Evaluation of Sensory, Chemical and Physical Characteristics of Bread Prepared from White Kidney Beans and Oat Flours and Its Effect on Obese Rats

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Abstract

The increasing prevalence of overweight & obesity is a global concern that increases the risk of many non-communicable diseases. The current research was undertaken to produce high quality, nutritional value, sensory and physical properties of bread from white kidney beans (WKBF) and whole oat flours (WOF). The effect of feeding obese rats with bread containing WKBF+WOF on biochemical examinations was assessed. Results clarified that WKBF contained the highest value of protein (25.88%) and ash (4.00%), whereas, the highest content of fat (4.40%) and fiber (11.45%) was estimated in WOF compared to other flours. WKBF contained the highest level of Ca, P, Zn and Fe, while the highest value of K & Mg was estimated in WOF compared to other flours. Findings displayed that the addition of WKBF and WOF to WF increases the nutritional value of bread, as a result of the increase in protein, fat, ash and minerals. Bread containing 10%WKBF+10%WOF, 15%WKBF+10%WOF, 10% WKBF+15%WOF, 15%WKBF+15%WOF and 10%WKBF+20% WOF had a very good degree of preference by panelists, so they were selected for biological evaluation. Results revealed that significantly decreased *($p \leq 0.05$)* in body weight gain, feed intake, feed efficiency ratio, glucose, TG, TC, LDL-C and VLDL-C among obese rats consumed bread containing WKBF and WOF compared with obese rats. Also, findings showed that significantly improved *($p \leq 0.05$)* in kidney and liver functions. Results confirmed that the best improvement for all parameters was found in obese rats consumed bread containing 15%WKBF+15%WOF. Therefore, bread made with WKBF+WOF can be recommended to be used for obese patients.

Key words: Obesity, bread, white kidney beans, oat flour, nutritional value.

Introduction

Obesity and overweight are known as abnormal or immoderate fat cumulation that causes a serious health problem **(WHO, 2021)**. Obesity is related to the development of hypertension, diabetes, obstructive sleep apnea & fatty liver, in addition to many other serious illnesses **(Aboulghate *et al.*, 2021)**. Obesity is a global public health problem, with obesity rates tripling in the past four decades in all over the world and continuously escalating in pandemic proportions **(Blüher, 2019)**. In 2020, 39 million children (<5 years old) were recorded overweight or obese globally. In adults, more than 1.9 billion were determined to be overweight or obese globally, in 2016 **(WHO, 2021)**. Obesity causes around 4.7 million premature deaths every year. It was in fifth place among the most preventable causes of mortality in all over the world **(Mehrzad, 2020)**. According to **World Population Review (2022)**, Egypt ranked 18th with the highest prevalence of obesity in all over the world and the seventh highest country in the Arab region, moreover about 32% of adults (above18 years old, BMI $\geq$ 30) were obese. Obesity-related deaths were recorded to be almost 115 thousand per year (19.08 percent of the total estimated deaths in 2020), in Egypt. Obesity costs the Egyptian economy approximately 62 billion Egyptian pounds every year. This number shows the costs of treating obesity-related diseases in adults **(Aboulghate *et al.*, 2021)**.

Bread is the main food made from flour, yeast, salt & water. From recorded history, bread is popular in all over the world and is considered one of the oldest food products **(Dendegh *et al.*, 2018)**. It is believed that Egyptians were the pioneers by making the art of bread making popular all over the world **(Bredariol and Vanin, 2021)**. In a weight loss regimen, bread can be a useful combat tool. Eating bread can lead to the feeling of fullness, allowing to limit calorie consumption and lose weight. As long as the bread consumed has a higher fiber content than white bread **(Zain *et al.*, 2022)**.

Kidney beans (*Phaseolus vulgaris*) are a legume that belongs to the *Leguminosae* family. Dry beans are a vital part of the human diet, particularly for people in low-income groups in developing countries. Beans are the main food & low-cost source of protein where malnutrition is prevalent, in developing countries **(Van Heerden and Schönfeldt, 2004)**. Egypt and India consume the largest quantity of legumes; in these countries, legumes play a vital role in ensuring that people get enough of numerous important nutrients, particularly proteins **(Rochfort and Panozzo, 2007)**. In addition, beans are the most vital food legumes utilized for direct consumption in the world. It has one of the widest ranges of differences in maturation times, growth habits, adaptation and seed properties (size, color and shape) compared to other food crops. Beans are an excellent source of protein, and rich in minerals (iron, manganese, phosphorous, copper and magnesium) & vitamins (E and B9). Moreover, it contains a high level of soluble dietary fibers like gums, pectin and beta glucans **(El-Syiad and Hassan, 2014)**. Kidney beans have many health benefits. Beans consumption is associated with a lower risk of diabetes mellitus, obesity and cardiovascular disease **(Rodríguez *et al.*, 2022)**. These health benefits are attributed to the presence of antioxidants, free cyclitol, protein & soluble carbohydrates **(Ribeiro *et al.*, 2011)**. Beans bioactive compounds, mainly saponins & flavonoids, have been utilized to protect against chronic diseases & cancer **(De la Rosa-Millán *et al.*, 2019)**.

Oat grains (*Avena sativa*) are special among the cereals result to their richness in nutritional components and multifunctional characteristics. Incorporating oat grains into food products enhances the nutritional value, moreover acting as a treatment for a variety of lifestyle diseases. Oat grains are a source of dietary fiber. The most vital dietary fiber in oat grains are β-glucans, which are water-soluble fiber that has many health benefits. β-glucans can decrease the risk of diabetes, cholesterol & coronary heart disease **(Tiwari *et al.*, 2017)**. β-glucans also help to decrease body weight **(Reyna-Villasmil *et al.*, 2007)**. Oats contain a high level of desirable complex carbohydrates that have been linked to reducing the various types of cancers. Oats have the best amino acid composition of all cereal grains. Oats have the highest protein level among cereals, often ranging from 12 - 20%. It is also the source of vitamins, especially vitamin E, thiamine & pantothenic acid. Oats contain a high level of unsaturated fatty acids, antioxidants and minerals **(Flander *et al.*, 2008; Mohamed et al., 2009)**. Phenolic compounds are the most vital bioactive components in oats. Some oat phenolics have significant nutraceutical potential, whereas others are effective antioxidants **(Webster, 2002)**. Oats are utilized in various forms, including flakes, rolled and flour. Oat flour is used to make breakfast cereals, biscuits, infant food and cookies **(Kaur and Singh, 2017)**.

Today's consumers are conscious of their diet, and many prefer eating healthy foods. As a result, the nutritional value of food has become a new dimension in the production of food products. The demand for protein-rich diets has elevated with increasing consumer awareness of the benefits of protein in the diet and its beneficial effects on weight loss & muscle building **(Friedman, 2004)**. The high value of fiber & protein in legumes has been proven to promote satiety, which may help reduce the appearance of obesity by reducing calorie intake and controlling body weight over time **(McCrory *et al.*, 2010)**. The protein in beans is rich in lysine, being a good complement to cereals protein like wheat, which is deficient in this amino acid **(Tiwari and Singh, 2012)**. β-glucans in oats also help to decrease body weight. WKBF and WOF are available in Egypt at a cheap price with high nutritional value. Therefore, this research was intended to study the evaluation of sensory, chemical and physical characteristics of bread prepared from white kidney beans and oat flours and its effect on obese rats.

Materials and Methods

Materials

Dried white kidney bean seeds, oat, wheat flour, skim milk powder, yeast, sugar, bread improver & salt were bought from the local market in Sharkia Governorate, Egypt. Kits for blood analysis were procured from Alkan-Medical Division Biocon, Germany. Chemicals used in current work were bought from El-Gomhoriya Company for Trading Drugs, Chemicals & Medical Instruments, Sharkia Governorate, Egypt.

Methods

Preparation of whole oat (WOF) & white kidney beans flours (WKBF)

Oat grains were cleaned and ground using a grinder **(El-Qatey *et al.*, 2018)**. Whole white kidney bean flour was prepared by grinding the seeds in a mill **(Sparvoli *et al.*, 2016)**. Flours were kept in the polyethylene bags in a refrigerator at 4°C until used.

Toast bread preparation

Toast bread was prepared according to **(Lotfy, 2015)** method with a slight modification in the ingredients of the bread, where no vegetable oil was used. Ten formulas of toast bread were produced using WF, WOF and WKBF as clarified in Table (1). All the ingredients were mixed in a dough mixer until the homogenization process was complete and water was added as needed. The dough was fermented at 28°C for 90 min and put in a rectangular pan after punching. Again, the dough was left for another 90 min to ferment. Then the bread was baked at 250°C, for 30 minutes. The bread was cooled, packed into polyethylene bags and stored in a refrigerator at 4°C till analysis.

Table (1): Bread formulas produced from WF, WOF and WKBF.

Sample	Ingredient (g)							
	WF	WOF	WKBF	Skim milk powder	Sugar	Yeast	Bread improver	Salt
TB0	100	-	-	2.5	5	1.4	1.2	1.65
TB1	80	10	10	2.5	5	1.4	1.2	1.65
TB2	75	10	15	2.5	5	1.4	1.2	1.65
TB3	70	10	20	2.5	5	1.4	1.2	1.65
TB4	75	15	10	2.5	5	1.4	1.2	1.65
TB5	70	15	15	2.5	5	1.4	1.2	1.65
TB6	65	15	20	2.5	5	1.4	1.2	1.65
TB7	70	20	10	2.5	5	1.4	1.2	1.65
TB8	65	20	15	2.5	5	1.4	1.2	1.65
TB9	60	20	20	2.5	5	1.4	1.2	1.65

WF: wheat flour**; WOF:** Whole oat flour; **WKBF:** White kidney bean flour.

Chemical analysis and energy value

Protein, fiber, ash, fat and moisture of flours and the different bread formulations were estimated as described by **AOAC, (2005)**. The amount of carbohydrate was calculated by difference and the following equation was used: % Carbohydrate = 100 – (% moisture + % protein + % fat + % ash + % fiber). The energy value (EV) was determined using the **Chaney, (2006)** formula: Energy value (Kcal/100g sample) = 4 (g protein + g carbohydrate) + 9 (g fat). Calcium, potassium, magnesium, iron & zinc were measured by Atomic Absorption Spectrophotometer (Hitachi Z6100, Tokyo, Japan) as described by **AOAC, (2005)**. Whereas, phosphorus level was estimated by the phosphovanado-molybdate (yellow) method **(AOAC, 2005)**. All determinations for treatments were done in triplicate.

Physical qualities of bread

The volume (V) of bread was measured according to the formula: V(cm^3) = average length × average width × average height (**Pauline *et al.*, 2020**). The specific volume (SV) was the quotient of bread volume (V) by its mass (M): SV (cm^3/g) = V/M.

Organoleptic properties of bread

The bread was assessed by a panel of 20 trained judges from the staff members of the Department of Food Science, Faculty of Agriculture, Zagazig University, Egypt. The bread was assessed for appearance, color, odor, taste, texture & overall acceptability by the hedonic a 9-point scale, where 9 represents extremely liked and 1 extremely disliked **(Watts *et al.*, 1989)**.

Animals and experimental design

Forty-eight male albino rats (weigh 110 ± 10g) were procured from the Faculty of Veterinary Medicine, Zagazig University, Sharkia Governorate, Egypt. Rats were housed individually in stainless steel cages under standard conditions of temperature, humidity with a 12-h light per 12-h dark cycle. Animals had access to the designated diet and water *ad libitum*. Rats were maintained for 7 days as an adaptation period and fed on a standard diet (**Reeves *et al.*, 1993)**.

Rats were separated randomly into eight groups (named as G0, G1, G2, G3, G4, G5, G6 and G7), comprising 6 rats in each group. The control group (G0) was fed only the standard diet (-ve), while the other groups were fed the high fat diet (HFD) which was prepared by substituting starch in the standard diet with 40% beef tallow **Chien *et al.*, (2016)** for four weeks. Group (G1), rats were fed on HFD (+ve). Other groups (G2, G3, G4, G5, G6 and G7) were fed on HFD and 40% bread (from the starch quantity) containing 100% WF (control), 10% WKBF + 10% WOF, 15% WKBF + 10% WOF, 10% WKBF + 15% WOF, 15% WKBF +

15% WOF and 10% WKBF + 20% WOF, respectively throughout the experiment period (eight weeks). Feed intake was determined daily. The variation in the body weight of animals was estimated weekly.

After eight weeks and under diethyl ether anesthesia, blood samples were collected via cardiac puncture from animals after overnight fasting. The serum was separated by centrifugation at 3000 rpm for 20 min, which was kept at -20 °C till analysis.

Biochemical analysis

Triglycerides (TG), Cholesterol (TC) & High-density lipoprotein (HDL-C) were estimated according to **Fossati and Prencipe, (1982); Richmond, (1973); Burstein *et al.*, (1970)**, respectively. Calculation of LDL-C and VLDL-C was as described by **(Friedewald *et al.*, 1972)**. Serum aspartate aminotransferase (AST) & alanine aminotransferase (ALT) were estimated by **(Reitman and Frankle, 1957)** method. Urea & creatinine were estimated by (**Patton and Crouch, 1977)** and **(Larson, 1972)** methods, respectively. Glucose level was measured by **(Trinder, 1969)** method.

Statistical analysis

SPSS program, version 25 (IBM Corp., Armonk, New York. 2017) was used for statistical analysis of the results. The mean of the results and their standard deviation of triplicate experiments were reported. Data were subjected to analysis of variances by using one-way-ANOVA and Duncan multiple range test. Statically significant means were at *($P \leq 0.05$)* among all treatments **(Bailey, 1995)**.

Results and Discussion

Chemical analysis of WF, WKBF and WOF

Chemical analysis of WF, WKBF and WOF is explained in Table (2). Findings clarified a significant difference *($P \leq 0.05$)* in the chemical analysis of WF, WKBF and WOF. WF had the lowest level of protein (10.70%), fat (0.76%), ash (0.52%) and fiber (0.40%) compared with WKBF and WOF. The highest content of carbohydrate was recorded in WF (76.45%), followed by WOF (54.20%) and WKBF (49.67%). **Man *et al.*, (2021)** estimated that WF had 9.12% protein, 1.03% fat, 0.48% ash, 0.37% fiber and 74.45% carbohydrate. WKBF had the highest amount of protein (25.88%) and ash (4.00%) compared with other flours. Whereas, the highest content of fat (4.40%) and fiber (11.45%) was estimated in WOF compared to other flours. The fat level of oat flour in the present study is close to that estimated by **Chauhan *et al.*, (2018)**. Oat flour contained 17.06% protein and 2.44% ash **(Suzauddula *et al.*, 2021)**. **Zaki *et al.*, (2018)** found that oat flour had 11.13% fiber. The protein level of WKBF is close to that determined by **Saleh *et al.*, (2018)** who proved that protein reached 25.69% in white beans. According to **El-Syiad and Hassan, (2014)**, the value of fiber & ash was 10.76 and 4.19%, respectively, in white beans (on a dry weight base).

Table (2): Chemical analysis of WF, WKBF and WOF (on a wet weigh base).

Component %	Raw Material		
	WF	WKBF	WOF
Moisture	11.17±0.06[a]	10.60±0.05[b]	10.55±0.06[b]
Protein	10.70±0.05[c]	25.88±0.09[a]	17.30±0.07[b]
Fat	0.76±0.02[b]	1.20±0.03[b]	4.40±0.04[a]
Fiber	0.40±0.01[c]	8.65±0.05[b]	11.45±0.05[a]
Ash	0.52±0.02[c]	4.00±0.04[a]	2.10±0.03[b]
Carbohydrate	76.45±0.30[a]	49.67±0.20[c]	54.20±0.21[b]

Averages placed in the same row and with various letters are significantly different at *(p≤0.05)*.
WF: wheat flour**; WOF:** Whole oat flour; **WKBF:** White kidney bean flour.

Minerals content of WF, WKBF and WOF

Minerals content of WF, WKBF and WOF are displayed in Table (3). A significant difference *(p≤0.05)* was noticed among WF, WKBF and WOF in minerals content. Results displayed that the lowest content of calcium (22.91), phosphorus (95.00), potassium (132.0), magnesium (45.48), iron (1.25) and zinc (1.35) mg/100g was recorded in WF compared with WKBF and WOF. Results clarified that WKBF had the highest value of Ca, P, Zn and Fe than other flours. Whereas, the highest content of K and Mg was recorded in WOF compared with WKBF and WF. Potassium level of WF and WOF in the present study are in concurrence with obtained results of **Suzauddula *et al*., (2021)** who proved that K level in WF and oat flours were 32.70 and 534.98 mg/100g, respectively. Similar findings were obtained by **Inglett *et al*., (2015)** for Mg, P, Fe & Zn in WOF. The iron content of WKBF and WF was 8.95 and 0.94 mg/100g, respectively, while zinc level was 2.88 and 1.35 mg/100g, respectively **(Ibrahim, 2017)**. A similar result was reported by **Saleh *et al*., *et al*., (2018)** for calcium levels in white beans.

Table (3): Minerals content of WF, WKBF and WOF (on a wet weigh base).

Mineral (mg/100g)	Raw Material		
	WF	**WKBF**	**WOF**
Calcium	22.91 ± 0.20^{c}	300.0 ± 0.81^{a}	64.00 ± 0.34^{b}
Phosphorus	95.00 ± 0.40^{c}	480.0 ± 0.92^{a}	458.0 ± 0.90^{b}
Potassium	132.0 ± 0.56^{c}	290.0 ± 0.77^{b}	429.0 ± 0.91^{a}
Magnesium	45.48 ± 0.30^{c}	143.0 ± 0.50^{b}	270.0 ± 0.71^{a}
Iron	1.25 ± 0.01^{c}	7.50 ± 0.16^{a}	4.75 ± 0.11^{b}
Zinc	1.35 ± 0.02^{c}	4.90 ± 0.10^{a}	3.20 ± 0.10^{b}

Averages placed in the same row and with various letters are significantly different at *($p\leq0.05$)*.
WF: wheat flour**; WOF:** Whole oat flour; **WKBF:** White kidney bean flour.

Chemical analysis of bread

The chemical analysis of bread samples is summarized in Table (4). Results clarified that control bread recorded low content of moisture (29.30%), protein (10.28%), fat (0.72%), fiber (0.40%) and ash (0.71%) compared with all other treated bread samples. Moreover, the highest carbohydrate & energy values were recorded in the control bread compared with other samples. Findings displayed that the addition of WKBF and WOF to WF increased the nutritional value of bread. Moisture, protein, fiber, fat & ash levels significantly increased *($p\leq0.05$)* in bread containing WKBF+WOF at different levels compared with the control bread. Whereas, carbohydrate & energy values were significantly reduced *(p≤0.05)* compared to the control sample. These results probably are result to WKBF and WOF having a higher level of protein, ash, fat and fiber than WF. Replacing rice flour with beans improved protein, ash and fiber contents in biscuits **(Wesley *et al.*, 2021)**. A gradual elevate in protein & fiber levels was determined with increasing the proportion of oat flour in biscuits **(El-Qatey *et al.*, 2018)**. Protein, fiber, fat & ash values of noodles made with oat flour were increased comparing to control **(Suzauddula *et al.*, 2021)**. Moisture level of bread significantly increased *(p≤0.05)* from 29.30% in control bread to 32.40% in bread containing 20% WKBF and 20% WOF. The gradual increase in moisture level probably is result to the elevate in water retention ability of fibers. The highest amount of protein (14.40%), fiber (3.92%) and ash (1.62%) was recorded in sample TB9 (20% WKBF + 20%WOF) comparing to control. These results might be because of WKBF and WOF have higher content of protein, ash & fiber compared with WF. Protein level of bread in treatments TB1, TB2, TB3, TB4, TB5, TB6, TB7, TB8 and TB9 was 21.7, 28.0, 36.2, 24.8, 32.3, 37.6, 27.4, 35.2 and 40.1%, respectively, higher than control (TB0). Ash amount of all kinds of bread was almost 2-times more than control. Fiber level of TB1, TB2, TB3, TB4, TB5, TB6, TB7, TB8 and TB9 was approximately 5-fold, 6-fold, 7-fold, 7-fold, 8-fold, 9-fold, 8-fold, 9-fold and 10-fold, respectively, more than control bread. There were significant differences *(p≤0.05)* in the fat content from TB4 to TB9 comparing to control. Control bread had the lowest level of fat (0.72%), whereas the highest value was estimated in sample TB9 (1.45%). These results probably are because of WKBF and WOF had higher level of fat comparing with WF.

Table (4): Effect of substituting WF with WKBF and WOF on chemical analysis of bread (on a wet weigh base).

Sample	Component						
	Moisture %	Protein %	Fat %	Fiber %	Ash %	Carbohydrate %	EV Kcal/100g
TB0	29.30 ±0.22[d]	10.28 ±0.10[e]	0.72 ±0.02[b]	0.40 ±0.01[e]	0.71 ±0.01[b]	58.59 ±0.45[a]	281.96 ±0.92[a]
TB1	30.50 ±0.23[c]	12.51 ±0.15[d]	1.08 ±0.03[ab]	2.14 ±0.03[d]	1.21 ±0.03[a]	52.56 ±0.40[b]	270.00 ±0.85[b]
TB2	31.00 ±0.26[bc]	13.16 ±0.14[cd]	1.10 ±0.04[ab]	2.54 ±0.04[cd]	1.36 ±0.02[a]	50.84 ±0.25[c]	265.90 ±0.60[c]
TB3	31.62 ±0.30[ab]	14.00 ±0.17[ab]	1.13 ±0.03[ab]	3.00 ±0.04[bc]	1.47 ±0.03[a]	48.78 ±0.30[f]	261.29 ±0.53[e]
TB4	31.20 ±0.24[bc]	12.83 ±0.16[d]	1.23 ±0.02[a]	2.70 ±0.04[cd]	1.31 ±0.04[a]	50.73 ±0.27[c]	265.31 ±0.75[c]
TB5	31.60 ±0.32[ab]	13.60 ±0.15[bc]	1.26 ±0.03[a]	3.10 ±0.05[bc]	1.40 ±0.03[a]	49.04 ±0.30[e]	261.90 ±0.60[e]
TB6	32.00 ±0.33[ab]	14.15 ±0.20[ab]	1.30 ±0.04[a]	3.44 ±0.06[ab]	1.55 ±0.04[a]	47.56 ±0.35[h]	258.54 ±0.52[g]
TB7	31.40 ±0.34[bc]	13.10 ±0.16[cd]	1.41 ±0.03[a]	3.20 ±0.03[bc]	1.34 ±0.03[a]	49.55 ±0.45[d]	263.29 ±0.55[d]
TB8	31.80 ±0.43[ab]	13.90 ±0.20[ab]	1.44 ±0.04[a]	3.54 ±0.04[ab]	1.47 ±0.02[a]	47.85 ±0.43[g]	259.96 ±0.50[f]
TB9	32.40 ±0.43[a]	14.40 ±0.22[a]	1.45 ±0.05[a]	3.92 ±0.05[a]	1.62 ±0.03[a]	46.21 ±0.36[i]	255.49 ±0.63[h]

Averages placed in the same column and with various letters are significantly different at *($p \leq 0.05$)*. EV: Energy value. **TB0:** 100%WF (control)**; TB1:** 80%WF+10%WOF+10%WKBF**; TB2:** 75%WF+10%WOF+15%WKBF**; TB3:** 70%WF+10%WOF+20%WKBF**; TB4:** 75%WF+15%WOF +10%WKBF**; TB5:** 70%WF+15%WOF+15%WKBF**; TB6:** 65%WF+15%WOF+20%WKBF**; TB7:** 70%WF+20%WOF+10%WKBF**; TB8:** 65%WF+20%WOF+15%WKBF**; TB9:** 60%WF+20%WOF +20%WKBF.

Minerals content of bread

The effect of substituting WF with WKBF and WOF on minerals content of bread are clarified in Table (5). Findings displayed that there were significant differences *($p \leq 0.05$)* between the control bread and other treatments in minerals content. The lowest amount of calcium (49.37), phosphorus (109.10), potassium (158.60), magnesium (43.90), iron (1.16) and zinc (1.25) mg/100g was recorded in control. Results clarified that Ca, P, K, Mg, Fe & Zn values significantly increased *($p \leq 0.05$)* in bread containing WKBF and WOF comparing to control. These values elevated with increasing the content of WKBF and WOF in bread. These results perhaps are attributed to elevate the amount of Ca, P, Mg, K, Fe & Zn in WKBF and WOF than WF (Table 3). The highest minerals content was determined in TB9 (20% WKBF + 20% WOF) compared to control. Adding beans to rice flour increased the minerals content in biscuits **(Wesley *et al.*, 2021)**. The addition of oat flour to noodles significantly improved the nutritional value especially increases minerals content (**Suzauddula *et al.*, 2021**).

Table (5): Effect of substituting WF with WKBF and WOF on minerals content of bread (on a wet weigh base).

Sample	Mineral (mg/100g)					
	Calcium	Phosphorus	Potassium	Magnesium	Iron	Zinc
TB0	49.37 ±0.26^{j}	109.10 ±0.56^{j}	158.60 ±0.52^{j}	43.90 ±0.30^{j}	1.16 ±0.01^{d}	1.25 ±0.02^{d}
TB1	78.27 ±0.30^{i}	177.20 ±0.65^{i}	199.45 ±0.65^{i}	73.20 ±0.40^{i}	2.10 ±0.02^{c}	1.77 ±0.03^{c}
TB2	91.90 ±0.40^{f}	196.64 ±0.73^{g}	207.63 ±0.73^{h}	77.60 ±0.45^{h}	2.35 ±0.03^{abc}	1.94 ±0.04^{bc}
TB3	103.45 ±0.50^{c}	212.10 ±0.83^{e}	213.82 ±0.87^{f}	82.60 ±0.52^{g}	2.65 ±0.05^{abc}	2.15 ±0.04^{ab}
TB4	80.18 ±0.40^{h}	193.61 ±0.75^{h}	213.00 ±0.86^{g}	83.40 ±0.60^{f}	2.25 ±0.03^{bc}	1.79 ±0.03^{c}
TB5	92.73 ±0.45^{e}	211.30 ±0.81^{f}	220.20 ±0.91^{e}	88.86 ±0.70^{e}	2.50 ±0.04^{abc}	2.02 ±0.04^{ab}
TB6	106.36 ±0.52^{b}	229.70 ±0.84^{b}	228.10 ±0.97^{c}	92.30 ±0.73^{d}	2.81 ±0.05^{ab}	2.17 ±0.04^{ab}
TB7	83.50 ±0.40^{g}	213.40 ±0.84^{d}	227.45 ±0.83^{d}	93.70 ±0.62^{c}	2.40 ±0.04^{abc}	1.94 ±0.03^{bc}
TB8	94.70 ±0.46^{d}	227.65 ±0.91^{c}	233.70 ±0.90^{b}	98.55 ±0.65^{b}	2.66 ±0.05^{abc}	2.10 ±0.04^{ab}
TB9	109.20 ±0.55^{a}	245.80 ±0.93^{a}	240.80 ±0.96^{a}	102.45 ±0.76^{a}	3.00 ±0.06^{a}	2.23 ±0.05^{a}

Averages placed in the same column and with various letters are significantly different at *($p \leq 0.05$)*. TB0: TB0: 100%WF (control)**; TB1:** 80%WF+10%WOF+10%WKBF**; TB2:** 75%WF+10% WOF+15%WKBF**; TB3:** 70%WF+10%WOF+20%WKBF**; TB4:** 75%WF+15%WOF+10%WKBF**; TB5:** 70%WF+15%WOF+15%WKBF**; TB6:** 65%WF+15%WOF+20%WKBF**; TB7:** 70%WF+20% WOF+10%WKBF**; TB8:** 65%WF+20%WOF+15%WKBF**; TB9:** 60%WF+20%WOF+20%WKBF.

Physical qualities of bread

Results of the physical qualities of bread are displayed in Table (6). The loaf weight of the bread containing WKBF and WOF increased compared with the control sample. These finding perhaps are result to elevate the amount of WKBF and WOF, and probably poor leavening ability of the composite flour dough. The volume of bread containing WKBF and WOF decreased with increased the content of kidney beans and oat flours compared with control (TB0). These findings probably are because of the production of more gas in the control bread than the composite bread samples. Similar findings were obtained by **Chauhan *et al.*, (2018)** and **Hoxha *et al.*, (2020)** in bread containing oat and kidney beans fours, respectively. Current findings proved that bread containing 10% WKBF + 10% WOF, 15% WKBF + 10% WOF, 10% WKBF + 15% WOF, 15% WKBF + 15% WOF and 10% WKBF + 20% WOF did not record any significant effects *(P≤0.05)* in specific volume comparing to control. Whereas, specific volume in TB3, TB6, TB8 and TB9 significantly decreased *(P≤0.05)* comparing to control (TB0).

Table (6): Effect of substituting WF with WKBF and WOF on physical properties of bread.

Sample	Physical characteristic		
	Loaf weight (g)	Loaf volume (cm^3)	Specific volume (cm^3/g)
TB0	143.1 ± 0.40^{e}	488.5 ± 0.91^{a}	3.41 ± 0.09^{a}
TB1	144.0 ± 0.45^{de}	487.9 ± 0.82^{ab}	3.39 ± 0.07^{a}
TB2	145.0 ± 0.50^{cd}	487.0 ± 0.87^{b}	3.36 ± 0.09^{a}
TB3	158.0 ± 0.60^{ab}	445.0 ± 0.70^{d}	2.82 ± 0.05^{b}
TB4	145.3 ± 0.51^{cd}	487.2 ± 0.76^{ab}	3.35 ± 0.06^{a}
TB5	146.0 ± 0.56^{c}	486.6 ± 0.87^{b}	3.33 ± 0.07^{a}
TB6	159.0 ± 0.66^{a}	444.0 ± 0.77^{d}	2.79 ± 0.04^{b}
TB7	144.8 ± 0.46^{cd}	480.0 ± 0.78^{c}	3.31 ± 0.08^{a}
TB8	157.0 ± 0.55^{b}	445.0 ± 0.90^{d}	2.83 ± 0.05^{b}
TB9	159.2 ± 0.62^{a}	430.0 ± 0.70^{e}	2.70 ± 0.04^{b}

Averages placed in the same column and with various letters are significantly different at *(p≤0.05)*. TB0: TB0: 100%WF (control)**; TB1:** 80%WF+10%WOF+10%WKBF**; TB2:** 75%WF+10% WOF+15%WKBF**; TB3:** 70%WF+10%WOF+20%WKBF**; TB4:** 75%WF+15%WOF+10%WKBF**; TB5:** 70%WF+15%WOF+15%WKBF**; TB6:** 65%WF+15%WOF+20%WKBF**; TB7:** 70%WF+20% WOF+10%WKBF**; TB8:** 65%WF+20%WOF+15%WKBF**; TB9:** 60%WF+20%WOF+20%WKBF.

Organoleptic properties of bread

Organoleptic properties of bread made from WKBF and WOF are explained in Table (7). Current study indicated that no any significant changes *(p≤0.05)* among control bread and (TB1, TB2, TB4, TB5 and TB7) in appearance, color, odor, taste, texture & overall acceptability scores. Whereas, all organoleptic properties significantly decreased *(p≤0.05)* in TB3, TB6, TB8 and TB9 comparing to control. WF can be successfully replaced with oat flour up to 20% in bread **Chauhan *et al.*, (2018)**. Bread containing 15% white beans flour and 85% WF was the most preferred **(Ukeyima *et al.*, 2019)**.

Table (7): Effect of substituting WF with WKBF and WOF on organoleptic properties of bread.

Sample	Organoleptic property					
	Appearance	Color	Odor	Taste	Texture	Overall acceptability
TB0	8.60±0.20[a]	8.54±0.18[a]	8.50±0.25[a]	8.62±0.22[a]	8.52±0.16[a]	8.50±0.14[a]
TB1	8.52±0.13[a]	8.46±0.16[a]	8.44±0.16[a]	8.55±0.16[a]	8.40±0.14[a]	8.44±0.13[a]
TB2	8.48±0.14[a]	8.42±0.15[a]	8.38±0.17[a]	8.50±0.17[a]	8.35±0.13[a]	8.40±0.14[a]
TB3	7.50±0.15[b]	7.62±0.17[b]	7.64±0.20[b]	7.52±0.16[b]	7.43 ±0.12[b]	7.62±0.12[b]
TB4	8.50±0.16[a]	8.43±0.16[a]	8.40±0.18[a]	8.50±0.21[a]	8.36±0.15[a]	8.42 ±0.14[a]
TB5	8.44±0.14[a]	8.38±0.18[a]	8.30±0.17[a]	8.42±0.18[a]	8.31±0.14[a]	8.35±0.11[a]
TB6	7.51±0.13[b]	7.70±0.16[b]	7.55±0.11[b]	7.49±0.14[b]	7.54±0.11[b]	7.60±0.10[b]
TB7	8.45±0.16[a]	8.45±0.17[a]	8.41±0.07[a]	8.51±0.17[a]	8.37 ±0.13[a]	8.41±0.13[a]
TB8	7.60±0.14[b]	7.80±0.16[b]	7.71±0.14[b]	7.54±0.15[b]	7.51±0.12[b]	7.70±0.12[b]
TB9	7.50±0.15[b]	7.62±0.15[b]	7.60±0.12[b]	7.48±0.14[b]	7.46±0.11[b]	7.62±0.11[b]

Averages placed in the same column and with various letters are significantly different at *($p \leq 0.05$)*. TB0: 100%WF (control)**; TB1:** 80%WF+10%WOF+10%WKBF**; TB2:** 75%WF+10%WOF +15%WKBF**; TB3:** 70%WF+10%WOF+20%WKBF**; TB4:** 75%WF+15%WOF+10%WKBF**; TB5:** 70%WF+15%WOF+15%WKBF**; TB6:** 65%WF+15%WOF+20%WKBF**; TB7:** 70%WF+20%WOF+ 10%WKBF**; TB8:** 65%WF+20%WOF+15%WKBF**; TB9:** 60%WF+20%WOF+20%WKBF.

Biological evaluation

Effect of feeding obese rats with bread containing WKBF and WOF on body weight gain (BWG), feed intake (FI) & feed efficiency ratio (FER)

After a period of 60 days, rats fed on the HFD (G1) displayed a significant elevate *($p \leq 0.05$)* in BWG, FI & FER than the healthy group (G0) fed with a standard diet (Table 8), and these results are in concurrence with the data published by **El-Shaer *et al.*, (2016)**. Results proved that significantly decreased *($p \leq 0.05$)* in BWG, FI & FER among obese rats consumed bread containing WKBF and WOF at different levels compared with rats fed a high fat diet or obese rats consumed control bread. Also, current study indicated no significant changes *($p \leq 0.05$)* in FER among obese rats consumed bread containing WKBF and WOF and healthy rats (G0). These decreases in BWG, FI & FER probably are result to the presence of the high level of fiber and protein in WKBF and WOF than WF (Table 2). Treatment with white kidney bean extract reduced body weight in mice fed a high-fat diet **(Song *et al.*, 2016)**. Addition of oat flour to wheat balady bread reduced body weight and FER of rats consumed a high-fat diet comparing to negative control **(El-Sayed *et al.*, 2019)**.

Table (8): Effect of feeding obese rats with bread containing WKBF and WOF on BWG, FI, FER.

Group	Body weight gain (BWG) (g)	Feed intake (FI) (g/rat/60days)	Feed efficiency ratio (FER)
G0	115.00±0.90^{g}	906.00±1.60^{h}	0.127±0.003^{bc}
G1	200.00±1.20^{a}	1200.00±1.80^{a}	0.167±0.006^{a}
G2	196.00±1.10^{b}	1188.00±1.60^{b}	0.165±0.005^{a}
G3	140.00±1.00^{c}	1050.00±1.35^{c}	0.133±0.003^{b}
G4	130.00±0.84^{e}	996.00±1.20^{e}	0.131±0.002^{b}
G5	135.00±0.82^{d}	1008.00±1.30^{d}	0.134±0.004^{b}
G6	110.00±0.62^{h}	918.00±1.40^{g}	0.120±0.002^{c}
G7	120.00±0.71^{f}	948.00±1.50^{f}	0.127±0.004^{bc}

Averages placed in the same column and with various letters are significantly different at *(p≤0.05)*. G0: Healthy rats; **G1:** Obese rats; **G2:** Obese rats consumed control bread; **G3:** Obese rats consumed bread containing 10%WKBF+10%WOF; **G4:** Obese rats consumed bread containing 15%WKBF+10%WOF; **G5:** Obese rats consumed bread containing 10%WKBF+15%WOF; **G6:** Obese rats consumed bread containing 15%WKBF+15%WOF; **G7:** Obese rats consumed bread containing 10%WKBF+20%WOF.

Effect of feeding obese rats with bread containing WKBF and WOF on lipid profile

Findings of lipid profile are explained in Table (9). A significant elevate *(p≤0.05)* in TG, TC, LDL & VLDL levels was determined in obese rats (G1), whereas, a significant reduce *(p≤0.05)* was estimated in HDL content compared to healthy rats (G0). Feeding obese rats bread containing 10% WKBF + 10% WOF (G3), 15% WKBF + 10% WOF (G4), 10% WKBF + 15% WOF (G5), 15% WKBF + 15% WOF (G6) and 10% WKBF + 20% WOF (G7) significantly improved *(p≤0.05)* all lipid parameters by decreasing TG, TC, LDL-C and VLDL-C values, and increasing HDL-C value compared with (G1). These results perhaps are because of the higher dietary fiber content in WOF and WKBF compared with WF. The best findings were recorded in (G6), where TG, TC, LDL-C and VLDL-C values reduced by

62.2, 55.0, 74.2 and 62.2%, respectively, and HDL-C level increased by 55.9% comparing with (G1). All lipid profile values of (G6) were reached close to the normal range. Addition of oat and okra flours to wheat balady bread decreased TG, TC, LDL & VLDL, as well as increased HDL-C of rats consumed a high-fat diet compared to negative control **(El-Sayed *et al.*, 2019)**. A significant reduction in serum triglycerides was determined in healthy participants who took white kidney bean extract **(Nolan *et al.*, 2020)**.

Table (9): Effect of feeding obese rats with bread containing WKBF and WOF on serum lipid profile (mg/dl).

Group	TG	TC	HDL -C	LDL-C	VLDL-C
G0	83.20±0.82[f]	130.00±1.00[g]	62.00±0.60[a]	51.36±0.50[g]	16.64±0.20[e]
G1	222.00±1.11[a]	292.00±1.50[a]	39.00±0.20[g]	208.60±1.12[a]	44.40±0.30[a]
G2	221.50±1.10[a]	291.40±1.30[a]	39.10±0.21[g]	208.00±1.11[a]	44.30±0.32[a]
G3	148.20±1.00[b]	214.60±1.24[b]	41.50±0.30[f]	143.46±1.00[b]	29.64±0.28[b]
G4	132.00±0.91[d]	150.00±1.13[d]	53.20±0.43[d]	70.40±0.80[d]	26.40±0.26[c]
G5	134.00±0.95[c]	155.30±1.23[c]	52.50±0.36[e]	76.00±0.76[c]	26.80±0.25[c]
G6	84.00±0.75[f]	131.50±1.00[f]	60.80±0.60[b]	53.90±0.56[f]	16.80±0.21[e]
G7	93.00±0.82[e]	140.20±1.13[e]	59.00±0.55[c]	62.60± 0.66[e]	18.60±0.23[d]

Averages placed in the same column and with various letters are significantly different at *(p≤0.05)*. G0: Healthy rats; **G1:** Obese rats; **G2:** Obese rats consumed control bread; **G3:** Obese rats consumed bread containing 10%WKBF+10%WOF; **G4:** Obese rats consumed bread containing 15%WKBF+10%WOF; **G5:** Obese rats consumed bread containing 10%WKBF+15%WOF; **G6:** Obese rats consumed bread containing 15%WKBF+15%WOF; **G7:** Obese rats consumed bread containing 10%WKBF+20%WOF.

Effect of feeding obese rats with bread containing WKBF and WOF on liver & kidney functions

Kidney & liver functions of animals are reported in Table (10). ALT, AST, urea & creatinine levels significantly elevated *(p≤0.05)* in rats consumed HFD compared to the healthy group. Obese rats fed on control bread (G2) did not appear any significant changes *(p≤0.05)* in all liver & kidney function parameters compared with (G1). A significant decrease *(p≤0.05)* in ALT, AST, urea & creatinine was estimated in obese rats consumed bread containing10% WKBF + 10% WOF (G3), 15% WKBF + 10% WOF (G4), 10% WKBF + 15% WOF (G5), 15%

WKBF + 15% WOF (G6) and 10% WKBF + 20% WOF (G7) compared with (G1). Results clarified that (G6) recorded the best findings for liver & kidney functions, where ALT, AST, urea & creatinine levels decreased by 46.3, 37.7, 31.6 and 53.3%, respectively compared to (G1), and values were reached close to the normal range. Feeding with bread prepared from oat and okra flours improved kidney & liver functions of rats fed a high-fat diet compared with negative control **(El-Sayed *et al.*, 2019)**.

Table (10): Effect of feeding obese rats with bread containing WKBF and WOF on kidney & liver functions.

Group	Liver functions (U/L)		Kidney functions (mg/dl)	
	ALT	AST	Urea	Creatinine
G0	26.40 ± 0.23^{f}	37.20 ± 0.34^{f}	40.50 ±0 .36^{g}	0.76 ± 0.02^{f}
G1	50.30 ± 0.36^{a}	61.00 ± 0.43^{a}	60.20 ± 0.45^{a}	1.80 ± 0.03^{a}
G2	50.00 ± 0.34^{a}	60.40 ± 0.36^{a}	59.90 ± 0.40^{a}	1.78 ± 0.03^{a}
G3	40.00 ± 0.26^{b}	55.00 ± 0.38^{b}	55.00 ± 0.36^{b}	1.14 ± 0.02^{b}
G4	32.20 ± 0.30^{d}	50.50 ± 0.35^{d}	49.40 ± 0.34^{d}	0.91 ± 0.03^{cd}
G5	34.15 ± 0.31^{c}	52.00 ± 0.36^{c}	50.50 ± 0.40^{c}	0.96 ± 0.01^{c}
G6	27.00 ± 0.30^{f}	38.00 ± 0.26^{f}	41.20 ±0.34^{f}	0.84 ± 0.01^{e}
G7	29.20 ± 0.27^{e}	39.90 ± 0.30^{e}	42.50 ±0.33^{e}	0.88 ± 0.01^{de}

Averages placed in the same column and with various letters are significantly different at *($p \leq 0.05$)*. **G0:** Healthy rats; **G1:** Obese rats; **G2:** Obese rats consumed control bread; **G3:** Obese rats consumed bread containing 10%WKBF+10%WOF; **G4:** Obese rats consumed bread containing 15%WKBF+10%WOF; **G5:** Obese rats consumed bread containing 10%WKBF+15%WOF; **G6:** Obese rats consumed bread containing 15%WKBF+15%WOF; **G7:** Obese rats consumed bread containing 10%WKBF+20%WOF.

Effect of feeding obese rats with bread containing WKBF and WOF on glucose level

As presented in Fig. (1), results proved that significantly increased *($p \leq 0.05$)* in glucose level of obese rats (G1) compared with the healthy rats. Obese rats consumed bread containing WKBF and WOF at different levels clarified that a significant decrease *($p \leq 0.05$)* in blood glucose values, compared with obese rats (G1) or obese rats fed on control bread (G0). This improvement increased with increasing the amount of WKBF and WOF in bread. These results perhaps are because of WKBF and WOF have higher level of flavonoid compounds comparing with WF. Also, these results probably are a result of kidney beans are rich in α-amylase inhibitor, and have been utilized to reduce glycemia and calories absorption by preventing or delaying the digestion of complex carbohydrates **(Wang *et al.*, 2020)**. The best value of glucose was in obese rats consumed bread prepared with 15% WKBF and 15% WOF (G6), where glucose amount reached to be close to the healthy control group. Incorporating white kidney beans into a high-fat diet lowered obesity risk **(Neil *et al.*, 2019)**. For pregnant women with gestational diabetes, adding oat bran to their regular diet lowered fasting blood glucose values **(Barati *et al.*, 2021)**.

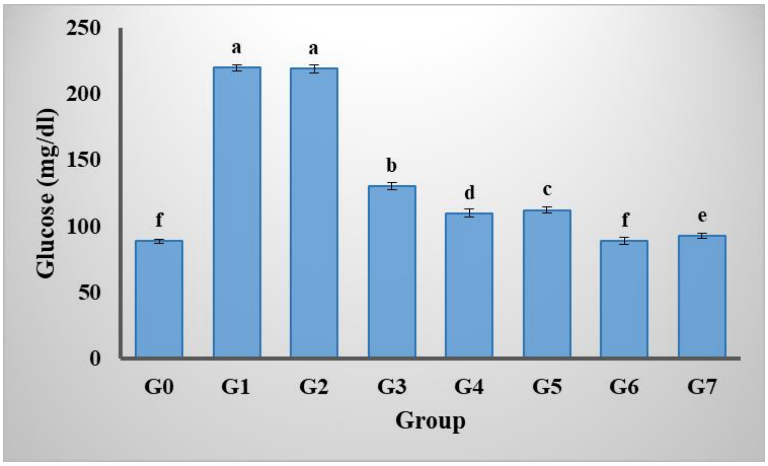

Fig. (1): Effect of feeding obese rats with bread containing WKBF and WOF on glucose level.

G0: Healthy rats; **G1:** Obese rats; **G2:** Obese rats consumed control bread; **G3:** Obese rats consumed bread containing 10%WKBF+10%WOF; **G4:** Obese rats consumed bread containing 15%WKBF+ 10%WOF; **G5:** Obese rats consumed bread containing 10%WKBF+15%WOF; **G6:** Obese rats consumed bread containing 15%WKBF+15%WOF; **G7:** Obese rats consumed bread containing 10%WKBF+20%WOF.

Conclusion

Based on the results in the present study, it can be concluded that WKBF and WOF together can be incorporated in toast bread making as follows: 10% WKBF + 10% WOF, 15% WKBF + 10% WOF, 10% WKBF + 15% WOF, 15% WKBF + 15% WOF and 10% WKBF + 20% WOF without adverse effect on the sensory and physical properties. The nutritional quality of the bread was improved due to the increased protein, fat, ash, fiber and mineral contents. Treating of obese rats with bread containing WKBF and WOF reduced the body weight & feed intake, and restored the biochemical changes close to the normal range. Therefore, bread prepared from WKBF and WOF could be beneficial for people suffering from obesity.

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تقييم الخصائص الحسية والكيميائية والفيزيائية للخبز المحضر من دقيق الفاصوليا البيضاء والشوفان وتأثيرة على الفئران المصابة بالسمنة

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يُعد الانتشار المتزايد لزيادة الوزن والسمنة مصدر قلق عالمي والذي يُزيد من خطر الإصابة بالعديد من الأمراض غير المعدية. يهدف البحث الحالي إلى انتاج خبز عالي الجودة والقيمة الغذائية والخصائص الحسية والفيزيائية من دقيق الفاصوليا البيضاء (WKBF) والشوفان الكامل (WOF). وتم تقييم تأثير تغذية الفئران المصابة بالسمنة بالخبز المحتوي على دقيق الفاصوليا والشوفان على الاختبارات البيوكيميائية. وأوضحت النتائج أن الفاصوليا احتوت على أعلى قيمة للبروتين (25.88٪) والرماد (4.00٪)، بينما تم تقدير أعلى محتوى للدهون (4.40٪) والألياف (11.45٪) في دقيق الشوفان مقارنة بانواع الدقيق الآخرى. واحتوت الفاصوليا على أعلى مستوى من الكالسيوم والفسفور والحديد والزنك، بينما تم تقدير أعلى قيمة للماغنسيوم والبوتاسيوم في دقيق الشوفان مقارنة بانواع الدقيق الآخرى. وأظهرت النتائج أن إضافة دقيق الفاصوليا والشوفان إلى دقيق القمح يُزيد من القيمة الغذائية للخبز، كنتيجة لزيادة نسبة البروتين والدهون والرماد والمعادن. وسجلت انواع الخبز المختلفة المحتوية على 10٪ فاصوليا+10٪ شوفان و15٪ فاصوليا+10٪ شوفان و10٪ فاصوليا+15٪ شوفان و15٪ فاصوليا+15٪ شوفان و10٪ فاصوليا+20٪ شوفان درجة جيدة جدًا من التفضيل من قبل المحكمين، لذلك تم اختيارهم للتقييم البيولوجي. وأشارت النتائج إلى حدوث انخفاضاً معنوياً ($p \leq 0.05$) في زيادة وزن الجسم والمتناول الغذائي ونسبة كفاءة الغذاء والجلوكوز والجليسريدات الثلاثية والكوليسترول والليبوبروتينات منخفضة الكثافة والليبوبروتينات منخفضة الكثافة جداً بين الفئران المصابة بالسمنة والتي تناولت الخبز المحتوي على دقيق الفاصوليا والشوفان مقارنة بالفئران المصابة بالسمنة. كما أظهرت النتائج تحسناً معنوياً ($p \leq 0.05$) في وظائف الكلى والكبد. وأثبتت النتائج أن أفضل تحسناً لجميع الاختبارات كان في الفئران المصابة بالسمنة والتى تغذت على الخبز المحتوى على 15٪ فاصوليا+15٪ شوفان. لذلك، يمكن التوصية باستخدام الخبز المحضر من الفاصوليا والشوفان لمرضى السمنة.

الكلمات الافتتاحية: السمنة – الخبز – الفاصوليا البيضاء – دقيق الشوفان – القيمة الغذائية.