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PRODUCTION OF NUTRITIOUS LOW-COST SUPPLEMENTARY BABY FOODS FOR INFANTS FEEDING

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ABSTRACT

This research was performed to try to produce low-cost infants foods from locally available inexpensive cereals and legumes; characterized by a high nutritional value sufficient for providing infants with their recommended daily dietary allowances (RDA) of the most needed nutrients and by a good organoleptic quality. The obtained results revealed that the all formulated infants food formula having a great highly nutritive value as illustration from their enrichment of protein and the most determined minerals, and vitamins and characterized with an excellent organoleptic quality, and more acceptability for infants, especially the formula No. 2 (composed of 5% cod liver oil and 20% chick pea; 10% defatted soy bean (DSB); 25% maize; 15% skim milk; 10% soy protein isolate (S-PI); 2.5% of each apricot and mango fruits' pulp, and 10% egg yolk powders) and the formula No. 5 (composed of 5% cod liver oil and 15% of each common bean and DSB; 20% of each maize and skim milk; 10% of each S-PI and egg yolk and 2.5% of each apricot, and mango fruits' pulp powders). In addition that the produced infants food formulations exhibited a great highly nutritional protein quality, especially the former two enriched formulae (F2 & F5) as confirmed by containing a better balance and a higher content of all IAAs in their protein, when compared with the reference protein pattern of FAO/WHO/UNU for infants and by having high values of the biological terms; protein efficiency ratio (PER), net protein utilization (NPU), TD and biological value (BV) which were analogous to the corresponding values of milk protein. The infants feeding on 100g of either F_2 or F_5 was sufficient to provide them with their RDA of the all tested nutrients, with the exception of the energy value (K.cal), Mn, Pyridoxine (Vit. B_6), folic acid and the indispensable amino acids (IAAs) which were satisfied by about 47, 40-43, 24-26 and 53-78%, respectively. In general, the produced infant foods formulae had nutritional and organoleptic quality attributes of more better than those of the commercially produced baby food formula namely Cerelac.

Therefore, it is recommended to the direction towards the production of infant food formulations from available cheap cereals and legumes with fortification by the natural enriched ingredients, with protein and some minerals and vitamins needed, such as skim milk, plant protein isolates, egg yolk, cod liver oil and fruits to improve the nutrition status of infants and to share in solving the problem associated with suffering infants from malnutrition diseases.

Keywords: Infant foods; baby foods; legumes; cereals; nutritional quality; organoleptic quality.

INTRODUCTION

The malnutrition diseases were extremely prevalent globally all over the world in children under the age of five years. It was found about 190 millions of them are reported to be chronically malnourished (WHO/UNICIEF, 1989). The mortality rate because of the malnutrition for infants below one year of age in the developing countries was estimated to be 10-20 times greater than in the industrialized nations of the world (Nout, 1993). Since a combination of nutritionally inferior diets and improper feeding practices are majors contributing factors to the development of childhood malnutrition (Huffman and Martin, 1994).

During the first months of human life, the breast milk should preferably be the only food given to the infants up to 4-6 months of age, and it contains most of the nutrients in appropriate proportions sufficient to sustain adequate child growth. Thus, the supplementation with other foods became a necessary in order to maintain the expected rate of infants' growth and to bridge the gap of energy and protein requirements. (Davadas *et al.*, 1984 and Gahlawat & Sehgal, 1993). On the other hand, there is one of the most dangerous problem that is the shortage of the acceptable nutritious supplementary foods for infants which have never been feeding on the breast milk.

Because of the small infant stomach limits the food volume that they can reasonably consume, besides the increasing of the nutritive requirements in relation to the size that at any other period in life, it is imperative that the food be carefully selected to be small in quantity but high in the nutritive value. However, the main goal of infant feeding is to provide enough calories and nutrients to support optimal growth and development. Thus the supplementation with other foods became a necessity. Efforts to improve the health and nutritional status of growing infants has focused primarily on the production of nutritious low-cost supplementary foods and their acceptability and shelf life (Chandrasekhar & Devadas, 1986 and Walker, 1990). Such infant food must be easy to swallow and be microbiologically safe when consumed, the level of antinutritional and flatulence-causing factors must be also minimized and the ingredients applied must be locally available, cheap and acceptable such as legumes, cereals and fruits. Several simple technological processing , including soaking, germination, roasting and autoclaving, were traditionally employed to improve the nutritional and sensory quality properties as well as to produce a safety food for infant's health (Jood *et al.*, 1986 and Nout, 1993).

The best nutritional programs for feeding of infants, especially whom have never fed on the breast milk, were applied by supplementing the cereals-legumes mixture with the skim milk and enriched ingredients of some minerals and vitamins which infants essentially needed such as fruits, meat, egg yolk and some lipids. The nutritional and organoleptic quality attributes of infants food formulations are better than those of each ingredient alone due to the complementary nature of their amino acids profiles, minerals and vitamins content, and components responsible for forming the organoleptic properties (Kshirsagar *et al.*, 1994 and Baskaran *et al.*, 1999).

It is well known that the Third World Countries, including Egypt, are actually facing a critical situation which is the greatly shortage of available cheap nutritious infant foods, especially with the continuous over population during the last ten years and the most baby foods are imported by several millions of the hard currency which really lakes in Egypt.

Therefore, this research was carried out to try to produce a nutritious low-cost supplementary foods formulae from the locally available and cheap cereals and legumes for infants feeding provided them with their RDA of nutrients and the required energy. This study was also included to evaluate the organoleptic properties of the produced infant food formulations.

MATERIALS AND METHODS

Materials :

Legume seeds; including common bean (*Phaseolus vulgaris* L.) Giza-3 variety, chick pea (*Cicer arietinum* L.) Giza-2 variety and soybean (*Glycine max* L. *Merr.)* Clarck's variety, and cereal grains; including rice (*Oryza sativa* L.) Rhio variety, maize (*Zea maize)* single cross 10-variety and wheat (*Triticum asetivum*) Giza-164 variety, were obtained during 2001-2002 season from the Department of Agricultural Research of Plant Breeding, Ministry of Agriculture, Giza, Egypt. Legume seeds and cereal grains were manually cleaned of debris, dust and other foreign materials with discarding the split and unusual coloured ones.

Apricot (*Prunus armeniaca*) fruits, variety of El-Hamawy; mango (*Mangifera indica*) fruits, variety of Timour and cod liver oil were obtained from the local market, Cairo, Egypt on 2001- 2002 season. The skim milk powder was obtained from Misr Dairy Company, Cairo, Egypt. The hen's eggs were obtained from the Farm of Fac. of Agric., Al-Azhar Univ. Cairo, Egypt.

Methods:

Preparation of applied ingredients:

Legume seeds of common bean and chick pea, and the cereal grains of maize and wheat were prepared for using in the formulation of infants food formulae according to the procedures of Dahiya & Kapoor, (1993); Gahlawat & Sehgal, (1993) and Griffith *et al.*, (1998). The former legume seeds and cereal grains were washed and soaked in tap water (1:5 w/v) at ambient temperature ($\simeq 25^{\circ}C$) for 24 hrs except wheat grains which soaked for 48 hrs, with changing water every 8 hrs. Then, they were transferred to keep them between moistened cotton layers and allowed to germinate in the dark at ambient temperature for 72 and 48 hrs for legumes and cereals, respectively. The germinated legumes' samples were cooked under the atmospheric pressure ($100 \pm 5^{\circ}C$) in plenty of water for 30 min. While, the germinated cereals were autoclaved (at 1.2 bar & $121^{\circ}C$) for 15 min. Whereas, the cooked samles were oven dried under vacuum at $60 \pm 5^{\circ}C$ till the constant weight.

Soybean seeds were prepared as the method described by Kheir (1990). The soybeans were soaked in a salt solution (2.5% NaCl, 1.5% $NaHCO_3$ and 0.5% Na_2CO_3) at ratio of 1:5 (w/v) for 24 hrs, at ambient temperature. The soaked beans were rinsed twice in distilled water then cooked under the atmospheric pressure in plenty of the distilled water for 30 min. The cooked beans were mashed and dried in the oven under vacuum at

60±5°C until the constant weight. The dried samples were then defatted twice, for 3 hrs of each, by using petroleum ether at ratio of 1:4 (w/v) with continuous stirring at ambient temperature. The defatted meal was separated by the filtration under vacuum through Whatman filter paper No.3.

Rice grains were prepared according to the method of Som *et al.*, (1992). The rice grains were washed, soaked in tap water (1:3 w/v) for 2 hrs and sun dried for overnight. They were then roasted in an electric roaster at 80±5°C for about 30 min.

The former prepared legumes and cereals samples were separately dried in an electric vacuum oven at 60±5°C till the constant weight, pulverized in an electric mill, sieved through a mesh siever and kept in polyethylene bags at 4±1°C until used.

Mango and apricot pulps were separated manually and dried by using an electric oven under vacuum at 60±5°C until the constant weight. After that, they were separately pulverized, as previously mentioned, and kept in polyethylene bags at 4±1°C until used.

Hen's egg yolk was separated manually and dried and then pulverized, as mentioned before, and kept in polyethylene bags at 4±1°C until used.

Soy protein isolate (S-PI) preparation:

Soybeans protein isolate was prepared according to the method of Elizalde *et al.*, (1988) by alkali-aqueous extraction of their protein concentrate followed by clarification of the extract by centrifugation (1600 xg, 20 min) and precipitation of protein by acidification at pH 4.5.

Formulation and processing of infant foods formulae:

The formulation of the resulted infants food formulae from the applied ingredients was selected in such a way to produce a nutritious low-cost supplementary food formulae sufficient to provide the infants (3-24 months of age) with the most RDA of nutrients and the required energy. The proportions of prepared ingredients (g/100 g on wet weight basis) of each infant food formula, as shown in Table (1), were again milled, carefully mixed and sterilized 3 times 85±5°C for one hour on three successive days (United States of Pharmacopeia, 1985).

The sterilized formulae were separately packed in polyethylene bags and kept at 4±1°C until analyzed and organoleptically evaluated.

Analytical methods:

The analytical methods were carried out for the five produced infants food formulae in the comparison with the commercially produced infant food formula (F_{cp}); namely Cerelac.

Protein, fat, ash and fiber contents were determined according to AOAC (1995). Total carbohydrates content was calculated by difference. The energy value was calculated as the sum values of 4 K cal/g of protein, 4 K cal /g of carbohydrates and 9 K cal/g of fat, according to Livesey, (1995).

Table (1): Composition of the produced infant foods formulae (g/100g on wet weight basis).

Ingredient (%)	Infant foods formulae				
	F1	F2	F3	F4	F5
Cod liver oil	-	5	5	-	5
Prepared legumes					
Common bean	20	-	30	10	15
Chick pea	10	20	-	25	-
Soy bean (DSB)	15	10	-	20	15
Prepared cereals					
Rice	15	-	20	10	-
Maize	-	25	10	-	20
Wheat	20	-	10	15	-
Sucrose	5	-	-	-	-
Skim milk powder	10	15	20	10	20
Dried apricot pulp	-	2.5	5	-	2.5
Dried mango pulp	-	2.5	-	5	2.5
Soy protein isolate (S-PI)	-	10	-	-	10
Dried egg yolk	5	10	-	5	10

Minerals' contents in the of the formulated diets after digestion, by using a mixture of concentrate nitric acid (HNO_3) and concentrate perchloric acid ($HClO_4$) at ratio (2:1), were determined as described in AOAC, (1995) by the atomic absorption spectroscopy using Pye Unicum SP-1900 apparatus for Zn, Mn, Ca, Fe, Cu, Mg, I and Se. While K content was estimated by using flame photometer (Jenway, model PF PV, serial No. 2422). Phosphorus content was determined colourimetrically based on measuring the optical density of the developed blue colour of the reduced molybdo-phosphoric complex formed in dilute sulphoric acid by using Digital Spectrophotometer Spekoll 11, No. 849101 at a wavelength of 660 nm.

Vit. (A) and Vit. (D) were extracted according to the procedures of Epler *et al.*, (1993) and Schanderl, (1970), respectively, and determined by using high performance liquid chromatography (HPLC) system. Pyridoxine (Vit. B_6) and folic acid were extracted as the methods described by De-Leemheer & De-Ruyter, (1975) and Pearson, (1976), respectively, and also estimated by the HPLC system. All analysis were carried out with TSP (Thermo Separation Products Inc.) HPLC system consisting of Consta METRIc 4100 series pump, spectra series AS 100, autosampler spectra system UV 1000, UV-visible variable wavelength detector and interfaced with IBM computer equipped with PC1000 chromatograph software version 3.5. The column used for the estimation of vit (B_6) and folic acid was a normal ultrasphere Si (5μM; 250 mm x 4.6 mm I.d., Alltech USA) and the chromatographic conditions were the flow rate, 1.5 ml/min;; detection, UV absorption at 265 nm; volume of injection, 20 μl; and the mobile phase composition was an isocratic system of isopropanol: hexane (1:99) for determination of Vit. (A) and Vit. (D). While, the column used was a reversed-phase water Adsorbosil C_{18} (5μM; 100 mm x 4.6 mm I.d. Alltech USA) and the chromatographic conditions were the flow rate, 1 ml/min; detection, UV absorption at 254 nm; volume of injection, 20 µl; and the mobile phase composition was an isocratic system of 100% methanol.

Thiamine (Vit. B1) and riboflavin (Vit. B2) contents were determined flourometrically using the methods recommended by Pearson, (1973) and Hawk, (1971), respectively.

Individual Indispensable amino acids (IAAs) contents were determined by ion-exchange chromatography using Amino Acid Analyzer (Bekman 4151 alpha plus) after hydrolyzing the sample with 6N HCl at 110±2°C in an oven for 24 hr., according to the method of Andrews and Bladar, (1985), except, trytpophan which was determined colourimetrically in the alkaline hydrolyzate of the sample, resulted by the digestion of the sample with saturated barium hydroxide in an oven at 120± 2°C for 24 hr., using Digital Spectrophotometer Spekoll, 11 No. 849101) at 460 nm as described by Sastry and Tammuru, (1985). Amino acid score (A.S) was calculated for IAAs in the formulated infants food formulae in relation to the reference protein pattern of FAO/WHO/UNU, (1985) for infants according to Bhanu *et al.*, (1991) as the following equation:

$$A.S = \frac{\text{IAA content (g/16gN) in formula protein}}{\text{IAA content (g/16 g N) in FAO/WHO/UNU reference pattern}} \times 100$$

Whereas, the AS value less than 100 indicates deficiency in considered amino acid. The IAA has the lowest A.S value (highest deficiency) is called restricting AA.

The quantity (g) of the formulated baby foods formulae should be consumed to cover the recommended daily allowances of nutrients (GDR values) for infants (3-24 months of age), and percent satisfaction of their RDA either in protein, energy value, minerals and vitamins when consuming 100 grams of formula (P.S/100 g%) or in the IAAs when feeding on 200 g of formulated diet were calculated using the RDA for infants of protein, energy value and the IAAs as recommended by FAO/WHO/UNU, (1985), and of minerals and vitamins as reported by Food and Nutrition Board, (1989).

Biological assays:

The formulation of diets used in biological assays (Table 2) and their contents of salt and vitamin mixtures, as well as biological evaluation for the nutritional protein quality of the formulated infants foods formulae and the F_{cp} were carried out in terms of PER, NPU, TD and BV values according to the procedures described in AOAC, (1995).

Table (2): Formulation of diets used in the biological evaluation for protein quality of produced infant formulae, compared to the F_{cp} (g/100 g on dry weight basis).

.Ingredient	Casein diet	Protein free diet	Baby foods formulae diets					
			F1	F2	F3	F4	F5	*Fcp
Corn starch	70.8	80.8	47.0	56.1	42.1	52.1	57.4	17.9
Cellulose	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Corn oil	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Cod liver oil	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Salt mixture	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Vitamins mixture	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Choline chloride	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Casein	1.0	-	-	-	-	-	-	-
Formula (1)	-	-	33.8	-	-	-	-	-
Formula (2)	-	-	-	24.7	-	-	-	-
Formula (3)	-	-	-	-	38.7	-	-	-
Formula (4)	-	-	-	-	-	28.7	-	-
Formula (5)	-	-	-	-	-	-	23.4	-
Fcp* (Cerelac)	-	-	-	-	-	-	-	62.9

Fcp*: Commercially produced baby food formula in Egypt, namely Cerelac .

Sensory evaluation of the formulated infant foods formulae:

The organoleptic quality properties (colour, taste, odour, texture and overall acceptability) of the produced infant foods formulae and the F_{cp} were evaluated organoleptically by ten educated Egyptian mothers in Cairo, to provide us with the sense of their infants and with their opinion organoleptically about the produced formulae, by scoring each property on a 10-points hedonic scale, the higher values denoting better quality according to the procedure of Dahiya and Kapoor, (1994) as the following numerical system: Excellent (8.5-10) , very good (7.5- 8.4), good (6.5-7.4) accepted (5.0- 6.4), poor (4.0 – 4.9) and very poor (> 4.0).

Statistical Analysis:

Statistical analysis of variance was carried out using SAS program for the multiple comparison between the biological measurements for protein quality and the organoleptic properties' scores of the produced baby foods formulae, the procedure of ANOVA and Duncan's Multiple Range Test were used according to Helwing, (1983).

RESULT AND DISCUSSION

The proximate chemical analysis of the produced infant foods formulae:

As shown in table (3), the proximate chemical constituents (on wet weight basis) of the formulated infant food diets ranged between 5.6- 6.6%, 24.1-40.4%, 3.1-9.2%, 1.5-3.6%, 2.7-4.9% and 39.1-61.14%, versus 2.5, 15.5, 9.0, 1.4, 2.7 and 68.9% in the commercially produced baby food formula (Cerelac) for moisture, Protein, fat, crude fiber, ash and carbohydrates contents, respectively. Therefore, the produced formulae No (2) and (5) exhibited the highest contents of protein, fat and ash; and the lowest content of crude fiber and carbohydrates

Table(3): The proximate analysis of (% on wet weight basis) for the formulated infants food formulae.

Constituents (%)	Baby foods formula					
	F1	F2	F3	F4	F5	Fcp*
Moisture	6.31	5.84	6.57	6.13	5.66	2.5
Crude protein	27.75	38.07	24.12	32.68	40.39	15.5
Crude fat	5.19	9.23	3.06	4.94	8.70	9.0
Crude fiber	2.88	1.69	2.43	3.57	1.53	1.4
Ash	3.42	4.90	2.68	3.70	4.58	2.7
Carbohydrates	54.45	40.27	61.14	48.98	39.14	68.9
Energy value (Kcal)	354.72	396.43	368.58	371.10	396.42	419

Fcp* : Commericaly produced formula(Cerelac).

The former data also illustrated that the formulated food blends No. 2 and 5 and had the highest energy value of 396Kcal, against 419 K.cal for the commercial produced formula (Cerelac).

The nutritive value of the produced foods formulae in relation to the RDA for infants:

Table (4) clearly evident that the formulated baby food mixtures are enrichment with protein and the all tested minerals, especially formula (2) and formula (5), when compared to the RDA of these nutrients for infants (3-24 months of age) as reported by FAO/WHO/UNU, (1985), for protein and food & Nutrition Board, (1989) for minerals. The infants feeding on 100g of the formulated baby foods formulae No. 2 & 5 was sufficient to provide them with their RDA from protein and the all tested minerals, with the exception of K and Mn which where satisfied by about 89 and 63-67%, respectively as the result of the fortification of them with the incorporated egg yolk and fruits' pulp. The predominant minerals in all produced formulae were K, Ca, P and Mg which were found at level of 982-1308, 390-575, 369-470 and 230-262 mg/100g formula (on wet weight basis), respectively. On the other hand, the infants needed to feed on about 200-240 g to intake their RDA of the required energy (840 K.Cal) reported by FAO/WHO/UNU, (1985).

From the obtained data of table (4), it could be also seen that the formulated baby diets fortified by 5% cod liver oil (F_2, F_3 & F_5) exhibited a highly richness in their contents of the vitamins A and D, while the unfortified ones by that additive were poorly in them.

Table(4): The nutritive value of the produced foods formulae N relation to the RDA for infants

Nutrient	RDA*	Formula 1			Formula 2			Formula 3			Formula 4			Formula 5			Commercially produced formula*		
		Content/100g sample	GDR***	PS/100g(%)**	Content/100g sample	GDR***	PS/100g(%)**	Content/100g sample	GDR***	PS/100g(%)**	Content/100g sample	GDR***	PS/100g(%)**	Content/100g sample	GDR***	PS/100g(%)**	Content/100g sample	GDR***	PS/100g(%)**
Protein (g)	18	27.8	65	154	38.1	47	213	24.1	75	133	32.7	55	182	40.4	45	222	15.5	116	86
Energy value (K.cal)	840	355	237	42	396	212	47	369	228	44	371	226	44	396	212	47	413	203	49
Minerals (mg) :																			
Potassium	1200	1239	97	103	1064	113	88	982	122	82	1308	92	109	1073	112	89	726	165	61
Zinc	5	5.6	89	112	5.2	96	104	3.8	132	76	5.6	89	112	5.1	98	102	4.2	119	84
Manganse	60	31	194	52	40	150	67	51	118	85	26	231	43	38	158	63	12	500	20
Calcium	500	408	123	81	575	87	115	457	109	92	390	128	78	552	91	110	457	109	92
Phosphorus	400	425	94	106	449	89	112	445	90	111	369	108	93	470	85	118	352	114	88
Iron	10	11.3	88	114	10.1	99	101	8.7	115	87	12.3	81	123	10.7	93	108	7.5	133	75
Copper	0.5	3.1	16	625	2.4	21	476	2.9	17	588	3.7	14	714	3.1	16	625	0.5	100	100
Magnesium	200	247	81	123	230	87	115	214	93	108	262	76	132	237	84	119	209	96	104
Iodine	0.05	0.09	56	179	0.07	71	141	0.09	56	179	0.07	71	141	0.06	83	120	0.04	125	80
Selenium	0.02	0.03	67	149	0.02	100	100	0.04	50	200	0.03	67	149	0.04	50	200	ND	ND	00
Vitamins :																			
Vit. A (IU)	3000	514	584	17	4170	72	139	4018	75	133	649	462	22	4170	72	139	1033	290	34
Vit. D (IU)	400	42	952	11	469	85	118	424	94	106	46	870	11	482	83	120	200	200	50
Vit. B_1 (mg)	1.1	0.81	136	74	0.96	115	87	1.29	85	118	1.40	79	127	1.04	106	94	0.80	138	72
Vit. B_2 (mg)	1.1	0.76	145	69	1.23	89	112	0.67	164	61	1.05	105	95	1.19	92	109	0.30	367	27
Vit. B_6 (mg)	2.0	0.63	317	32	0.81	247	40	0.51	216	46	0.58	345	29	0.85	235	43	0.30	667	15
Vit. B_{12} (μg)	2.5	1.28	195	51	2.64	95	105	1.93	130	77	1.62	154	65	2.64	95	105	0.75	333	30
Folic acid (μg)	400	110	364	27	97	412	24	117	342	29	104	385	26	102	392	26	22	1818	6

* RDA : Recommended Daily Allowances of nutrient for infants reported by FAO/WHO/UNU, (1985) and Food and Nutrition Board, (1989).
** P.S. 200 g (%): Percent satisfaction of the daily requirements of nutrient for infants.
*** G.D.R. : Grams consumed to cover the daily requirements of nutrient for infants.

The consumption of about 70-90 g from the above richness formulae provided the infants with their RDA of vitamins A and D. The produced formulae also exhibited their enrichment with Vit B_1, Vit. B_2 and Vit B_{12}, and their a moderately contents of Vit. B_6 and folic acid. In general, the produced formulae No (2) and (5) approximately had the highest contents of all the estimated vitamins,. The infants feeding on 100g of each the two previous richness formulae was nearly enough to cover their RDA of all tested vitamins reported by Food and Nutrition Board, (1989), with the exception of both vit B_6 and folic acid which satisfied by 40-43% and 24-26%, respectively. The enrichment of the formulated baby food diets with the tested nutrients attributed to fortify with the incorporated food ingredients enriched with them as reported by Dahiya & Kapoor, (1993) and Kshirsagar *et al.*, (1994) who mentioned that the highly contents of some minerals and vitamins in the baby foods might be to the fortification with enriched ingredients. In this concern, Olaofe, (1988); Ros *et al.*, (1994) and Baskaran *et al.*, (1999) reported that baby foods formulated from cereals and legumes cannot provide enough minerals and vitamins unless fortified with enriched resources such as skim milk, dried egg, meat and fruits.

It is worth to mention that the formulated infants formulae, under investigation, exhibited much higher contents of all tested nutrients than the commercially produced baby mixture in Egypt; namely Cerelac.

Nutritional evaluation for protein quality of the formulated infant foods formulae:

The nutritional evaluation for protein quality was carried out according to the indispensable amino acids (IAAs) profile as compared with the reference protein pattern of FAO/WHO/UNU, (1985) for infants and to the biological assays in terms of protein efficiency ratio (PER); net protein utilization (NPU), true protein digestibility (TD) and biological value (BV).

(a)- Composition of the IAAs:

From the obtained results (Table 5), it could be observed that the produced baby foods formulae contained an adequate contents and a better balance of all IAAs in their protein; much greater than the commercially produced formula (F_{cp}) namely (Cerelac). If the contents of the individuals IAA in the produced baby food mixtures are compared with the reference protein pattern of FAO/WHO/UNU, (1985) for infants feeding as shown in table (6), it could be concluded that all baby food formulations had a higher content (g/16gN) of the most individual IAAs than the reference pattern, especially formula (2) and formula (5) which approximately showed no deficiency in the IAAs of their protein. The first restricting IAA, having the least chemical score, (Table 5) was found to be the amino acids- containing sulpher (Methionine & Cycstine) in all tested formulae, except the formula No (4) in which the first limiting IAA was leucine. While the first limiting IAA for the F_{cp} was found to be lysine. The second restricting IAA was leucine for F (1); tryptophan for F(3) & Fcp and lysine for F(4).

Table (5): Indispensable amino acids (IAA$_s$) composition (on wet weight basis) of the produced foods formulae, compared with FAO/WHO/UNU protein pattern for infants feeding.

Amino acid	FAO/WHO/ UNUPattern*	F1		F2		F3		F4		F5		Fcp**	
		g/16 g N	g/100g sample	g/16 g N	g/100 g sample	g/16 g N	g/100 g sample	g/16 g N	g/100 g sample	g/16 g N	g/100 g sample	g/16 g N	g/100 g sample
Leucine	9.3	7.80	2.16	9.65	3.67	8.41	2.03	8.10	2.65	9.42	3.80	7.62	1.18
Isoleucine	4.6	5.34	1.48	5.10	1.94	4.89	1.18	6.02	1.97	5.60	2.26	4.80	0.74
Lysine	6.6	5.79	1.61	6.47	2.46	6.26	1.51	5.90	1.93	6.85	2.77	4.42	0.69
Methionine & Cystine	4.2	3.01	0.84	3.86	1.47	2.93	0.71	3.79	1.24	3.44	1.39	3.26	0.51
Threonine	4.3	4.53	1.26	4.58	1.74	5.35	1.29	4.68	1.53	5.01	2.02	3.73	0.58
Histidine	2.6	2.67	0.74	2.96	1.13	2.60	0.63	2.95	0.96	2.79	1.13	2.40	0.37
Phenylalanine & Tyrosine	7.2	7.85	2.18	7.43	2.83	7.76	1.87	8.31	2.72	7.56	3.05	8.01	1.24
Tryptophan	1.7	1.51	0.42	1.99	0.76	1.38	0.33	1.53	0.50	1.88	0.76	1.18	0.18
Valine	5.5	5.60	1.55	5.72	2.18	6.04	1.46	5.70	1.86	5.73	2.31	5.54	0.86
Total IAAs	42.5	44.10	12.24	47.67	18.18	45.62	11.01	46.98	15.66	48.28	19.49	40.96	6.35

* FAO/WHO/UNU, (1985) protein pattern (g/16 gN) for infants (3-24 months of age).
Fcp**, Commercially produced baby food formula (Cerelac).

Table (6): Nutritional evaluation for protein quality of the produced foods formulae for infants feeding.

Description	FAO/WHO/UNU/ Pattern (g/16gN)	USRDA (g)	Formula 1			Formula 2			Formula 3			Formula 4			Formula 5			Fcp		
			I.A.A. Score	G.D.R.	P.S./200g %	I.A.A. Score	G.D.R.	P.S./200g %	I.A.A. Score	G.D.R.	P.S./200g %	I.A.A. Score	G.D.R.	P.S./200g %	I.A.A. Score	G.D.R.	P.S./200g %	I.A.A. Score	G.D.R.	P.S./200g %
Indispensable amino acids																				
Leucine	9.3	5.859	84**	271	74	104	160	125	90	289	69	87*	221	90	101	154	130	82	497	40
Isoleucine	4.6	2.898	116	196	102	111	149	134	106	246	81	131	147	136	122	128	156	104	392	51
Lysine	6.6	4.158	88	258	78	98	169	118	95	275	73	89**	215	93	104	150	133	67*	603	33
Methionine & Cystine	4.2	2.646	72*	315	63	92*	180	111	70*	373	54	90	213	94	82*	190	105	78	519	39
Threonine	4.3	2.709	105	215	93	107	156	128	124	210	95	109	177	113	117	134	149	87	467	43
Histidine	2.6	1.638	103	221	90	114	145	138	100	260	77	113	171	117	107	145	138	92	443	45
Phenylalanine & Tyrosine	7.2	4.536	109	208	96	103	160	125	108	243	82	115	167	120	105	149	134	111	366	55
Tyrptophan	1.7	1.071	89	255	78	117	141	142	81**	325	62	90	214	93	111	141	142	69**	595	34
Valine	5.5	3.465	102	224	89	104	159	126	110	237	84	104	186	108	104	150	133	101	403	50
Biological Status **																				
Protein efficiency ratio (PER)			1.76 ± 0.10^{b}			2.54 ± 0.07^{d}			1.97 ± 0.12^{c}			2.04 ± 0.10^{c}			2.59 ± 0.12^{d}			1.32 ± 0.08^{a}		
Net protein utilization (NPU)			63.84 ± 0.86^{a}			83.19 ± 1.10^{c}			66.23 ± 0.91^{b}			70.61 ± 1.23^{b}			82.26 ± 1.05^{c}			62.50 ± 0.90^{a}		
True protein digestibility (TD)			85.10 ± 1.22^{b}			90.74 ± 1.82^{d}			83.57 ± 0.74^{ab}			81.85 ± 1.05^{a}			88.42 ± 1.93^{cd}			87.10 ± 2.06^{c}		
Biological value (BV)			75.02 ± 0.95^{b}			91.68 ± 2.26^{e}			79.25 ± 1.10^{c}			86.27 ± 0.97^{d}			93.03 ± 2.09^{e}			71.76 ± 1.52^{a}		

USRDA : United State Recommended Daily Allowances of Indispensable Amino Acid (IAA) for infants as reported by FAO/WHO/UNU, (1985).

G.D.R. : Grams consumed to cover the daily requirements of the IAA for infants.

P.S. 200 g (%): Percent satisfaction of the daily requirements of the IAA for infants.

* : First restricting indispensable amino acid,

**: Second restricting indispensable amino acid.

*** Biological status: Mean ± standard error ; the means of prepared formula (in the same row) having different superscripts are significantly varied.

b) Biological evaluation:

The results of table (6) also show that the all tested baby food formulations and the F_{CP} had a good true protein digestibility (TD). This enhancement may be due to reduce the levels of the antinutritional and flatulence- producing factors at high extent as well as to improve the digestibility of the proteineous compounds in cereals and legumes as the effect of preparation treatments for them, such as soaking, germination and autoclaving (Jood *et al.*, 1986 and Rosaiah *et al.*, 1993).

The obtained results of the biological assay (Table 6) also exhibited that the produced food formulations had a significant higher values of the biological terms than those of the F_{CP} (Cerelac). In addition that the highest values of the biological indices were observed for both F_2 and F_5 which having the values of PER (2.54 & 2.59); NPU (83.19 & 82.26) and BV (91.68 & 93.03) analogous to the corresponding values of milk protein (casein) being 2.57, 81.70 & 92.14, respectively, in accordance with their adequate contents and a better balance of all IAAs in their protein as previously explained. The formulated baby foods, under investigation, had a high nutritional quality and biological value of protein because of the complementary effect of their mixed ingredients resulting a better balance of the IAAs and an improvement of the nutritional quality of their protein (Malleshi *et al.*, 1986; Livingstone *et al.*, 1993 and Griffith *et al.*, 1998). Also, the preparation treatments including soaking, germination and autoclaving for the applied legumes and cereals led to remove or reduce the antinutritional factors in them resulting an improvement of the bioavailability and nutritional quality of protein in the formulated diets as previously interpreted.

The ogranoleptic quality attributes of the produced infants foods formulae:

Sensory evaluation for the organoleptic characteristics (Color, taste, odour, texture and overall acceptability) of the produced supplementary foods formulae was performed by educated Egyptian mothers to feed their infants on these diets after immediately prepared for feeding and to support us with the senses of them. The scores' mean of the tested properties are recorded in table (7).

Table(7): The arganoleptic quality properties of the produced infant foods formulae.

Formula	Scores of organoleptic properties (M+S.E.) **				
	Colour	Taste	Odour	Texture	Overall acceptability
Fcp*	7.5±0.13^{b}	8.8±0.08^{bc}	7.9±0.11^{c}	8.2±0.07^{b}	8.1±0.10^{b}
F1	7.1±0.19^{a}	8.3±0.11^{a}	7.2±0.08^{a}	7.5±0.10^{a}	7.5±0.08^{a}
F2	8.7±0.07^{c}	9.0±0.09^{c}	8.5±0.12^{d}	9.3±0.07^{d}	8.9±0.11^{d}
F3	7.3±0.10^{ab}	8.2±0.13^{a}	7.5±0.10^{b}	8.9±0.09^{c}	8.5±0.12^{c}
F4	9.1±0.12^{d}	8.6±0.07^{b}	9.6±0.09^{c}	7.5±0.12^{a}	8.7±0.09^{bc}
F5	8.5±0.09^{c}	9.5±0.12^{d}	8.9±0.08^{f}	9.1±0.10^{cd}	9.0±0.10^{d}

Fcp* : Commercially produced baby food formula; namely Cerealc.

M±S.E.** : Mean of each property's scores ±standard error, means (in the same column) having different superscripts are significantly varied.

From the above table, it could be observed that the most produced baby foods had an excellent organoleptic quality and they were more acceptable for infants, especially the formulae No. (2) and (5). The obtained observations of the sensory evaluation also indicated that the formulated baby foods formulae had pleasant colour, taste and odour; and consistency smooth texture. The organoleptic quality of the produced infant diets was better than that of the F_{cp} (Cerelac). These findings are in agreement with those found by Almedia-Dominguez *et al.*, (1993); Idowk *et al.*, (1993) and Dahiya & Kapoor, (1994) who reported that the supplement baby food mixtures containing cereals; legumes and skim milk showed an excellent organoleptic quality and acceptability.

CONCLUSION AND RECOMMENDATION

Thereafter, the formulated baby food mixtures are considered to be a highly nutritious and pleasant for infants. Therefore, it is recommended that we should increase the production of the nutritious supplemented baby foods for infants feeding from available inexpensive cereals and legumes with fortifying by the natural enriched ingredients, with protein, minerals and vitamins needed, such s skim milk, plant protein isolates, egg yolk and cod liver oil and fruits to improve the nutrition status of infants and to help in solving the problem associated with suffering children from malnutrition diseases.

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إنتاج أغذية ذات جودة عالية ومنخفضة التكلفة لتغذية الأطفال الرضع

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أجرى هذا البحث لمحاولة إنتاج أغذية عالية فى جودتها الغذائية والحسية ومنخفضة التكلفة لتغذية الأطفال الرضع (٣-٢٤ شهر من العمر) من الحبوب والبقوليات التى تنتج محليا بكميات كبيرة والمخفضة السعر ولقد أوضحت النتائج التى تم الحصول عليها أن جميع الخلطات الغذائية التى تم توليفها تتميز بقيمة غذائية عالية والذى اتضح من ارتفاع محتواها من المعادن والفيتامينات والبروتين خاصة التوليفة رقم ٢ (F_2) والتى تكونت من (٥% زيت كبد الحوت، ٢٠% من دقيق الحمص، ١٠% من دقيق فول الصويا المنزوع الدهن، ٢٥% من دقيق الذرة، ١٥% من مسحوق اللبن الفرز، ١٠% من دقيق بروتين الصويا المعزول، ٢,٥% من مسحوق لحم ثمار كل من المانجو والمشمش، ١٠% من مسحوق صفار البيض) والتوليفة رقم٥ (F_5) والتى تكونت من (٥% زيت كبد الحوت، ١٥% من دقيق كل من الفاصوليا وفول الصويا المنزوع الدهن، ٢٠% من دقيق كل من الذرة واللبن الفرز، ١٠% من مسحوق كل من بروتين الصويا المعزول وصفار البيض، ٢,٥% من مسحوق لحم ثمار كل من المانجو والمشمش).

كما بينت النتائج المتحصل عليها أن الخلطات الغذائية التى تم إنتاجها لتغذية الأطفال الرضع خاصة التركيبتين ٢، ٥ قد أظهرت أن الجودة الغذائية للبروتين التى تحتويه كانت مرتفعة بدرجة كبيرة وممتازة والذى تبين من إحتوائه على محتوى عال من جميع الأحماض الأمينية الأساسية وبتركيب متزن إذا ما قورن بتركيب البروتين القياسى ومن ارتفاع قيم القياسات البيولوجية والتى تماثلت مع مثيلتها لبروتين اللبن حيث أن تغذية الأطفال الرضع على مائة جرام من أى من الخلطتين (F_2 & F_5) كاف للوفاء بجميع احتياجاتهم اليومية من جميع العناصر الغذائية التى تم دراستها باستثناء الطاقة اللازمه، المنجنيز، فيتامينات البيرودكسين (ب٦) وحامض الفوليك، الأحماض الأمينية الأساسية والتى يتم الوفاء بـ ٤٧، ٤٠-٤٣، ٢٤-٢٦، ٥٣-٧٨% من احتياجاتهم اليومية من تلك المغذيات على الترتيب. كما أشارت نتائج التقييم الحسى بأن الخلطات التى تم تحضيرها أظهرت جودة حسية ممتازة ودرجة قبول عالية وبصفة عامة فإن تلك التوليفات التى تم إنتاجها كانت أعلى فى جودتها الغذائية والحسية عنها فى مثيلتها للتوليفة المتاحة تجاريا لتغذية الأطفال الرضع (سيريلاك).

لذا فإنه ينصح بالاتجاه نحو إنتاج خلطات غذائية عالية فى جودتها الغذائية من مخلوط البقوليات والحبوب المدعمة بمسحوق اللبن الفرز وصفار البيض وبعض الفواكه وزيت كبد الحوت كمصادر طبيعية غنية بالمغذيات الضرورية اللازمة لهم.