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EFFECT OF ENRICHEMENT WHEAT FLOUR ٧٢٪ WITH FIBER ENRICHED BARLEY FLOUR ON MACARONI PRODUCTION

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ABSTRAT

A part of wheat flour (٧٢٪ extraction) was replaced with fiber enriched barley flour at ٥, ١٠, ١٥ and ٢٠٪ levels and processed into pasta. The physiochemical properties, minerals and amino acid composition of raw materials, composite flour, uncooked and cooked pasta were studied. Cooking quality, sensory characteristics of the produced pasta were also studied. The effect of ١٥٪ fiber enriched barley flour supplemented cooked pasta on blood glucose level, total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides and risk ratio of plasma and liver of rats were also studied.

Results indicated that addition of fiber enriched barley flour to wheat flour (٧٢٪) increased protein, fat, fiber, mineral and amino acid content and improved chemical scores of amino acids of produced pasta.

Total cholesterol, LDL cholesterol, triglyceride, and risk ratio values of rats decreased significantly while, HDL cholesterol value increased.

Fiber enriched barley flour can be successfully incorporated into pasta formulation at ١٥٪ substitution level resulting in pasta samples with acceptable quality characteristics .

INTRODUCTION

As a wheat-derived stable food, pasta is the second most consumed in the world after bread. Its world wide acceptance is attributed to its low cost, easy preparation, versatility, nutritional qualities, sensory attributes and long shelf-life. In particular, pasta is regarded as low glycemic index food product. (Newman *et al.,* ١٩٩٤ and Jenkins *et al.,* ٢٠٠٠).. Pasta products have been fortified to enhance their nutritional and functional properties with supplements from various cereals and legumes such as fiber enriched barley flour, The changing consumption pattern can result in nutrition problems since these foods often provide high fat, sugar, refined carbohydrates and energy, but low dietary fiber.

Barley, one of the earliest cultivated cereals in the world, is now gaining renewed interest as a food component because of its soluble dietary fiber and β-glucan content. In particular ,compared with other cereals, barley has relatively high levels of β-glucans of ٢-١١ g/١٠٠g. Soluble dietary fiber and β-glucan of barley were reported to lower plasma cholesterol and postprandial serum glucose levels in humans and animals (Yokoyama *et al.,* ١٩٩٧). Functional pasta, enriched with fiber enriched barley flour have interesting amounts of bioactive compounds (dietary fiber and β-glucan) and could therefore be proposed as potential ingredients for the manufacture of functional food. The objective of this study was to evaluate the effect of adding fiber enriched barley flour to wheat flour (٧٢٪) on physical, chemical and nutritional properties of pasta.

MATERIALS AND METHODS

Materials

Wheat flour.

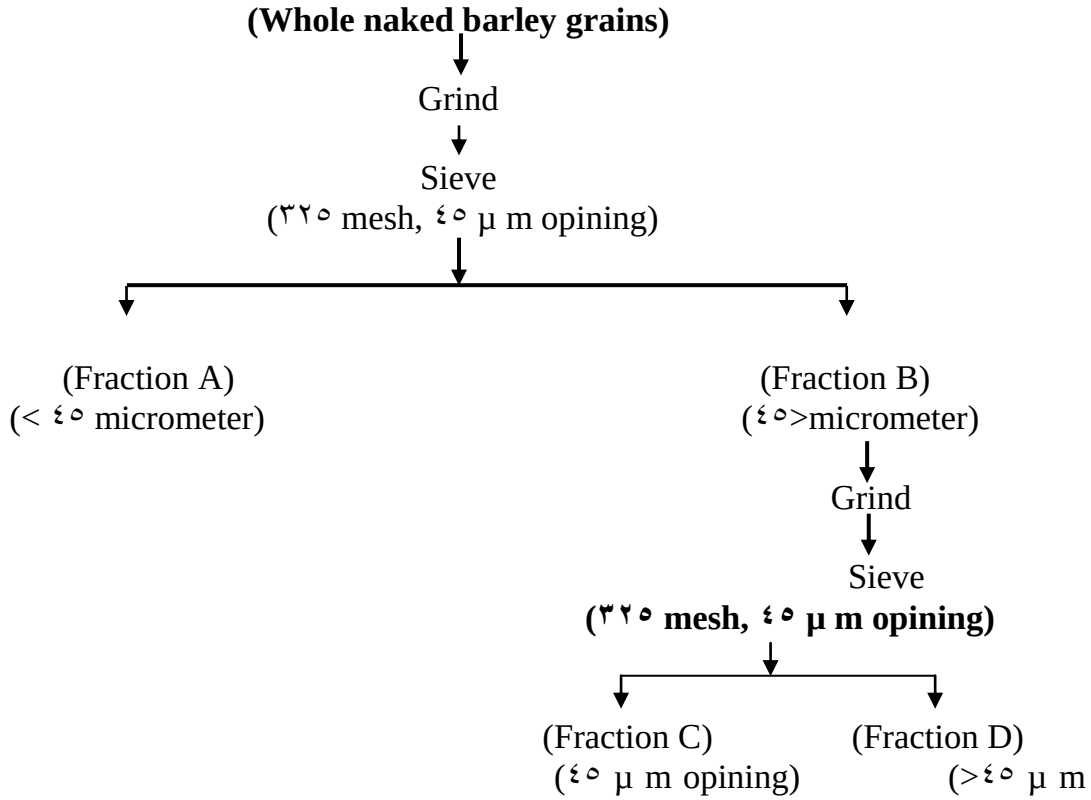
Wheat flour ٧٢٪ extraction was obtained from Gerga mill, Upper Egypt Milling Company, Sohag, Egypt.

Supplementation of barley flour in macaroni making from wheat flour

Fiber enriched barley flour.

A six rowed naked barley grains of Giza ١٢٩ variety season ٢٠٠٧ were obtained from Agronomy department, Faculty of Agriculture, Minia University, Egypt. The enrichment process involved repeated milling and sieving to remove barley starch, as described by (Knuckles *et al.*, ١٩٩٢). illustrated in Fig.١.

Fig. ١ : Fiber enrichment diagram of barley materials



٢.)

Albino rats: of four weeks age, weighing ٥٠ ± ٤ grams was obtained from Egyptian Organization for pharmaceutical products and vaccines- Helwan, Egyp.

Methods

Pasta formula

Table ١: Pasta formulas made from wheat flour ٧٢٪ extraction supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour

Blends		Wheat flour (٧٢٪).		Fiber enriched barley flour		water	
		Kg	%	Kg	%	Kg	%
control	٠	٢٥	١٠٠			٧.٧٥	٣١
Fiber enriched barley flour	٥٪	٢٣.٧٥٠	٩٥	١.٢٥٠	٥	٧.٧٥	٣١
	١٠٪	٢٢.٥٠٠	٩٠	٢.٥٠٠	١٠	٧.٧٥	٣١
	١٥٪	٢١.٢٥٠	٨٥	٣.٧٥٠	١٥	٧.٧٥	٣١
	٢٠٪	٢٠.٠٠	٨٠	٥.٠٠	٢٠	٧.٧٥	٣١

Pasta making process.

Pasta was prepared on a commercial scale according to the method described by Singh *et al.,* (٢٠٠٤).

Chemical analysis:

Moisture, protein, fat and ash contents of each sample were determined according to AACC (٢٠٠٠) method NO. ٤٤-١٥ A, ٤٦-١٢, ٣٠-٢٥, and method ٠٨ – ٠١.

Determination of dietary fiber.

Total dietary fiber of each sample was determined according to AOAC Method ٩٩١-٤٣ (AOAC, ١٩٩٥).

Determination of carbohydrates .

The carbohydrates of each formula was calculated by differences as described by El–Gammal, (٢٠٠٠).

Minerals content .

Total content of Na, P, K, Ca, Mg, Fe, Zn and Mn were determined according to Chapan and Pratt, (١٩٧٨).

Determination of amino acids.

Amino acids determination was performed according to the method of Winder and Eggum, (١٩٦٦).

Tryptophan content

Tryptophan was determined according to the method of Sastry and Tummuro, (١٩٨٥) .

Sensory evaluation.

Sensory analysis was performed according to the sensory assessment procedure reported by Cubadda, (١٩٨٨), considering control as١٠٠٪.

Biological methods to assess the nutritive value:

Serum and liver lipids determination: Total cholesterol, HDL-cholesterol and triglycerol contents in serum were determined according to Kalra and Jood, (٢٠٠٠). LDL-cholesterol was calculated as described by Friedewald *et al.,* (١٩٧٢). Lipids from liver tissues were extracted by the method of Folch *et al.,* (١٩٥٧).

The chemical, physical, biological results and sensory evaluation were expressed as the means $\pm$ standard deviation (S.D). Data was analyzed with GLM (General Linear Model) program using statistical analysis system (SAS, ١٩٨٧). Mean values were compared by Duncan's Multiple Range Test (١٩٥٥).

RESULT AND DISCISONS

Chemical composition of wheat flour ٧٢٪ extraction.

Results in Table ٢ indicate that, moisture, protein, fat, fiber, ash and carbohydrates contents of wheat flour ٧٢٪extraction were١٣.٩٤, ١٢.١٢, ٠.٩٨, ٠.١٦, ٠.٤٨ and ٨٦.٢٦٪, respectively. These results are in accordance with those reported by Abd El-Baki (١٩٩٩) and Gad El-Kareem (٢٠٠٦), who found that wheat flour ٧٢٪ extraction, has a low content of protein, fat, fiber, ash and high content of carbohydrates. This could be due to the fact that wheat flour ٧٢٪ extraction was freed from the outer layers of wheat grains rich in protein, fat, fiber and ash.

Chemical composition of fiber enriched barley flour.

Table ٢ shows that, fiber enriched barley flour contained ١٣.٥٠, ١٣.١٠, ٣.٥٠, ٣٠.٢٠, ٤.٢٠ and ٤٩.٠٠٪ moisture, protein, fat, fiber, ash and carbohydrates, respectively. The results are in agreement with the data obtained by Knuckles *et al.,* (١٩٩٧) and Yokoyama *et al.,* (١٩٩٧), who reported that, fiber enriched barley flour is rich in protein, fat,

fiber and ash. This is possibly due to the fact that fiber enriched barley flour has a high content of the outer layer of barley grains which are rich in protein, fat, fiber and ash.

Table ٢: Chemical composition of wheat flour ٧٢٪ extraction, fiber enriched barley flour (On dry weight basis) .

Contents (%)	Wheat flour ٧٢٪ extraction.	Fiber enriched barley flour
Moisture	١٣.٩٤ ± ٠.١٥	١٣.٥٠ ± .٠٢٦
Protein	١٢.١٢ ± ٠.١١	١٣.١٠ ± ٠.١٠
Fat	٠.٩٨ ± ٠.٠٧	٣.٥٠ ± ٠.٢٣
Dietary Fiber	٠.١٦ ± ٠.٠٦	٣٠.٢٠ ± ١.٦٦
Ash	٠.٤٨ ± ٠.٠٨	٤.٢٠ ± ٠.١٠
Carbohydrates*	٨٦.٢٦ ± ٠.١٤	٤٩.٠٠ ± ١.٩٠

- Value ± S D (Standard Deviation) * Carbohydrates were calculated by difference.

Chemical composition of uncooked pasta supplemented with fiber enriched barley flour at ٠, ٥, ١٠, ١٥ and ٢٠٪ levels.

Table ٣ shows that moisture content values of the uncooked pasta increased significantly ($P \leq ٠.٠٥$) with supplementation. The same trend was observed by Finney *et al.*, ١٩٨٢ and Gad El-Kareem, (٢٠٠٦). Protein, fat, dietary fiber and ash content values of pasta contained fiber enriched barley flour increased significantly ($P \leq ٠.٠٥$). The increase was due to the high content of fiber enriched barley flour in which the outer layer of barley grain had a high content of protein (Newman *et al.*, ١٩٩٢). Total carbohydrates were significantly ($p \leq ٠.٠٥$) decreased by the addition of fiber enriched barley flour. Similar results were reported by Yokoyama *et al.*, (١٩٩٧).

Mineral composition of uncooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour:

Table (٤) shows the mineral contents of the uncooked pasta supplemented with fiber enriched barley flour. Supplementing decreased Na, K, Fe and Mn contents of the produced uncooked pasta. This decrease was due to that barley flour had low values of Na, K, Fe and Mn compared to wheat flour ٧٢٪ extraction (Pedersen *et al.*, ١٩٨٩).

Table ٣: Chemical composition of uncooked pasta supplemented with fiber enriched barley flour at levels of ٠, ٥, ١٠, ١٥ and ٢٠ %. (On dry weight basis) .

Contents (%)	Supplementation ratio				
	Control (٠ %)	٥٪	١٠٪	١٥٪	٢٠٪
Moisture	١٢.٠٠ ± ٠.٢٠ d	١٢.٢٠ ± ٠.١٠ c	١٢.٣١ ± ٠.١٢ b	١٢.٤٠ ± ٠.١٣ a	١٢.٥٠ ±٠.١٥ a
Protein	١٢.٢٦ ± ٠.١٥ e	١٢.٧٣ ± ٠.١٣ d	١٣.٣٨ ± ٠.١٢ c	١٣.٧٦ ± ٠.١٥ b	١٤.٣٣± ٠.٢٠a
Fat	١.١٠ ± ٠.١١ e	١.٣١ ± ٠.١٠ d	١.٥٠ ± ٠.١٧ c	١.٦٤ ± ٠.١٥ b	١.٩٥ ± ٠.١٤ a
Fiber	٠.٢١ ± ٠.٠٧ e	١.٧١ ± ٠.١٦ d	٣.٣٥ ± ٠.١٠ c	٤.٨٢ ± ٠.١٩ b	٦.٦٤ ± ٠.٢٣ a
Ash	٠.٥٤ ± ٠.١٠ e	٠.٦٣ ± ٠.١٥ d	٠.٧٦ ± ٠.١٢ c	٠.٨٩ ± ٠.١٥ b	١.١١ ± ٠.١٢ a
Carbohydrates*	٨٥.٨٩ ± ٠.٥٧ a	٨٣.٦٢ ± ٠.٦٥ b	٨١.٠١ ± ٠.٦٨ c	٧٨.٨٩ ± ٠.٨١ d	٧٥.٩٧ ±٠.٨٦ e

* Carbohydrates were calculated by differences. ± SD (Standard Deviation)
abcde Means followed by the same letter in the same row are not significantly different (P ≤ ٠.٠٥).

Table ٤: Mineral composition of the uncooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour (mg / ١٠٠ g. dry weight).

Minerals (*)	Supplementation ratio				
	٠٪	٥٪	١٠٪	١٥٪	٢٠٪
Na	١٤.٢٠ ± ٠.١١ a	١٤.٠٠ ± ٠.١٣ b	١٣.٨٠ ± ٠.١٠ c	١٣.٦٧ ± ٠.١٨ d	١٣.٥٠ ± ٠.١٥e
P	١٣٥ ± ٣.٠٠ e	١٤٠ ± ٢.٠٠ d	١٤٨ ± ٢.١١ c	١٥٩ ± ٢.٠٠ b	١٦٦ ± ١.٥٣ a
K	١٤١ ± ٣.٦٠ a	١٣٧ ± ١.٥٠ b	١٣١ ± ٢.٠٠ c	١٢٨ ± ١.٠٠ d	١٢٢ ± ١.٧٣ e
Ca	٥٦ ± ٢.٠٠ e	٦٤ ± ٢.٦٦ d	٧٣ ± ٢.٩٢ c	٨١ ± ١.٣٧ b	٩٢ ± ١.٥٠ a
Mg	٥٤ ± ١.٠٠ b	٥٤ ± ١.٥٨ b	٥٥ ± ٠.١٨ b	٥٥ ± ٠.٥١ b	٥٧ ± ١.٠٠ a
Zn	٣.٤٥ ± ٠.١٢ e	٤.٠١ ± ٠.١٤ d	٤.٣١ ± ٠.١٢ c	٤.٥٢ ± ٠.١٣ b	٤.٧١ ± ٠.١٥ a
Fe	٢.٥٠ ± ٠.١٠ a	٢.٤٢ ± ٠.١٠ a	٢.٣٣ ± ٠.١٢ b	٢.٢١ ± ٠.٠٨ c	٢.١٦ ± ٠.٠٥ c
Mn	٣.١٠ ± ٠.١٠ a	٣.٠٠ ± ٠.١٢ a	٢.٨٣ ± ٠.١٠ b	٢.٧١ ± ٠.١٣ c	٢.٦٠ ± ٠.١٠ d

* On dry basis ±SD (Standard Deviation).
abcde: Means followed by the same letter in the same row are not significantly different (P≤ ٠.٠٥).

The results also showed that P, Ca,Mg and Zn contents of uncooked pasta supplemented with fiber enriched barley flour were significantly increased with increasing the level of substitution. This could be due to that fiber enriched barley flour is rich in P, Ca,Mg and

Zn compared to wheat flour. Similar results were obtained by Pedersen *et al.*,(١٩٨٩) and Yokoyama *et al.*, (١٩٩٧), who reported that the supplementation of wheat flour with ß- glucan enriched barley flour increased ash and mineral contents of the produced pasta.

Amino acid composition and chemical scores of uncooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour (g / ١٦ gN).

Results in Tables ٥ and ٦ show that replacing of wheat flour (٧٢% extraction) with ٥,١٠,١٥ and ٢٠٪ levels of fiber enriched barley flour significantly($P \leq ٠.٠٥$) increased leucine, isoleucine, lysine, therionine and tryptophan contents of the produced pasta compared to the control. This could be due to that fiber enriched barley flour had a high values of leucine, isoleucine, lysine, therionine and tryptophan compared to wheat flour (٧٢٪ extraction).

Table ٥: Amino acid composition of uncooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour (mg / ١٦ g nitrogen).

Amino acid E.A.A.	Supplementation ratio				
	Control	٥٪	١٠٪	١٥٪	٢٠٪
Leucine	٦.٣٤±٠.١٠ e	٦.٤٨±٠.١١ d	٦.٦١±٠.١٣ c	٦.٨٤±٠.٢١ b	٧.٠٨±٠.١٥ a
Isoleucine	٣.٣٠±٠.١٣ d	٣.٤٢±٠.١١c	٣.٥٨±٠.١٥ b	٣.٧١±٠.١٠ ab	٣.٨٢±٠.١٠ a
Lysine	٢.٣٢±٠.١٢ e	٢.٥٥±٠.١١d	٢.٨٢±٠.١٦ c	٣.١٨±٠.١٥ b	٣.٣٥±٠.١٤ a
Methionine +cystine	٤.٤٤±٠.١٨ a	٤.٣٠±٠.١١ b	٤.١٨±٠.١٢ c	٤.٠١±٠.١٤ d	٣.٨٥±٠.١١ e
Phenylalanine +tyrosine	٨.٠٠±٠.٣١ a	٧.٨٨±٠.١٠ b	٧.٦٨±٠.١٣ c	٧.٥٥±٠.١٦ d	٧.٣١±٠.١٢ e
Therionine	٣.٠٣±٠.٢١ e	٣.١٦±٠.٢٢ d	٣.٢٦±٠.١٢ c	٣.٣٤±٠.١٠ b	٣.٥٣±٠.١١ a
Valine	٥.٢٠±٠.٢٢ a	٥.١٥±٠.١٦ ab	٥.٠٠±٠.١٣ c	٤.٨٨±٠.١٨ d	٤.٧٣±٠.١٥ e
Tryptophan	٠.٩٥±٠.١٥c	١.٠٨±٠.١١ b	١.١٥±٠.١٢ b	١.١٨±٠.١٦ b	١.٣٢±٠.١٢ a
Total E.A.A	٣٣.٥٨±٠.١٨e	٣٤.٠٢±٠.١٥d	٣٤.٢٨±٠.١١c	٣٤.٦٩±٠.١٥b	٣٥.٢١±٠.١٣a
Alinine	٣.٥٢±٠.١٧ b	٣.٥٩±٠.١٢ b	٣.٧٢±٠.١٠ b	٣.٨١±٠.١٥ ab	٣.٩٤±٠.١٢ a
Aspartic acid	٤.٥٦±٠.٢٢ e	٤.٧٢±٠.١٥d	٤.٩٢±٠.١١ c	٥.١٧±٠.١٣ b	٥.٢٨±٠.١٣ a
Glutamic acid	٣١.١٠±٠.٢٧ a	٣٠.٧١±٠.١١ b	٣٠.٢٢±٠.١٩c	٢٩.٧٠±٠.١١d	٢٩.٤٢±٠.١٨e
Glycine	٤.١٢±٠.١١a	٤.٠٣±٠.٠٧ a	٣.٩٠±٠.١٠ b	٣.٨٣±٠.١٢ c	٣.٧١±٠.١٥ d
Histidine	٢.٣٠±٠.١٥ d	٢.٤١±٠.١٠ c	٢.٥٦±٠.١١ b	٢.٧١±٠.١٦ a	٢.٨٥±٠.١٢ a
Proline	١١.٠٠±٠.١٤a	١٠.٩١±٠.١٠ a	١.٧٢±٠.١١ b	١٠.٦٣±٠.١٤c	١٠.٥٠±٠.١٥d
Serine	٥.٦٧±٠.١٣ e	٥.٨٨±٠.١١d	٦.١٢±٠.١٨c	٦.٣١±٠.١٤b	٦.٤٧±٠.١١a
Arginine	٤.١٥±٠.١٠ c	٤.٢٢±٠.١٠b	٤.٣٣±٠.١٢ a	٤.٤٦±٠.١٥ a	٤.٥١±٠.١٧ a

Total non E.A.A	٦٦.٤٢±٠.١٨b	٦٦.٤٧±٠.٢١b	٦٦.٤٩±٠.١١b	٦٦.٦٢±٠.١٥a	٦٦.٦٩±٠.٢١a
E.A.A/Non E.A.A ratio	٠.٥٠	٠.٥١	٠.٥٢	٠.٥٢	٠.٥٣

abcde : Means followed by the same letter in the same row are not significantly different (P≤٠.٠٥)
±SD (Standard Deviation).

Also, supplementation of wheat flour significantly decreased (P≤٠.٠٥) methionine + cystine, phenylalanine + tyrosine and valine content of the produced pasta. because fiber enriched barley flour had low values of these amino asid compared to wheat flour (٧٢٪ extraction). However, the non-essential amino acid composition of fiber enriched barley supplemented uncooked pasta, (arginine, aspartic acid, histidine, serine and alanine) were increased with increasing the level of substitution, while glutamic acid, glycine and proline showed the opposite trend. This was due to fiber enriched barley flour being rich in arginine, aspartic acid, histidine, and alanine and poor in glutamic acid, glycine and proline compared to wheat flour (٧٢٪ extraction). These findings are in agreement with those reported by Pedersen *et al.,* (١٩٨٩).

Table ٦: Chemical score and limiting amino acids of uncooked pasta supplemented with ٠, ٥,١٠,١٥ and ٢٠٪ levels of fiber enriched barley flour.

Amino Acid	**Protein pattern FAO, ١٩٧٣**	**Supplementation ratio**				
		٠٪	٥٪	١٠٪	١٥٪	٢٠٪
Leucine	٧.٠٠	٩٠.٥٧	٩٢.٥٧	٩٤.٤٣	٩٧.٧١	١٠١.١٤
Isoleucine	٤.٠٠	٨٢.٥٠	٨٥.٥٠	٨٩.٥٠	٩٢.٧٥	٩٥.٥٠
Lysine	٥.٥٠	٤٢.١٨	٤٦.٣٦	٥١.٢٧	٥٧.٨٢	٦٠.٩١
Methionine+ cystine	٣.٥٠	١٢٦.٨٦	١٢٢.٨٦	١١٧.٧١	١١٤.٥٧	١١٠
Phenylalanine + tyrosine	٦.٠٠	١٣١.٣٣	١٢٨	١١١.٣٣	١٢٥.٨٣	١٢١.٨٣
Therionine	٤.٠٠	٧٥.٧٥	٧٧.٥٠	٨٠.٢٥	٨٣.٥٠	٨٨.٢٥
Valine	٥.٠٠	١٠٤	١٠٢.٢٠	١٠٠	٩٧.٦٠	٩٤.٦٠
Tryptophan	١.٠٠	٩٥	١٠٠	١٠٥	١١٨.٠٠	١٣٢
First limiting Amino acid	**Lysine**	**Lysine**	**Lysine**	**Lysine**	**Lysine**	**Lysine**
Second limiting Amino acid	**Therionine**	**Therionine**	**Therionine**	**Therionine**	**Therionine**	**Therionine**

Lysine was the limiting amino acid of unsupplemented pasta (control) .On the other hand, supplementation of wheat flour improved the limiting amino acids and increased the percent of lysine in the produced uncooked pasta. This means that the presence of fiber enriched barley flour succeeded in raising the scores of the limiting amino acids in the tested samples.

Cooking quality of pasta supplemented with fiber enriched barley.

Table٧ shows cooking quality parameters for pasta products prepared with blends of wheat flour ٧٢٪ extraction and fiber enriched barley flour. The substitution of wheat flour affected significantly ($P \leq ٠.٠٥$) the cooking quality parameters. Pasta products made from wheat flour and fiber enriched barley flour were cooked in a shorter time than the control. The level of fiber enriched barley flour substitution did not affect the cooking time ($P \leq ٠.٠٥$). Similar results were obtained by Marconi *et al.,* (٢٠٠٠).

Cooking water absorption, cooking loss and protein loss for pasta supplemented with fiber enriched barley flour increased significantly ($P \leq ٠.٠٥$) by increasing supplementation level. This may be due to that the fiber enriched barley flour had a higher content of fiber and protein. Similar results were reported by Marconi *et al.,* (٢٠٠٠). While the increase in cooking loss and protein loss in the supplemented pasta in comparison with control pasta could be a consequence of the weakened gluten network by fortification of fiber enriched barley flour. Similar results were reported by Marconi, *et al.,* (٢٠٠٠) in cooking parameters of pasta products fortified with ß-glucan enriched barley flour.

Table ٧ : Cooking quality parameters of pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour.

cooking quality parameters / supplementation ratio	Cooking time (min.)	Cooking water absorption (%)	Cooking loss (%)	Protein loss in water (mg/١٠٠g d.w)
Control ٠٪	١٢.٠٠ ± ٠.٥٠ a	١٥٠ ± ٢.٠٠ e	٥.٥٠ ± ٠.٢١ e	٦.٧٤ ± ٠.١٠ e
٥٪	١١ ± ٠.٥٠ b	١٥٢ ± ١.٠٠ d	٥.٨١ ± ٠.١١ d	٦.٨٨ ± ٠.١٢ d

١٠٪	١١.٠٠ ± ٠.٠٠ **b**	١٥٤ ± ١.٥٠ **c**	٦.٢١ ± ٠.١٧ **c**	٧.١٠ ± ٠.١٨ **c**
١٥٪	١١.٠٠ ± ٠.٥٠ **b**	١٥٦ ± ٢.٠٠ **b**	٦.٥٣ ± ٠.١٢ **b**	٧.٢٣ ± ٠.١٠ **b**
٢٠٪	١١.٠٠ ± ٠.٥٠ **b**	١٦٠ ± ٣.٠٠ **a**	٦.٨٢ ± ٠.٢١ **a**	٧.٥٠ ± ٠.١٧ **a**

± SD (Standard Deviation).

abcde: Means followed by the same letter in the same column are not significantly different ($P \leq ٠.٠٥$).

Sensory evaluation of the fiber enriched barley supplemented pasta

From Table ٨, it could be seen that all sensory characteristics of pasta supplemented with fiber enriched barley flour were higher from which made without additives D'egidio *et al.,* (١٩٩٣) and Marconi *et al.,* (٢٠٠٠).

Table ٨: Sensory evaluation of pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour.

Sensory parameters / **Supplementation Ratio**	**Appearance**	**Color**	**Flavor**	**Tenderness**	**Stickiness**	**Bulkiness**	**Firmness**	**Overall acceptability**
Optimum score	١٠	١٠	١٠	١٠	١٠	١٠	١٠	١٠٠٪ **(of control)**
٠٪	٩.٥٠ ± ٠.٥٠ **a**	٩.٠٠ ± ٠.٠٠ **a**	٩.٥٠ ± ٠.٥٠ **a**	٨.٠٠ ± ٠.٧٩ **a**	٩.٥٠ ± ٠.٥٠ **a**	٩.٥٠ ± ٠.٧٥ **a**	٩.٥٠ ± ٠.٧٣ **a**	٩٢.١٤ ± ١.٠٠ **a**
٥٪	٨.٥٠ ± ١.٠٠ **a**	٩.٠٠ ± ٠.٥٠ **a**	٩.٥٠ ± ٠.٥٠ **a**	٨.٠٠ ± ١.٠٠ **a**	٩.٥٠ ± ٠.٥٠ **a**	٩.٥٠ ± ٠.٠٠ **a**	٩.٥٠ ± ٠.٥٠ **a**	٩٠.٧١ ± ١.٠٠ **a**
١٠٪	٨.٥٠ ± ٠.٥٠ **a**	٩.٠٠ ± ١.٠٠ **a**	٩.٥٠ ± ٠.٥٠ **a**	٨.٠٠ ± ٠.١٨ **a**	٩.٥٠ ± ٠.٢٥ **a**	٨.٠٠ ± ١.٠٠ **b**	٩.٥٠ ± ٠.١٤ **a**	٨٨.٥٧ ± ١.٥٠ **a**

١٥٪	٧.٥٠ ± ٠.٤١ b	٧.٠٠ ± ١.٠٠b	٨.٥٠ ± ٠.٨٧b	٨.٠٠ ± ٠.٢٧ a	٨.٥٠ ± ١.١٤ a	٩.٠٠ ± ٠.٥٨ a	٨.٥٠ ± ٠.٧١b	٨١.٤٣ ± ١.٢٨ b
٢٠٪	٦.٥٠ ± ١.٠٠ c	٦.٠٠ ± ٠.٥٧c	٧.٠٠ ± ١.٠٠ c	٨.٠٠ ± ٠.١٢ a	٨.٠٠ ± ٠.٥٠ b	٨.٠٠ ± ١.٠٠ b	٧.٠٠ ± ٠.٥٠c	٧٢.١٤ ± ١.٦٠ c

± SD (Standard Deviation).

[abc]: Means followed by the same letter in the same column are not significantly different (P≤٠.٠٥).

It could be concluded that pasta made from wheat flour ٧٢٪ extraction with ٥, ١٠ and ١٥٪ of fiber enriched barley flour were well accepted and similarly the control pasta in most sensory characteristics and overall acceptability, while that substituted with ٢٠٪ barley flour had poor acceptability. This latter product were soft, had unsatisfactory flavor, coarse texture and darker than the other four pasta products According to these results, pasta products with a maximum ١٥٪ fiber enriched barley flour substitution was selected for biological evaluation.

Chemical composition of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ of fiber enriched barley flour.

From Table ٩ it is clear that moisture, protein, fat, fiber and ash content of barley supplemented cooked pasta were significantly (P≤٠.٠٥) increased .The increase of these content values were due to that barley enriched flour being rich in fiber, protein, fat and ash which are in accordance with those reported by Yokoyama *et al.*, (١٩٩٧) and Marconi *et al.*,(٢٠٠٠)..Also, total carbohydrates of cooked pasta supplemented with fiber enriched barley flour was significantly decreased .This was due to that the fiber enriched barley flour has a higher content of protein, fat, fiber, and ash compared to wheat flour ٧٢٪ extraction Marconi *et al.*,(٢٠٠٠).

Table ٩: Chemical composition of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ of fiber enriched barley flour.

Contents (%)	Supplementation ratio

Supplementation of barley flour in macaroni making from wheat flour

	٠٪ control	٥٪	١٠٪	١٥٪	٢٠٪
Moisture	١٢.٠٠± ٠.٢٠d	١٢.٢٠ ± ٠.١٠ c	١٢.٣١ ± ٠.١٢ b	١٢.٤٥ ± ٠.١١ b	١٢.٦٢ ± ٠.٢٠a
Protein	١٢.٢٦± ٠.١٥e	١٢.٨٥ ± ٠.١٣ d	١٣.٧٤ ± ٠.١٨ c	١٤.٦٣ ± ٠.١٦ b	١٥.٦٧ ± ٠.٢١ a
Fat	١.١٠ ± ٠.١٧d	١.١٨ ± ٠.١٢ d	١.٢٧ ± ٠.١٦ c	١.٤٨ ± ٠.١٠ b	١.٦٨ ± ٠.١٣ a
Fiber	٠.٢١ ± ٠.٠٧ e	٠.٣٢ ± ٠.١٠ d	٠.٤٧ ± ٠.١٤ c	٠.٦٣ ± ٠.١٦ b	٠.٧١ ± ٠.١٠ a
Ash	٠.٥٤ ± ٠.١٠ e	٠.٨٠ ± ٠.١٨ d	٠.٩٢ ± ٠.١٥ c	١.١٧ ± ٠.١٣ b	١.٣٨ ± ٠.١٢ a
Carbohydrates *	٨٥.٨٩ ± ٠.٥٧ a	٨٤.٨٥ ± ٠.٣١ b	٨٣.٦٠ ± ٠.٥٢ c	٨٢.٠٩ ± ٠.٦٠ d	٨٠.٥٦ ± ٠.٤٣ e

* Carbohydrates were calculated by differences. ± S D (Standard Deviation).
[abcd]: Means followed by the same letter in the same row are not significantly different ($P \leq ٠.٠٥$)

Mineral composition of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ of fiber enriched barley flour.

The mineral composition of fiber barley supplemented cooked pasta is shown in Table ١٠. Replacing ٥, ١٠, ١٥ and ٢٠٪ of wheat flour ٧٢٪ extraction with barley flour significantly increased ($P \leq ٠.٠٥$) P, Ca, Mg and Zn contents of the produced cooked pasta. This increase was due to that fiber enriched barley flour being rich in P, Ca, Mg and Zn compared to wheat flour(٧٢٪ extraction) while, Na, K, Fe and Mn contents of cooked pasta supplemented were significantly decreased with increasing the level of substitution. The decrease was due to that barley flour being poor in Na, K, Fe and Mn compared to wheat flour (٧٢٪ extraction) similar results were reported by Pedersen *et al.*, (١٩٨٩) and Yokoyama *et al.*, (١٩٩٧). Who reported that the supplementation of wheat flour ٧٢٪ extraction with fiber enriched barley flour increased the total ash content of the produced pasta

Table ١٠: Mineral composition of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ levels of fiber enriched barley flour (mg/١٠٠ dry weight).

Minerals	Supplementation ratio				
	٠٪	٥٪	١٠٪	١٥٪	٢٠٪
Na	١٣.٨٢ ± ٠.١٢ a	١٣.٧١ ± ٠.١٧ a	١٣.٦٢ ± ٠.١٠ b	١٣.٥٥ ± ٠.١٢ b	١٣.٤٢ ± ٠.١٨ c
P	١٣٠ ± ٣.٤٠ e	١٣٦ ± ٢.٠٠ d	١٤٢ ± ٣.١٠ c	١٥٣ ± ٤.٠٠ b	١٦٠ ± ٦.١٠ a
K	١٣٧ ± ١.٥٠ a	١٣٢ ± ٢.٤٠ b	١٢٩ ± ٣.١٢ c	١٢٤ ± ٢.٦٦ d	١٢٠ ± ١.٤١ e
Ca	٥٠ ± ٢.٦٦ e	٦٠ ± ١.٧٣ d	٦٥ ± ٢.١١ c	٧٣ ± ٢.٠٠ b	٨٦ ± ٣.١٢ a
Mg	٤٩ ± ٢.١٢ b	٥٠ ± ٢.٥٠ b	٥١ ± ٢.٤٠ b	٥٤ ± ٢.٠٠ a	٥٦ ± ٢.٥٦ a
Zn	٣.٠٢ ± ٠.١١c	٣.٦٧ ± ٠.١٥b	٤.٠٣ ± ٠.١٣b	٤.٤٢ ± ٠.١٦ a	٤.٥١ ± ٠.١٤a
Fe	٢.٤٠ ± ٠.١١a	٢.٣١ ± ٠.١٠a	٢.٢٠ ± ٠.١٢ b	٢.١٠ ± ٠.١١ c	٢.٠٠ ± ٠.١٢ c
Mn	٣.٠٠ ± ٠.١٢ a	٢.٨٢ ± ٠.١٥ b	٢.٧٠ ± ٠.١١b	٢.٦١ ± ٠.١٦ c	٢.٥٠ ± ٠.١١ c

± S D (Standard Deviation).

[abcd]: Means followed by the same letter in the same row are not significantly different (P≤ ٠.٠٥)..

Amino acid composition and chemical score of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ of fiber enriched barley flour.

Results in Table١١ show that supplementation of wheat flour (٧٢٪ extraction) with barley flour significantly (P≤٠.٠٥) increased leucine, lysine, therionine and tryptophan contents of the produced cooked pasta compared to the cooked control. This increase trend was coincided with the increasing levels of substitution. While, isoleucine, methionine + cystine, phenylalanine + tyrosine and valine contents of barley enriched cooked pasta were decreased with increasing the level of substitution. These findings are in agreement with those reported by Pedersen *et al.,* (١٩٨٩).

Regarding to the non essential amino acid composition of fiber enriched barley cooked pasta, alanine, histidine aspartic acid, serine and arginine were increased with increasing the level of

substitution, while glutamic acid, glycine, and proline were decreased with increasing the levels of substitution. This was due to fiber enriched barley flour being rich in alanine, aspartic acid, serine, histidine and arginine and poor in glutamic acid, glycine, and proline compared to wheat flour ٧٢٪ extraction. Similar results were obtained by Pedersen *et al.,* (١٩٨٩) and Yokoyama *et al.,* (١٩٩٧).

Barley flour significantly (P≤٠.٠٥) decreased LDL-cholesterol, triglycerol in rats than those fed on casein diet (Table ١٢). Similar results were obtained by Kahlon *et al.,* (١٩٩٢), who reported that β-glucan rich diet caused reduction in the LDL- cholesterol, triglycerol and risk ratio levels in the serum and liver of rats. The HDL-cholesterol level was found to be higher in the serum and liver of rats that fed on fiber enriched barley flour diet than those that fed on casein diet. Similar results were obtained by Kalra and Jood, (٢٠٠٠) .

Supplementation of barley flour in macaroni making from wheat flour

Table ١١: Amino acid composition of cooked pasta supplemented with ٠, ٥, ١٠, ١٥ and ٢٠٪ of fiber enriched barley flour (g/١٦g nitrogen).

Amino acid	Supplementation ratio				
	٠٪	٥٪	١٠٪	١٥٪	٢٠٪
Essential A.A.					
Leucine	٦.٢١ ± ٠.١١ e	٦.٣٨ ± ٠.١٤ d	٦.٤٥ ± ٠.١٥ c	٦.٦١ ± ٠.١٠ b	٦.٧٤ ± ٠.١٢ a
Iso leucine	٣.٢٣ ± ٠.١٣ a	٣.١١ ± ٠.١٠ b	٣.٠٤ ± ٠.١٢ c	٢.٩٧ ± ٠.١٤ d	٢.٩٠ ± ٠.١٠ e
Lysine	٢.٢٤ ± ٠.١٥ e	٢.٤٣ ± ٠.١٤ d	٢.٦٤ ± ٠.١٢ c	٣.٠٢ ± ٠.١٤ b	٣.١٨ ± ٠.١٠ a
Methionine+cystine	٤.٣٥ ± ٠.١٥ a	٤.٢٢ ± ٠.١٢ b	٤.١٣ ± ٠.١٠ c	٤.٠٢ ± ٠.١٥ d	٣.٨٥ ± ٠.١٢ e
Phenylalanine+tyrosine	٧.٨٥ ± ٠.١٣ a	٧.٨٠ ± ٠.١٥ a	٧.٧١ ± ٠.١٢ b	٧.٦٠ ± ٠.١٦ b	٧.٥١ ± ٠.١١ c
Therionine	٢.٩٤ ± ٠.١١ e	٣.٠٥ ± ٠.١٠ d	٣.٢٢ ± ٠.١٣ c	٣.٤١ ± ٠.١١b	٣.٥٧ ± ٠.١٤ a
Valine	٥.١١ ± ٠.١٠ a	٥.٠٠ ± ٠.١٢ ab	٤.٩١ ± ٠.١٥ b	٤.٨١ ± ٠.١٢ c	٤.٧٢ ± ٠.١١ c
Tryptophan	٠.٨٢ ± ٠.١٢ d	٠.٩٠ ± ٠.١٠ d	١.١٠ ± ٠.١٣ c	١.٢٧ ± ٠.١٣ b	١.٣٨ ± ٠.١٥ a
Total	٣٢.٧٥ ٠.١٧e	٣٣.٠٠ ± ٠.١١ d	٣٣.٢٠ ± ٠.٢٤ c	٣٣.٤٠±٠.١٢ b	٣٣.٥٠ ± ٠.١٥a
Non-Essential A.A.					
Alanine	٣.٢٨ ± ٠.١٢	٣.٣٩ ± ٠.١٠	٣.٤٨ ± ٠.١٤	٣.٦١ ± ٠.١٠	٣.٧٣ ± ٠.١٦
Aspartic acid	٤.٣٢ ± ٠.١٣ e	٤.٤٦ ± ٠.١٥ d	٤.٥٩ ± ٠.١١ c	٤.٨٣ ± ٠.١٥ b	٥.١١ ± ٠.١٦ a
Glutamic acid	٣٠.٠٠ ± ٠.٢٢ a	٢٩.٤١±٠.١٥ b	٢٩.١١ ± ٠.١٢ c	٢٨.٥٥ ± ٠.١٦ d	٢٧.٩٤ ± ٠.٢١ e
Glycine	٣.٩٤ ± ٠.١٣ a	٣.٨٢ ± ٠.١١ b	٣.٧١ ± ٠.١٥ b	٣.٥٩ ± ٠.١٥ c	٣.٤٤ ± ٠.١١ d
Histidine	٢.٢١ ± ٠.١١ c	٢.٣١ ± ٠.١٧ c	٢.٤٢ ± ٠.١٥ b	٢.٥٧ ± ٠.١١ b	٢.٧١ ± ٠.١٣ a
Proline	١٠.٣٢ ± ٠.١٣ a	١٠.١٨±٠.١١ b	١٠.٠٠ ± ٠.١٧ c	٩.٨٩ ± ٠.١٥ d	٩.٧٨ ± ٠.١٠e
Serine	٥.٤٧ ± ٠.١٤ d	٥.٦٢ ± ٠.١٠ c	٥.٨٠ ± ٠.١٢ b	٥.٩٤ ± ٠.١١b	٦.١١ ± ٠.١٩ a
Arginine	٣.٩١ ± ٠.١٢ d	٤.٠٢ ± ٠.١٠ d	٤.١٣ ± ٠.١٥ c	٤.٢٩ ± ٠.١١ b	٤.٤٥ ± ٠.١١ a
Total non. E.A.A.	٦٣.٤٥ ± ٠.١٧a	٦٣.٢١ ± ٠.٢١ b	٦٣.٢٤ ± ٠.١٠b	٦٣.٢٧ ± ٠.٢١b	٦٣.٢٢ ± ٠.١٧b
E.A.A/Non A.A. ratio	٠.٥١	٠.٥٢	٠.٥٢٥	٠.٥٢٧	٠.٥٣

± SD Standard Deviation.

[abcd] :Means followed by the same letter in the same row are not significantly different (P≤ ٠.٠٥).

Supplementation of barley flour in macaroni making from wheat flour

Table ١٢. Effect of wheat flour ٧٢٪ extraction fiber enriched barley flour, on total cholesterol, LDL cholesterol ,HDL-cholesterol, triglyceride and risk ratio by feeding rats for ٦ weeks .

Diets	Total-Cholesterol		LDL-Cholesterol		HDL-Cholesterol		Triglycerides		Risk ratio (*)
	Serum*	Liver**	Serum	Liver	Serum	Liver	Serum	Liver	
Casein diet	٢٤١±٢.٥٠a	٥ ± ١.٠٠a	١٦٨±٢.٧٠a	٤.٧ ± ٠.٥٠a	٤٥.٥٠±١.٨٠e	٠.١٨±٠.١٠e	١٦٤±٢.٠٠a	٠.٧٦±٠.١٠a	٥.٢٩a
Wheat flour	١٧٣±٢.٥٠b	٣.١٥±٠.٣١b	١٠١±٢.٣١b	٣.٢٢±٠.٢٠b	٥٠ ± ٠.٨٨d	٠.٢٠±٠.١١d	١٤٣±٢.٠٠b	٠.٦١±٠.١٧b	٣.٤٦b
Fiber enr.barley flour	١٣٨±١.٠٠f	٢.٢٧±٠.١٨f	٥٠ ± ٠.٥٠f	١.٣٠±٠.١٧f	٦٤.١٥±٠.٣٠ a	٠.٣٨±٠.١٠b	١٢٠±١.٤٠d	±٠.٣٧٠.١٠e	٢.١٥e

± SD Standard Deviation * mg/١٠٠m ** mg/g.

(*) Risk Ratio = $\frac{\text{Total-Cholesterol}}{\text{HDL-Cholesterol}}$

abcdef: Means followed by the same letter in the same row are not significantly different ($P \leq ٠.٠٥$).

It could be concluded that use of fiber enriched barely flour at ١٥٪ was effective to improve the nutritional and functional properties of pasta. Total cholesterol, LDL cholesterol, triglyceride and risk ratio values of those rats were significantly decreased while; HDL cholesterol value was increased with adding the fiber enriched fiber barley flour

Fiber enriched fiber barley flour can be successfully incorporated into pasta formulation upon ١٥٪ substitution level resulting in pasta samples with acceptable quality characteristics.

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Supplementation of barley flour in macaroni making from wheat flour

تأثير تدعيم دقيق القمح ٧٢٪ بدقيق الشعير عالى الألياف على إنتاج المكرونة.

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تم استبدال دقيق القمح استخراج ٧٢% بدقيق الشعير الغني بالألياف بنسب ٥ و١٠ و ١٥ و ٢٠% اجري تصنيع مكرونة من هذا المخلوط. درست الخواص الكيميائية ومحتوي المعادن والأحماض الامينية للمخلوط والمكرونة الخام والمطبوخة. أيضا تم دراسة تأثير التغذية علي المكرونة المحتوية علي ١٥% دقيق شعير الغني بالألياف علي مستويات كل من والكوليسترول الكلي والكوليسترول المنخفض والعالي الكثافة و الجليسريدات الثلاثية في دم وبلازما وكبد الفئران.

أظهرت النتائج أن إضافة دقيق الشعير الغني بالالياف رفع نسب كل من البروتين والدهون والألياف والمحتوي المعدني والأحماض الامينية في المكرونة الناتجة. انخفض مستويات كل من والكوليسترول الكلي والكوليسترول المنخفض الكثافة و الجليسريدات الثلاثية في دم وبلازما وكبد الفئران. يمكن استخدام دقيق الشعير الغني بالألياف حتي مستوي ١٥% في تصنيع مكرونة لها خصائص وظيفية و جودة مقبولة.