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Preparing new and healthy weaning blends and its relation to nutritional status of infants

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ABSTRACT

Low nutrient density in weaning foods is the major cause of under-nutrition among infants and young children in developing countries. The aim of the present study was to develop weaning blends based on germinated cereal and legumes and supplemented with dried carrots and milk powder to improve and increase their quality. Also, the current intervention study was conducted on 102 infant who received weaning food consist of cereals (wheat, rice), legumes (chickpea). In comparison to 100 infants as a control group were not received the weaning food. It was noticed that the iron contents in all blends were high with values of 7.8 and 8.2 mg/100 g. Their iron content covered about 66% of the recommended daily requirement of infant consuming 50gm of prepared blend. The mean values of infants' weight were statistically significantly higher at 6, 9 and 12 months of age in the intervention group (8.30, 9.96 and 10.84 Kg) as compared to the control group (6.98, 8.51and 9.92 Kg), respectively. Apparent also, the mean values of infants' serum iron were statistically significantly higher at 6, 9, and 12 months of age in the intervention group compared to the control group (6 mo.-45.15 - 65.19 / 9 mo.-77.5 - 90.44 / 12 mo.-107.2 - 112.5, -P < 0.001, µg/dl), respectively.

Keywords: weaning, blends, children, growth,

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INTRODUCTION

Infancy is a critical period of human life development, growth, health, and survival. Malnutrition is a world-wide human suffering. Malnutrition (indicated by infant-child mortality, underweight and low birth weight) was stable in South America and decreased in Asia and Central America. Africa suffered from decline in food supplies and increased malnutrition. Solutions founder-nutrition in the Third World involve economics, politics, food availability and distribution. They may include Inadequate or inappropriate weaning diets and poor nutritional status due to improper timing of introducing weaning foods or infections from their food contamination. The World

Health Organization recommends the practice of exclusive breastfeeding of infants for the first 6 months after birth and to continue breastfeeding with supplementary diet up to two years or more **(WHO, 2015).** Weaning period is a transitional phase in children feeding, it should commence after the 6th month of life based on recommendations from most international organization and this period often coincides with the eruption of the first primary dentition -a possible indication of the child's readiness for chewing food. At this age, breast milk is not always sufficient in providing adequate nutrition for the growing child hence the need for additional non-breast milk based complementary meal **(Kramer and Kakuma, 2002, Umar and Oche, 2013)**. Iron deficiency in early life is associated with developmental problems, which may persist until later in life. Micronutrients are essential to sustain life and for optimal physiological function, Widespread global micronutrient deficiencies (MNDs) exist, with pregnant women and their children less than five years at highest risk. Iron, iodine, folate, vitamin A, and zinc deficiencies are the most. Iron deficiency leads to microcytic anemia, decreased capacity of work, impaired endocrine and immune function. Prevention of MNDs is critical and accomplished via supplementation and fortification **(Bailey et al., 2015).**

In a study in Egypt, as high as 92.5% of the respondents defined weaning as cessation of breastfeeding with only 33.6% of respondents knowing that 6 months is the suitable age for initiating weaning (Eman et al., 2014). Weaning food is normally a semi-solid food to be used in addition to breast milk and not only to replace it. In many countries, introducing weaning foods is recommended from the end of 6months of age **(Lutter and Dewey, 2009).** Weaning foods are prepared mostly as gruels made from cereals (rice, wheat, corn). Gruels are prepared from cereal: legumes combinations which carry a more favorable nutrient profile than gruels made from cereals alone. (**Griffith et al., 1998).**

Germination enhanced flavor and nutritional qualities, particularly through breakdown of phytate and flatulence factors **(Urooj and Puttaraj, 2006).** Germination is also known to improve the vitamin and mineral contents. It has been reported that vitamin C and riboflavin are synthesized during germination **(Henry and Massey, 2001).** Malnutrition causes 35 % of disease burden on children under the age of five. In fact, the best practices in the areas of breastfeeding and complementary feeding are important degree with the ability to save the lives of 1.5 million children under the age of five every year. Globally less than 40% of infants under the age of six months are exclusively breastfed **(WHO, 2015)**. Thus, in this study, weaning blends were formulated from locally-available materials in Egypt (wheat, rice, chickpea, dried carrots and Powder milk) with emphasis on the physicochemical properties of their blends. The objective was to evaluate the functional properties of this weaning food in order to know the appropriateness of the diet for infants.

MATERIALS AND METHODS

Raw Materials

All materials were purchases locally from Cairo, Egypt. The weaning food in the study consists of these mixtures: Cereals: rice and wheat 70%; Legumes: chickpea 20%; Dried carrot 5% and Powder milk 5%.

Design of the study

Phase-I: descriptive study.

Phase-II: intervention study.

Inclusion criteria

Infant age 6 months and exclusively on breast feeding and who were followed until completed one year of age.

Exclusion criteria

Infant who was artificially fed or took other food beside the breast milk.

History

Full history was taken from the parent of infants about his health during the first 6 months of age, methods of feeding of infants, immunization and any family disease

Examination

Anthropometric measurements included weight, length, head circumference, and routine medical examination of infants was taken in the first visit to the clinic and every month after that. according to **(Hammond, (1998).**

Investigations

These laboratory studies were done at the first visit of the infant to the clinic and at 6 and 9 months and when the infant completed his first year of age (Serum iron, Serum ferritin and Serum transferrin). All infants in the study were attending the outpatient clinic of the National Nutrition Institute. All infants were exclusively breast fed at the age of 6 months, with total number was 202 infants. The first group took the mixture of germinated cereals and legumes (102 infants). The second group is a control group of infants who were fed the ordinary prepared weaning food at home (100 infants).

Preparing the mixture of germinated cereals and legumes

All cereals and legumes were cleaned, washed, soaked in excess tap water for 6 hours except rice for 18 hours. They were spread in 1 cm of thick layer of wet cotton cloth to avoid seeds accumulation and sprayed with water twice daily. The germinated time was 48 hours for legumes and 72 hours for cereals. According to **(Gloria et al.,2005).**

Cooking

The germinated seeds were boiled for 6-12 minutes.

Drying

Oven air dryer was used at 60-70°c for 48 hours. The dried seeds were grinded in electrical mill, they were sieved through a silk sieve for a fine powder.

Preparation of yellow carrot

Carrot was cleaned, washed, peeled, cut into slices then soaked in boiled water for 5 minutes and dried in oven air dryer (60-70°c) for 3-4 days and grounded into powder.

Preparation of weaning food mixtures

Weaning food mixtures were prepared using the germinated legumes in these ratios from 6-9 months:70% rice powder, 20% powder of germinated chickpea, 5% powder of dried carrot and 5% powder of milk formula of infants. Weaning food mixtures were prepared using the germinated legumes in these ratios from 9-12 months:70% wheat powder, 20% powder of germinated chickpea, 5% powder of dried carrot and 5% powder of milk formula of infants.

Analytical methods

The chemical analysis was conducted at Food Safety and Quality Control Lab, Faculty of Agriculture, Cairo University. The prepared samples were subjected to the chemical analysis moisture, protein, fat and ash by the methods described by **A.O.A.C. (2000).** Crude fiber was measured using the method described by **Kirk and Sawyer (1991).** Total carbohydrates were determined using the method described by **James (1995).** Minerals were measured according to in **A.O.A.C. (2000).** Amino acids measured according to the method of **Block et al., (1958).**

Ethical consideration

Agreement was taken from every parent after verbal informed consent was obtained from the parents after explanation of the nature and aims of the risks for the study, its benefits and any expected risks for their children who participate in the study and discussing with them all the steps of the study and the benefit of the mixture to their infant. Any parents refused to be included were excluded from the study even if they refused to continue during the study. All the mixture fulfilled all the safety condition of infant's food to prevent chocking and any other possible problem **(IPCS.; 2014).**

Statistical analysis

Data were collected, and statistically analyzed using SPSS software version 12.
Qualitative (nominal) data were presented in the form of number and percent.
Quantitative (numerical) data were presented as mean and standard deviation. The level of significance at ($P < 0.05$) was used as cut-off points for all significance tests **(Salah and El Shourbagy, 2012).**

RESULTS AND DISCUSSION

The importance of nutrition as a foundation for healthy development is underestimated. Poor nutrition leads to ill health, and ill health causes further deterioration in nutritional status. These effects are most dramatically observed in infants and young children, who bear the brunt of the onset of malnutrition and suffer the highest risk of disability and death associated. But the children who die represent only a small part of the total health burden due to nutritional deficiencies. Child malnutrition is affected by several determinants, such as intrauterine growth retardation, lack of exclusive breastfeeding, inappropriate complementary feeding, and repeated attacks of infectious illnesses, food scarcity, and micronutrient deficiencies **(Ahmed et al., 2009).**

Data obtained from table (1) illustrated the chemical composition of raw materials which used in blends. It could be noticed that the germinated chickpea and powder milk were high content of protein than other materials, meanwhile the total carbohydrates of germinated rice was highest than other materials. The fat content of dried carrot was lowest but powder milk was the highest with values 1.34 and 26.37%, respectively. Chemical composition of weaning food blends are showed in table (2) indicated that wheat and chickpea blend was high in protein content while rice and chickpea blend was higher in total carbohydrates, these data maybe due to the higher content of carbohydrates in germinated rice but chickpea high in protein content as seen table (1).

In table (3) it was noticed that the iron contents in both blends are high with values 7.8 and 8.2 mg/100 g. Those iron contents could covered about 66% of the recommended daily requirement of infant consuming 50gm of prepared blend. Iron is important for young babies during weaning. Iron is needed as a component of hemoglobin found in the red blood cells. Also, in table (4) we can see the percentage of the daily requirements of energy and protein covered by

50gm of each blend for infants as recommended by **FAO/WHO (1985).** The obtained results showed that 50gm of each blend covered about 21-22% of energy and 50-65% of protein of the daily requirements.

Data obtained from table (5) illustrated the amino acids pattern on the various germinated blends compared to the **FAO/WHO (1985)** reference pattern. The results showed that the combination of cereals and legumes mixtures gave efficient complementation of the amino acids, which met the FAO/WHO reference pattern. The inclusion of various cereals and legumes in the development of infant food supplements has been extensively investigated. Cereals, the main source of calories, are adequate in methionine and cysteine and are a good source of B-complex vitamins but limiting in lysine. Most legumes are rich in lysine but low in Sulphur amino acids, allowing the combination of cereals and legumes into complementary blends **Griffith et al., (1998).**

There was no significant difference between both studied groups as regard the sex distribution, where the percentage of male in intervention group were 46.4 % in comparison to 53.4% in control group, while the percentage of female were 55.8 & 44.2%,respectively as shown in table (6).The nutritional content of weaning foods becomes of increasing importance as infancy progresses. The most pertinent concerns are the nutrient densities of the foods and the bioavailability of essential micronutrients therein. Good nutritional practice, incorporating all of the above, would be compatible with guidelines that include the initial use of baby rice mixed with the infant's normal milk, followed by the gradual introduction of vegetables, then fruits, cheese, yoghurt or , and lean meat, all in pureed form. It is essential that accurate information about appropriate weaning foods and practice is disseminated to prevent infant malnutrition, problems with development, or longer term eating and health problems **(Henry and Massey, 2001).**

Table (7) shows that the mean values of infants' weight were statistically significantly higher at 6, 9 and 12 months of age in the intervention group (8.30, 9.96, 10.84 Kg) than the control group (6.98, 8.51, 9.92 Kg) respectively. Apparent also, from table (8) that the mean values of infants' height were significantly higher at 6, 9, and 12 months of age in the intervention group than the control group (6 mo, 69.63(1.72), 72.55(3.76), P < 0.001, 9 mo. 74.84(2.53), 77.49(5.18), P < 0.001and 12 mo. 80.56(2.44), 83.04(8.0), P< 0.003), respectively.

The mean values of infants' head circumference were statistically significantly higher at 6, 9, and 12 months of age in the intervention group than the control group (-6 mo.-43.17(1.2)-44.58(3.38)-P< 0.001/-9 mo.-44.87(0.95)-46.22(4.87)-P< 0.007/-12 mo.-45.74(0.83)-36.35(1.1)-P < 0.001, cm), respectively (Table 9).

Table (10) shows that the mean values of infants' serum iron were statistically significantly higher at 6, 9, and 12 months of age in the intervention group than the control group (6 mo._ 45.15-65.19/ 9 mo._ 77.5 - 90.44 / 12 mo._107.2 - 112.5 , -P < 0.001, ug/dl), respectively. Table (11) shows that the mean values of infants' serum ferritin were significantly higher at 6 and 9 months of age in the intervention group than the control group (6 mo.-36.1(12.4)-43.4(9.8)-< 0.001/ 9 mo.-99.9(40.6)-91.3(12,9)-<0.043 , ng/ml), respectively. There was no statistical difference at 12 months of age. Data presented in table (12) showed the mean values of infants' serum transferrin were significantly higher at 6 and 9 months of age in the intervention group than the control group (6 mo.-189.6 -194.7 -P<0.005/ 9 mo.-239.1 - 254.7.2 - P< 0.001, mg/ml), respectively. There was no statistical difference at 12 months of age. The World Health Organization recommended exclusive breastfeeding of all full-term infants up to the age of 6 months. After 6 months of age breast milk alone may not meet needs of nutrition for all infants, leading them at risk for deficiencies. A study to investigate the relationship between 4 months vs. 6 months introduction of complementary foods to full-term breast-fed infant on iron status and growth. An electronic systematic review was conducted for RCTs and observational studies related. Iron status and growth data were analyzed. Meta-analysis showed significantly higher hemoglobin levels in infants fed solids at 4 months versus those fed solids at 6 months in developing countries (the mean difference) 5.0 g/L; 95 % CI: 1.5, 8.5 g/L; $P < 0.005$]. Meta-analysis showed higher ferritin levels in four month group in developed and developing countries (26.0 μg/L; 95 % CI: -0.1, 52.1 μg/L, $P<0.050$), (18.9 μg/L; 95 % CI: 0.7, 37.1 μg/L, $P < 0.040$). They concluded that the rate of iron deficiency anemia in breast-fed infants could be altered by introducing solids foods at the age of 4 months ***(WafaaQasem et al., 2015).***

Kissa et al., (2015) showed that inadequate feeding practices, low nutrient content of complementary meals, decreased dietary contribution to nutritional requirements and high prevalence of chronic undernutrition (i.e. stunting) are very common among infants in rural Dodoma during the post-harvest season. Inclusion of groundnuts, cow's milk or oil in porridge improves energy, protein and fat contents. Composite porridge and relish based on ASFs provide higher energy, protein and fat per portion than other meals. Relish made from beef, fish, sardines, dried jute mallow leaves, sweet potato leaves, beans and cowpeas are better sources of iron, zinc and calcium than other meals. These data provide a foundation for promoting best dietary practices (increased meal frequency, inclusion of nutrient-dense foods, adequate portion sizes, increased food variety) using feasible strategies such as nutrition education and counseling**.**

There was limited inclusion of other nutrient-dense foods (e.g. legumes, beef, fish, sardines, vegetables) in the meals. In addition, few infants consumed these foods. Low consumption of animal source foods (ASFs) has also been reported in developing countries, resulting in inadequate dietary intake and poor growth **(Leonard *et al.*, 2000).**

Figures and Tables

Table 1. Chemical composition of raw materials (gm/100 gm).

Materials	Moisture	Protein	Fat	Total carbohydrate	Fiber	Ash
Germinated wheat	7.40	13.56	3.60	65.09	2.75	4.00
Germinated rice	5.50	10.30	2.15	75.9	3.00	1.00
Germinated chickpea	5.30	24.32	7.85	49.68	2.50	2.50
Dried carrot	8.93	7.24	1.34	69.59	5.18	6.38
Powder milk	4.25	23.58	26.37	13.45	ND	5.98

Table 2. Chemical composition of weaning food blends (g/100 g mixture)

Component	Wheat and Chickpea	Rice and Chickpea
Moisture	6.56	4.79
Energy(Kcal)	368	377
Protein	16.20	14.17
Fat	4.66	3.76
Total carbohydrate	65.21	71.62
Fiber	3.39	3.56
Ash	3.98	2.11

Table 3. Minerals content of weaning food blends (mg/100 g blend)

Component	Wheat and Chickpea	Rice and Chickpea
Ca	131.0	108.0
P	353.0	256.0
Fe	7.8	8.2
Mg	23.0	22.0
Zn	3.7	3.5

Table 4. The percentage of the daily requirements for infants of energy and protein covered by 50gm consumption of each weaning food blends.

Component	Wheat and Chickpea	Rice and Chickpea
Energy (850Kcal)	21.62	22.18
Protein (14 gm)*	57.85	50.60

Table 5. Amino acid contents of weaning food blends compared with FAO/WHO (1985) reference pattern (mg/g protein)

Component	Wheat and Chickpea	Rice and Chickpea	FAO/WHO (1985)
Isoleucine	40.8	42.5	40
Leucine	66.3	69.7	70
Lysine	48.7	53.4	55
Methionine + cystine	31.6	30.5	35
Phenylalanine	61.3	63.5	60
Threonine	41.3	49.5	40
Tryptophan	10.0	10.4	10
Valine	47.8	59.7	50

Table 6. Sex distribution among both groups of the study

		No. of control group (%)	No. of intervention group (%)	Chi-Square	P-value
Sex	Male	62 (53.4%)	54 (46.6%)	1.695	0.193 NS
	Female	38 (44.2%)	48 (55.8%)		

NS: non-significant

Table 7. Mean values of weight among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	p-value
Weight (kg)	6 mo.	6.98± 0.22	8.30 ±0.65	18.920	< 0.001**
	9 mo.	8.51± 0.51	9.96±0.88	11.659	< 0.001**
	12 mo.	9.92± 0.78	10.84±0.93	7.584	< 0.001**

Table 8. Mean values of height among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	p-value
Height (cm)	6 mo.	69.63(1.72)	72.55(3.76)	7.138	< 0.001**
	9 mo.	74.84(2.53)	77.49(5.18)	4.630	< 0.001**
	12 mo.	80.56(2.44)	83.04(8.0)	2.999	0.003**

Table 9. Mean values of head circumference among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	P-value
HC/cm	6 mo.	43.17(1.2)	44.58(3.38)	3.954	< 0.001**
	9 mo.	44.87(0.95)	46.22(4.87)	2.753	0.007**
	12 mo.	45.74(0.83)	36.35(1.1)	4.390	< 0.001**

Table 10. Mean values of serum iron among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	P-value
Iron (µg / dl)	6 mo.	45.15±5.43	65.19±7.98	20.889	< 0.001**
	9 mo.	77.5±8.9	90.44±9.33	10.074	< 0.001**
	12 mo.	107.2±9.4	112.5±5.8	4.766	< 0.001**

Table 11. Mean values of serum ferritin among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	P-value
Ferritin (Nano gram / ml)	6 mo.	36.1(12.4)	43.4(9.8)	4.616	< 0.001**
	9 mo.	99.9(40.6)	91.3(12,9)	2.034	0.043*
	12 mo.	118(16.7)	120(12.8)	1.329	0.185

Table 12. Mean values of serum transferrin among studied infant groups

		Control group mean(±SD)	Intervention group mean(±SD)	t test	P-value
Transferrin (mg / dl)	6 mo.	189.6±6.8	194.7±16.7	2.854	0.005**
	9 mo.	239.1±24.9	254.7±21.2	4.789	< 0.001**
	12 mo.	301±16.33	300±11.5	0.406	0.685

CONCLUSION

The weaning period is a vulnerable period of life and especially so when resources are limited. The weaning formulations in the present study are based on commonly consumed, low-cost food materials locally-available. They will be potentially suitable for use as weaning foods, both at the home and commercial levels.

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