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CHEMICAL AND NUTRITIONAL STUDIES ON MANGO SEED KERNELS

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ABSTRACT

Mango seed kernels flour (MSKF) were analyzed for proximate chemical composition, amino acid composition, functional properties and protein quality. As well as, effects of soaking in tap water or in sulphited water up to 72 hr or boiling of MSK either raw, soaked in tape water or in sulphited water were studied. From the obtained results it could be concluded that:

1- Mango seed kernel flour contained reasonable chemical composition except protein content, which was relatively low (6.61 %).

2- MSKF protein was considered a poor source of methionine, cystine and tyrosine. On the other hand, isoleucine and leucine are the predominant essential amino acids. Also, essential amino acids represented 33.47 % of total amino acids. Among non-essential amino acids, glutamic (23.23%) and aspartic acids (9.21%) were found in the highest levels. Methionine was the first limiting amino acid followed by threonine and lysine. The protein efficiency ratio (PER) and biological value were 1.914 and 69.241, respectively. It was observed that mango seed kernel flour was a rich source for valine, isoleucine and leucine when compared with FAO of school child and adult requirement patterns.

3- MSKF had relatively high water and fat absorption (186, 89 ml/100g sample, respectively), as well as good oil emulsification and foaming capacity (18 ml oil /100g sample and 51.2 %, respectively). On the other hand, foaming stability was low.

4- Raw mango seed kernels contained tannins (6.377mg catechin /g sample) and trypsin inhibitory activity (34.834 TIU/ g sample). Both soaking and boiling treatments reduced the contents of these antinutrients factors, but boiling was more effective. The in vitro protein digestibility value of raw kernel was low (21.05 %); soaking and boiling improved it. The observed improvement parreled with the reductions in tannin contents,

5- The sensory evaluation of cakes made from wheat flour and processed flour, illustrated that, there were not significant differences between the samples displaced wheat flour by 5, 10 % processed flour and control concerning appearance, color, taste and over all acceptability ($P \leq 0.05$). In addition, 15% displacement had a good scale

It could be concluded that, although mango seed kernel has a low content of protein, the quality of protein is good because it was rich in some essential amino acids, with good functional properties and high invitro digestibility. The results also indicated that, soaking and boiling treatments had a great reduction of the antinutritional factors. So the processed flour could be a principal ingredient for making products as cakes and cookies for infant and adults and also other products as bread and pastry.

Keywords: Mango seed kernels flour, chemical composition, protein quality, tannins, trypsin inhibitory activity, sensory evaluation.

ITRODUCATION

Wastes of food processing by-products had become an important factor and a serious sanitary problem that need to be studied. At present time, such efforts have been made for converting these refused materials into valuable products (Abd El- Aal *et al.* 1987; Rahma and Abd El- Aal 1988; Rashwan 1990 and Seleim *et al.* 1999). In Egypt about 32 7000 tons of mango fruit were produced in 2004 (FAO 2004). The seed represents from 8.1 to 23.24 % (with an average 17.58%) of the whole fruit weight according to mango varieties. The kernel inside seed represents 24.1 to 50% (with an average 45.38 %) of the seed and 12.5% of the whole fruit (Moharram and Moustafa 1982; Hemavathy *et al.* 1988; and Arogba 1997). However, about 40875 tons of mango seed kernels are considered as waste disposal problem every year.

The seed kernel obtained after removal the hard seed coat, is a rich source of carbohydrates and also contains 6 – 12% fat; 5.5 – 10% protein; 1.6 – 2.8 % ash and 2.6 – 5.3 % fiber (Ravindran and Sivakanesan 1996; Arogba 1997; Odunsi and Farinu 1997; Youssef 1999 and El – Soukkary *et al.*2000). Augustin and Ling (1987) and Seleim *et al.* (1999), observed that most of the essential amino acids in some varieties were at higher level than the FAO Reference protein. Also, El-Soukkary *et al.* (2000) reported that mango seed kernels had high lysine content (3.479/100g) and amino acid score (63.1%) compared with wheat flour (2.05 g/100g) and (37.27%), respectively. On the other hand, Okai and Aboagye (1990) revealed that replacing mango seed kernel up to 20% of the diet of the experimental rats had no adverse effects on growth, feed intake or liver weight. So, mango seed kernel flour could be used to produce mixtures such as bakery products.

According to Arogba (1997), the shortage in knowledge of the toxicological status, functional properties of the flour and appropriate processing technology of mango seed are behind it's limited utilization.

The present work aimed to study the chemical composition and amino acid of mango seed kernels. The effect of soaking and boiling on antinutritional factors, functional properties of the processed flour and its utilization for making some bakery products such as cup cakes were also investigated.

MATERIALS AND METHODS

Materials :

Mango seeds were collected from a local fruit-processing unit (fruit juice shops, air–dried and the kernels were removed by manual dehusking from the hard seed coat.

Methods :

1- Technological Methods

•Preparation of mango seed kernels

The kernels were manually chopped and processed as follows:

(1) Raw kernels (control)

A portion was sun–dried and ground by a hammer mill into a powdery form.

(11) Soaked kernels

(1) *Water –soaked kernels* Another part was soaked in tap water for 72 hr at room temperature (25 ± 2°C). During the soaking period, samples were withdrawn at 24 hr intervals.

(2) Sulphited water–soaked kernels

The third part was soaked in sulphited tap water (730 mg/Liter sodium metbisulfate) for not more than 72 hr with occasional decantation and replacement with an equivalent amount of water until the water remained colorless. During soaking period, samples were withdrawn at 24 hr intervals up to 72 hr according to the method described by Arogba (1997).

(C) Boiled Kernels

A part of all treated samples were blanched "boiled" in tap water for about 30 min in a stainless – steel bowl and cooled. The whole slurries were dried at 55°C overnight in an electric oven. All the treated samples were ground to pass through a 60-mesh sieve packaged in polyethylene bags and stored at 4°C until analysis. All samples were analyzed in triplicate and all results were calculated on dry weight basis.

• Technological application (Cup Cake making)

Cup cake was prepared according to the method used by Bisco Misr Company (Bennion and Bamford 1973). Cake was made from wheat flour as control and mango seed kernel flour, which was, displaced wheat flour at ratios: 0,5,10,15 and 20% and baked at 180° C for 35 min in preheated baking oven.

The cake was evaluated organoleptically for color, aroma, texture and overall acceptability according to the method of Molander (1960). Scores of judging scale were as follows: very good 8-9; good 6-7; fair 4-5; poor 2-3; very poor 0-1. The obtained data were statistically analyzed using analysis of variance (ANOVA). Also, means comparisons were performed using Duncan's multiple Range Test (Steel and Torrie 1980)

2- Analytical methods

• **Moisture, crude protein** (Nx 6.25), **crude fat, crude fiber** and **ash** were determined according to the methods of AOAC (1990). **Carbohydrate** was calculated by difference.

• **Amino acid composition**: Amino acids were determined in the acid hydrolysate according to the method described by Pellet and Young (1980) using Beckman amino acid analyzer (Model 119CL) as described by Youssef *et al.* (1986).

Table (1): The basic formula of cup cake

Ingredients	%	kg
Wheat flour (72 extraction)	31.75	8.0 kg
Sugar	26.99	6.8 kg
Fresh egg	23.81	6.0 kg
Baking powder	1.27	320 gm
Butter	15.87	4.0 kg
Dry milk powder	0.12	30.0 gm
Vanilla	0.01	2.5 gm
Orange essence	0.15	38.0 gm
Water	Variable	
	100 %	25.19 kg.

- **Computation of chemical score**
  The chemical score is defined according to Bhanu *et al.* (1991) as follows:

$$\frac{\textit{Mg}\text{ of essential amino acid in 1 gm test protein}}{\text{Mg of essential amino acid in 1gm reference protein}} \times 100$$

  The lowest score was taken as the first limiting amino acid.
- **Computation of A/E ratio**

The ratio between the content of an individual essential amino acid in the food protein (A) and the total essential amino acids contents (E) was accounted according to FAO (1985) as follows:

$$\frac{\textit{Mg of the individual essential amino acid}}{\textit{Mg of total essential amino acids}} \times 100$$

- **Computation of protein efficiency ratio** (C-PER) was calculated using the equation suggested by Alsmeyer *et al.* (1974) as follows: PER = - 0.468 + 0.454(Leucine) – 0.105 (tyrosine).
- **Computation of biological value (BV)** of protein samples was calculated according to the equation of Oser (1959) as follows:
  BV = 49.09 + 10.53 (PER)
- **In- vitro protein digestibility** was estimated according to the procedure of Saunders *et al.* (1973).
- **Tannins** in the methanol extracts were measured according to the vanillin method of Price *et al.* (1978). The developed color was read at 500 nm after 20 min at room temperature. A standard curve was prepared using catechin. Tannin content was expressed in mg catechin equivalents.
- **Trypsin Inhibitory activity** was determined by caseinolytic procedure of Kakade *et al.* (1969). Trichloroacetic acid soluble digested products were measured by the method of Lowry *et al.* (1951). Trypsin inhibitor unit (TIU) was expressed in terms of the tryptic units inhibited per gm of dry sample.

- **Phytate phosphorus** was extracted and determined according to the method of Mohamed *et al.* (1986). Phytic acid was calculated by multiplying mg phytate phosphorus by a factor 3.553, assuming that 1 mol of phytic acid ($C_6H_{18}O_{24}P_6$) contains 6 mol of phosphorus.

3- Functional properties of mango seed kernels flour.

Raw kernel was dried to be in the same case of the processed kernel (sulphited soaked and boiled) concerning moisture level and particle size. Water absorption capacity (the amount of water retained by 100g sample) and oil absorption capacity (ml oil absorbed per gram sample) were determined according to the methods of Sousulski (1962) and Sousulski *et al.* (1976), respectively. Emulsification capacity expressed (ml oil emulsified by 100 gram sample) was determined by the titration method of Beuchat (1977). Wherein, foaming capacity (percent increase in volume) and foam stability according to Coffman and Garcia (1977). Refined corn oil was used for oil absorption and emulsifying capacity studiés.

RESULTS AND DISCUSSION

Gross chemical composition of mango seed kernel flour (MSKF)

The results in Table 1 indicated that, the major component of MSKF was carbohydrates (75.97%) followed by crude oil (10.19%), crude protein (6.61%) and ash (2.28%).

Table(1) :Gross chemical composition of whole mango seed kernels flour (MSKF) (on dry wt basis).

Components	%
Crude protein	6.61
Crude oil	10.19
Crude fiber	4.95
Ash	2.28
Total carbohydrates*	75.97

* Total carbohydrates were calculated by difference.

Generally the obtained values were in line with those reported by Van Pee *et al.* (1981); Ravindran and Sivakanesan (1996); Seleim *et al.* (1999) and El – Soukkary *et al.* (2000). While Arogba (1997) had higher value of fat (14.0%) and lower value of protein (5.3%), Youssef (1999) had higher value of protein (10.20%) and lower value of fat (9.10%). Crude fiber content of MSKF (4.95%) (Table 1) was higher than values reported by the previous investigators, but it is lower than the value of 5.32% reported by Odunsi and Farinu (1997).

Amino acid composition and protein quality

The amino acid contents of MSKF were given in Table 2. The results showed that MSKF protein was considered a poor source of methionine, cystine and tyrosine. On the other hand, isoleucine and leucine are the predominant essential amino acids. Lysine (3.84%%) was higher than that the value of wheat flour (2.41) and triticale flour (3.74%) [Kassab *et al.* 2000]. Also, essential amino acids represented 33.47 % of total amino acids. These results were agreed with those of El-Soukkary *et al.* (2000). Augustin and Ling (1987) found that MSKF protein contained the most of the essential amino acids in higher levels than in the FAO (1985) reference. Among non-essential amino acids, glutamic (23.23%) and aspartic acids (9.21%) were found in the highest levels. These results were paralleled with those reported by Lasztity *et al.* (1988) and Arogba (1997). They found that amino acids presented in the greatest amount in MSKF protein were glutamic (24.27 – 27.5%) and aspartic (13-15%).

Table(2): Amino acid composition of mango seed kernel flour (MSKF) (on dry wt basis).

Amino acids	g/100g protein	Amino acids	g/100g protein
Essential amino acid		*Non essential amino acids*	
Threonine	2.74	Histidine	
Valine	3.84	Arginine	2.84
Methionine	1.24	Aspartic acid	4.65
Isoleucine	6.17	Glutamic acid	9.21
Leucine	5.69	Serine	23.23
Phenylalanine	2.62	Proline	3.14
Lysine	3.84	Glycine	4.25
Tyrosine	1.92	Alanine	4.69
Cystine	0.46		4.67
Total EAA	28.52	Total NEAA	56.69
Total (EAA+NEAA) = 85.21			

Table (3): The chemical score, computed protein efficiency ratio (C-PER) and biological value of mango seed kernel flour.

Essential Amino Acids	Protein Pattern*	Mango seed Kernel flour	Amino acids Score
Isoleucine	4.0	6.17	154.25
Leucine	7.0	5.69	81.29
Lysine	5.5	3.84	69.82
Methionine	2.2	1.24	56.36
Phenylalanine	2.8	2.62	93.57
Threonine	4.0	2.74	68.50
Valine	5.0	3.84	76.80
Limiting amino acid		Methionine	
Protein efficiency ratio (PER)		1.914	
Biological value (BV)		69.244	

***Bodwell (1981).**

Chemical scores of essential amino acids of MSKF are shown in Table 3. The results revealed that methionine was the first limiting amino acid in MSKF followed by threonine and lysine. These results were in accordance with those of Dhingra and Kapoor (1985b) and El- Soukkary *et al.* (2000), where their values of PER and BV were 1.73 and 68.10, respectively. Although the data in the present study revealed that mango kernel flour was low in protein content and very poor in methionine (sulphur-containing amino acid). So it cannot be used as a single source of it, and can be used for preparing mixtures for bakery products, since it was rich in the majority of essential amino acids.

Table 4 illustrated A/E ratio between an individuals essential amino acid content and the total essential amino acids content of mango seed kernel flour as compared with FAO requirement patterns (1985). It was observed that mango seed kernel flour was a rich source of valine, isoleucine and leucine when compared with FAO of school child and adult requirement patterns.

Table(4):A/E* ratio of mango seed kernel flour compared with FAO (1985).

Essential amino acids	FAO (1985)		Mango seed kernel flour
	School child	Adult	
Threonine	126	81	98
Valine	112	117	137
Methionine	99	153	44
Isoleucine	126	117	220
Leucine	198	171	203
Phenylalanine	99	171	93
Lysine	198	144	137

*Total essential amino acids content of MSKF=26.14

Functional properties of processed mango seed kernel flour

Studying the functional properties of proteins was necessary to use them effectively in food products. Water absorption, oil absorption, emulsification capacity as well as foaming properties were some of the major functional properties of proteins that affect their utilization (Hung and Zayas 1992).

Table 5. Some functional properties of processed mango seed kernel flour (PMSKF).

Functional properties	PMSKF
Water absorption (ml H_2O / 100 g sample)	186.0
Oil absorption (ml oil / 100g sample)	89.0
Emulsification capacity (ml oil / 100g sample)	18.0
Foaming capacity (% volume)	51.2
Foaming Stability ml /time (min)	
0.0 min	72.3
10.0 min	48.5
20.0 min	21.3
30.0 min	0.0

As seen from Table (5), the PMSKF had a good water (186 ml /100g) and oil (89 ml / 100g) absorption, this may be due to its high contents of carbohydrates that absorbs both water and oil. These results are in agreement with those reported by Giami *et al.* (1994), who found that mango seed kernel flour had comparatively better water and oil absorption than the raw soy meal. Also emulsification capacity (18.0ml oil /100g sample) as well as foaming capacity (51.2%) were high, but foam stability was low. Sousulski and McCurdy (1987) reported that the volume and stability of foam are based on the nature and structure of the protein and foaming stability increased with the increase of protein concentration. Our results were in agreement with those reported by Pokharkar and Prasad (1991), Arogba (1997), Youssef (1999) and El-Soukkary *et al.* (2000).

In general processed mange seed kernel flours had promising functional properties, which may be used to advantage in many products such as bakery products or as meat filler ingredient of meat products.

Anti-nutritional Factors and In vitro protein digestibility of Mango seed kernel flour

Tannins and phytic acid

Tannins have the property of complexing with minerals and proteins, consequently impede in–vitro digestibility of protein–rich foods significantly (Narasinga Rao and Prabhavathi 1982; Adewusi and Osuntogun 1991). Data in Table (6) clear the effect of soaking and heat treatments on tannins content of mango seed kernel flours. From such data, it was observed that soaking either in tap water or in sulphited water had reduced tannins by 82.67% and 83.39%after 72 hr, respectively. Also, boiling in water had reduced tannins by 88.71%; 92.60% and 94.31% for raw, water soaked and sulphited soaked, respectively. The best effect as shown, was boiling especially after soaking in sulphited water up to 72 hr. From the same results presented in Table 6, it was observed that however soaking and boiling resulted in reduction of tannin contents, substantial amount of tannins still remained. Similar results, were reported by Dhingra and Kapoor (1985 a, b), Parmar and Sharma (1990) and Arogba (1997).

Table(6):Effect of soaking and boiling on tannins and phytic acid contents of mango seed kernel flour (on dry wt basis).

The Treatments	Tannins (mg catechin / g sample)	Phytic acid (mg /g sample)
Raw	6.377	2.409
Soaking in tap water		
24 hr	4.107	1.945
48 hr	3.492	1.456
72 hr	1.105	1.328
Soaking in sulphited water	2.494	1.749
24 hr	1.950	1.732
48 hr	1.059	1.618
72 hr		
Boiling in water:		
Raw	0.720	2.067
After water soaking	0.474	1.044
After sulphited water soaking	0.363	1.049

Phytic acid contents of raw kernels (2.409 mg/g) were low compared to the value of 5.0 – 9.9 mg/g dry mater reported for cereal grains (Ravindran *et al.* 1994). Data in Table 6 indicated that phytic acid contents had decreased by boiling after soaking in sulphited water (by 56.45%). This was more than occurred by soaking in tap water or in sulphited water only (44.87% and 33.84%, respectively). These results in agreement with the results attained by Ravindran and Sivakanesan (1996). They stated that, about 44%of tannins in mango seed kernels were removed by soaking and up to 67%by boiling the kernels, while phytic acid was decreased by 39 % and 61% after soaking and boiling, respectively.

In this relation, Youssef (1999) reported that tannin and phytic acid contents of mango seed kernels were reduced by 74% and 53%, respectively after washing the kernels with current hot water (60°C) for 6 hr.

Trypsin inhibitor and in – vitro digestibility

The results shown in Table 7 indicated that a low level of trypsin inhibitory activity was found in raw mango seed kernels (34.834 TIU/g). Some residual activity remained even after soaking and boiling (11.525 –12.527%). It is probable after soaking the observed heat – resistant trypsin inhibitory activity in mango seed kernels may be due to tannins. Since, tannins have been reported to inhibit the activities of proteolytic enzymes (Griffiths 1989, Longstaff and McNabb 1991).

Table(7):Effect of soaking and boiling on trypsin inhibitor and In vitro digestibility of mango seed kernel flour (on dry weight).

The treatments	Trypsin inhibitor		In – Vitro Digestibility
	TIU / g	% TI	
Raw	34.834	93.256	21.05
Soaking in tap water			
24 hr	22.029	58.975	39.77
48 hr	20.483	54.836	42.68
72 hr	12.527	33.537	46.67
Soaking in sulphited water			
24 hr	20.447	54.740	42.05
48 hr	14.124	37.812	45.33
72 hr	12.004	32.492	48.20
Boiling in water			
Raw			
After water soaking	23.470	62.833	57.65
After sulphited water soaking	15.553	41.638	58.83
	11.525	30.853	62.14

TIU /g = Trypsin inhibitor unit/g dry sample % TI = % of trypsin enzyme inhibition

Also results in the same Table 7 show that, the in – vitro digestibility of protein in raw mango seed kernels was low (21.05%), but it was improved to 46.67- 48.2% and 62.14% by soaking and boiling respectively. The best digestibility was obtained for samples that were soaked in sulphited water up to 72 hr prior to boiling. The improvements in protein digestibility closely paralleled with the reduction in tannin contents during processing suggesting that tannins are largely responsible for low protein digestibility of raw kernels either by direct binding of feed proteins, by inhibiting the activities of proteolytic enzymes or by the increasing losses of endogenous protein (Mangan 1988). Adewusi and Osuntogun (1991) and many investigators reported that soaking decreased trypsin inhibitory activity, hence increased the protein digestibility (Sathe *et al.* 1983; Hamza and Youssef 1988; El Shimi *et al.* 1992 and El – Bagoury *et al.* (1999).

From the previous results, it could be concluded that, the best investigated treatment was boiling the samples after soaking the kernels in sulphited water, since that treatment caused a high reduction in tannins (94.31%), phytic acid (56.45%), Trypsin inhibitory activity (63%) and improved true digestibility of protein to 62.14%.

Organoleptic evaluation of cakes prepared from wheat and mango seed kernels flour (processed flour)

Data in Table 8 illustrate the sensory evaluation of cakes made from wheat flour and processed flour. The results indicated that there were not significant differences between the samples displaced wheat flour by 5, 10 % processed flour and control concerning appearance, color, taste and over all acceptability ($P \leq 0.05$), Table 8). On the other hand, there were significant differences between 15 and 20% displacement level and other samples. In spit of, data in Table 8 indicated that up to 10% addition of processed flour did not affected over all acceptability, 15% had a good scale. This result was in full agreement with those obtained by El- Soukkary *et al.* (2000), who used mango seed kernel flour in pan bread up to20%.

Table(8):Sensory evaluation of cakes made up from wheat flour and mango seed kernel flour (MSKF).

Supplementation Level % MSKF	Appearance 10	Color 10	Texture 10	Flavor 10	Taste 10	Over all acceptability
0.0	8.86 a	8.79 a	9.14 a	9.14 a	8.79 a	8.94 a
5	8.43 a	8.71 a	8.36 b	8.86 a	8.50 a	8.57 a
10	8.00 a	8.00 a	7.43 c	7.86 b	7.86 a	7.89 a
15	6.86 b	6.57 b	6.00 d	6.71 c	6.71 b	6.57 b
20	5.57 c	5.57 b	4.14 e	5.14 d	5.24 c	5.34 c

*Very good (8-9) Good (6-7) Fair (4-5) poor (2 – 3)
** Values in the same column with different letters are significantly different ($P \leq 0.05$) using Duncan´s multiple range test.

From the previous results, it could be concluded that although mango seed kernel has a low content of protein, the quality of protein was good because it was rich in some essential amino acids, with good functional properties high in vitro digestibility. The results also indicated that soaking and boiling had a great reduction of the antinutritional factors, so the processed flour could be a principal ingredient for making products as cakes and cookies for infant and adults and also other products as bread and pastry.

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دراسات كيماوية وغذائية على لب بذور المانجو

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تم تحليل دقيق لب بذور المانجو من حيث التركيب الكيماوي والأحماض الأمينية والخصائص الوظيفية وجودة البروتين. كما تم دراسة تأثير عمليات النقع في ماء الصنبور والماء الكبريتي لمدة ٧٢ ساعة وأيضا الغلي سواء لعينات دقيق لب بذور المانجو الخام أو المنقوعة في الماء أو في الماء الكبريتي واستخلصت النتائج الآتية:

١ - يحتوى دقيق لب بذور المانجو على تركيب كيماوي مناسب فيما عدا البروتين والذي كان منخفضا نسبيا (٦,٦١%).

٢ - كان البروتين فقيرا في الأحماض الأمينية مثيونين والستين والتيروسين بينما كان غنيا في محتواه من الايزوليوسين والليوسين ومن الأحماض الأمينية الغير ضرورية كان غنيا في الجلوتاميك (٢٣, ٢٣%) والاسبارتيك (٩,٢١%). كان المثيونين هو الحمض الأميني المحدد الأول يليه التيروسين ثم اللايسين .وعند تقييم هذا البروتين من حيث كفاءته وقيمته الحيوية ومقارنة محتواه من الأحماض الأمينية الضرورية باحتياجات الأطفال والبالغين وجدت أن هذه القيم كانت مرتفعة

٣ - أظهرت النتائج ارتفاع امتصاصية دقيق لب بذور المانجو للماء والزيت بجانب الاستحلاب الجيد للزيت (١٨ مل زيت/١٠٠ جم عينة)والسعة الرغوية (٢, ٥١ %) و كان ثبات الرغوة الناتجة منخفضا.

٤ - احتوى دقيق لب بذور المانجو على تانينات (٦,٣٧٧ ملجم كاتيكن/جم عينة)ومثبط لنشاط أنزيم التربسين (٨٣٤، ٣٤ وحدة تثبيط/جم عينة) ولقد انخفضت هذه العوامل المضادة للتغذية نتيجة لمعاملات النقع والغلي وان كان الغلي الأكثر فعالية. أيضا الهضمية المنخفضة للب البذور الخام (٠٥, ٢١%) تحسنت نتيجة للنقع والغلي .

٥ - لم توجد أية فروق معنوية عند التقييم الحسي للمنتجات المصنعة من دقيق القمح مع دقيق لب بذور المانجو المعالج حتى نسبة استبدال ١٠ % من حيث المظهر واللون والمذاق والقابلية بوجه عام كما كان الاستبدال بنسبة ١٥ % جيدا.

مما سبق يمكن استنتاج أن دقيق لب بذور المانجو رغم انخفاض محتواه من البروتين ألا أن جودته كانت عالية لارتفاع محتواه في بعض الأحماض الأمينية الضرورية والخصائص الوظيفية والهضمية كما أن عمليات النقع والغلي كان لهما تأثير كبير في خفض العوامل المضادة للتغذية ومن ثم يمكن استخدام هذا الدقيق لإعداد بعض المخبوزات سواء للأطفال أو البالغين .