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Nutritional Evaluation of Some Commercial Infant Formula Consumed in Misurata-Libya

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ABSTRACT

Baby food for infants and young children conforms to a set of strict guidelines e.g. maximum levels for pesticide residues, microbiological contamination. In this study the nutritive value of some commercial baby food commonly consumed in Misrata, Libya was evaluated chemically including determination of pesticide residues and bacterial contamination. The protein contents differed significantly among most of the examined baby food and ranged from 7.5% to 13.4% while the fat contents of the infant formulas ranged from 1.79% to 13.2%. The actual protein and fat contents were lower than that declared on the label in all the baby foods evaluated. The crude fiber content was in the range of 5.68 – 15.73% for the Pulp of fruits and from 13.85 – 20.45% for dried fruits and vegetables. All samples in this study had low ascorbic acid content and total dissolved solids content and did not meet Libyan standard/specifications. The data presented showed that all of the pesticide residues monitored were observed to be in the concentrations below the limit of detection (LOD). All products analyzed during the study did not reveal any bacterial contamination. In Conclusion, there were discrepancies between the actual chemical composition of the infant formulas and those declared by the manufactures on their labels. Further studies are required to evaluate the chemical composition of infant formulas on a greater number of brands to ensure the accuracy of the contents declared on their labels.

***Keywords*:** Infant formula, Misurata-Libya, Nutritional evaluation, Pesticide.

Introduction

There is much evidence that the quality and composition of commercial baby food may contribute to the present and future health benefits of young children. Since infants between 6 months and 3 years are rather limited in their food choices, the commercially available fruit baby foods serve as a very important source of energy, basic nutrients, fiber, vitamins and minerals and determine their future taste and eating patterns**.** Whereas the safety of baby food with respect to chemical and microbiological contamination is a priority for both producers and state authorities. The composition and nutritive quality of these products are often underestimated.[1]

The nutritive value of baby food depends significantly on the composition, the raw materials used. Apart from being a source of energy, fruit baby foods are perceived to be major sources of the fiber, ascorbic acid, polyphenols and other antioxidants in diet based on the fruit and vegetable content and composition.[2,3]

The other important factors affecting the nutritive value of baby foods are the conditions of processing and associated parameters which could cause the reduction of nutrients in products, such as oxidation, non-enzymatic browning and the presence of contaminants. These factors are usually affected by heating, therefore the thermal damage that arises during the blanching, boiling, sterilization in the preparation and improper storage conditions prior to retailing are critical for the nutritive value of baby food.[3,4]

Prolonged breastfeeding up to 2 years has been widely practiced in the UK. However, due to rapid socioeconomic changes and urbanization, breastfeeding rates have declined and bottle-feeding trends at an early age have increased.[5] The protein quality of milk-based and milk cereal foods for infants and children, consumed in different countries, have been reported to be lower than that for whole milk; adequate information on the nutritional quality of the commercial baby food consumed in Libya is not available currently.[4, 6-8]

Reduction of the risk to children from pesticide contamination in agricultural products requires an understanding of the pathways by which exposure occurs. Dietary ingestion is one of the main pathways by which children are exposed to pesticides. Children eat more food relative to their body mass than adults and their dietary requirements are different from those of adults.[9] Baby foods should be free of pesticide residues, according to the extremely low maximum residue limits (MRLs) established by the European Community in 2006.[10] Thus, the monitoring of pesticide residues in such high-risk matrices should be accurate and reliable.[11] Pesticides protect crops from pests and are economically beneficial. However, these substances can transfer to the food and affect consumer health, especially in the food consumed by infants and children, who are a vulnerable risk group. Moreover, pesticide residues represent food safety issues of high concern and on this account various surveillance/compliance programmes exist in all developed countries as a part of measures aimed at consumer protection. As shown in the available reports.[12-21] Pesticides have hitherto been determined in baby food by the use of a wide range of techniques such as HPLC-MS/MS,[22] GC-MS,[23] GC-ECD,[24] GC-MS/MS.[25] The present paper deals with the nutritional evaluation of some common commercial infant formula sold in Libya by chemical analysis including determination of contamination with pesticide residues.

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Materials and Methods

Selection of infant formula
Two different types of infant formula: (1) Cereal blends and (2) Pulp of fruits were selected on the basis of their popularity and availability in Misurata City and were purchased from the commercial market. A pool of samples was prepared by combining a portion of each brand. An aliquot of this pooled sample was divided into three portions and each was analyzed separately. Table 1 shows the description of the baby food as indicated on the packages.

Chemical analysis
The chemical composition of infant formula was determined according to standard methods.[26] Crude protein was estimated from the nitrogen content by Kjeldahl methods. Fat content was determined by ether extraction using a Soxhlet apparatus. Available carbohydrates were calculated by difference, phosphorus by spectrophotometry, lactose, titratable acidity and solids not fat (SNF) contents by Milk-O-Scan as described by Marques and Belo.[27]

Pesticide Residues analysis
Homogenized infant formula (15 g) was added to a 50 mL DisQuE extraction tube. 15 mL of 1% acetic acid in acetonitrile was added and shaken vigorously for 1 min and then centrifuged at 1500 rcf for 1 min. The acetonitrile extract (1 mL) was transferred into a 50 mL DisQuE cleanup tube and shaken for 30 sec and then centrifuged at 1500 rcf for 1 min. The final extraction (100 µL) was transferred into an auto-sampler vial, diluted with 900 µL water, mixed and injected. The extracted baby food samples were analyzed using waters Ultra Performance Liquid Chromatography (UPLC) system combined with the fast MS acquisition rates of the Xevo^{TM} TQD Mass Spectrometer (Waters Xevo^{TM} TQD, with ACQUITY UPLC System).

Data analysis
All measurements were carried out in triplicate and presented as mean ± standard deviation (SD). Where applicable, significant differences among mean values were determined by one-way analysis of variance (ANOVA). P-value < 0.05 was considered statistically significant. For all statistical calculations, a standard statistical package software SPSS 20 was used.[28]

Results and Discussion

Moisture Content
The Moisture content in infant formula is given in Table 2. The results of this study revealed that the moisture content was in the range of 70.877 – 75.61% in the Pulp of fruits and from 2.985 - 4.617% for dried baby food. A comparison of moisture content in baby food with Libyan standard indicated that rice based with vegetables (4.617 ± 0.631%), Cereal with milk based, wheat, honey, rice (4.428 ± 0.853%) and Cereal with rice and honey (4.348 ± 0.938%) had higher content than Libyan standard (4% w/w%). The moisture content is used as a quality factor for prepared cereals which should have 2-8% moisture content.[29]

Ash Content
The ash content in infant formula is given in Table 1. The results of this study revealed that the ash content was in the range of 0.122 - 0.553% for the Pulp of fruits and from 1.20 – 2.7% for dried fruits and vegetables. Table 1 shows that the samples (Pm, Pb, Pc, Pf), pulp of fruits samples, ash contents were slightly higher than that stated in the Libyan standard specifications for these foods, where the Libyan standard specification recommended that the ash content should not exceed 0.25% for dry weight. While for the samples (Rv, Ra, Cm, Rf), the percentage of ash was higher than Libyan standard specification. The study revealed that lower doses were obtained compared to the previous report of Khan *et al*.,[30] and Raza *et al*.[31]

Total Dissolved Solids Content
The present study revealed that the total dissolved solids content of different kind of baby foods ranged from 18.1% to 21.8%. The content of samples from total dissolved solids did not meet Libyan standard specifications (25%).[32]

Protein Content
During infancy, high amount of protein is required because it is essential for normal growth, body development, and tissue repair. The present study revealed that protein contents differed significantly among most of the examined baby food and ranged from 7.5% to 13.4% as shown in table 3. Moreover, the actual protein contents were lower than that written on the label in all infant formula.
Another study reported protein contents of 11.63% in formulas collected from developing countries while they were 12.14% in formulas collected from developed countries.[33] Protein contents of infant formulas set in Codex Alimentations range between 1.8 and 3.0 g/100 kcal (about 12.0 to 20%).[34] Kan *et al*.[30] reported that the protein content of milk-based formula and cereal – milk blend varied between 13.3 and 26.0% and between 11.1 and 13.2%, respectively. In the present study, the protein quality of all the baby food tested fulfilled the FAO/WHO requirements, except samples Pf, Fc, and Pc.

Fats Content
The present study showed that the fat contents ranged from 1.79 to 13.2%. The actual fat contents were lower than that declared on the label in all formulas. A wider range was reported by another study (3.86 and 29.83%).[33] Fat contents of infant formulas set in Codex Alimentations range between 29.3 to 40.0%.[34] The infant formulas should supply fat from 22 to 40%.[35] All samples in this study had low-fat content and could not meet Codex requirements.
The low-fat content of canned baby foods and dried baby foods during storage at room temperature may be due to storage conditions or oxidation of the fatty substances contained in the mixture, the exposure to light and oxygen or the presence of metals in mixtures, Which helped to oxidize fat.[36, 37]

Crude Fiber
The crude fiber content is given in Table 4. The results of this study revealed that the crude fiber content was in the range of 5.68 – 15.73% for the pulp of fruits and from 13.85 – 20.45% for dried fruits and vegetables. From table 3, it was observed that the fiber content was irregular in most samples. In general, fiber content in dry samples was higher than in wet baby food samples. This variation in fiber content may be due to the storage temperature of the product or the feeder system.

Ascorbic Acid
The present study showed that ascorbic acid contents in the infant formula ranged from 2.11 to 8.6 mg/100g. All samples in this study had low ascorbic acid content (below the Libyan standard specifications). It was recommended that the content of ascorbic acid should not be less than 20 mg/100 g. Čížková [38] reported that the ascorbic acid content of baby food varied between 18.6 to 55.5 mg/100g which is higher than that of the present study. The decrease in the content of ascorbic acid may be due to its intense oxidative breakdown during storage.[39]

Acidity
The percentage of acidity based on citric acid ranges from 0.18 to 0.6%, meaning that the acidity content in most samples falls within the limits recommended by the Libyan standard specifications. It recommended that the content of acidity should not be higher than (0.4%).

Pesticide Residues
The data presented show in general that all the residues monitored were observed to be in the concentrations below LOD.

Bacterial Contamination
All products analyzed during the study did not contain any bacterial contamination, contrary to what was observed by Iversen *et al*.[40] who analyzed 82 powdered infant formulas and found a contamination by *Enterobacter sakazakii, Enterobacter cloacae, Klebsiella pneumonia* and *Citrobacter freundii*. In recent years manufacturers have implemented strategies to control microbial contamination. This may explain the absence of these pathogens in this study.

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Table 1: Infant formula packaging and their characteristics

Sample ID	Sample characteristics	Date of manufacture	Expiry dates	Package type	Place of purchased	Place of manufacture
Pf	Pulp of fruits and vegetables mixed	10-2-2017	03-01-2018	Glass bottle	Al - Na'as Pharmacy	Egypt
Fc	Fruit paste of carrot, apple and guava	02-1-2017	07-01-2018	Glass bottle	Al - Na'as Pharmacy	Egypt
Pc	Pulp carrot and apple	14-3-2017	03-02-2018	Glass bottle	Al - Rmila Pharmacy	Egypt
Pb	Pulp banana and apple	20-1-2017	05-02-2018	Glass bottle	Al - Rabi Pharmacy	Egypt
Pm	Pulp, mixed fruit	11-1-2017	27-01-2018	Glass bottle	Al - Rabi Pharmacy	Egypt
Rv	Rice-based parsley	06-3-2017	14-01-2018	Paper box	Al - Rabi Pharmacy	Libya
Ra	Rice based with apple	02-1-2017	12-02-2018	Paper box	Al - Rabi Pharmacy	Libya
Cm	Cereal with milk based, wheat, honey and rice	20-4-2017	05-05-2018	Paper box	Al - Na'as Pharmacy	Libya
Ch	Cereal with rice and honey	22-2-2017	28-02-2018	Paper box	Al - Na'as Pharmacy	Libya
Rf	Rice based with fruits	21-1-2017	20-01-2018	Paper box	Al - Rabi Pharmacy	Libya

Table 2: Moisture, Ash and Total Dissolved Solids Content (%) in different kind of infant formula

Samples	Moisture Content (%)	Ash Content (%)	Total Dissolved Solids Content (%)
Pf	75.61 ± 0.167	0.372 ± 0.168	21.8 ± 1.316
Fc	75.591 ± 0.393	0.122 ± 0.482	18.1 ± 1.853
Pc	70.877 ± 0.215	0.289 ± 0.571	20.6 ± 0.723
Pb	73.661 ± 0.227	0.344 ± 0.398	19.4 ± 2.341
Pm	74.765 ± 0.296	0.553 ± 0.741	21.348 ± 1..983
Rv	4.617 ± 0.631	1.20 ± 0.635	-
Ra	2.985 ± 0.496	1.70 ± 0.519	-
Cm	4.428 ± 0.853	1.8 ± 0.758	-
Ch	4.348 ± 0.938	2.7 ± 0.286	-
Rf	3.514 ± 0.689	1.9 ± 0.395	-

Table 3: Protein, Fats, Ascorbic acid, Fibres and Acidity Content in infant formula

Samples	Protein (%)	Fats (%)	Ascorbic Acid (mg/100g)	Crude Fiber (g/100g)	Acidity (%)
Pf	7.5 ± 0.412	4.3 ± 0.212	4.60 ± 0.131	5.68± 0.252	0.6 ± 0.173
Fc	8.6 ± 0.371	5.3 ± 0.615	4.70 ± 0.517	8.34± 0.964	0.3 ± 0.284
Pc	11.4 ± 0.482	8.7 ± 0.176	8.60 ± 0.461	6.92± 0.692	0.4± 0.217
Pb	12.1 ± 0.253	13.2 ± 0.953	6.30 ± 0.731	10.49± 0.391	0.5 ± 0.215
Pm	13.4 ± 0.815	2.6 ± 0.276	4.10 ± 0.624	15.73±0.756	0.6 ± 0.371
Rv	12.3 ± 0.426	1.93 ± 0.612	3.60 ± 0.725	18.75± 0.274	0.16 ± 0.153
Ra	12.5 ± 0.715	1.97 ± 0.362	6.80 ± 0.826	13.85± 0.212	0.18 ± 0.029
Cm	12.1 ± 0.451	1.80± 0.274	2.11±0.742	20.45± 0.167	0.20 ± 0.1.21
Ch	12.9 ± 0.215	1.79± 0.153	6.30±0.287	17.74± 0.235	0.18± 0.1.23
Rf	12.3 ± 0.145	1.85± 0.128	7.10±0.195	18.98± 0.123	0.21± 0.149

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Table 4: List of pesticides screened in all samples

No	Pesticide	Result (ppm)	LQ (ppm)	MRL-EU (ppm)
1	Abamectine	<LQ	0.010	0.010
2	Acetamipride	<LQ	0.010	0.010
3	Acrinatrine	<LQ	0.010	0.010
4	Aldrine	<LQ	0.010	0.010
5	Azoxystrobine	<LQ	0.010	0.010
6	Bromuconazole	<LQ	0.010	0.010
7	Bentazone	<LQ	0.010	0.010
8	Boscalide	<LQ	0.010	0.010
9	Carbofuran	<LQ	0.010	0.010
10	Carbaryl	<LQ	0.010	0.010
11	Cloquintocet-mexyl	<LQ	0.010	0.010
12	Cymoxanil	<LQ	0.010	0.010
13	Chlorantraniprole	<LQ	0.010	0.010
14	Clodinafop-propargyl	<LQ	0.010	0.010
15	Chlorpyrifos ethyl	<LQ	0.010	0.010
16	Chromafenozoide	<LQ	0.010	0.010
17	Cyproconazole	<LQ	0.010	0.010
18	Carbendazime	<LQ	0.010	0.010
19	Difenoconazole	<LQ	0.010	0.010
20	Deltamethrine	<LQ	0.010	0.010
21	Dimethothoate	<LQ	0.0010	0.003
22	Dimexostrobine	<LQ	0.010	0.010
23	Ethofumezate	<LQ	0.010	0.010
24	Epoxiconazole	<LQ	0.010	0.010
25	Fenamidone	<LQ	0.010	0.010
26	Fenexaprop-p-ethyl	<LQ	0.010	0.010
27	Flubendiamide	<LQ	0.010	0.010
28	Flufenoxuron	<LQ	0.010	0.010
29	Fenproproximate	<LQ	0.010	0.010
30	Fenpropimorphe	<LQ	0.010	0.010
31	Fenamiphos	<LQ	0.010	0.010
32	Fluodioxinil	<LQ	0.010	0.010
33	Fenhexamide	<LQ	0.010	0.010
34	Fenoxycarbe	<LQ	0.010	0.010
35	Hexythiazox	<LQ	0.010	0.010
36	Imidaclopride	<LQ	0.010	0.010
37	Iindoxacarbe	<LQ	0.010	0.010
38	Lufenuron	<LQ	0.010	0.010
39	Lamda-cyhalothrine	<LQ	0.010	0.010
40	Myclobutanil	<LQ	0.010	0.010
41	Metrhomyl	<LQ	0.010	0.010
42	Metribuzine	<LQ	0.010	0.010
43	Methiocarbe	<LQ	0.010	0.010
44	Methabenthiazuron	<LQ	0.010	0.010
45	Methidathion	<LQ	0.010	0.010
46	Malathion	<LQ	0.010	0.010
47	Metalaxyl	<LQ	0.010	0.010

48	Propamocarbe-HCl	<LQ	0.010	0.010
49	Penconazole	<LQ	0.010	0.010
50	Propagite	<LQ	0.010	0.010
51	Pyraloxystrobine	<LQ	0.010	0.010
52	Pencycuron	<LQ	0.010	0.010
53	Pinoxadene	<LQ	0.010	0.010
54	Pyrimethanil	<LQ	0.010	0.010
55	Tefluthrine	<LQ	0.010	0.010
56	Tebuconazole	<LQ	0.010	0.010
57	Thimethoxame	<LQ	0.010	0.010
58	Triticonazole	<LQ	0.010	0.010
59	Thiabendazole	<LQ	0.010	0.010
60	Trifloxystrobine	<LQ	0.010	0.010
61	Thiaclopride	<LQ	0.010	0.010
62	Tetradifon	<LQ	0.010	0.010
63	Spiromesifene	<LQ	0.010	0.010
64	Spinosad (A+D)	<LQ	0.010	0.010
65	Spirodiclofene	<LQ	0.010	0.010

*LQ= Limit of Quantification
*ppm= mg/kg
*MRL-EU= Maximum residue limits-European Union.

Conclusion

Infant formula is a rich source of major and minor components which are essential to provide the nutritional requirements to the human body. Moreover, the LC-MS/MS analysis of pesticide residues in all samples showed that most of the detected and quantified residues were below 0.01 ppm which corresponds to the maximum residual limit for pesticide residues in baby food, all of the infant formula products analyzed in this study do not contain the declared bacterial species. It suggests that the technology and quality control for baby food processing should be improved and environmental pollution should be controlled.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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