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Effect of Enrichment Wheat Flour 72% with De-coated Mung Bean Flour on Macaroni Production

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Abstrat

Wheat flour 72% extraction was replaced with decoated mung bean flour at 0, 5, 10, 15 and 20% levels and processed into pasta. The physiochemical properties, minerals and amino acids composition of raw materials, composite flour and cooked pasta were determined. Cooking effect and sensory properties of the produced pasta were evaluated. Protein Efficiency Ratio (PER), Biological value (BV), Serum and liver lipids, and blood glucose were studied. The results indicated that the addition of decoated mung bean flour to wheat flour (72%) increased protein, fat, fiber, minerals and amino acids of the formulas and the produced pasta with increasing the substitution levels of mung bean flour. Weight gained, PER, NPU, TD and BV values of rats fed on decoated mung bean flour and cooked pasta supplemented with 15% mung bean flour were significantly increased. Total cholesterol, LDL cholesterol, triglyceride, risk ratio, glucose level, and Glycemic index (GI) values of those rats were significantly decreased while, HDL cholesterol value was increased. Mung bean flour can successfully incorporated into pasta formulation upon 15% substitution level from wheat flour (72% extraction) resulting pasta samples with acceptable quality characteristics.

Introduction

Pasta is the second most consumed in the world after bread. Its almost 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. The glycemic index provides a means of quantifying the effect of ingestion of a food product on the blood glucose level when compared with standard white bread or glucose (Newman *et al.*, 1994 and Jenkins *et al.*, 2000). Leguminous seeds constitute one of the richest and cheapest sources of proteins and are consequently becoming an important part of the people's diet in many parts of the world. Mung bean (*Vigna radiata* (L) Wilcezk) is one of the edible legumes, widely distributed in different countries all over the world. In Egypt, it has been recently introduced by Ministry of Agriculture, that mung bean contribute to increasing the supply of plant protein for human consumption.

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Mung bean seeds have a high content of protein (>25%) and rich in lysine. It could be combined with cereals and grains which have low protein and are poor in certain amino acids "in particular lysine" to make new products with improved amino acids and good quality protein. In addition, its natural high digestibility, balanced amino acids composition, and reasonable amount of minerals make cereal-mung bean based products very nutritious foods. Mung bean seeds contained β-galactoligosaccharide (glactosyl-sucroseoligosaccharides) including raffinose, stachyose and verbascose and consist of galactose residues linked β 1-6 to the glucose moiety of sucrose (El-Morsi and Gad-El-Hak,1985). The physiological effects of these compounds may relieve constipation, improve calcium and iron absorption and retard the development of colon cancer in rats model systems (Schoterman and Timmermans, 2000).

Materials and Methods

Materials:

Wheat flour: Wheat flour 72% extraction used in the present study was obtained from Gerga mill, Upper Egypt Milling Company, Sohag, Egypt. The flour was passed through a 60 mesh sieve, packaged and stored until analysis and processing.

Mung bean seeds: Mung bean seeds (*Vigna radiata(L) wilezek*) of Giza(1) variety season 2007 was obtained from Agronomy Department, College of Agriculture, Minia University , Egypt during 2007 season .

Preparation of mung bean flour :

The cleaned Mung bean seeds were split ,the splits were soaked in access tap water for 3-4 hr and the hulls were removed by hand (Chung *et al.*, 2000). The dried dehulled cotyledons were milled into a straight grade flour 85.7% extraction. The produced mung bean flour was passed through a 70 mesh sieve, packaged and stored until analyzed and processing.

Methods:

Pasta formula

Wheat flour 72% extraction supplemented with decoated mung bean flour at levels of 0, 5, 10, 15 and 20% (Table (1). Pasta was prepared on a commercial scale according to the method described by Singh *et al.*, (2004) the pieces of pasta were ground to uniform particle size to pass through 20 mesh sieve. The ground pasta was analyzed for moisture, protein, fat, fiber, ash, mineral and amino acids.

Animals: Albino rats of Sprague Dawley strain of four weeks age, weighing 50 + 4 grams were obtained from Egyptian Organization for pharmaceutical products and vaccines- Helwan, Egypt and were used in the biological assays.

Table (1): Pasta formulas made from wheat flour 72% extraction supplemented with different levels of mung bean flour.

Blends		Wheat flour (72%).		Decoated mung bean flour		Water	
		Kg	%	Kg	%	Kg	%
Control	0	25	100	-	-	7.75	31
Formulas contained mung bean flour	5%	23.750	95	1.250	5	7.75	31
	10%	22.500	90	2.500	10	7.875	31.50
	15%	21.250	85	3.750	15	7.925	31.70
	20%	20.00	80	5.00	20	8.00	32.00

Chemical methods.

Moisture, protein, fat, and ash contents of each sample was determined according to (AACC 2000) method .

Dietary fiber determination.

Total dietary fiber of samples was determined according to AOAC (AOAC, 1995).

Carbohydrates determination .

The carbohydrates were calculated by differences .

Minerals determination.

Total content of Na, P, K, Ca, Mg, Fe, Zn and Mn were determined according to Chapan and Pratt, (1978).

Amino acids determination

Amino acids determination was performed according to the method of Winder and Eggum, (1966).

Tryptophan was determined according to the method of Sastry and Tummuro, (1985).

Sensory evaluation.

Sensory analysis was determined according to the sensory assessment procedure reported by Cubadda, (1988).

Biological methods:

Protein Efficiency Ratio (PER): PER was measured according to Osborne *et al.*, (1919)

Biological value (BV): It was calculated according to Mitchell, (1924).

Serum and liver lipids determination:

Total cholesterol, HDL-cholesterol and triglyceride contents in serum were determined according to Kalra and Jood, (2000). LDL-cholesterol was calculated as described by Friedewald *et al.*, (1972). Lipids were extracted from liver tissues by the method of Folch *et al.*, (1957).

Blood glucose and glycemic index determination:

Blood glucose levels and glycemic index were determined according to the procedures of Goni and valentin ,(2003) .

Statistical Analysis.

The chemical, physical, biological results and sensory evaluation were expressed as the means ± standard deviation (S.D). Data was analyzed with GLM (General Linear Model) program using statistical analysis system (SAS, 1987). Mean values were compared by Duncan's Multiple Range Test (1955).

Results and Discussion

Chemical composition of wheat flour 72% extraction and decoated mung bean flour.

The chemical composition of wheat flour is shown in Table (2). These results were accordance with those reported by Abd El-Baki (1999) and Gad El-Kareem (2006), who noticed that wheat flour 72% extraction, has a low content of protein, fat, fiber and ash and a high content of carbohydrates. This might be due to the fact that wheat flour 72% extraction is freed from the outer layers of wheat grains which are rich in protein, fat, fiber and ash. From these results, it could be noticed that, mung bean flour is rich in protein, carbohydrates and has a high amount of ash and fiber. These results were found to be in accordance with those data reported by Nagib, (1998), El-Reffaei, (1999) and Gad El-Kareem, (2006).

Table (2): Chemical composition of wheat flour 72% extraction and decoated mung bean flour (On a dry weight basis) .

Contents (%)	**Wheat flour72%extr.**	**Decoated mung bean flour**
Moisture	13.94 ± 0.15	8.66 ± 0.12
Protein	12.12 ± 0.11	26.90 ± 0.20
Fat	0.98 ± 0.07	1.66 ± 0.19
Dietary Fiber	0.16 ± 0.06	2.49 ± 0.24
Ash	0.48 ± 0.08	3.90 ± 0.35
Carbohydrates*	86.26 ± 0.14	65.05 ± 0.23

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

Mineral content

The contents of macro elements (Na, P, K, Ca, and Mg) and micro elements (Fe, Zn, and Mn) of the wheat flour 72% extraction and decoated mung bean flour were determined. The results are presented in Table (3). It could be noticed that the decoated mung bean flour is rich in P, K, Ca,Fe and Mg and had the lowest value of Mn and Zn. These results were Similar to which were reported by Nagib, (1998) and El-Reffaei, (1999).

Table (3): Mineral composition of wheat flour 72% extraction and decoated mung bean flour (mg / 100g dry weight).

Elements (mg/100g)	Wheat flour 72% extraction	Mung bean flour
Na	14.80 ± 1.50	7.92 ± 0.12
P	128 ± 1.73	997 ± 7.00
K	133 ± 2.71	1212 ± 17
Ca	54 ± 1.00	140 ± 1.00
Mg	149 ± 7.00	250 ± 5.00
Zn	3.30 ± 0.17	2.60 ± 0.16
Fe	2.50 ± 0.16	6.16 ± 0.20
Mn	2.80 ± 0.10	2.03 ± 0.15

Amino acids :

All amino acids were identified in wheat flour 72% extraction. When compared to protein pattern of FAO/WHO, (1973), it found that lysine is lower amino acid and some other essential amino acids showed a marked decrease in wheat flour 72% extraction including leucine, isoleucine. and therionine. Similar results were obtained by Bushuk, (1974) and Abd El-Baki, (1999). It could be noticed that 17 amino acids were identified in the decoated mung bean flour. All the essential amino acids of decoated mung bean flour are not limiting except methionine and therionine which the limiting amino acids. The chemical score of phenylalanine + tyrosine, isoleucine and lysine increased in decoated mung bean flour when compared to protein pattern of FAO/WHO, (1973).Whereas methionine + cystine, therionine and leucine were decreased Regarding to-Table (4), glutamic acid was the highest amino acid followed by asparatic acid. Similar results were obtained by El-Reffaei, (1999). Results in Tables (4) and (5), indicated that as the mung bean flours had a high content of protein (> 25%), rich in lysine and the chemical score than that of wheat flour 72% extraction. Mung bean flour may be combined with cereals and grains which have low protein and are poor in certain amino acids, in particular lysine, for making some new products with improved amino acids and good quality protein. In addition, the nature of high digestibility and balanced amino acids composition make cereal mung bean based products a very nutritious food.

Table (4): Amino acids composition of the wheat flour 72% extraction and decoated mung bean flour (g / 16 gN.)

Amino acids	Wheat flour 72% extraction.	Decoated mung bean flour	FAO/WHO 1973
Essential A.A.			
Leucine	6.41 ± 0.10	6.70 ± 0.11	7.00
Isoleucine	3.41 ± 0.12	4.50 ± 0.17	4.00
Lysine	2.38 ± 0.10	5.80 ± 0.17	5.50
Methionine + Cystine	4.54 ± 0.18	2.00 ± 0.13	3.50
Phenylalnine + Tyrosine	8.00 ± 0.30	7.50 ± 0.17	6.00
Therionine	3.13 ± 0.19	3.10 ± 0.12	4.00
Valine	5.29 ± 0.27	5.00 ± 0.15	5.00
Tryptophan	1.07 ± 0.03	1.00 ± 0.05	1.00
Total E.A.A	34.23 ± 0.80	35.60 ± 0.38	36.00
Non essential A.A			
Alinine	3.45 ± 0.18	4.90 ± 0.21	-
Aspartic	4.50 ± 0.27	15.00 ± 0.19	-
Glutamic	30.00 ± 1.21	20.30 ± 0.38	-
Glycine	4.00 ± 0.11	4.01 ± 0.10	-
Histidine	2.36 ± 0.12	2.80 ± 0.15	-
Proline	11.12 ± 0.71	4.21 ± 0.16	-
Serine	5.64 ± 031	5.51 ± 0.15	-
Arginine	4.02 ± 0.15	4.70 ± 0.10	-
Total E.A.A	65.09 ± 0.18	61.43 ± 0.48	-
E.A.A/non(*)E.A.A ratio(**)	0.53	0.58	

Table (5): Chemical score and limiting amino acid of the wheat flour 72% extraction and decoated mung bean flour (%).

Amino acids	Protein pattern FAO, 1973	Wheat flour 72%	Decoated mung bean flour
Leucine	7.00	91.57	94.00
Isoleucine	4.00	85.25	120.50
Lysine	5.50	43.27	103.27
Methinonine + cyctine	3.50	129.71	57.14
Phenylalanine+ Tyrosine	6.00	133.33	107.00
Therionine	4.00	78.25	78.00
Valine	5.00	105.80	110.60
Tryptophan	1.00	107.00	130.00
First limiting amino acid	-	Lysine	Methinonine + cystine
Second limiting amino acid	-	Therionine	Therionine

Color grade value of the composite flour

The color degree was increased with increasing the level of substitution in the blends. This increase may be due to the higher content of caroteniod and other pigments in decoated mung bean flour compared to the wheat flour 72% extraction. Similar observations were reported by Abd El-Baki, (1999) and Gad El-Kareem, (2006).

Wet Gluten content of the composite flour.

The data showed that wheat flour72% extraction had relatively higher gluten content (32%). These results are in agreement with those reported by Gad El-Kareem,(2006). Gluten content values of supplemented wheat flour decreased significantly with increasing the level decoated mung bean flour in the blends. This decrease in gluten content was due to that mung bean flour is freed from gluten. Similar trend was observed by Abd El-Baki, (1999) and Gad El-Kareem,(2006).

Table (6): Color, wet gluten%, Falling number sec. and sedimentation value ml of wheat flour 72% extraction supplemented with decoated mung bean flour

Decoated mung bean flour %	Color*	Wet gluten %	Falling number sec.	Sedimentation value (ml)
Control 0%	0.90 ± 0.09e	32.00 ±1.00a	360 ± 10a	35.50 ±1.50a
5%	1.11 ± 0.15 d	31.00 ± 0.50 b	318 ± 21 b	31.50 ± 2.00 b
10%	1.32 ± 0.12 c	28.00 ±1.50 c	285 ± 20c	31.10 ± 1.00 c
15%	1.57 ± 0.11 b	27.00 ± 1.00 d	260 ± 18 d	29.00 ± 0.71 d
20%	2..17 ± 0.19 a	25.50 ± 1.80 e	211 ± 10 e	28.50 ± 0.41e

* Kent – Jones units.

Means followed by the same letter in the same column are not significantly different (P≤ 0.05).

Falling number decreased with adding mung bean flour. Supplementation of the wheat flour with 5, 10, 15 and 20% mung bean flour decreased the falling number value Similar results were reported by Gad El-Kareem,(2006). This may be due to that mung bean flour had a higher level of α – amylase activity.

Sedimentation value of the composite flour

Data in Table (6) showed that supplementation of wheat flour with 5, 10, 15 and 20% level of decoated mung bean significantly caused a reduction in the sedimentation value of wheat flour. These findings are in agreement with those reported by Nefisa *et al.*, (1994) and Abd El-Baki, (1999), who reported that fortification of wheat flour with legume flours decreased the sedimentation value and a consequent reduction of protein quality. The weakening effect observed may be due to several factors i.e., dilution of gluten, high lipid and ash contents presented in mung bean flour

Mung bean enriched pasta cooking quality

The substitution of wheat flour 72% extraction with 5, 10, 15 and 20% of decoated mung bean flours affected significantly (P≤0.05) the cooking quality parameters. Pasta products made from wheat flour 72% extraction and decoated mung bean flours cooked in a shorter time than pasta prepared from only wheat flour, and the level of mung bean flour substitution did not affect the cooking time (P≤0.05), with the exception of pasta products fortified with 20% mung bean flour, where a slight but significantly (P≤0.05) longer time was observed in comparison with the other levels of mung bean flour substitution.

Table (7): Cooking quality of pasta supplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour.

Decoated mung bean flour %	Cooking quality			
	Cooking time (min.)	Cooking water absorption (%)	Solids loss (%)	Protein loss in water (mg/100g)
Control 0%	12.00 ± 0.50a	150.00± 2.00 e	5.50 ± 0.22 e	6.74 ± 0.15 e
5%	11.00 ± 0.50 b	156.00±3.00 d	5.61 ± 0.20d	6.82 ± 0.18 d
10%	11.00 ± 0.50 b	162.00±2.00 c	5.84 ± 0.31 c	6.98 ± 0.11 c
15%	11.00 ± 0.50 b	169 ± 1.00 b	6.10 ± 0.10 b	7.18 ± 0.10 b
20%	11.50 ± 0.50 c	176 ± 4.00 a	6.70 ± 0.15 a	7.31 ± 0.14 a

Means followed by the same letter in the same column are not significantly different (P ≤0.05).

Similar results were obtained by Torres *et al.*, (2007), who reported that pasta products made from semolina and α – galactoside-free lupin flours cooked in a shorter time than pasta prepared from only with semolina and the level of lupine flour substitution did not affect the cooking time. From results presented in Table (7) it could be noticed that the increase in cooking water absorption, cooking loss and protein loss in water in the mung bean supplemented pasta in comparison with control pasta could be a consequence of a weakening gluten network by fortification of mung bean flour. Similar results have bean reported by Bergman *et al.*, (1994) in cooking parameters of pasta products fortified with cowpea flour.

Sensory evaluation of the enriched pasta.

From the results presented in Table (8), it could be concluded that pasta made from wheat flour 72% extraction with 5, 10 and 15% of decoated mung bean flour were well accepted and similarly the control pasta in the most sensory characteristics and overall acceptability, while a substitution of 20% led to poor acceptability and had a benny flavor, a coarse texture and was darker than the other four pasta products studied. Similar results were obtained by Torres *et al.*, (2007). According to these results, pasta products with a maximum of 15% decoated mung bean flour substitution was selected for biological evaluation.

Table (8): Sensory evaluation of pasta supplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour.

Decoated mung bean flour %	Appearance	Color	Flavor	Tenderness	Stikiness	Bulkiness	Firmess	Overall accept-ability (%)
Optimum score	10	10	10	10	10	10	10	100%
0%	9.50 ± 0.50 a	9.00 ± 0.00 b	9.50 ± 0.30 a	8.00 ± 0.79 a	9.50 ± 0.50 a	9.50 ± 0.35 a	9.50 ± 0.23 a	92.11± 1.00 a
5%	9.50 ± 0.00 a	10 ± 0.00 a	9.50 ± 0.29 a	8.00 ± 0.50 a	9.50 ± 0.50 a	9.00 ± 0.00 b	9.00 ± 0.50 b	92.14 ± 0.87 a
10%	9.50 ± 0.50 a	10.00 ± 0.00 a	9.50 ± 0.25 a	8.00 ± 0.50 a	9.50 ± 0.41a	9.50 ± 0.50 a	8.50 ± 0.73 c	91.42 ± 0.92a
15%	8.50 ± 0.50 b	9.00 ± 1.00 a	8.00 ± 1.00 b	7.50 ± 0.50 a	9.00 ± 0.50 a	8.50 ± 1.00 b	8.00 ± 1.50 c	83.57 ± 1.50 b
20%	6.00 ± 0.50 c	6.50 ± 1.00 c	5.50 ± 1.50 c	7.00 ± 0.50 b	7.50 ± 1.00b	7.50 ± 1.00 c	7.00 ± 0.50 d	67.14 ± 0.87 c

Means followed by the same letter in the same column are not significantly different ($P \leq 0.05$).

Chemical composition of the cooked pasta supplemented with mung bean flour. From results presented in Table(9), it could be concluded that the supplementation of wheat flour 72% extraction with decoated mung bean flour, led to increasing the contents of the produced cooked pasta with protein, fat, fiber and ash except its content of carbohydrate was decreased. This may be due to the fact that mung bean flour had a higher content of protein, fat, fiber and ash compared to the wheat flour 72% extraction (El-Adawy, 1996 and Gad El-Kareem, 2006)

Table (9): Chemical composition of the cooked pasta upplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour.

Content (%)	Supplementation ratio				
	0%	5%	10%	15%	20%
Moisture	30.00± 0.20e	31.21± 0.11d	32.25± 0.15c	33.50± 0.18b	34.83± 0.17a
Protein	12.16± 0.15e	12.61± 0.14d	13.52 ±0.21c	14.48± 0.24b	15.46± 0.12a
Fat	1.00± 0.12e	1.10± 0.10d	1.22± 0.13c	1.40± 0.11b	1.57± 0.14a
Fiber	0.17± 0.04e	0.28± 0.10d	0.41± 0.13c	053 ±0.14b	0.62± 0.13a
Ash	0.41± 0.10e	0.71± 0.15d	0.87± 0.11c	1.07± 0.10b	1.22± 0.12a
Carbohydrates(*)	86.26± 0.57a	85.30± 0.18b	83.98± 0.51c	82.52± 0.27d	81.13± 0.31e

(*) Carbohydrates were calculated by differences

Table (10): Mineral composition of the cooked pasta supplemented with 0,5,10,15 and 20% of decoated mung bean flour (mg/100g dry weight).

Content	Supplementation ratio				
	0%	5%	10%	15%	20%
Na	13.82± 0.12a	13.61± 0.11b	13.26± 0.15c	12.91± 0.21d	12.63±0.18e
P	130 ±3.40e	132.00± 0.31d	138.18 ±0.81c	144.00 ±0.92b	151.00± 1.50a
K	137 ±1.53e	187± 2.48d	238 ±4.00c	294± 5.00b	342 ±1.81a
Ca	50± 2.56e	54.82± 1.75d	58.12± 0.31c	63.20± 0.76b	68.18 ±1.21a
Mg	49.00± 2.12e	52.50± 0.21d	71.21± 0.26c	83.13± 0.34b	94.28± 0.51a
Zn	3.02± 0.11a	3.00± 0.10a	2.90± 0.10b	2.80± 0.12b	2.60 ±0.17c
Fe	2.40± 0.11e	2.55± 0.13d	2.80 ±0.10c	3.00± 0.17b	3.25± 0.16a
Mn	3.00± 0.12a	2.81± 0.10b	2.70 ±0.10c	2.53 ±0.14d	2.42± 0.13e

Mineral composition of the cooked pasta supplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour :

Table (10) shows that phosphorus , potassium , calcium , Mg and Fe content values of mung bean supplemented cooked pasta were significantly ($P \leq 0.05$) increased at a level 5,10,15 and 20% of mung bean flour compared to the control .This increase was due to that mung bean flour is rich in this minerals compared to the wheat flour 72% extraction . On the other hand Na, Zn and Mn content values of the cooked pasta supplemented with mung bean flour were significantly ($p \leq 0.05$) decreased with increasing the substitution level. This reduction was due to that mung bean flour had a lower content of Na, Zn and Mn than the wheat flour (Nagib, 1998 and El-Reffaei, 1999).

Amino acids composition of the cooked pasta supplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour.

From results in Table (11) noticed that the leucine , isoleucine , lysine, Phenylalanine + tyrosin, valine and tryptophan content values of the cooked pasta supplemented with 5, 10, 15 and 20% decoated mung bean flour were significantly ($p \leq 0.05$) increased compared to the control . This increase was due to their higher contents in mung bean flour than wheat flour 72% extraction (Finney *et al.*, 1982 Nagib, 1998 and El-Reffaei, 1999). Methionine + cystine and therionine values were significantly ($p \leq 0.05$) decreased with increasing the levels of substitution. This reduction was due to their lower contents in mung bean flour compared to the wheat flour 72% extraction (Finney *et al.*, 1982). Nagib, (1998) and El-Reffaei, (1999).

Table (11): Amino acid composition of the cooked pasta supplemented with 0, 5, 10, 15 and 20% of decoated mung bean flour (gram/16 gram nitrogen)

Amino acid	Supplementation ratio				
	0%	**5%**	**10%**	**15%**	**20%**
Essentia AA					
Leucine	6.21± 0.11d	6.38± 0.15c	6.52± 0.21b	6.65± 0.14ab	6.71 0.17a
Isoleuine	3.23± 0.13e	3.36± 0.16d	3.46± 0.14c	3.58 0.08b	3.70 0.18a
Lysine	2.24±0.15e	2.38± 0.12d	2.57± 0.16c	2.99±0.09b	3.22 0.13a
Methionime + cystine	4.35± 0.15a	4.21± 0.11b	4.05 ±0.14c	3.90± 0.17d	3.71 0.19e
Phenylalanine + tyrosine	7.85± 0.13e	8.00 ±0.22d	8.10 ±0.14c	8.19± 0.16b	8.29 0.22a
Therinine	2.94± 0.1al	2.81 ±0.17b	2.62 ±0.12c	2.51± 0.17d	2.38 0.06e
Valine	5.11 ±0.10e	5.17± 0.12d	5.28 ±0.13c	5.51± 0.11b	5.73 0.14a
Tryptophan	0.82 ±0.12e	0.93 ±0.10d	1.05± 0.05c	1.11± 0.08b	1.19 0.14a
Total E.A.A	32.75 ±0.17e	33.24±0.10d	33.65±0.11c	34.13±0.11b	34.61±0.15a
Non. Essental A.A					
Alanine	3.28± 0.12e	3.49± 0.14d	3.78 0.13c	3.97± 0.11b	4.19± 0.17a
Aspartic acid	4.32 ±0.13e	4.71± 0.11d	5.20 0.15 c	5.63± 0.17b	6.10± 0.10a
Glutamic acid	30.00±0.22a	28.98± 0.18b	28.00 0.19c	27.75± 0.20d	26.24± 0.19e
Glysine	3.94 ±0.13a	3.86± 0.10ab	3.75 0.10b	3.68± 0.12c	3.50± 0.11d
Histidine	2.21 0.11e	2.30± 0.15d	2.41 0.11c	2.53± 0.18b	3.14± 0.15a
Proline	10.32± 0.13a	9.85± 0.21b	9.53 0.17c	9.28± 0.11d	8.90± 0.21e
Serine	5.47±0.14a	5.38± 0.13b	5.20 0.10c	5.10 ±0.12c	4.93± 0.10d
Arginine	3.91± 0.12c	4.18 ±0.16b	4.20 0.19b	4.22± 0.17b	4.56± 0.13a
Total non-E.A.A	63.45±0.17a	62.75±016b	62.07±0.15d	62.36±0.21c	62.06±0.18d
E.A.A/Non-EAA ratio	**0.52**	**0.53±**	**0.54**	**0.55**	**0.65**

Means followed by the same letter in the same row are not significantly different ($p \leq 0.05$).

Biological evaluation :

Body weight :

Data in Table (12) shows that rat groups fed decoated mung bean flour gained in their body weight higher than those fed on wheat flour which gained little weight. It could be noticed that decoated mung bean flour were approximately identical with that of rats fed on casein, this could be explained due to their protein content. These findings are in agreement with the results of Abd El- Baki , (1999).It could also be concluded that the decrease in gain of body weight of rats fed on untreated pasta was not due to a decrease in protein intake. For these reasons the protein efficiency ratio of the different diets are calculated. These findings are in agreement with the results of Abd El-Rahim *et al.*, (1985), who found that body weight gain correlated better with protein efficiency ratio (PER) than with the protein intake .

True Digestibility (TD)

From the data presented in Table (12) it is clear that the legume flour (mung bean) and substituted pasta products exhibited higher TD than the wheat flour and the untreated pasta products . The highest value of the TD was observed in the group of rats that fed on casein diet followed by the pasta supplemented with 15 % decoated mung bean flour this may be due to its high essential amino acid of casein, defatted soy bean and decoated mung bean flour

Net Protein Utilization(NPU)

The addition of decoated mung bean flour to pasta products increased the NPU from 55.05 in untreated pasta to 66.93.

Table (12): Protein efficiency ratio (PER), True digestibility (TD), Net Protein Utilization (NPU), Biological Value (B.V), and Body weight gain (B.W) of rats fed on flour and pasta products.

Experimental Diets	B.W	PER	TD	NPU	B.V
Wheat Flour 72% Extraction	60 ± 2.00h	1.40 ± 0.15 h	74 ± 1.50 h	50 ± 0.42 k	68 ± 0.40 j
Decoated mung bean flour	66 ± 2.25e	1.75 ± 0.13 d	78 ± 1.67 d	60.84± 0.57 f	78 ± 0.81 f
Casein Diet	72 ± 0.51 a	2.88 ± 0.17 a	91 ± 1.52 a	77.50 ± 1.00 a	85.16 ± 1.50 a
15% Mung bean enriched pasta	71 ± 0.87b	2.29 ± 0.15 b	81.85 ± 0.92 c	66.93 ± 0.50 c	81.77 ± 1.15c
Untreated pasta (control)	55 ± 0.72 k	1.57 ± 0.10 f	75.22 ± 1.20 f	55.05 ± 0.50 i	73.18 ± 0.63 i

Each Value represents the mean of four rats ± SD

Means followed by the same letter in the same row are not significantly different ($P \leq 0.05$)

Biological value (BV)

Data in Table (12) it was found that the highest percentage of biological value was noticed for rats that fed on casein diet, decoated mung bean flour. These results are in accordance with those obtained by Chandrasekharappa, (1979) and Abd El-Baki, (1999). The low nutritional value of the wheat flour may be explained by the deficient of lysine content in wheat flour. The high fiber content of fiber enriched barley flour may be contributing to the nutritive value.It has been demonstrated that the nutritive value of the untreated pasta protein is low but its amino acid profile can be improved through the addition of plant protein or lysine. On the other hand mung bean and soy bean protein are deficient in S-containing amino acid but have an adequate lysine content (El–Reffaei, 1999)

Effect of the untreated pasta diet on lipid components of serum and liver of rats.

The data in table(13) revealed that total cholesterol, LDL - cholesterol, triglycerides and risk ratio values were significantly decreased in plasma and liver of rats fed on the untreated pasta compared to those values in serum and liver of rats that fed on the casein diet .These results are in agreement with those of Jenkins *et al.* (1999) and Kahlon and Chow, (2000), who reported that high intakes of gluten and dietary fiber of wheat products may have beneficial effects on cardiovascular disease risk by reducing oxidized LDL, serum triglycerides and uric acid. They also binding of bile acids and increasing the fecal extraction .

Effect of the mung bean supplemented pasta diet on lipid components of serum and liver of rats.

The results are summarized in Table (13). A significantly lower level of total cholesterol was observed in the serum and liver of rats that fed on decoated mung bean supplemented pasta diet compared to their values in those that fed on casein diet. This may be due to the present of nondigestibility oligosaccharides in mung bean flour which reducing the total cholesterol and LDL – cholesterol in rats A similar trend was observed by Yamashita et al., (1984). On the other hand, HDL – cholesterol was increased in the serum and livers of rats that fed on decoated mung bean supplemented pasta diet compared to their values in serum and livers of rats that fed on the casein diet. Similar results were obtained by Abd El-latif et al., (2006) in hyperlipidemic subjects fed on soy flour

Table (13): Effect of wheat flour 72% extraction and mung bean flour on total cholesterol, LDL cholesterol ,HDL-cholesterol, triglyceride and risk ratio by feeding rats for 6 weeks .

Experimental diets	Total-Cholesterol		LDL-Cholesterol		HDL-Cholesterol		Triglycerides		Risk ratio (*)
	Serum*	Liver**	Serum	Liver	Serum	Liver	Serum	Liver	
Casein diet	241 ±2.50a	5.00 ± 1.00a	168 ±2.70a	4.7.00 ± 0.50a	45.50 ±1.80e	0.18 ±0.10e	164 ±2.00a	0.76 ±0.10a	5.29a
Wheat flour	173 ±2.50b	3.15 ±0.31b	101 ±2.31b	3.22 ±0.20b	50.00 ± 0.88d	0.20 ±0.11d	143 ±2.00b	0.61 ±0.17b	3.46b
Decoated mung bean flour	15 ±1.50c	2.96 ±0.20c	64 ± 1.50c	2.67 ±0.11c	60.21 ±0.50c	0.28 ±0.10c	132 ±1.00c	0.53 ±0.12c	2.61c

* mg/100ml ** mg/g.

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

Means followed by the same letter in the same row are not significantly different (P ≤ 0.05).

The serum and liver triglyceride level for rats that fed on decoated mung bean supplemented pasta diet were significantly (P≤0.05) lower .Similar observation have also been reported earlier for rats fed on soy bean flour Abd El –Latif et al., (2006) . The risk ratio (total – cholesterol HDL-cholesterol) was lower for the rats fed on the decoated mung bean supplemented pasta diet compared with the casein diet group.

Effects of Wheat flour (72%),decoated flour mung bean flour and their pasta products on blood glucose level of rats :

The results presented in Table (14) revealed that the blood glucose level values of rats that fed on diets contained decoated mung bean flour were significantly (P≤0.05) decreased compared to their values in blood of rats that fed on white bread only. This reduction in blood glucose level may be due to that the decoated mung bean flour had a higher content of dietary fiber than wheat flour which reduced the rate of absorption of carbohydrates, resulting in lowered postprandial blood glucose. The blood glucose level values of rats that fed on plain pasta (control) were significantly (P≤0.05) decreased compared to white bread diets .This reduction was due to that pasta had a lower GI than white bread (Jenkins *et al.*, 1976).Blood glucose level was found to be lower in the rats that fed on cooked pasta supplemented with decoated mung bean flour than those that fed on white bread diet. This may be due to that decoated mung bean flour had a higher content of dietary fiber than white bread which is probably due to delayed gastric emptying or to slower absorption due to viscosity-related effects at intestinal surface rather than further reduction in rate of digestion (Leclere et al., 1994). From the results presented in Table (14) it may be noticed that, the incorporation of decoated mung bean flour into pasta can further reduce the glycemic and insulinemic responses of a food product already low in glycemic properties.

Table (14): Blood glucose levels of rats that fed on wheat flour and mung bean flour and their pasta products (mg/dL).

Samples	0 min.	60 min.	120 min.	180 min.	G.I
White bread	100 ± 2.00a	135 ± 2.41a	140 ± 1.00a	122 ± 1.50c	100.00a
Decoated mung bean flour	95 ± 1.50b	121 ± 2.00d	132 ± 1.67d	121 ± 1.50c	58.50d
Casein diet	95 ± 1.71b	130 ± 2.27b	136 ± 1.11b	121 ± 1.52c	61.20c
Pasta with mung bean	85 ± 1.00d	118 ± 2.00e	132 ± 1.50d	119 ± 0.87c	54.22f
Untreated pasta	85 ± 1.57d	128 ± 2.00b	134 ± 1.88c	120 ± 1.20c	72.50b

G.I = Glycemic Index.

Means followed by the same letter in the same row are not significantly different ($P \leq 0.05$).

Glycemic index (GI) of rats fed on decoated mung bean flour was lower than those that fed on the white bread. This may be due to that decoated mung bean flour had a higher content of dietary fiber which has been shown to lower postprandial glucose level and insulin response (Jenkins et al., 2000).

GI values of rats fed on plain cooked pasta, 15% mung bean cooked pasta compared to rats that fed on white bread which was 100%. This decrease in GI was due to that plain pasta, decoated mung bean flour, had a higher content of dietary fiber which reduces the absorption of carbohydrates in the small intestine than white bread (Jenkins et al., 1976 and 2000).

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تأثير تدعيم دقيق القمح 72% بدقيق فول المانج المنزوع القشرة على انتاج المكرونة

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تم اضافة دقيق فول المانج المنزوع القشرة الي دقيق القمح استخلاص 72% بنسب0 و 5 و10 و 15 و 20% اجري تصنيع مكرونة من هذا المخلوط. درست الخواص الفيزيوكيميائية ومحتوي المعادن والاحماض الامينية للمخلوط والمكرونة الخام والمطبوخة. تم تقدير تاثير الطهي والخواص العضوية الحسية للمكرونة .ايضا تم دراسة تاثير التغذية علي المكرونة المحتوية علي 15% دقيق فول المنج المنزوع القشرة علي مستويات كل من القيمة الغذائية والبيولوجية والكوليسترول الكلي والكوليسترول المنخفض والعالي الكثافة و الجليسريدات الثلاثية في دم وبلازما وكبد الفئران.

اظهرت النتائج ان اضافة دقيق فول المنج المنزوع القشرة رفع نسب كل من البروتين والدهون والالياف والمحتوي المعدني والاحماض الامينية **Chemical score** في المخلوط و المكرونة الناتجة. كما لوحظ ارتفاع كل من معدل الزيادة في وزن الفئران و **PER, NPU, TD and BV values** . بينما انخفض مستوي كل من والكوليسترول الكلي والكوليسترول المنخفض الكثافة و الجليسريدات الثلاثية و **Glycemic index (GI) values** في دم وبلازما وكبد الفئران. وقد أظهر التقييم العضوى الحسي أنة يمكن استخدام دقيق فول المنج المنزوع القشرة حتي مستوي 15% من دقيق القمح (72%) في تصنيع مكرونة لها خصائص وظيفية و جودة مقبولة.