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QUALITY CHARACTERISTICS OF BREAD MADE FROM COMPOSITE FLOURS OF WHEAT, CORN, BARLEY AND FENUGREEK

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ABSTRACT

Wheat composite flours from some cereals and fenugreek were processed into four formulas beside the control (wheat flour 72%) prior to preparing supplemented pan breads. The four formulas were from 80% wheat flour and 20% of each of barley and corn flours and 90% wheat flour and 10% fenugreek seeds flour and the last one of 75% wheat flour and 10% barley, 10% corn and 5% fenugreek flours. Some studies were done to evaluate the nutritional, rheological and sensory properties of the raw materials and the resulted bread from the four formulas and the control. Chemical results of raw materials showed that the corn and barley flours showed the lowest contents of ash and protein, while the fenugreek flour contained the highest values of crude fat, protein and fibers and the lowest of carbohydrate and calories compared with the others.

The results showed also that the supplementation with composite flours lead to increasing the water absorption, dough development time (DDT) and decreasing the weakening degree and the fenugreek dough showed the highest value of DDT and the lowest of softening degree. Also, the same additive levels ought to increasing the bread weight and decreasing the volume and specific volume.

On the other hand, the sensory evaluation of resulted pan breads showed that there were slight differences ($p \geq 0.05$) between control and formulas and barley and corn breads were the closest to control.

As regard to mineral analysis, fenugreek and blend breads showed the highest levels of pb, Zn, K, Co, Ni, Cd, Cr, Fe, Na and Ca compared with the control.

On the other side, amino acids analysis showed that the incorporation with composite flours improved the isolucine, lysine, methionine, threonine, tryptophan, valine and total essential amino acids compared with the control. Also, it was increasing in the chemical score (CS%), PER and BV for all composite flour breads than the control.

INTRODUCTION

Due to the continuous rise in petrol prices in the last years, the researches were concerned on the production of bio-fuel, particularly in the countries having surplus of grains production. This caused a reduction in the quantity of the grains in the world market and sequently an increase in their prices. Therefore, efforts have been done to prepare bread from a composite flour of wheat and other's locally grown crops such as cassava, plantain, cocoyam, soybean…et (Giami *et al*., 2004, Essien, 2006, Olaoye *et al.*, 2006, Eddy *et al*., 2007 and Horsfall *et al*., 2007).

Results of Eggleston et al., (1992) indicated that wheat flour should not less than 70% in composite flour to prepare an acceptable bread. This was confirmed from the data of Essien (2006) who found that Cocoyam flour can replace 50% of wheat flour in bread making. Also, Olaoye *et al*., (2006) mentioned that bread made from a composite flour of 85% wheat and 15% soya was nutritionally superior than that prepared from wheat flour.

Horsefall *et al*., (2007) showed that showed that breads made from the replacing of 5, 10, 15, 20 and 30% of wheat flour with plantain flour were comparable in their nutritional and sensorial properties with that made of whole wheat.

In Egypt, bread is an important stable food. It is consumed with each meal. The local production of wheat in Egypt is still limited and covered only 30% of the population requirements. The rest amount is imported from different outside countries. Therefore, utilization a composite flour of wheat and other's local cereals and legumes crops may participate in the solution of such problem. This was the aim of this study, preparing and characterizing the pan bread made of a composite of 70-80% wheat flour with whole corn, barley and fenugreek flours.

MATERIALS AND METHODS

Materials:

Wheat flour (72% extraction) was taken from Upper Egypt Mills Company in El-Minia governorate. Barley, corn and fenugreek seeds were purchased from the local market in El-Minia and ground using National Matsushita Elec., grinder (Ind. Co., LTD, Japan) to obtain the whole grain flours.

Composite flours were prepared from 100% wheat flour as control, 80% wheat and 20% barley, 80% wheat and 20% corn, 90% wheat and 10% fenugreek and 75% wheat and 10% barley, 10% corn and 5% fenugreek.

Methods:

Analytical methods. The proximate composition (moisture, total ash, crude protein, crude fat and crude fiber) of wheat, barley, corn and fenugreek flours and breads after drying for 12 hrs at 40- 50°C in an electrical air draught oven and grinding were determined according to AOAC (1995).

The other carbohydrate content than crude fiber was calculated as nitrogen free extract (NFE) by difference.

Mineral analysis was carried out after digesting with mixture of concentrated sulfuric acid and percholoric acid as stated in AOAC (1995). Sodium and potassium were measured by flame photometry (Corning 400), while calcium, zinc, manganese, iron, copper, lead, cobalt, nickel, cadmium, chromium and magnesium were estimated using an AASI atomic absorption spectrophotometry (Perkin- Elmer Instrument Model 2380).

Amino acids analysis was determined using a Beckman amino acid analyzer (Model 118/119 CL) according to the method described by Moore & Stein (1963) after hydrolysis of flour in the presence of 6 N HCL at 110 °C for 22 h in a nitrogen atmosphere. Sulfur containing amino acids were determined after performic acid oxidation. Tryptophan was chemically determined by the method of Miller (1967).

Chemical scores of the amino acids were calculated using the mentioned procedure of FAO/WHO (1973).

Rheological properties of composite flour dough. Water absorption, development time, dough stability and dough softening of the various

formulas were determined using a Barbender Farinograph with a 100 mixing bowl (A.A.C.C. 1983).

Pan bread preparation. The procedure of Pollhamer (1981) was used to assess weight, volume and specific volume of loafs. The dough was made by weighing 50 g flour, 0.3 g dry yeast, 0.5 g salt and water (determined by fariongraph) then kneaded for 3 min in the 100 g mixing bowel of the farinograph and was pre-fermented at 30 °C for 70 min in a proofing cabinet. The fermented dough was placed in a lightly oiled glass cylinder and leveled with a cylindrical piece of wood. The dough was left at 30 °C for 60 min in a proofing cabinet. The pan bread was baked in an oven at 260 °C for 15 min. Loaf volume was measured by rapeseed displacement after cooling the bead for 1 h at room temperature (~ 25 °C).

Sensory evaluation. The freshly sliced bread was cut into 5 × 5 cm pieces and served to ten staff members of Food Science and Technology Dept, University of Minia, EL-Minia, Egypt. The panelists were provided with five randomly coded samples (control, 20% barley, 20% corn, 10% fenugreek and blend of 10% barley, 10% corn and 5% fenugreek flour breads. General attribute ranking evaluations were made in individual tables under fluorescent light at ambient temperature (~ 25 °C). Six sensory attributes were evaluated (crust color, crumb color, crumb texture, flavor, crumb staling and overall quality) using a 5-point scale according to Amerine *et al*., (1965). Accuracy and precision were evaluated statistically.

Calories determination. Calories of wheat composite flours and breads were calculated on the basis of each 1 g of protein and carbohydrate give 4 calories and each 1 g of fat give 9 calories.

Statistical analysis. Chemical composition and sensory properties of wheat composite flours and breads were analyzed using Statistical Analysis System SAS (1986). Significant differences between treatments were determined at the 5% level.

RESULTS AND DISCUSSION

Proximate composition of wheat, corn, barley and fenugreek flours

The proximate composition of flours of wheat, barley, corn and fenugreek seeds was shown in Table (1). There were significant differences ($p \leq 0.05$) between the flours of wheat, barley, corn and fenugreek in moisture, ash, crude fat, crude protein, crude fibers and calories.

Wheat flour showed the highest percent of moisture (8.22), followed by barley, corn and fenugreek flours, respectively. In contrast fenugreek seeds showed the highest value of ash (3.97), followed by barley, corn and wheat flour, respectively. Also, fenugreek flour had the highest value of crude fat (9.06), followed by corn, barley and wheat flours, respectively. The highest value of protein (23.76) was in fenugreek flour followed by wheat, barley and corn flours, respectively.

In the other side, fenugreek flour contained the lowest percent of carbohydrate (37.23), followed by barley, wheat and corn flours.

Crude fibers in fenugreek flour was the highest (25.98), followed by barley, wheat and corn flours, respectively.

Table (1): Proximate composition of wheat, barley, corn and fenugreek flours (on dry weight basis)

Flour	Moisture	Ash	Crude fat	Crude protein	Carbohydrate (NFE)	Crude fiber	Calories/ 100g
Wheat *	8.22a ±0.02	0.95d ±0.03	3.56d ±0.21	14.17b ±0.65	76.36b ±1.2	5.01c ±0.73	394.16b ±2.28
Barley	7.40ab ±0.0	2.56b ±0.40	3.64cd ±0.19	12.24cd ±0.47	66.43c ±0.80	15.13b 1.61	347.44c ±5.08
Corn	7.00b ±0.14	1.37cd ±0.14	5.16b ±0.08	11.61d ±0.29	79.28a ±0.63	2.58d ±0.32	410.10a ±1.45
Fenugreek seeds	5.80c ±0.0	3.97a ±0.22	9.06a ±0.52	23.76a ±0.49	37.23d ±0.14	25.98a 0.43	325.50d ±4.72
LSD	0.883	0.4612	0.5742	1.045	1.447	2.163	9.536

***Wheat flour, 72% extraction rate**

As resulted to the previous results corn flour showed the highest content of calories (410.1 kcal/100 g), followed by wheat flour (394.16 kcal/ 100 g), while the others were the lowest and similar, especially fenugreek flour which were having the lowest (325.50 kcal/100 g).

According to Hood and Jood (2004) replacement of wheat flour with fenugreek flour increased the protein, fat, lysine, minerals and dietary fiber contents. Products (bread, biscuits, noodles and macaroni) prepared from the 9:1, 5.7:1 and 4:1 w/w wheat: fenugreek blends were organoleptically acceptable.

Rheological properties of the dough of composite flour of wheat with each of barley, corn, fenugreek and their mixture

Farinograph properties of composite flour of wheat with each of barley, corn, fenugreek and their mixture were shown in Table (2).

Table (2): Farinograph characteristics of wheat flour and composite flour of wheat with barley, corn, fenugreek and their blends

Composite flour	Water absorption %	Dough development time (min)	Stability (min)	Softening (BU)
100% Wheat flour*	64.40	2.5	5.75	70.0
1	70.30	3.5	4.00	110
2	64.00	4.0	4.25	100
3	70.80	5.0	> 12	18
4	75.25	4.5	7.75	42

***Wheat flour, 72% extraction rate**
[1]4:1 w/w wheat: barley
[2]4:1 w/w wheat: corn
[3]9:1 w/w wheat: fenugreek
[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek

Water absorption of composite flour consisting of 75% wheat and the mixture of barley, corn and fenugreek was the highest (75.25), followed by wheat and fenugreek, wheat and barley, wheat and corn and wheat alone. As shown, increasing the contents of fibers in the whole grain of wheat composite flours increased the water absorption capacities (El-Soukkary, 1995 and Ayo, 2001), therefore such results may be attributed to the differences in their contents of crude fibers.

The increase in fibers was also affected the DDT. It caused an increase in the time for developing as reported by Sosulski and Wu (1988) and El-Soukkary (1995), therefore, wheat flour had the lowest DDT, therefore composite flour containing fenugreek had the highest DDT (5 and 4.5 min).

In the other side, composite flours containing fenugreek had higher dough stability (> 12 and 7.75 min, respectively) than the others. This may be due to their high viscosities owing to their higher soluble fiber and content of protein (EL-Soukkary, 1995) and this was also caused a reduction in softening (18 and 42 BU) of composite containing fenugreek than the other blends.

These results agreed well with those reported by Park *et al.*, (1997) who stated that adding the fiber ingredients to the formula of bread dough increased water absorption by 25% and mixing time by 50% and imparted stickiness of the dough.

Weight, volume and specific volume of breads

It was cleared from data in Table (3) that adding of barley, corn, fenugreek and their mixture to wheat flour resulted in reduction in volume and specific volume and an increase in weight of loaf. This addition diluted gluten which responsible of such properties. These results in a good agreement with Park *et al.*, (1997) and also Shittu *et al.*, (2007) who use the composite cassava-wheat flour and found that the loaf volume, weight and specific volume varied significantly ($p \leq 0.001$).

Table (3): Weight, volume and specific volume of composite flour breads

Composite flour	Weight (g)	Volume (Cm^3)	Specific volume (C^3/g)
100% Wheat flour*	555.63±2.47	1679.97±1.2	3.02±3.87
1	571.40±1.59	1387.40±0.86	2.43±6.22
2	533.93±1.78	1462.40±0.90	2.74±7.53
3	564.17±1.20	1464.07±1.33	2.60±6.92
4	581.47±2.14	1477.63±1.17	2.54±7.46

***Wheat flour, 72% extraction rate**
[1]4:1 w/w wheat: barley
[2]4:1 w/w wheat: corn
[3]9:1 w/w wheat: fenugreek
[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek

Sensory properties of composite flour breads

Sensory evaluation of wheat composite flour breads are shown in Table (4). There were no significant differences ($p \leq 0.05$) in crust colors between the prepared wheat composite flour breads. As regard to crumb color, crumb texture, flavor, crumb staling and overall quality of wheat composite flours, there were significant differences ($p \leq 0.05$) among their breads.

Table (4): Sensory properties of composite flour breads*

Composite flour	Crust color	Crumb color	Crumb texture	Flavor	Crumb staling	Overall quality
100%Wheat flour*	3.60± 1.02	4.30a± 0.60	4.10a± 0.54	4.15a± 0.71	4.10a± 0.74	4.05a± 0.51
1	2.75± 0.75	3.40abc± 0.76	2.95cde± 0.57	3.25bcd± 0.60	3.15bcde± 0.71	3.10cde± 0.76
2	2.75± 0.68	3.50abc± 1.15	3.05bcde± 0.91	3.40abcd± 0.92	3.05cde± 0.79	3.19bcde± 0.82
3	2.80± 1.08	2.75c± 1.47	2.80de± 1.12	2.80d± 1.20	2.70e± 1.17	2.75e± 1.10
4	3.20± 1.0	2.83bc± 1.51	2.76e± 0.98	2.85cd± 1.15	2.75de± 1.11	2.85de± 1.15
LSD	NS	1.009	0.7061	0.7567	0.8143	0.7095

***Wheat flour, 72% extraction rate**
[1]4:1 w/w wheat: barley
[2]4:1 w/w wheat: corn
[3]9:1 w/w wheat: fenugreek
[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek

Table (5): Proximate composition of composite flour breads (dry weight basis)

Composite flour	Moisture	Ash	Crude fat	Crude protein	Carbohydrate	Crude fiber	Calories/ 100g
100% Wheat flour*	5.02e ±0.10	1.73e ±0.005	5.72e ±0.29	8.97e ±0.30	76.49a ±0.51	7.09d ±0.48	393.31a ±1.06
1	5.35d ±0.003	2.10b ±0.06	8.28b ±0.12	9.94d ±0.33	69.69bc ±0.14	9.99bc ±0.33	393.04a ±3.4
2	6.12a ±0.02	1.81d ±0.008	9.27a ±0.005	10.44cd ±0.16	68.67c ±0.73	9.81c ±0.91	399.87a ±3.74
3	5.51c ±0.07	1.99c ±0.008	5.96de ±0.12	17.14a ±0.22	64.36e ±0.36	10.55abc ±0.60	379.64c ±0.51
4	5.76b ±0.085	2.25a ±0.67	7.76c ±0.30	12.16b ±0.23	66.34d ±0.41	11.49a ±0.25	383.84bc ±2.06
LSD	0.1331	0.05954	0.4082	0.5894	1.1940	1.391	6.697

***Wheat flour, 72% extraction rate**
[1]4:1 w/w wheat: barley
[2]4:1 w/w wheat: corn
[3]9:1 w/w wheat: fenugreek
[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek

As regard to crumb color, textures, flavor and crumb staling properties, barley and corn flour breads were the closest to control and similar ($p \leq 0.05$), while composite flours containing fenugreek were the lowest among the breads, but still acceptable ($p \leq 0.05$). These results agreed well with Park *et al.*, (1997) who stated that the fiber bread showed a 10% reduction in loaf volume and a somewhat inferior crumb grain with an off-color, also the crumb of the fiber bread remained much softer than control bread during one to seven days of storage at room temperature.

Also, these results consistency well with those reported by Gujral and Pathak (2002) who found that upon storage to 24 h, the extensibility and energy to rupture chapaties made from supplemented whole wheat flour with

rice, corn, barley, millets and black gram decreased and showed higher extensibility even after 24 h of storage, especially barley.

As regard to the overall quality, the panelists evaluated the wheat composite flour breads as acceptable ($p \leq 0.05$). These results also agreed well with Ayo (2001) who found that the sensory means scores of the odor taste, color and texture decreased with increasing the level of amaranth grain flour to make bread and also with Lorenz and Coulter (1991) who evaluated using quinoa flour blends (5, 10, 20 and 30%) in breads. They found that breads baked with 5 and 10% quinoa flour were of good quality. Loaf volume decreased, crumb grain became more open and the texture slightly harsh at higher usage levels of quinoa flour and a bitter aftertaste was noted at the 30% level.

These results agreements with those reported by Hatcher *et al.*, (2005) who stated that the addition of hull less barley flour at either level to the wheat flour resulted in significantly decreased brightness (L) and yellowness (b) and elevated redness (a), and also Shittu *et al.*, (2007) who use the composite cassava-wheat flour and found that fresh crumb moisture, density, porosity and softness as well as the dried crumb hardness were significantly ($p \leq 0.01$) affected by both the addition and the baking temperature and time.

Also Sanni *et al*., (1998) mentioned that incorporation of maize into wheat flour caused producing cracked and hard breads, while the volume of breads ranged from 200 to 320 cm^3. Also, statistical analysis of the sensory attributes revealed a consumer acceptance of the maize-supplemented breads.

Nutritional value of wheat composite flour breads

The proximate composition of breads from composite flours are shown in Table (5). The results showed significant ($p \leq 0.05$) differences in proximate composition among the composite breads. This was mainly due to the variation in the proximate composition of their composite flours.

As regard to moisture content, the breads from wheat composite flours showed the highest contents compared with the control and also this due to the highest content of fibers. Also the breads from composite flours were having the highest values of ash contents compared with control as mentioned previously in the raw materials results.

On the other side, the breads from corn, barley and the blends had the highest contents of crude fat (9.27, 8.28 and 7.76%) compared with the control.

As expected wheat composite fenugreek flour bread were having the highest content of crude protein (17.14) and the lowest content of carbohydrate (64.36) among the breads as paralleled with the raw materials.

As regard to fiber content, the wheat composite flour breads, especially containing fenugreek were the highest and almost similar ($p \leq 0.05$) compared to the control which was the lowest.

Also fenugreek flour breads showed the lowest contents of calories (379.64 and 383.84 k calories/100 g) compared with the others.

These results agreed well with Olaoye *et al*., (2006) and much better of those reported by *Sanni et al*., (1998) who stated that incorporation maize with wheat flour resulted in decreasing the moisture content and increasing the shelf life of the bread samples. Crude protein of the bread samples were in the range of 4.36 to 8.87%, while crude fat contents ranged between 3.66 to 7.67%. The ash contents increased from 2.29 to 2.54%, while total carbohydrate values were between 46.31 and 65.3%.

Mineral contents

The mineral contents of wheat composite flour breads are shown in Table (6).

The data revealed that there were marked increases in some minerals in the final product. As regard to copper, cobalt, cadmium, there were no marked increases, while Pb increased in the composite flour breads of barley, fenugreek and mixture (0.94, 1.03 and 1.20 ppm).

As regard to Zn, barley and corn flour breads showed the half percent of control, while composite flours containing fenugreeks showed the highest values (15.27 and 19.88 ppm).

Also as regard to Mn, there was a decrease reached to the half of the control in the wheat composite flour breads.

On the other side, potassium was moderate in the control then decreased to the half in the composite flour breads, except which containing fenugreek and blend since showed the highest increase approximately one and half times the K content of the control (3451.11 and 3551.1 ppm).

Ni content was high in the control, then decreased to approximately the half in the composite breads, except containing fenugreek and blend which were higher than the others (1.81 and 1.91 ppm).

As regard to Cr, the supplementation with composite flours ought to increasing the contents approximately to the double, especially in the corn and breads containing blend and fenugreek (0.328, 0.301 and 0.279 ppm, respectively).

Also the supplementation with composite flours caused an increasing in iron contents in the composite flours containing fenugreek and blend (301.91 and 320.51 ppm, respectively).

On the other hand, there were slight decrease in magnesium contents in breads containing composite flours.

Corn, barley and the mixture of composite flours showed the highest contents of sodium compared to the fenugreek and control (8277.68, 9491.06 and 9991.50 ppm, respectively).

As regard to calcium content, the wheat composite flour breads were much higher than the control and the blend and fenugreek flour breads showed the highest (1042.9 and 1051.5 ppm, respectively) (Olaoye *et al*., 2006).

Amino acids and chemical score

Data presented in Table (7) show the amino acid composition of wheat and wheat composite flour breads.

The use of composite flours appeared to increase the concentration of most of the essential amino acids (isolucine, lysine, methionine, threonine, tryptophan and valine) compared to the control.

Table (7): Amino acid composition of composite flour bread

Amino acid	Control*	1	2	3	4	FAO/WHO (1973)
Isolucine	3.85	4.79	5.50	5.20	6.59	4.00
Lucine	7.95	7.94	7.07	7.93	7.82	7.00
Lysine	2.52	2.62	2.86	3.64	3.06	5.50
Cystine	1.95	0.29	0.21	1.36	0.24	-
Methionine	0.96	1.93	2.14	1.64	2.18	-
Total sulfur AA	**2.91**	**2.22**	**2.35**	**3.00**	**2.42**	3.50
Tyrosine	4.95	3.86	4.21	3.86	3.53	-
Phenylalanine	5.50	5.14	5.36	5.71	4.94	-
Total aromatic AA	**10.45**	**9.00**	**9.57**	**9.57**	**9.47**	6.00
Threonine	3.93	5.43	5.43	4.43	4.47	4.00
Tryptophan	0.60	0.70	0.66	0.75	0.68	1.00
Valine	3.75	5.14	4.14	4.29	4.65	5.00
Total essential AA	**35.96**	**37.84**	**37.58**	**38.82**	**39.16**	36
Histidine	3.35	2.79	3.29	2.86	4.18	-
Arginine	4.17	3.93	4.86	6.14	7.82	-
Aspartic acid	5.65	6.08	7.21	6.07	8.88	-
Glutamic acid	24.79	26.86	22.86	21.14	18.00	-
Serine	6.09	4.43	4.43	4.43	3.65	-
Proline	14.39	14.00	13.43	13.36	10.88	-
Glycine	3.55	3.86	4.00	3.79	4.88	-
Alanine	3.51	4.00	4.43	4.00	6.00	-
Amonia	1.31	1.93	1.71	1.64	1.53	-
Total non-essential AA	**66.81**	**67.88**	**66.22**	**63.43**	**65.82**	-

***Wheat flour, 72% extraction rate,[1]4:1 w/w wheat: barley,[2]4:1 w/w wheat: corn, [3]9:1 w/w wheat: fenugreek,[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek.**

For lysine, the increment was 110-150% compared to the control. Comparison of the amino acid composition of wheat composite flour breads showed that breads contained similar or higher total essential amino acids levels than the FAO/WHO (1973) pattern, except for modest deficiencies, especially in cysteine and tyrosine, this increment due to the highest content of fiber in those composite flours. Breads containing fenugreek and blend showed the highest contents of isolucine, lysine, tryptophan and total essential amino acids.

Also, fenugreek bread had the highest contents of lysine, total sulfur amino acids, phenylalanine and tryptophan compared to the control and the other breads (El-Adawy 1992 and 1995).

From the results in the Table (8) it can be concluded that the supplementation with composite flours ought to improving the chemical

scores (CS) % better than the control, especially the fenugreek and blend (61.29 and 51.07%, respectively).

The same trend was observed by El-Adawy (1992 and 1995) who showed that supplementation of wheat with detoxified apricot kernel and sesame seed products improved the chemical score and essential amino acids.

Table (8): Biological value of bread fortified with wheat composite flours (dry weight basis)

Composite flour	Chemical score (CS)%	First limiting AA	Second limiting AA	Third limiting AA	PER**	BV***
100% Wheat flour*	45.80	Lysine (45.80)	Tryptophan (60)	Valine (75)	2.26	73.75
1	45.25	Lysine (45.25)	Total sulfur AA (60.48)	Tryptophan (66.07)	2.28	73.89
2	49.74	Lysine (49.74)	Tryptophan (62.72)	Total sulfur AA (64.47)	1.91	70.00
3	61.29	Lysine (61.29)	Tryptophan (69.00)	Valine (79.50)	2.30	74.16
4	51.07	Lysine (51.07)	Tryptophan (62.02)	Total sulfur AA (63.71)	2.37	74.86

***Wheat flour, 72% extraction rate**
[1]4:1 w/w wheat: barley
[2]4:1 w/w wheat: corn
[3]9:1 w/w wheat: fenugreek
[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek
****PER = -0.684 + 0.456 Leucine – 0.047 Proline (Alsmeyer *et al*., 1974)**
*****BV = 49.9 + 10.53 PER (Michel and Block, 1946)**

Also, the same trend was observed for PER and BV, especially for breads containing fenugreek and blend which were the best compared to the others. On the other side corn bread showed the lowest PER and BV among the breads (1.91 and 70.00, respectively).

Lysine was the first limiting amino acid for the control and breads containing composite flours, while tryptophan was the second limiting amino acid for all breads, except barley which was the total sulfur AA.

On the other side valine and total sulfur AA were the third limiting amino acids for most the wheat composite flour breads.

Conclusion

In conclusion, breads produced from wheat composite flours were nutritionally superior to that of the control (wheat flour 72% extraction), so enable them to replace wheat flour in making bread. The nutritional qualities of fenugreek and blend flours substituted breads are superior than the other composite flours, especially for ash, protein, fat, fiber, total calories, K, Ni, Fe, Ca, lysine, tryptophan, total sulfur AA, CS%, PER and BV. On the other side, the nutritional qualities and sensory attributes of the other wheat composite flour breads were similar and superior than the wheat control, especially for barley and corn flours.

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خصائص الجودة للخبز المصنوع من الدقيق المركب من القمح، الذرة، الشعير والحلبة

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تم تصنيع اربعة خلطات من دقيق القمح المركب من بعض الحبوب والحلبة بجانب العينة الكنترول
(دقيق القمح ٧٢ % أستخلاص) من أجل صناعة الخبز الأفرنجى المدعم.
كانت الأربع خلطات من 80% دقيق القمح و٢٠% من كل من دقيق اشعير والذرة و90% دقيق القمح و10% دقيق بذور الحلبة والأخيرة من 75% دقيق القمح و 10% دقيق الشعير و10% دقيق الذرة و5% دقيق الحلبة. تم عمل بعض الدراسات لتقييم الخصائص الحسية, الريولوجية والتغذوية للمواد الخام والخبز الناتج من والأربع خلطات والعينة الكنترول. أوضح التقييم الكيمائى للمواد الخام أن دقيق الشعير الذرة كان لهما النسبة الأقل من الرماد والبروتين, بينما أحتوت الحلبة على القيم الأعلى من الدهن الخام, البروتين والألياف الخام, والأقل من الكربوهيدرات والسعرات الحرارية بالمقارنة مع الاخرين.
وأوضحت النتأئج أيضا أن التدعيم بالدقيق المركب أدى الى زيادة نسبة أمتصاص الماء, الوقت اللازم لتحسين العجينة (DDT), ونقص درجة الضعف, وأظهرت عجينة الحلبة القيمة الأعلى من DDT والأقل من درجة الطراوة. أيضا أدت نفس مستوى الأضافات الى زيادة وزن الخبز ونقص الحجم والحجم النوعى. على الجانب الاخر, أظهر التقييم الحسى للخبز الأفرنجى النانج أنة كانت توجد اختلافات بسيطة (عند ٥% مستوى معنوية) ما بين العينة الكنترول والخلطات وكان خبز الشعير والذرة الأقرب الى العينة الكنترول. أظهر التحليل المعدنى أن خبز الخلطة والحلبة كان لهما النسب الأعلى من الرصاص, الزنك، البوتاسيوم, الكوبالت, النيكل, الكادميوم, الكروميوم, الحديد, الصوديوم والكالسيوم, بالمقارنة مع العينة الكنترول.
على الجانب الاخر, أظهرت نتأئج تحليل الأحماض الأمينية أن التدعيم بالدقيق المركب أدى الى تحسين نسب كل من الأيزوليوسين, الليسين, الميثونين, الثريونين, التربتوفان, الفالين والأحماض الأمينية الأساسية الكلية, بالمقارنة بالعينة الكنترول. أيضا كانت هناك زيادة فى CS%, معدل كفاية البروتين (PER) والقيمة الحيوية للبروتين (BV) لكل من خلطات الخبز مع الدقيق المركب أكثر من الخبز العادى.

Table (6): Mineral content of composite flour breads (ppm)

Composite flour	Cu	Pb	Zn	Mn	K	Co	Ni	Cd	Cr	Fe	Mg	Na	Ca
100% Wheat flour*	14.54	0.79	17.99	44.53	2118.98	0.44	1.24	0.067	0.134	79.66	3865.33	7365.13	993.6
1	11.69	0.94	9.29	17.99	1266.59	0.50	0.58	0.062	0.142	57.05	3598.24	9491.06	1032.8
2	13.93	0.71	8.90	18.95	1378.58	0.38	0.77	0.042	0.328	88.65	2916.51	8277.68	1035.5
3	15.63	1.03	15.27	20.40	3451.11	0.54	1.81	0.079	0.279	301.91	2213.26	7748.10	1051.5
4	14.00	1.20	19.88	22.20	3551.1	0.60	1.91	0.085	0.301	320.51	2990.1	9991.50	1042.9

***Wheat flour, 72% extraction rate**

[1]4:1 w/w wheat: barley

[2]4:1 w/w wheat: corn

[3]9:1 w/w wheat: fenugreek

[4]7.5:1:1:0.5 w/w wheat: barley: corn: fenugreek