CHEMICAL AND NUTRITIONAL EVALUATION OF WATER MELON (CITRULUS VULGRIS) KERNELS AS A NEW SOURCE FOR VEGETABLE OILS AND PROTEINS

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تقييم بذور البطيخ كيميائيا وغذائيا كمصدر جديد للزيوت والبروتينات النباتية

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ملخص البحث

تم دراسة التركيب الكيماوى لبذور البطيخ الشليان المستخدم بكثرة فى موسم الصيف بالاضافة الى توصيف كل من الزيت والبروتين لهذه البذور وكانت النتائج كما يلى :ـ

١ ـ بذور البطيخ عالية فى كل من البروتين (٣٤,٤٪) والزيت (٥٠,٥٪) ٠

٢ ـ بدراسة المعادن بالبذور وجد أنها تحتوى على المغنيسيوم والحديد والنحاس والزنك والفوسفور بتركيز ١٦٩٥ ـ ٩,٢ ـ ٢,٤ ـ ٨,٧ ـ ٨٦٧,٥ ملليجرام / ١٠٠ جم لب بالاضافة الى بعض المعادن الأخرى ٠

٣ ـ الرقم اليودى ورقم التصبن لزيت بذور البطيخ كان ١٢٣,٦ ، ١٩٥,٣ على التوالى كذلك فان نسبة الجلسريدات الثلاثية وصلت الى ٩٥,٨٪ أما الليبيدات القطبية فلم تتعد ١,١٪ ٠

٤ ـ تحليل الأحماض الدهنية أوضح أن حمض الأولبيك يمثل ٢٠,٥٪ أما حمض اللينوليك فكانت نسبته ٥٣,٣٪ أما الأحماض الدهنية المشبعة فكانت ٢٥,٥٪ ومعظمها حمض البالمتيك (١٤,٩٪) والاستياريك (٩,٤٪)٠

٥ ـ دراسة المركبات البروتينية بينت أن الجلوبيولين هو المكون الرئيسى لبروتينات بذور البطيخ يليها الألبيومينات ٠

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٦ ـ معامل ذوبان البروتين تأثر بالزيادة مع القوة الأيونية لمحلول الاستخلاص وكذلك بزيادة رقم حموضة المحلول المستخدم •

٧ ـ الخواص الوظيفية مثل القدرة على امتصاص الماء والزيت والسعة الاستحلابية لبذور البطيخ كانت عالية ومماثلة لمعظم البروتينات النباتية الأخرى أما خواص الرغوة فكانت ضعيفة •

٨ ـ بذور البطيخ غنية فى الأحماض الأمينية الأساسية وخاصة الليسين أما الليوسين والمثيونين والفالين فكانت فقيرة •

٩ ـ نموذج الهجرة الكهربية للبروتين أوضح وجود بعض المركبات ذات الوزن الجزيئى المنخفض (ألبيومين) وكذلك المرتفع (الجلوبيولين) •

من ذلك يمكن الاستفادة من هذه البذور كمصدر للزيت الغذائى جيد الخواص وكذلك من الجزء البروتينى المتبقى بعد استخلاص الزيت كمصدر للأملاح المعدنية وبعض الأحماض الأمينية الأساسية أو استخدامه فى بعض الأغذية نظرا لما له من خواص وظيفية جيدة •

ABSTRACT

The Kernels of water melon seeds, contain 34.4% protein and 50.5% oil. Atomic absorption spectrophotometric analysis indicated Mg, Fe, Cu, Zn, Co levels of 1695, 9.2, 2.4, 8.7 and 1.2 mg/100 g Kernel respectively. Other mineral contents also are reported. The oil had an iodine value of 123.6 and saponification value of 195.3. Total lipid contained 95.8% triglycerides and 1.1% polar lipids. Fatty acid composition revealed the presence of oleic (20.5%), linoleic (53.3%) and 25.5% saturated acids, mainly palmitic (14.9%) and stearic (9.4%). Globulin was the major protein fraction followed by albumin and non-protein nitrogen. The nitrogen solubility increased with ionic strength and pH of solvent. Water, oil and emulsifications capacities were fairly good but foaming properties very poor. Gel electrophoresis of total protein and individual fractions showed the presence of high and low molecular weight proteins in the kernel.

INTRODUCTION

The shortage of oil and protein in several parts of the world has become more acute with rapid increase of population, especially in developing countries. Possible means to meet this problem, are cultivation of new crops and/or the use of Agricultural Food processing by-products and wastes.

Water melon (Citrullus vulgaris) is one of the most popular vegetable crops in Egypt. Large quantities of seed could be produced as a waste from the manufacturing of water melon fruit (Khalafalla, 1971). All of the seeds are consumed locally after roasting and salting as snacks. These seeds contain about 46-62% kernel, the oil and protein obtained from these kernel amount to 52% and 35%, respectively (Chowdhury et al., 1955; El-Sharkawy, 1974 and Kamel et al., 1985). Preliminary studies as reported by Nowokolo and Sim, (1987) indicated that melon seeds are excellent source of dietary oil and their defatted meals are exceptionally high in protein. Sao and Potts (1952) pointed out that the yield of seeds per acre can be substantially greater than that of soybean.

A survey of the literature reveals only very sparse information on the characteristics of melon seed oil and protein, especially for those grown under our local conditions. Therefore, the purpose of this work is to report the general characteristics of both oil and protein fractions of melon kernels.

MATERIALS AND METHODS

Materials:

Water melon seeds:

Twenty five pieces of water melon (Chillian Black variety), were purchased from the local market of Alexandria-City during the summer season of 1987. The seeds were taken from the gourd, washed with tap water and sun-dried at ∿ 30°C for one week. The dried seeds were dehulled and the collected kernels ground to pass through 60 mesh sieve and used for physical and chemical analysis.

Standard lipids:

A lipid extract from mature cottonseeds was used as a reference containing all known classes of the neutral and polar lipids (Abd El-Aal, 1981).

Analytical Methods:

Moisture, crude oil, protein (N x 5.3), fiber and total ash were determined according to A.O.A.C. methods (1975).

Determination of minerals:

The levels of Na, K, Ca, Mg, Zn, Cu, Fe and Co were determined using a Shimadzu AA 630-2 atomic absorption spectrophotometer. Phosphorus content was determined by the method of A.O.A.C. (1975).

Physico-Chemical Characteristics of the oil:

Refractive index, specific gravity, saponification number, unsaponifiable matter, iodine, peroxide, acid values, titer and colour were determined according to A.O.C.S. methods (1973).

Lipid classes analysis:

The lipids were separated into individual lipid classes by thin-layer chromatography technique (Abd El-Aal *et al.*, 1986b) and determined following established procedure (Abd El-Aal and Rahma, 1986 and Rahma and Abd El-Aal, 1988).

Fatty acids analysis:

The methyl esters were prepared as described else where (Abd El-Aal *et al.*, 1987) and analyzed using a Perkin-Elmer F 22 instrument, equiped with a flame ionization detector. The separation was carried out at 200°C on a 2m X 2.5 mm glass column, packed with 10% silar 5 CP on gas chrom Q 80-100 mesh, with nitrogen as a carrier gas. The percentages of various peaks were determined by the triangulation method.

Fractionation of total protein on the basis of solubility:

All the following determinations were conducted on defatted water melon kernel flour. This was done as previously described by Abd El-Aal *et al.* (1986a). The sequential solvents used to extract each protein fraction were distilled water of pH 6.8 (albumins), 1.0 M NaCl (globulins), 70% ethanol (prolamins) and 0.2 M NaOH (glutelins). The residue after these extractions was also digested for protein estimation and designated as residual protein. Non-protein nitrogen was determined separately and substracted from albumins value.

Protein solubility:

The nitrogen solubility index was determined in different solvents i.e., distilled water, 5% NaCL, and 0.02 M NaOH solutions according to Rahma and Narasinga Rao (1979), using a flour to solvent ratio of 1:30 W/V.

Polyacrylamide gel electrophoresis (PAGE):

This was carried out by the procedure of Ogita and Markret (1979) using 8% gel. The experiments were done in 0.0125 M tris-glycine buffer of pH 8.3 at a constant current rate of 2.5 milliaper per tube for 3.5 h. The gels were stained with 0.5% Amido Black in

7.5% acetic acid for 1 h and then destained in 10% acetic acid. Electrophoresis was conducted for total protein extracted in the same buffer as well as the individual protein fractions before and after dialysis against tris-glycine buffer for 24 h with several changes of the buffer solution.

<u>**Functional properties of defatted flour:**</u>

Water and oil absorption capacities were determined according to the methods of Sosulski (1962) and Sosulski <u>et al</u>. (1976) respectively. Emulsification capacity was determined by the method of Yasumatsu <u>et al</u>. (1972). Refined corn oil was used for oil absorption and emulsifying capacity studies. Foaming properties, capacity and stability, were measured by the method of Huffman <u>et al</u>. (1975).

<u>**Amino acid analysis:**</u>

The amino acids were determined in the acid hydrolysate according to Moore <u>et al</u>. (1958), using a Beckman Amino acid Analyzer (Model 121 M) as described by Youssef <u>et al</u>. (1986). The results are reported as g amino acid/16 g nitrogen.

RESULTS AND DISCUSSION

<u>**Physico-Chemical Characteristics:**</u>

The chemical composition of melon kernel along with some physical properties are given in Table (1). Results show that the weight of 100 seeds was lower than that given by El-Sharkawy (1974), while the percentage of kernel was higher than that reported by Chowdhury (1955) and El-Sharkawy (1974), where their values were 46% and 50%, respectively. Moisture content of whole fresh melon seeds was 53.3%. On dry weight basis, oil content of melon kernel was 50.5%, this reflects the importance of using such seeds for oil

Table (1) : Chemical composition and physical properties of water melon kernel .

Constituents	Percentage, dry basis
Crude protein (N X 5.3)	34.4
Crude lipid	50.5
Total ash	4.0
Crude fiber	2.2
Carbohydrate (by difference)	8.9
Physical properties	
Weight of 100 seeds* (gm)	19.8
Kernel %	52.3

* The moisture content of fresh whole seeds was 53.34 % .

Table (2) : Mineral constituents of water melon kernel .

Mineral	mg/100 g dry kernel
Na	147.7
K	21.9
Ca	23.5
Mg	1694.7
Fe	9.2
Cu	2.4
Zn	8.7
Co	1.2
P	867.5

production. Crude protein level was 34.4%, suggesting that the oil-free kernel would be a useful protein food supplement. Previous studies of Girgis and Said (1968); El-Sharkawy (1974) and Kamel _et al_. (1985) have reported values for oil and protein very close to ours for kernels of different varieties. The total ash content of melon kernel was about 4.0%, this level being higher than that reported by Kamel _et al_. (1985), which could be due to fertilizer conditions or genetic factors.

The total ash was rich in Mg, Fe, Cu, Zn, Co and P (Table 2) and low in Na, K, and Ca compared to that recorded for soybean meal (Nwokolo and Sim, 1987). However, the forementioned data were more or less in accordance with those reported by Kamel _et al_. (1985) and recently by Nwokolo and Sim (1987).

The physical and chemical characteristics of melon kernel oil is shown in Table (3). The iodine number of the oil was 123.6, thus, melon oil could be categorized as a semi-drying oil. The melon oil had a bright orange colour and nutty flavour. The values of saponification number, unsaponifiable matter, refractive index, and specific gravity were in good agreement with the previous data reported by Girgis and Said (1968) and El-Sharkawy (1974), but varies greatly to those reported by Kamel _et al_. (1985). The extracted oil showed relatively low peroxide and acid values, indicating its high stability to lipid deterioration. The relatively low titer value,confirm the unsaturation nature of this oil.

Fractionation and composition of melon kernel oil:

The fractionation of melon kernel oil as compared with standard cottonseed lipids revelaed the presence of sterolesters, triglycerides, 1, 3 and 1, 2 (2, 3) - diglycerides,free fatty acids, sterols and polar lipids (Table 4). The neutral lipids acounted for about 98.9%

Table (3) : Physical and chemical characteristics of melon oil .

Property	Value
Refractive index (25/25°C)	1.4715
Specific gravity (25/25°C)	0.9160
Titer (°C)	21.6
Acid value	1.05
Peroxide value meg/kg	0.1
Iodine number	123.6
Saponification value	195.3
Unsaponifiable matter, %	1.42
Color (lovibond 1" cell)	2.3 R, 17.3 Y

Table (4) : Chemical composition of melon kernel oil .

Constituent	%
Sterolesters	0.15
Free sterols	1.14
Triglycerides	95.83
1, 3 -diglycerides	0.35
1, 2 (2, 3) -diglycerides	0.43
Free fatty acids	1.02
Polar lipids	1.08

in which triglycerides was the major fraction (95.8%) while both of the sterolesters and free sterol as well as diglycerides and free fatty acids were minors. The polar lipids represented only 1.1% of the total lipids. These data are resembled to that found for other kernel lipids (Abd El-Aal et al., 1986b, and Abd El-Aal et al.,1987).

Fatty acid composition:

The fatty acid composition of melon kernel oil is given in Table (5). The total saturated fatty acids was 25.5%, while the total unsaturated was 74.5%, which are similar to cottonseed oil (Hamza et al., 1988). Palmitic and stearic acids were the major saturated, whereas, oleic (20.5%) and linoleic (53.3%) were the major unsaturated acids. The presence of fairly high amounts of the essential fatty acid linoleic, suggests that melon kernel is a highly nutritious oil. The use of melon kernel oil should be encouraged if only to supply the much needed linoleic acid, which is also a precurser of arachidonic acid, another essential fatty acid. The ability of some unsaturated vegetable oils to reduce serum cholesterol level may focus attention on melon kernel oil because of its highly unsaturation nature, since saturated fats are implicated in coronary heart disease.

Melon kernel flour proteins:

The protein fractions of melon kernel flour, according to Obsorne classification, are given in Table (6). Globulins represent the major protein in the kernel which is a storage protein. The functional protein fraction of albumin was only 10.65% of the total protein. Alcohol soluble protein (prolamins) was very low (3.31%). Glutelins and non-protein nitrogen were 8.13% and 9.23% respectively. Also the unextracted protein remained in the carbohydrate residue was fairly high (18.51%), which may indicate that the protein of melon kernel is strongly bound with the other constituents of the kernel.

Table (5) : Fatty acid composition of melon kernel oil .

Fatty acid	%
Myristic	0.17
Palmitic	14.89
Palmitoleic	0.10
Margaric	0.33
Stearic	9.35
Oleic	20.52
Linoleic	53.26
Linolenic	0.45
Arachidic	0.36
Eicosadienoic	0.21
Lignoceric	0.36
Total saturated	25.46
Total unsaturated	74.54

Table (6) : Nitrogen content of the protein fractions of water melon kernel flour[a] .

Protein fraction	Soluble nitrogen (%)	Nitrogen solubility index (%)
Albumins	1.14	10.65
Globulins	5.37	50.16
Prolamins	0.36	3.31
Glutelins	0.87	8.13
Non-protein nitrogen	0.99	9.23
Residu al protein	1.98	18.51
Total nitrogen	10.70	100

(a) : Average of two determinations .

Table (7) : Soluble protein and protein solubility index of water melon kernel flour in H_2O , 5 % NaCL and 0.02 M NaOH .

Solvent	Soluble * protein	Protein solubility index
H_2O	6.04	10.65
5 % NaCL	34.75	75.25
0.02 M NaOH	33.44	72.41

* Protein = N X 5.3 .

Protein solubility behaviour of melon kernel flour in different solvents is shown in Table (7). Distilled water showed the lowest solubility, buty 5% sodium chloride and 0.02 M sodium hydroxide solubilized equal quantity of the flour proteins (75% and 72% respectively). The lower solubility in distilled water indicates that the solubility of this protein depends upon both ionic strength, and pH of the solvent. Similar results were reported by Onoura and King (1983) for Nigerian melon kernel proteins.

Table (8) represents some functional properties of defatted melon kernel flour. The flour absorbs and retains more oil than water; the oil absorption capacity was 1.6 higher than water absorption. The water absorption capacity was quite high compared to the other vegetable proteins (1.38 gm H_2O/g peach kernel flour) (Rahma and Abd El-Aal, 1988). These two properties may give an advantage to use melon kernel flour in some bakery products, meat replacers and as thickning agent in soups. Emulsification capacity of the flour was fairly high and comparable to the other vegetable proteins, which may be of interest in sausage and other comminuted meat products. The foaming properties of the flour were very poor and this may be due to the lower solubility of the flour proteins in water at neutral pH (Tables 6 and 7). Addition of sodium chloride or sugars to water may improves foaming properties of melon kernel flour since, it increases the ionic strength of water and solubilized protein.

Table (9) represents the amino acid composition of melon kernel along with that of soybean for comparison. Higher histidine and arginine levels were present in melon kernel protein compared to soybean. Therionine and lysine contents were fairly high and comparable to their values in soybean. However, melon kernel has acute deficiency in methionine and sulphur containing amino acids and requires supplementation with complementary proteins if these kernel

Table (8) : **Functional properties of defatted water melon kernel flour[a] .**

Property	Value ml./g flour	Value g/g flour
Water absorption capacity .	--	2.27
Oil absorption capacity .	4.10	3.69
Emulsification capacity .	49.0	44.1
Foam capacity (% increase)	10.0	
Foam stability mL at :-		
0.0 min.	11.0	
15 min.	7.0	
30 min.	6.0	
45 min.	4.0	
60 min.	3.0	

(a) : Average of three determinations .

Table (9) : Comparative amino acids composition of water melon kernel and soybean .

Amino acid	Grams amino acid/16 g N.	
	Melon kernel	Soybean*
Essential :		
Lysine	6.35	6.39
Histidine	3.21	2.53
Phenylalanine	3.24	4.95
Leucine	3.93	7.78
Isoleucine	3.31	4.55
Therionine	3.71	3.86
Methionine	0.27	1.27
Valine	2.49	4.8
Arginine	9.69	7.23
Non-essential :		
Aspartic acid	3.28	11.70
Serine	3.51	5.12
Glutamic acid	7.80	18.71
Proline	2.9	5.49
Glycine	3.51	4.18
Alanine	7.68	4.26
Tyrosine	1.76	3.14

* Amino acid values from Braddock and Kesterson (1972).

proteins are to be used as a food source. The earlier studies of Nwokolo and Sim (1987) reported that melon kernel is superior to soybean in its content of all amino acids except lysine which, is in contrast to our finding for the lysine content. This is mainly due to genetic variation, since their work was on the bitter varieties of water melon.

Polyacrylamide gel electrophoresis pattern of melon kernel total protein and protein fractions before and after dialysis is given in Fig. (1-a and b). Total protein showed 6 bands with different relative mobilities one of them very well separated in a sharp band and one broad and difused. Both are major and the others minor in the lower part of the gel, one band also located on the top of the gel. Albumin fraction before dialysis showed 6 bands with good separation. The globulin separated into two broad bands and on minor, prolmins were not detected by electrophoresis even when higher concentrations were loaded. This could be due to their low molecular weight which should have been extracted with water along with albumin fraction. The same observation was reported before by Abd El-Aal and Rahma (1986) for fenugreek seed proteins. Glutelins also was not detected in the electrophoresis pattern. Dialysis improved the separation pattern of both total protein as well as the individual protein fractions (Fig. 6-b). Almost the same protein bands were identified with clear resolution.

REFERENCES

Abd El-Aal, M.H. (1981). Changes in lipids and proteins composition in developing cottonseeds, Ph.D. Thesis, Faculty of Agriculture, University of Alexandria, Alexandria, Egypt.

Abd El-Aal, M.H.; M.H. Hamza and E.H. Rahma (1986-a). In-vitro-digistibility, chemical and functional properties of apricot kernel protein. Food Chem., 19, 197

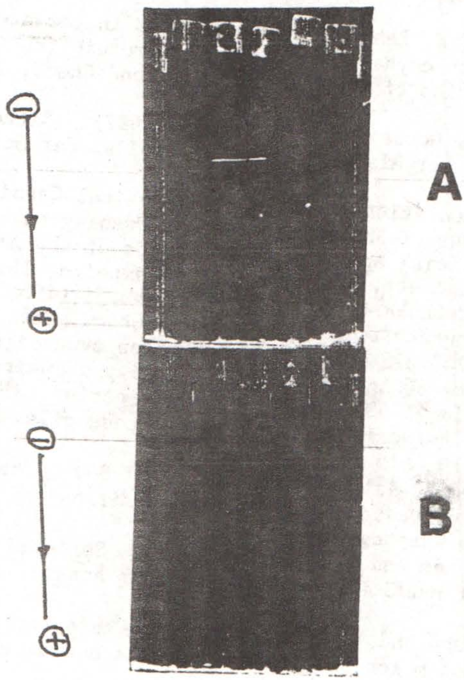

Fig.(6) : Electrophoresis pattern of melon kernel flour proteins A and B before and after dialysis respectively .

1) total proteins , 2) Albumins , 3) Globulins , 4) Prolamins, and 5) Glutelins .

Abd El-Aal, M.H.; M.M. Khalil and E.H. Rahma (1986-b). Apricot kernel Oil : Characterization, chemical composition and its utilization in some bakery products. Food Chem., 19, 287-

Abd El-Aal, M.H. and E.H. Rahma (1986). Changes in gross chemical composition with emphasis on lipid and protein fractions during germination of fenugreek seeds. Food Chem., 22, 193-207.

Abd El-Aal, M.H.; E.G. Gomaa and H.A. Karara (1987). Bitter almond, plum and mango kernels as sources of lipids. Fat Sci. Technol., 84, 304.

A.O.A.C. (1975). Association of Official Analytical Chemists. Official Methods of Analysis, 12th ed. Washington, DC, USA.

A.O.C.S. (1973). Official and Tentative Methods of the American Oil Chemists Society, 3rd ed., AOCS, Champaign, 1L.

Chowdhury, M.M.; A.T. Chakarborty and B.K. Mukharji (1955). Some seed fats of cucurbitaceae. J. Am. Oil Chem., Soc. 32, 384.

Elsharkawy, A.A. (1974). Studies on water melon seed oils. M.Sc. Thesis, Faculty of Agriculture, University of Cairo, Egypt.

Girgis, P. and E. Said (1968). Lesser known Nigerian edible oils and fats. 1- Characteristics of melon seeds oils. J. Sci. Food Agric., 19, 615-16.

Hamza, M.A.; M.H. Abd El-Aal and M.M. Khalil (1988). Studies on Egyptian cottonseeds : Fatty acid composition and protein patterns. Die Nahrung (In press).

Huffman, V.L.; C.K. Lee and E.E. Burns (1975). Selected functional properties of sunflower meal (Helianthus annus). J. Food Sci., 40, 70.

Kamel, B.S.; H. Dawson and Y. Kakuda (1985). Characteristics and composition of melon and grape seed oils and cakes. J. Amer. Oil Chem. Soc., 62, 881.

Khalafalla, A.M. (1971). Microbial and chemical studies on water melon juice. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.

Moore, S.; D.H. Spachman and W. Stein (1958). Chromatography of amino acids on sulphonated polystyrene resins. Anal. Chem., 30, 1185.

Nwokolo, E. and J.S. Sim (1987). Nutritional assessment of deffatted oil meals of melon (Colocynthis citrullus L.) and fluted pumkin (Telfaria occidentalis Hook) by chick assay. J. Sci. Food Agric., 38, 237.

Ogita, Z.I. and C.L. Markert (1979). A miniaturized system for electrophoresis on polyacrylamide gels. Anal. Bioch. 99, 233.

Onuora, J.O. and R.D. King (1983). Melon seed flour : Composition and factors affecting the extractability of nitrogenous constituents. Lebensm. Wiss. U. Technol., 16, 162.

Oyenuga, V.A. and B.L. Fetuga (1975). Some aspects of the biochemistry and nutritive value of the water melon seed (Citrullus vulgaris, Schard). J. Sci. Food Agric.,26, 843.

Rahma, E.H. and M.S. Narasinga Rao (1979). Characterization of sunflower proteins. J. Food Sci., 44, 579.

Rahma, E.H. and M.H. Abd El-Aal (1988). Chemical characterization of peach kernel oil and protein, functional properties, In-vitro-digestibility and amino acids profile of the flour. Food Chem., 27,

Sao Chung, M.T. and W.M. Potts (1952). The analysis and characterization of the oil from the seed of Citrullus vulgaris. J. Am. Oil Chem. Soc., 29, 444.

Sosulski, F. (1962). The centrifuge method for determining of flour absorption in hard spring wheats. Cer. Chem., 39, 344.

Sosulski, F.W.; E.S. Humbert; K. Bui and J.D. Jones (1976). Functional properties of rapessed flour, concentrate and isolates. J. Food Sci., 41, 1348.

Yasumatsu, K.; K. Sawada; S. Moritaka; M. Misaki; J. Toda; T. Wada and K. Ishii (1972). Studies on the functional properties of food grade soybean products. IV. Whipping and emulsifying properties of soybean products. Agric. Biol. Chem. 36, 517.

Youssef, M.M.; M.H. Hamza; M.H. Abd El-Aal; A. Laila Shekib and A.A. El-Banna (1986). Amino acid composition and In-vitro-digestibility of some Egyptian foods made from faba bean (Vicia faba L.). Food Chem., 22, 225.