat content ranged from 1.14 to 1.69% between the falafel free of legumes mixes manufactured. There are slight significant differences in carbohydrates, as the first mixture (M1) was high in its carbohydrate content (85.76 %) due to the presence of broken rice in the components of the mixture. The second mixture (M2) recorded a significant decrease in carbohydrates due to the presence of grits (80.93%). The third mixture (M3) recorded 83.70 % and the fourth mixture 83.56% due to the convergence of the ratios of the components of barley, grits, and broken of rice in the components of the mixture. These results agreed with scientists Marciniak, (2006) who reported that the cereal grain is one of the oldest components of human diet. It contains numerous nutrients: proteins, carbohydrates, vitamins, minerals (iron, potassium, phosphorus, zinc), and, next to fruits and vegetables, constitutes a source of antioxidants.

Table 3. Total, non soluble and soluble dietary fibre, antioxidant activity (%), total phenols and total flavonoid of raw materials

Raw materials	Contents (on dry weight basis)					
	Total dietary fibre %	Non soluble dietary fibre %	Soluble dietary fibre %	Antioxidant activity %	Total phenols (as mg gallic acid/100g sample)	Total flavonoid as quercetin mg/100g sample
Naked barley	12.07^{a}±0.152	7.05^{a}±0.532	5.02^{a} ± 0.542	0.88^{g}± 0.332	147.12^{e}± 0.432	1.60^{h}± 0.842
Broken rice	1.30^{f}± 0. 132	1.00^{f}± 0.932	0.30^{e}± 2.032	6.56^{f}± 0.152	21.24^{f}± 0.732	5.83^{f} ± 1.632
Grits wheat	6.80^{c}± 0.458	5.60^{c}± 0.742	1.20^{c} ± 0.552	11.80^{e} ±0.318	7.88^{g}±0.53	2.11^{g} ±0.88
Carrots powder	6.80^{c} ± 0.632	6.35^{b}± 0.632	0.45^{e}± 1.632	46.21^{d}± 0.432	476.56 ^{c} ± 0.642	66.25^{e}± 1.232
Parsley leaves powder	3.87^{e} ± 0.332	2.79^{e}± 0. 782	1.08^{c}± 1.742	66.98^{b}± 0.632	334.91 ^{d} ± 0.952	156.58^{c}± 1.362
Coriander leaves powder	5.60^{d} ± 0.742	4.27^{d}± 0.472	1.33^{c}± 1.872	65.91^{c}± 0.452	345.63 ^{d} ± 0.855	145.23^{d}± 1.442
Leek leaves powder	3.14^{e} ± 0.457	2.47^{e}± 0.732	0.67^{d}± 2.112	46,45^{d}± 0.562	645.12 ^{a}± 0.751	255.67^{a}± 1.952
Dill leaves powder	7.68^{b} ± 0.432	5.12^{c}± 0.132	2.56^{b}± 1.642	78.51^{a}± 0.852	503.12 ^{b} ± 0.432	165.23^{b}± 1.132

Mean values at same column with different letters are not significantly at $p \leq 0.05$

Table 4. The proximate analysis of falafel free of legumes mixtures (on dry weight basis)

Mixture number	Contents %					
	Moisture	Ash	Fibre	Protein	Fat	*Total carbohydrates
M1	8.57^{b}± 0.352	3.98^{a}± 0.842	1 3.8^{c}± 0.732	9.12^{c}± 1.732	1.14^{a}± 0.732	85.76^{a}± 0.772
M2	8.81^{b}± 0.822	3.99^{a}± 0.232	9.41^{a}± 0.966	13.39^{a}± 0.865	1.69^{a}± 1.125	80.93^{c}± 1.532
M3	9.20^{ab}± 0.482	3.63^{a}± 0.732	6.61^{b}± 0.732	11.25^{b}± 1.732	1.42^{a}± 1.654	83.70^{b}± 1.412
M4	9.70^{a}± 0.842	3.78^{a}± 0.432	6.70^{b}± 0.832	11.41^{b}± 0.987	1.25^{a}± 0.732	83.56^{b}± 1.232

Mean values at same column with different letters are not significantly at . $p \leq 0.05$. *Total carbohydrates in the mixture was calculated by difference. M1= 42g naked barley + 40g broken rice, M2= 42g naked barley + 40g grits wheat, M3= 42g naked barley +20g broken rice+ 20g grits wheat and M4=27.66 g naked barley +26.67g broken rice + 27.67g grits wheat.

The mineral contents of falafel free of legumes mixtures

Table 5 shows the falafel free of legumes content of some minerals (iron, calcium, zinc, and potassium), which have an important and clear role in the growth of children suffering from favsim anemia. The second mixture recorded a significant increase in its content of the elements Fe, Ca, Zn, and K, as they recorded values of 3.32, 51.33, 1.7, and 282.13 mg/100g sample, respectively. Mixture number one was the lowest in its content of measured minerals, with values recorded at 1.42 for iron, 36.13 for calcium, 1.21 for zinc, and 208.13 for potassium. This is due to the absence of grits, which is rich in its content of these minerals. There were significant differences between the mixtures M3 and M4 in iron and potassium (mg/100g mixture), as it recorded 3.11 and 2.22 in iron, respectively, and potassium recorded 245.12 in M3 and 236.51 in M4, while in zinc and calcium, there were no significant differences between them. The results agreed with Koca and Tasci (2016) reported that the vegetables are considered to be a good source of dietary minerals. The results revealed that leek was especially rich in potassium and iron. Ash consists mainly of inorganic compounds. Also, barley grain is an excellent source of vitamins and minerals (Sterna et al., 2015). The major mineral compounds in barley our is potassium, while iron and zinc are major trace minerals.

Table 5. The mineral contents of falafel free of legumes mixtures

Mixture number	Minerals content (mg/100g mixture)			
	Fe	Ca	Zn	K
M1	$1.42^{c}\pm 1.634$	$36.130^{c}\pm 0.755$	$1.21^{c}\pm 0.454$	$208.13^{d}\pm$ 1..634
M2	$3.32^{a}\pm 0.654$	$51.330^{a}\pm 0.112$	$1.70^{a}\pm 0.564$	$282.13^{a}\pm 0.664$
M3	$2.22^{b}\pm 0.954$	$43.730^{b}\pm 0.345$	$1.50^{b}\pm 0.554$	$245.12^{b}\pm 0.124$
M4	$3.11^{a}\pm 0.958$	$43.541^{b}\pm 0.985$	$1.48^{b}\pm 0.412$	$236.51^{c}\pm 0.654$

Mean values at same column with different letters are not significantly at . $p \leq 0.05$
M1= 42g naked barley + 40g broken rice, M2= 42g naked barley + 40g grits wheat, M3= 42g naked barley +20g broken rice+ 20g grits wheat and M4=27.66 g naked barley +26.67g broken rice + 27.67g grits wheat.

Physical properties of falafel free of legumes mixtures

The results of Figure 1 showed clear significant differences between the falafel free of legumes powder in oil absorption and water absorption index (WAI). Moreover, M1 recorded a high rate of oil absorption and WAI (13.80%-18.06 g gel/g sample), respectively) as a result of it containing broken rice, which is characterized by a high rate of water and absorption as a result of it being starchy. The second mixture was characterized by a low percentage of oil and WAI (4.46% - 13.28g gel/g sample), respectively), due to the absence of broken rice and the presence of grits wheat. According to Mellema (2003), explained that oil is absorbed as water evaporates because the oil is drawn into pores to replenish the lost water. More oil is absorbed on the surface when there is a larger surface area due to increased linear expansion. Suhaila and Norhasyimah (1994) also reported a positive correlation between oil absorption and volume expansion and this could be explained that when expansion occurs, more oil trapped in the surface layer of the bigger air cells. This prevented the starch gel from expanding in hot cooking oil. Chudasama et al. (2019) clarified that WAI is thought to be a measure of the level of starch breakdown and gelatinisation. The reduction of WAI values may be attributed to the increased concentration of soluble polysaccharides that are liberated from the starch polymer chains during gelatinisation.

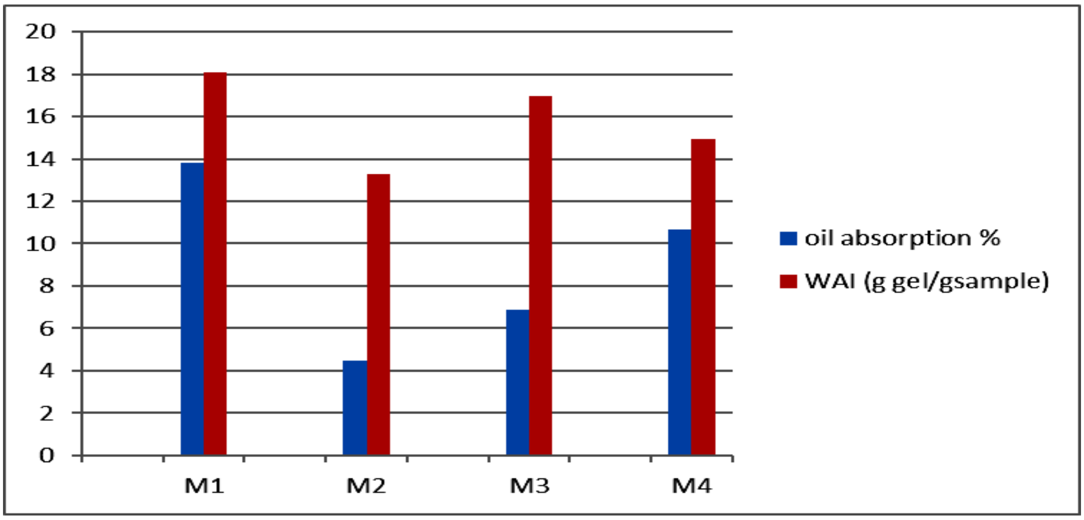

Figure 1. Physical properties of falafel free of legumes mixtures

M1= 42g naked barley + 40g broken rice, M2= 42g naked barley + 40g grits wheat, M3= 42g naked barley +20g broken rice+ 20g grits wheat and M4=27.66 g naked barley +26.67g broken rice + 27.67g grits wheat.

Sensory characterises of falafel free of legumes mixtures at zero time and storage period (3 months)

Table 6 shows the values of the sensory characteristics recorded by tasters for falafel free of legumes mixtures prepared in the two periods storage (zero time period and three months) after frying. The results in Table 6 showed significant differences between the sensory characteristics (color, appearance, taste, crispy, texture and overall acceptability) tested for falafel free of legumes at zero time period. Also, table 6 cleared the odor characteristic was not significant between the prepared mixtures. At the same time there were no significant differences between the third and fourth mixtures in all sensory characteristics. The second mixture (M2) recorded the best scores in both period in terms of color, appearance, taste, crispy, texture and overall acceptability. All mixtures achieved general acceptance, M2 recorded the highest value for sensory acceptance, 8.85, and M1, M3, and M4 recorded 8.00, 8.37, and 8.33, respectively. The first mixture (M1) was recorded the lowest value in the sensory properties mentioned above. The sensory test of manufacturer falafel free of legumes were slightly affected at the end of the storage period (three months).

Table 6. Sensory characterises of falafel free of legumes mixtures at zero time and storage period (3months)

Mixture number	Color (10)	Odor (10)	Appearance (10)	Taste (10)	Crispy (10)	Texture (10)	overall acceptability (10)
	Zero time						
M1	$8.13^{b}\pm 0.93$	$8.15^{ab}\pm 0.732$	$8.00^{b}\pm 0.432$	$7.00^{c}\pm 0.563$	$7.50^{c}\pm 0.732$	$7.71^{c}\pm 0.732$	$8.00^{c}\pm 0.632$
M2	$8.88^{a}\pm 0.542$	$8.90^{a}\pm 0.455$	$8.75^{a}\pm 0.552$	$8.74^{a}\pm 0.432$	$8.83^{a}\pm 0.478$	$8.57^{a}\pm 0.632$	$8.85^{a}\pm .732$
M3	$8.48^{b}\pm 0.652$	$8.55^{a}\pm 0.789$	$8.43^{b}\pm 0.332$	$8.24^{b}\pm 0.756$	$8.25^{b}\pm 0.332$	$8.12^{b}\pm 0.642$	$8.37^{b}\pm 0.456$
M4	$8.58^{b}\pm 0.652$	$8.45^{a}\pm 0.732$	$8.33^{b}\pm 0.96$	$8.28^{b}\pm 0.536$	$8.33^{b}\pm 0.632$	$8.00^{b}\pm 0.752$	$8.33^{b}\pm 0.456$
	End storage time(3months)						
M1	$7.00^{c}\pm 0.654$	$7.11^{c}\pm 0.452$	$7.77^{c}\pm 0.632$	$7.33^{c}\pm 0.782$	$7.00^{c}\pm 0.533$	$7.22^{c}\pm 0.432$	$7.33^{c}\pm 0.745$
M2	$8.61^{a}\pm 0.478$	$8.77^{a}\pm 0.856$	$8.60^{a}\pm 0.722$	$8.48^{a}\pm 0.432$	$8.58^{a}\pm 0.112$	$8.86^{a}\pm 0.125$	$8.66^{a}\pm 0.256$
M3	$8.10^{b}\pm 0.732$	$8.21^{ab}\pm 0.452$	$8.22^{b}\pm 0.482$	$8.08^{ab}\pm 0.786$	$8.15^{b}\pm 0.892$	$8.00^{b}\pm 0.145$	$8.11^{b}\pm 0.256$
M4	$8.27^{b}\pm 0.563$	$8.15^{ab}\pm 0.441$	$8.11^{b}\pm 0.692$	$8.11^{ab}\pm 0.486$	$8.10^{b}\pm 0.762$	$8.04^{b}\pm 0.732$	$8.13^{b}\pm 0.745$

Mean values at same column with different letters are not significantly at . $p \leq 0.05$
M1= 42g naked barley + 40g broken rice, M2= 42g naked barley + 40g grits wheat, M3= 42g naked barley +20g broken rice+ 20g grits wheat and M4=27.66 g naked barley +26.67g broken rice + 27.67g grits wheat.

Calculation of the daily requirement of protein, fibre and some minerals for falafel free of legumes

Table 7 shows the calculation of the daily required ratio of protein, fiber, calcium, iron, zinc and potassium for age group 4-18 years is calculated on the approximate phenotypic composition in Table 4 and 5 for falafel free of legumes samples. It can contain falafel protein, fiber, calcium, iron, zinc and potassium for age 4-18 years. The percentage of protein in the mixtures ranges from 48 - 70.43% of the daily protein requirements for ages 4-8 years. In the period from 9-13 years, the percentage ranges from 26.82-39.38% of daily needs.

Table 7. Relative percentage of daily requirement protein, fibre and some minerals for falafel free of legumes on fresh weight compare with recommended dietary allowances for age group (4-18 years)

Age group	Nutrients	RDA*	M1	M2	M3	M4
4-8years	Protein (g/day)	19	48	70.47	59.21	60.05
	Fiber (g/day)					
	Female	16.8	22.68	56.01	39.35	39.88
	Male	19.6	19.43	48.01	33.72	34.18
	Calcium (mg/day	1000	3.61	5.13	4.37	4.35
	Iron (mg/day)	10	14.2	30.2	22.2	33.1
	Zinc (mg/day)	5	24.2	33.6	29.0	29.6
	Potassium (mg/day)	3800	5.48	7.42	6.45	6.22
9-13years	Protein (g/day)	34	26.82	39.38	33.09	33.56
	Fiber (g/day)					
	Female	22.4	17.01	42.01	29.51	29.91
	Male	25.2	15.12	37.34	26.23	26.59
	Calcium (mg/day)	1300	2.78	3.95	3.36	3.35
	Iron (mg/day)	8	17.75	37.75	27.75	41.38
	Zinc (mg/day)	8	15.13	21.00	18.13	18.5
	Potassium (mg/day)	4500	4.63	6.27	5.45	5.26
14-18years	Protein (g/day)					
	Female	46	19.82	29.11	24.4	24.78
	Male	52	17.54	25.75	21.63	21.94
	Fiber (g/day)					
	Female	22.5	16.93	41.82	29.38	29.78
	Male	30.8	12.37	30.55	21.46	21.75
	Calcium (mg/day)	1300	2.78	3.95	3.36	3.35
	Iron (mg/day)					
	Female	15	9.47	20.13	14.80	22.07
	Male	11	12.91	27.45	20.18	30.09
	Zinc (mg/day)					
	Female	9	13.44	18.67	16.11	16.44
	Male	11	11.00	15.27	13.18	13.45
	Potassium(mg/day)	4700	4.42	6.00	5.22	5.03

***Recommended Dietary Allowances, (1989).**
M1= 42g naked barley + 40g broken rice, M2= 42g naked barley + 40g grits wheat, M3= 42g naked barley +20g broken rice+ 20g grits wheat and M4=27.66 g naked barley +26.67g broken rice + 27.67g grits wheat.

During the period from 14-18 years, the percentage for females ranges from 19.82-29.11%, while for males it ranges from 17.54-25.75% of daily needs. The percentage of daily fiber needs for females ranges from 16.93-56.01% in the period from 4-18 years. As for males, it ranges from 12.37-48.01% at the same age. Falafel free of legumes made from barley, some other grains and vegetables is a higher source of minerals, especially iron. Falafel free of legumes contains a greater amount of the daily iron requirement, ranging from 9.47-41.38% for females and males in the period from 4 to 18 years. As for zinc, falafel free of legumes is provided for the age group from 4-8 years, 24.20 to 33.60% for females and males. The results are partially close to those found by (Marciniak, 2006), cereal is among the earliest foods consumed by humans. Proteins, carbs, vitamins, minerals (iron, potassium, and zinc), and next to fruits and vegetables, constitutes a source of antioxidants. Vegetables are considered as a rich source of many antioxidants and nutrients that are essential for human health. Vegetables can contribute 35, 24, and 11% of the total daily potassium, magnesium, and phosphorous requirement, respectively, in human diet (Aghili et al., 2012). In light of their high nutritional content, leafy vegetables are a valuable component of a human's diet (Robinson, 1990). Finally, Beretta et al. (2023) stated that, while minimising cross-contamination is important, a case study did show that consuming broad bean-contaminated pumpkin seeds could cause a detrimental aggravation of symptoms. Consequently, when there are carriers of the G6PD deficiency, special attention must be paid to how foods are prepared and stored. This includes avoiding the use of soiled dishes and utensils that have been used for cooking or preparing broad beans, storing the beans in cupboards in special containers that keep them away from other foods, reading the labels of prepared foods, and, in the event that a meal is being served in a restaurant, disclosing the condition and alerting patrons to the need for caution.

4. Conclusion

Falafel free of legumes produced from barley, broken rice and grits wheat were high results in both sensory and physical properties. The results also showed that it is high in minerals (iron, zinc, calcium, and potassium), protein, and fiber. It also given a percentage of the daily needs of age group (4-18 years), especially those suffering from favism anemia, because all prepared falafel are completely free of legumes. Therefore, we recommend using these quick-to-prepare falafel free of legumes and producing them on a commercial scale.

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