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INNOVATED WEANING FOODS. I-CHEMICAL COMPOSITION AND REMOVAL OF ANTI-NUTRITIONAL FACTORS

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ABSTRACT

Available local raw materials: cereals; wheat, white maize, rice, legumes; faba beans, lentils, chickpeas, cowpeas, white beans, fruits; apple and bananas as well as vegetables; carrots and potatoes were used for preparing weaning foods. The raw materials were subjected to different treatments including: soaking, germination, cooking and sieving to remove the anti-nutritional factors (ANF). Treatments caused an apparent increase in protein, fat and ash, whereas carbohydrates and fibers were decreased. Treatments minimized (ANF) in prepared weaning foods in comparison to raw materials; e.g. tannin decreased to 67-93.69%, phytic acid decreased to 76.4-96.5%, trypsin inhibitor decreased to 67.9-88.4% and amylase inhibitor decreased to 89.2-99.8%.

Key words: *amylase inhibitor, anti-nutritional factors, phytic acid, tannins, trypsin inhibitor, weaning foods.*

1. INTRODUCTION

Millions of children in developing countries of the world are suffering from malnutrition. During weaning period, identified as the rapidly growing period between infancy and childhood (Hasanin, 1994), malnutrition is more common.

Poverty, lack of suitable food and ignorance of good nutritional knowledge, are the principle reasons of malnutrition. Weaning foods must bridge the gab between breast-feeding and the family diet. Cereals, legumes, fruits and vegetables must be subjected to different processing treatments to produce high digested and nutritionally valuable weaning foods.

In this respect, germination and decorticating of legume pulses reduced tannin to a low level with a significant increase in ionisable iron. (Rao and Prabhavathi, 1982). A rapid loss of about 60% of trypsin inhibitor activity of beans was found as a result of autoclaving or treatment with boiling water. (Egbe and Akinyele, 1989). Whereas, Dhurandhar and Chang (1990) reported that trypsin inhibitor activity (TIA) in beans was reduced by about 87% of the TIA in the raw beans due to increasing temperature or cooking time of beans. Also Mansour and El-Adawy (1994) found that heat treatment of fenugreek seeds destroyed most of trypsin inhibitor activity. On the other hand, germination of fenugreek reduced the levels of phytic acid, tannic acid and trypsin inhibitor activity by about 79%, 29% and 53%, respectively.

Comparison between malting and roasting of wheat was carried out by Gahlawat and Sehgal, (1993). They found that malting of wheat reduced phytic acid, saponin and polyphenols to 57.7%, 61.2% and 62.7%, while roasting decreased them to 40.8%, 48.6% and 51.0 %, respectively.

The present work deals with the production of weaning foods with a low level or free of anti-nutritional factors.

2. MATERIALS & METHODS

a) Cereals: Wheat (*Triticum aestivum*, L.variety Sakha 69), white maize (*Zea maize*, L.variety Giza 2) and milled rice (*Oryza sativa*, L commercial).

b) Legumes: Faba beans (*Vicia faba,* L. variety Giza Blanka), lentils (*Lens culinaris* L variety Giza 9), chickpeas (*Cicer arietinum*, L.variety Giza 531), cowpeas (*Vigna unguiculata*, L. variety Cream 7) and white beans (*Phaseolus vulgaris*, L. variety Giza 6].

c) Fruits: Apples (*Malus pumila,* L. variety Golden) and banana (*Musa banana*, L. variety Maghrabi).

d) Vegetables: Carrots *(Daucus carota,* L) and potatoes (*Salanum tubersonsum*, L) commerial.

The previous cereals and legumes were obtained from the Agricultural Research Center, Giza, Egypt, whereas fruits, vegetables and milled rice were purchased from the local market.

2.1.Removal of anti-nutritional factors

Cereals and legumes were cleaned and washed with water, then subjected to the following treatments: Soaking for 24 hr at room temperature, germinated for 96 hr at room temperature, cooked for 20-30 min in boiling water, dried at 50-60°C for 15 hr, then milled and sieved by using 40 mesh sieve . Concerning rice it was soaked for 6 hr, cooked for 10 min in boiling water and then dried and sieved. Fruits were peeled, sliced and dried after soaking in solution contained citric acid (1% w/v), ascorbic acid (1% w/v), and Na Cl (0.5% w/v) for 5-10min. Vegetables; potatoes were washed and blanched for 15-20 minutes in a boiling water, then peeled and cut into thin slices, while carrots were washed and peeled, then blanched in the same manner. The sliced materials were dried at 50°C for 15 hr, then ground to a fine powder. The dried milled cereals, legumes, fruits and vegetables were packed in polyethylene bags and stored at 5°C till analysis.

2.2.Chemical analysis

The treated and untreated materials were subjected to chemical analysis.

Moisture, protein, fat, crude fiber and ash contents of samples were determined according to the methods outlined in A.O.A.C, (1990), while total carbohydrates were calculated by difference.

Tannins were determined as catachin using methanol vanillin hydrochloric acid (MV-HCl) according to the procedure described by Maxson and Rooney, (1972) and modified by Price *et al*., (1978).

Phytate was determined according to the procedure described by Mohamed *et al*., (1986).

Trypsin inhibitor activity was determined according to the method described by Gatta *et al*. (1988).

Amylase inhibitor activity was determined according to the procedure described by Yetter *et al*. (1979).

3. RESULTS AND DISCUSSION

The data presented in Table (1) revealed that the protein content increased by about 1.17-1.27, 1.11-1.16 and 1.21-1.31 times as the controls for cereals, legumes and vegetables, respectively, while a slight decrease or no change for fruits. Fat content increased also in the range of 1.05-2.30 times for cereals, 1.20 for fruits and 1.04-1.33 for vegetables, meanwhile, it varied for legumes to be 1.20, 1.36 and 1.0

Table (1): Chemical composition of raw materials before and after treatments (gm / 100gm $_{dry\ wt.}$).

Ingredients	Protein*	Protein**	Fat*	Fat**	Ash*	Ash**	Fiber*	Fiber**	Carbohydrates*	Carbohydrates**
Cereals:	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
Wheat	15.76	17.90	2.32	2.69	2.01	2.05	2.65	1.07	77.19	72.78
White maize	13.08	15.30	3.42	3.59	1.21	1.40	1.53	0.76	79.96	75.32
Rice	7.79	10.67	0.76	1.75	0.76	0.53	0.54	0.53	89.19	83.97
Legumes:										
Faba beans	31.86	36.23	1.62	1.95	3.40	3.10	6.40	2.58	57.24	54.09
Lentils	30.97	34.38	1.36	1.85	2.92	2.57	4.10	2.99	57.89	55.34
Chickpeas	26.87	31.26	6.20	6.25	3.59	3.32	3.15	1.68	60.07	56.39
Cowpeas	29.27	33.41	1.69	1.50	3.36	3.41	5.21	3.41	60.96	58.41
White beans	34.18	38.34	2.13	1.43	3.80	3.55	4.57	2.07	56.56	53.04
Fruits:										
Apples	2.58	2.58	1.29	1.55	3.87	3.38	5.16	5.16	92.25	86.98
Banana	5.30	5.14	1.22	1.48	3.67	3.18	2.44	2.58	91.00	89.00
Vegetables:										
Carrots	6.15	7.47	1.53	1.59	5.38	7.69	8.65	8.46	79.23	74.60
Potatoes	7.17	9.40	0.51	0.68	4.10	7.17	2.98	2.10	80.95	77.43

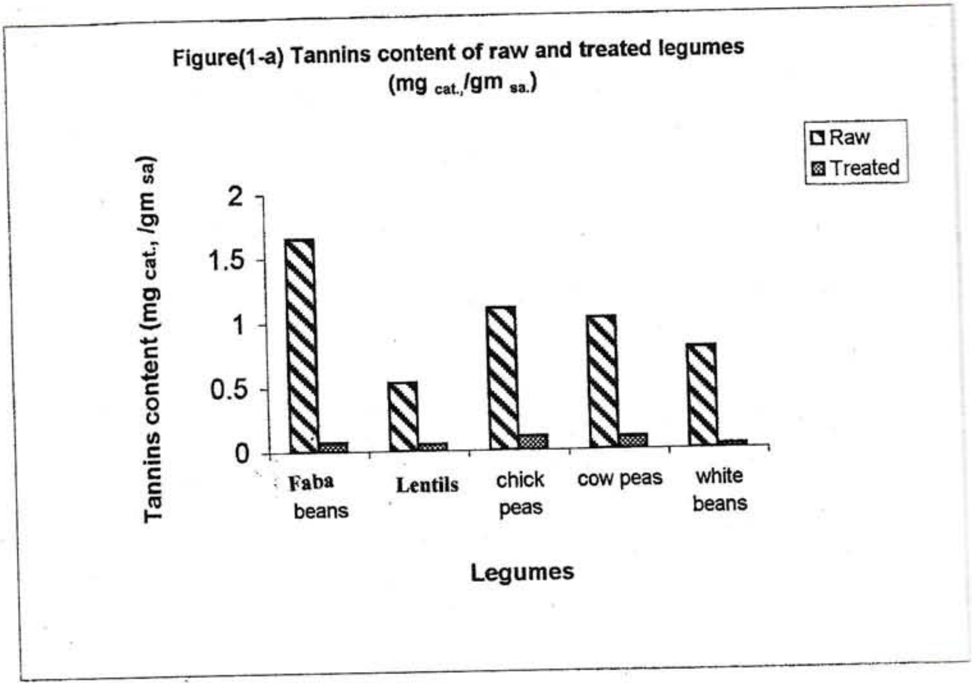
* Before treatment. ** After treatment.

for faba bean, lentils and chickpeas, while it decreased to 0.86 and 0.67 times for cowpea and white beans compared with control. Ash showed a decrease in its amount ranged between 0.86-0.93 times as that of control for legumes and fruits, while it increased for vegetables, by about 1.43-1.73 times and 1.02-1.16 for cereals except that of rice which decreased to 0.69 times as that of control. Concerning fibers, the data revealed that its amount decreased as a result of treatments. The maximum decrease was found in cereals followed by legumes and vegetables, while fruits showed no change. Carbohydrate content, due to treatments, showed a decrease ranging between 0.96-0.98, 0.96-0.99, 0.98-1.0 and 0.95 times as that of control for cereals, legumes, fruits and vegetables, respectively. The decrease of fiber may be due to the sieving, while ash decreased due to soaking, germination and cooking. On the other hand, solubility of the soluble sugars in the media is considered the main reason for the decrease of total carbohydrates after the different processes. In this respect, Rahma *et al.,* (1987) reported that total protein, non-protein nitrogen and ash increased during germination. Ali (1996) found that crude protein increased and total lipids decreased of kidney beans after 120 hr of germination compared with ungerminated ones.

Figures (1,2,3 and 4) showed the effect of different treatments, *i.e.*, soaking, germination, cooking and sieving on the antinutritional factors, *i.e.*, tannins, phytic acid, trypsin inhibitor and α-amylase inhibitor of some legumes (faba beans, lentils, chickpeas, cowpeas and white beans), cereals (wheat, white maize and rice), fruits (apples and banana) and vegetables (carrots and potatoes) which are used as ingredients for baby food formulas. Figure (1) illustrates the tannins content of treated and untreated materials. It is worth to mention that legumes were characterized by high tannin content (0.53-1.65 mg/g) of which faba bean was the superior, while lentils contained the lowest amount of tannins.

Other materials contained tannins ranging between 0.0-0.64 for cereals, 0.44-0.69 for fruits and 0.29-0.52 mg/g for vegetables. The treated materials resulted in a dramatic decrease in tannins content by amounts of 82-95.9% for legumes, 99.2-100% for cereals, 72.5-78.4% for fruits and 68.62-91.92% for vegetables (Fig. 1 a and b). The obtained data are in the line with the finding of Barampomo and Simard (1993) who found that tannins of dry bean decrease after soaking, cooking or soaking-cooking by about 28.76%-59.81% and 84.64%, respectively.

Phytic acid content of row and treated materials are shown in



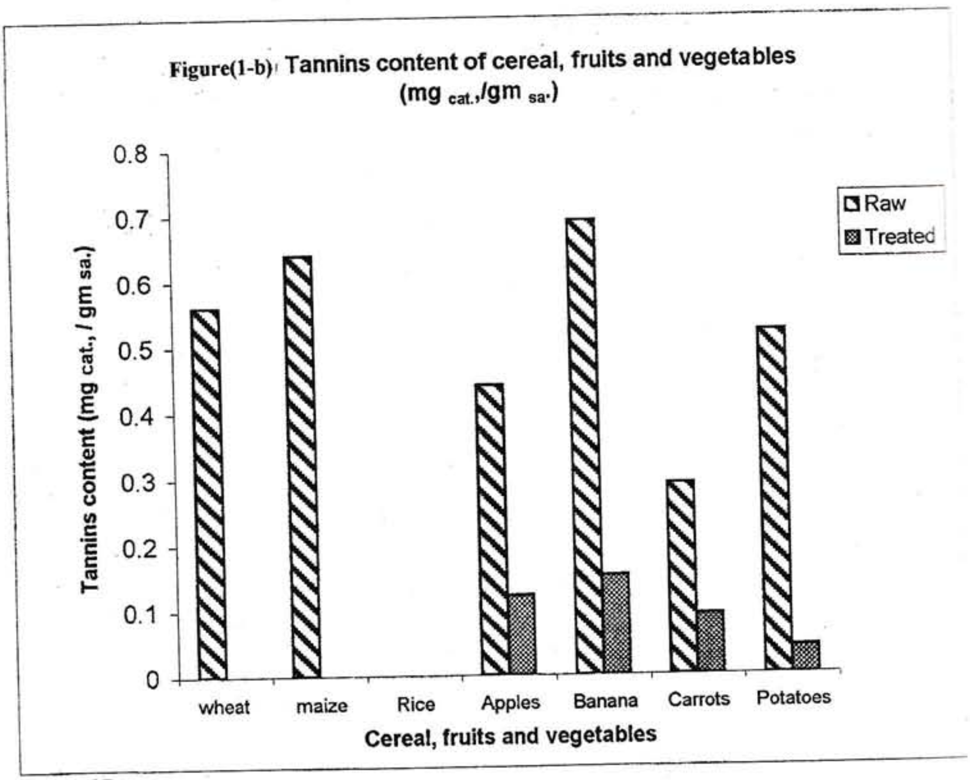


Figure (1): Tannins content of raw and treated materials .

Figure (2). It could be observed that cereals, except rice, contained the highest amount of phytic acid (8.11-11.2 mg/g) followed by potatoes (10.4 mg/g), faba bean (8.22 mg/g) and carrot (5.16 mg/g), while other legumes content of phytic acid ranged from 2.37-4.5mg/g. Treatments led to a decrease of phytic acid content by about 82.73-90.1% for cereals, 88.5% for vegetables, and 80.5-96.5% for legumes (Figure 2b).

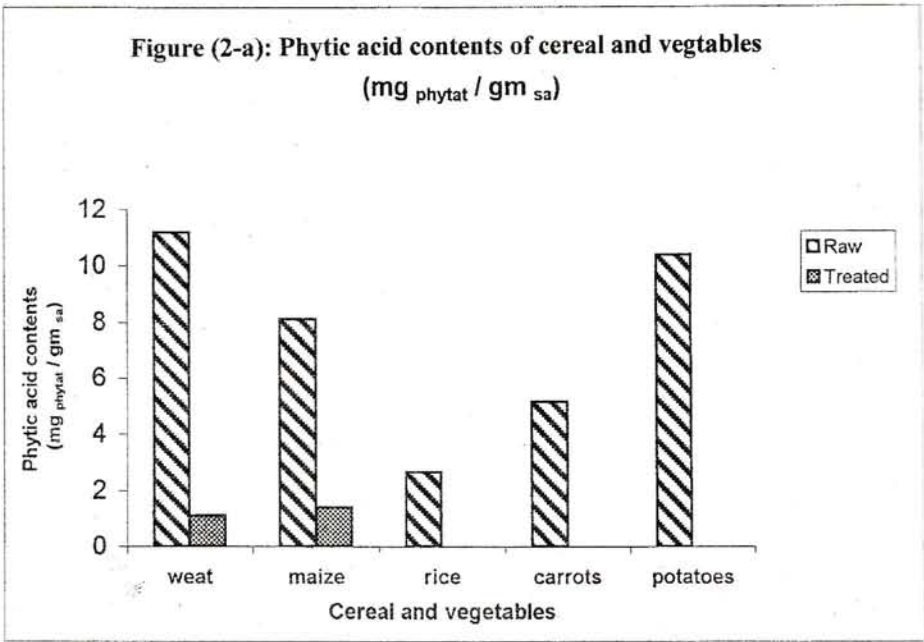
Table (2):Weaning food blends prepared from treated materials.

Blends	Ingredients
(1)	70%wheat+15%lentils+15%chickpeas.
(2)	70%maize+15%faba beans+15%whitebeans.
(3)	70%rice+30%faba beans.
(4)	405wheat+23%maize+15%faba beans+12%cowpeas+5%apples+5%banana.
(5)	30%wheat+33%rice+10%chickpeas +17cowpeas+10%carrots.
(6)	43%maize+20%rice+7%lentil +20cowpeas+10%potatoes.
(7)	25%wheat+13%maize+25%rice+12%lentil +15%beans+5%carrots+5%potatoes.
(8)	30%wheat+15%maize+18%rice+12%chickpeas+15%beans+5%apples+5%^ca rrots.

The obtained results are in agreement with Mansour and El-Adawy (1994) who reported that the reduction of phytic acid levels in beans during germination is due to the phytase activity.

Trypsin inhibitor content of the legumes under study can be arranged in the following descending order: chickpea > cowpeas > white beans > faba bean > lentils which was 13.4,8.88,8.4.6 and 2.61 TIU/mg, respectively (Figure 3). Treatment resulted in trypsin inhibitor decrease ranging from 67.9% for chickpea to 88.45% for white beans. The obtained data agree with those reported by Dhurandhor and Chang (1990) who found that rypsin inhibitor activity (TIA) in beans could be reduced to 87% of the TIA in the raw material by increasing temperature or cooking time.

Concerning the inhibitor activity of amylase content, results in Figure (4a) show that legumes were characterized with α-amylase inhibition activity ranging from 30.8 to 36.4%, except that of lentils which showed a value of 6.9%. Meanwhile, wheat showed the highest α-amylase inhibition value followed by maize and rice. (Figure 4b). Carrot and potatoes (Figure 4b) showed values of 14.31 and 21.2%, respectively. After treatments, rice, carrot and potatoes were free from amylase inhibitor, while legumes showed a decrease of 82.5-99.4%.



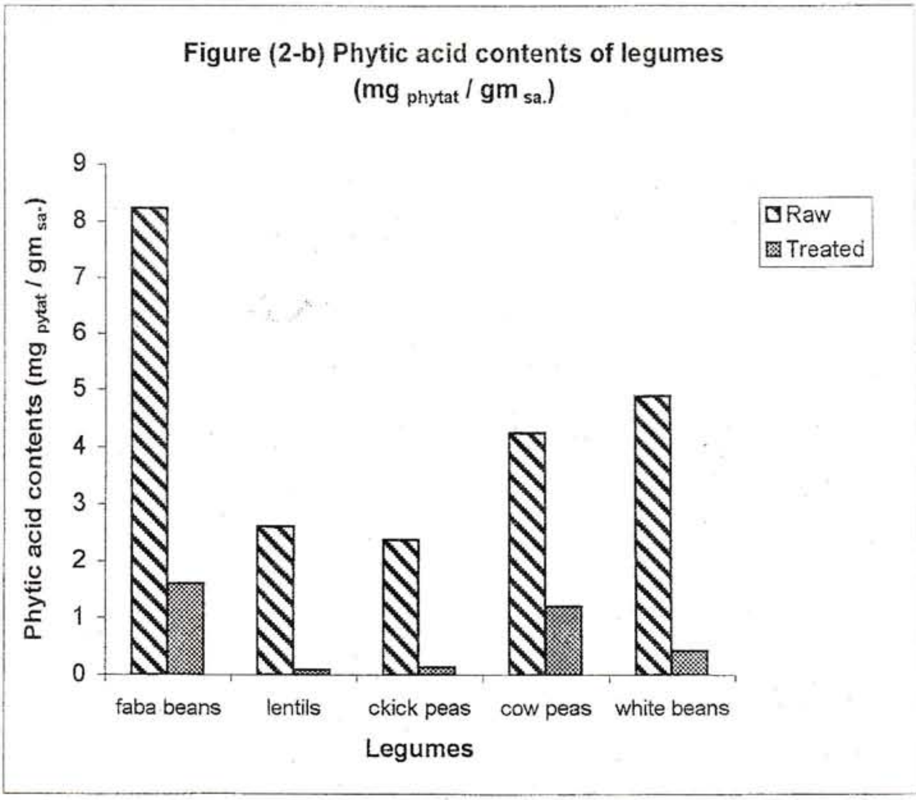


Figure (2): Phytic acid contents of raw and treated materials.

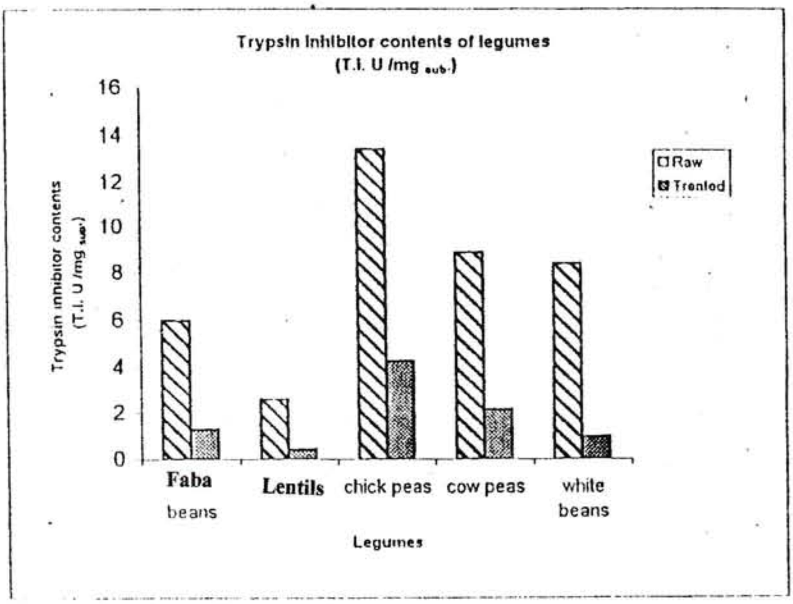
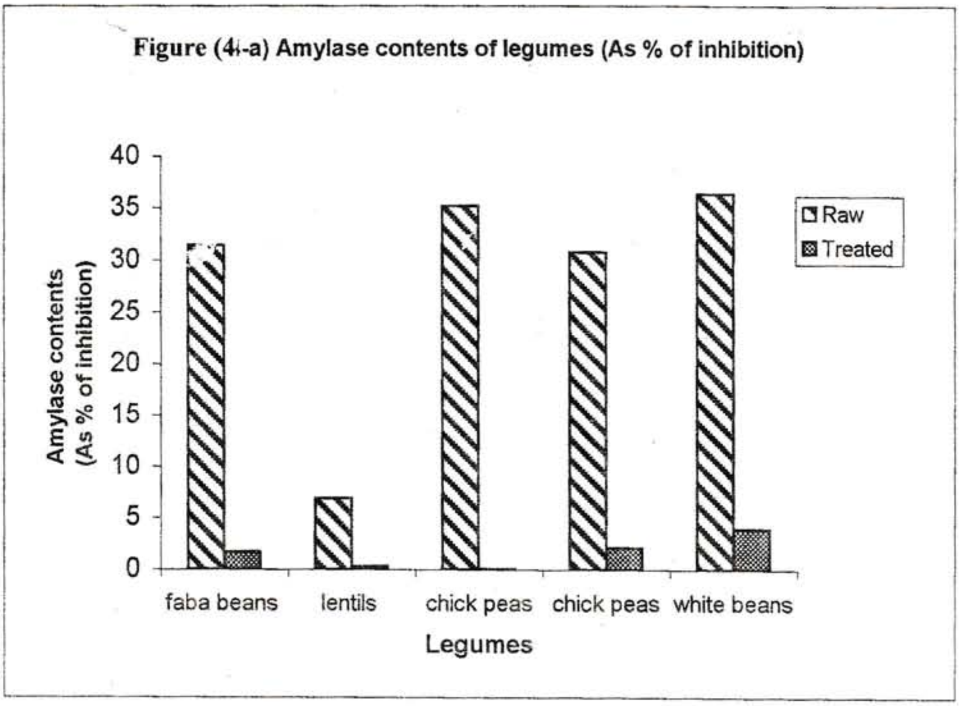


Fig. (3) Trypsin inhibitor contents of legumes

It could be concluded that heat treatment caused the maximum reduction of α-amylase inhibition. The obtained results are in agreement with Piergiovanni (1994) who found that the most pronounced decrease of amylase inhibitor was observed when soaked seeds were boiled. Also, Ali (1996) found that soaking, cooking, germination plus cooking and soaking plus cooking decreased amylase inhibition activity in legumes with varying degrees.

After reduction of the anti-nutritional factors from the materials under study and according to the chemical composition, trials were taken to formulate eight weaning food blends by mixing the forementioned ingredients in different ratios (Table 2). The data presented in Table (3) show the antinutritional factors of produced blends formulated from the treated ingredients compared with control samples prepared from untreated materials and mixed in the same ratios. The data revealed that the treated ingredients, consisted of formulated blends reduced tannin contents, phytic acid, trypsin inhibitor and amylase inhibitor by about 85.7 to 98.6%, 73.9-90.6%,85.7-92.3% and 91.9-95.7%, respectively compared with blends prepared from untreated materials. In this respect. Marero *et al*., (1991)



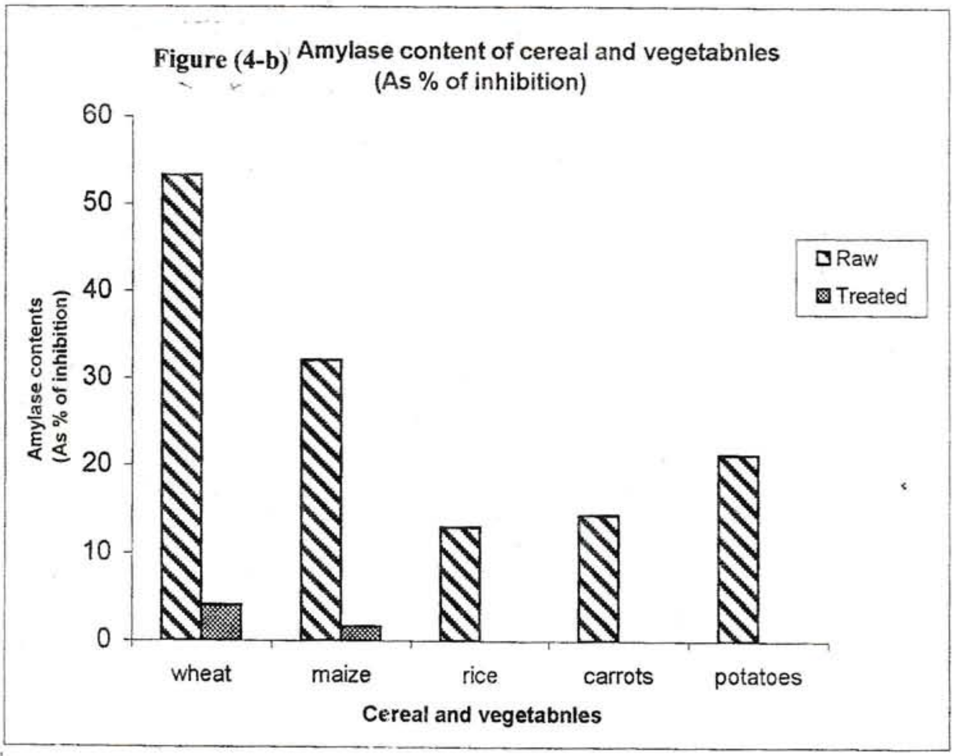


Figure (4) : **Amylase inhibitor contents of raw and treated materials .**

found that the successive treatments *i.e.,* germination, dehulling, roasting and cooking reduced the anti-trypsin factors namely; phytic acid, tannins, anti-trypsin activity from rice, corn, mungbean and cowpea as raw materials used for preparing weaning foods.

Table (3): Anti-nutritional factors of raw and treated blends.

No.	Blends	Tannins $mg/gm_{sa.}$	Phytic acid mg/gm_{sa}	T.I.A $Unit/mg_{suib.}$	A.I.A % Inhibition
(1)	Raw Treated	0.168	8.58	4.8	43.61
		0.023	0.8	0.7	2.92
		(86.30)*	(90.67)*	(85.41)*	(93.30)*
(2)	Raw Treated	0.64	7.62	4.32	32.56
		0.015	1.43	0.34	2.63
		(97.50)*	(81.23)*	(92.12)*	(91.92)*
(3)	Raw Treated	0.49	4.28	3.60	18.47
		0.021	0.78	0.39	1.11
		(95.71)*	(81.77)*	(89.16)*	(93.99)*
(4)	Raw Treated	0.45	7.58	3.93	37.8
		0.021	1.11	0.31	2.83
		(95.33)*	(85.35)*	(92.11)*	(92.51)*
(5)	Raw Treated	0.45	5.64	5.69	43.21
		0.035	0.68	0.79	1.87
		(92.22)*	(87.94)*	(86.11)*	(95.67)*
(6)	Raw Treated	0.33	5.67	3.91	25.02
		0.005	1.16	0.46	1.30
		(98.60)*	(79.54)*	(88.23)*	(94.80)*
(7)	Raw Treated	0.43	2.30	3.14	28.7
		0.028	0.60	0.24	2.13
		(94.0)*	(73.91)*	(92.35)*	(92.57)*
(8)	Raw Treated	0.53	5.42	5.73	33.41
		0.017	0.84	0.66	1.82
		(96.79)*	(84.50)*	(88.48)*	(94.55)*

* % of Anti-nutritional factors activity decrease.
TIA = Trypsin inhibitor activity.

Also, Hassona and Mekawy (1991) found that germination of wheat grains then boiling, redued phytic acid content by about 37%. It could be concluded that the successive treatments resulted in considerable reduction in the anti-nutritional factors and produced weaning foods contained the lowest level of them.

5. REFERENCES

Ali Heba M. (1996). Biochemical studies on amylase inhibitors in some local legume seeds. M.SC. Thesis, Chemistry Department, Fac. Agric., Minia University.

A.O.A.C. (1990). Official methods of analytical chemistry. (15^{Th} ed.), Washington, D.C., U.S.A.

Barampomo Z. and Simard R.E. (1993). Nutrient composition, food quality and anti-nutritional factors composition of some varieties of dry beans ground in Brundi. Food Chemistry, 47: 159- 167.

Dhurandhar N.V. and Chang K.C. (1990). Effect of cooking on firmness, trypsin inhibitor, lectins and cystine-cysteine content of navy and red kidney beans. J. Food Sci., 52(2): 470 – 474.

Egbe I.A. and Akinyele I. O. (1989). Effect of cooking on anti-nutritional factors of lima bean (*Phaseolus iunatus*). Food Chemistry, 35: 81 – 87.

Gahlawat P. and Sehgal S. (1993). The influence of roasting and malting on the total and extractable mineral contents of human weaning. Mixtures prepared from Indian raw materials. Food Chemistry, 46(3): 253 – 256.

Gatta C.D., Piergovanni A.R. and Perrino P.(1988). An improved method for the determination of trypsin inhibitor levels in legumes. Lebensm-Wiss-U. Technol., 21, 315-318.

Hasanin Manal A.M. (1994). National evaluation of some cereals and legumes. M.SC. Thesis, Rural Home Economics Branch, Department of Nutrition and Food Science, Faculty of Home Economics, Menoufia University.

Hassona H.Z. and Mekawy Afaf A. (1991). Improved weaning foods prepared from germinated cereals and legumes. Zagazig. J. Agric. Res. 18 (6): 1909 – 1915.

Mansour E.H. and El- Adawy T.A.(1994). National potential and functional properties of heat treated and germinated fenugreek seeds. Lebensm - Wiss. U. Technol., 27: 568.

Marero L.M., Payumo E.M., Aguinaldo A.R., Matsumoto L. and Hommo S.(1991). Anti-nutrifactors in weaning foods prepared from germinated cereals and legumes. Lebensmittel–Wissenschaft Und – Technologie, 24 (2): 177 – 181. [C.F. FSTA, (1994)].

Maxson E.D. and Rooney L.W. (1972). Evaluation of methods for tannin analysis in sorghum grain. Cereal Chemists, Vol. 49: 719 – 729.

Mohamed A.I., Perera P.A.J. and Hafez Y.S. (1986). New chromphore for phytic acid determination. Cereal Chemistry, 63(6):475– 478.

Piergiovanni (1994). Amylase inhibitors in cowpeas (*Vigna unguiculata)* : Effect of soaking and cooking method. Food Chemisy\try, 51: 79-81.

Price M.L., Scoyoc S.V. and Butler L.G. (1978). A critical evaluation of the vanillin reaction as assay for tannin in sorghum grain. J. Agric. Food Chem., 26(5): 1214 – 1219

Rahma F.H., El-Badawey A.A., El-Adawey T.A. and Goma M.A. (1987). Changes chemical and anti-nutritional factors and functional properties of faba beans during germination. Lebensm-Wiss, U -Technol, 20: 271 - 276.

Rao B.S.N. and Prabhavathi T.(1982). Tannin content of foods commonly consumed in India and its influence on ionisable iron. J. Sci. Food. Agric., 33:89 -96

Yetter M. A., Sauders R.M. and Boles H. P. (1979). Amylase inhibitors to postharvest – insects. Cereal Chemistry, 56(4): 243 – 244.

أغذية الفطام المحدثة: 1-المكونات الكميائية و التخلص من العوامل المضادة للتغذية

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ملخص

أستخدمت بعض المواد الغذائية الخام المحلية في إعداد أغذية الفطام, مثل الحبوب (القمح، الذرة البيضاء و الأرز), البقوليات (الفول, العدس، الحمص, اللوبيا و الفاصوليا البيضاء), الفاكهة (التفاح و الموز) و الخضر (الجزر و البطاطس). عوملت هذه المواد الخام الغذائية ببعض المعاملات التصنيعية المختلفة مثل النقع, الإنبات, الطبخ و النخل بغرض التخلص من المواد المضادة للتغذية و هي التانينات وحمض الفيتك و مثبطات انزيمى التربسين و الاميليز. و قد وجد أن لكل معاملة القدرة على تقليل عامل فقط من هذه العوامل المضادة للتغذية، فمثلا التقشير يقلل التانينات و الإنبات يقلل حمض الفيتك و المعاملة الحرارية تقلل كل من مثبطات انزيمى التربسين و الاميليز، لذلك كان لابد من دمج هذه المعاملات في معاملة واحدة (نقع ثم إنبات ثم طبخ ثم تجفيف ثم تقشير بواسطة المنخل). كما تحسن المحتوى الغذائي، فقد زاد محتوى البروتين و الدهون و العناصر المعدنية في حين قل محتوى كل من الألياف و الكربوهيدرات. و أمكن خلط المكونات المعاملة و تحضير مخاليط من أغذية الفطام المحدثة ذات نسبة قليلة جدا من العوامل المضادة للتغذية.

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