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Studies on the Development and Evaluation of Highly Nutritive baby Food Powder Fortified with Omega-3 Fatty Acid

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Abstract: Early weaning practices are one of the most important causes of malnutrition of children which ultimately increase the chance of baby morbidity and death rate. Omega-3 fatty acid(DHA ,ALA and EPA) is require for growth of brain and good vision in baby. The present study was carried out to develop cereals , pulses and dryfruit based baby food powder from indigenous raw materials for young children and to evaluate nutritional quality. The baby food powder was developed from different types of flour and omega-3 capsule .then it was analyzed for their physico-chemical, functional, microbiological and sensory qualities using standard methods. Moisture, Ash, Protein, Fat ,carbohydrate, DHA , ALA and EPA content was found 2.55%, 1.61%,13.33%,13.22%,82%, 240mg, 44mg and 360 mg respectively, it was able to meet the baby over 1 year recommended daily allowances. The values of functional properties such as water absorption capacity 115.37 ml/g , bulk density 0.57g/cm3 , solubility 57.41 % and swelling power 14.29% were found. The microbial analysis was done to see the acceptability of the product and the result was very good from the microbiological point of view. The main mineral of the baby food powder such as sodium, potassium, iron, magnesium and calcium were 220.4, 250, 8.9, 5.9 and 451 (mg/100g) respectively and Vitamin A and vitamin E was found 2800 and 3252µg/100gm.. On the basis of results pertaining to chemical and functional properties of the baby food powder the nutrient content was sufficient to meet the baby over 1 year basic need. Therefore, this baby food powder may support us to maintain a healthier life of baby at a cheap rate.

Keywords: *Baby Food Powder, Baby, Nutritional Quality, Microbiological and Physico-Chemical Qualities*

I. INTRODUCTION

Under nutrition is one of the large problems of infants and young children in the developing countries. However, at the age of 6 months and above 6 when the children birth weight is expected to have doubled, breast milk is not able to meet the nutritional needs of the growing infant. Protein energy malnutrition and micronutrient under-nutrition occur together billion of children and women tolerate from one or more forms of malnutrition including low birth weight, wasting, stunting, underweight, Vitamin A deficiencies, iodine deficiency disorders and anemia (BDHS, 2007 and General Economic Division, Planning Commission, GOB, 2007).

Weaning of a child is a serial process by which an infant is introduced the adult diet. Weaning food is a good formulation, which is a supplement to the breast milk. The composition will be as close as possible to breast milk except for high calories and protein and also carbohydrates values. Breast milk from a well-nourished . Infant feeding and rearing practices have a major effect on the short term and long-term nutritional status of children, as most of the under nutrition is associated with the faltering practices that occur in weaning period. Faulty feeding practices as well as lack of suitable weaning foods are also responsible for under nutrition. 42% of infants aged less than six months are exclusively breastfed and almost one-third (29%) of children aged 6-9 months not receive any solid or semi-solid foods. Complementary foods given to infants and young children in the world are often nutritionally inadequate and unsafe, leading to malnutrition.

Development of the supplementary foods based on locally available cereals and legumes has been suggested by the Integrated. Child Development Scheme (ICDS) and Food and Agriculture Organization (FAO) to combat malnutrition with the mothers and children of low socio-economic groups. Despite of all these efforts, it is evident that the formulated supplementary foods currently available are not accessible to many low income mothers due to the very high cost of production and non-availability of food materials used in the formulation of baby food(Agbede & Aletor, 2003).

Omega-3s area unit fatty acids that area unit integral to several aspects of health, together with foetal development, brain operate, heart health, and immunity . They'reought of essential fatty acids as a result of your body cannot turn out them on its own and desires to get them from food. The 3 main varieties area unit omega-3 (ALA), omega-3 (EPA), and omega-3 (DHA).

ALA is gift in an exceedingly kind of plant foods, together with vegetable oils, nuts, seeds, and bound vegetables. Yet, it isn't active in your body, and your body solely converts it into active forms, like DHA and EPA, in terribly little amounts . Meanwhile, EPA and DHA occur naturally in fatty fish, like salmon, mackerel, and tuna, and area unit wide accessible in supplements . While many sorts of polyunsaturated fatty acid supplements exist, a number of the foremost common area unit animal oil, krill oil, and alga oil. In general, most of the studies indicate that 120–1,300 mg of combined DHA and EPA per day is beneficial for children.

II. MATERIALS AND METHODS

Table 1: List of Glassware, Instruments, Ingredients and Chemicals

Glasswares	Instruments	Ingredients	chemicals
Beaker Conical flask	Hot air oven Soxhlet	• Oats • Rice Moong daal	• alcohol Acetic acid (10%)

Measuring cylinder Stirrer Test tube Pipette Burrete Silica crucible Petriplate	apparatus Drier Weighing balance Autoclave Tray drier Steel utensils	• Almond Kidney beans • Walnut Chocolatepowder Omega -3 capsule • Sorghum • Ragi Powder sugar	Boric acid - 4gm% Diethyl ether Methylene blue indicator Potassium oxalate Petroleum ether Phenolphthalein 1.25% H_2 so4 1.25% NaoH

Table 2:.Composition of ingredients in preparation of baby food powder sample

Ingredients	Sample T1	Sample T2	Sample T3
Rice	15g	5g	15g
Oats	15g	15g	15g
Sorghum	5g	5g	15g
Moong dal	15g	15g	5g
Kidney beans	5g	5g	5g
Almond	15g	15g	5g
Walnut	5g	15g	5g
Ragi	5g	5g	15g
Chocolate powder	10g	10g	10g
Sugar	10g	10g	10g
Omega-3 capsule	4 capsule	3 capsule	2 capsule

A. Preparation of Highly Cereal Based Instant Supplementary Baby Food

A highly nutritive baby food fortified with omega-3 has been prepared from different flour of cereals, pulses and dryfruits and omega-3 capsule at parul university, Vadodara. Oats,rice, moong dal, almonds, kidney beans, walnut, chocolate powder,sorghum, ragi, powder sugar,omega-3 capsule used for the preparation of formulated baby food in our laboratory and these ingredients were collected from local market of baroda .before experiment all ingredients were passed through sun drying of 2 days for remove extra moisture from it. Then All cereal , pulses were converted into powder form with the help of mill. Also convert walnut and almond in powder form with help of mixer. Different composition of all flour and no. of omega-3 capsule were used for making 3 sample(T1, T2 and T3) of baby food powder . All flour were sieving it with a siever to remove foreign particles if any and separate flour for making product. After sieving all flour were mixed in calculated amount for making 3 sample in different bowl with help of spatula. Then 2,3 and 4 capsule of omega-3 capsule were added into mixture in sample T1,T2,T3 and again it were mixed properly. Final baby food powder was ready and packed in poly bags. (At time of baby feeding boil milk in a steel utensils on a gas stove and Add 1 tablespoon(15gm) Into it and boil for nearby 10 min.then cool down for some time and then feed baby with this baby food powder milk which can full-fill all daily requirements with ALA , DHA and EPA)

B. Nutrient Analysis

Nutrient analysis was done for prepared sample . PH of the collected samples was determined with help of PH meter (AOAC, 2000). Moisture content of the collectedsamples was determined by drying the samples at 105^0 C in a drying oven till a constant weight was attained (AOAC, 1995).Ash content was determined in the triplicate using a muffle furnace at 600±2.00°C for 8 h by AOAC method (AOAC, 2000).fat was determined by the Soxhlet apparatus (AOAC,2005).In sample, Protein content was determined by the AOAC (2005)Kjeldahl method by the first determiningof the percent nitrogen content and then converted to % crude protein by multiplying withthe factor 6.25.total dietary fiberwas determined by the Acid-Alkali Hydrolysis followed by AOAC (2009). Available carbohydrate content was determined by the difference, i.e. by subtracting the sum of the values of moisture, ash,protein and fat from 100 (per 100gm) (AOAC, 2005).vitamins were determined with help ofthe high performance liquid chromatography (HPLC).minerals were determined with help of Gravimetric analysis, colorimetric methods and titration. Omega-3 fatty acid (ALA, DHA and EPA) was determined by use of gas chromatography analysis.

C. Functional Properties Analysis

Water absorption capacity of samples was determined by the method as described by Sathe and Salunkhe (1981). Bulk Density, Solubility and Swelling Power were determined by methods using as reported by Oladele and Ania, (2007.)

D. Sensory Evaluation of Formulated and Imported Baby Food Powder

The sensory properties of the different products is usually evaluated and ranked on the basis of scores given by the panel of judges to the product. They like or dislike the various parameters. The food with different subjected to sensory evaluation for color, flavor, taste, texture and overall acceptability by a panel of trained judges for acceptance or rejection. Before analysis of baby food powder was mixed with hot milk and served hot. Samples were presented in succession and panelists were asked to give mark evaluation variables according to 9- point Hedonic scale as described by Larmond (1977). The 9-point Hedonic scale was used, where the lowest point 1 = extremely dislike and highest point 9 = extremely like. and the result of the analysis of variance revealed that sensory result assigned by judges on color, flavor, taste, texture and overall acceptability were found statistically significant.

E. Microbiological Analysis

Microbial examinations of the baby food powder were performed to assess Bacterial, Fungal and Yeast load under laboratory condition. yeast and mold count and enumeration of total Coliform, E. coli and Staphylococcus aureus ssp of those baby food powder samples were also examined. All media and equipment were sterilized by use of steam Sterilization at 15 psi for 20 minutes at 1210C in an autoclave. For analysis of 10 gm of each sample was aseptically weighted and then diluted to 1:10 (10 gm in 90ml) with help of sterilized distilled water and mixed properly. Serial dilutions were prepared and then spread plate technique was used on appropriate selective media. In this method plates having 30-300 colonies were counted. Streak Plate method was used to isolate the specific microorganism. In the Pour Plate Method, 0.1 ml and 1ml samples were pipette on the sterilized Petri plates. Sterilized agar medium was cooled to nearby 450C and was poured on the plates. The media was mixed well by help of gentle swirling motion. Then Petri plate were then allowed to solidify. The plates were incubated at required temperature for 24-72 hours. In this study for each of the sample there were 2 Petri plates for 0.1 ml and other 2 for 1ml (Badau et al., 1999, Badau

et al., 2001). For Spread Plate Method approximately 15 ml of the previously autoclaved medium was poured into the sterilized Petri plate and was kept at room temperature until agar was solidified.

In Potato Dextrose Agar (PDA) plate 0.2 ml sample was dropped onto a solidified agar plate then the sample was spread on the agar plate with the help of the sterilized bent glass rod (spreader). By this method Yeast and Mould counts were determined (Mosupye et al. 1999, Mudgil et al. 2004). In Streak Plate Method, the media along with microbes were transferred with help of a a narrow headed loop from lactose broth conical flask and from LST tube and dropped with help of the loop; the streak was done on to the agar plate. The plate was then incubated at the required temperature (370C) for 24 to 72 hours. All steps of the media were done under the laminar airflow. Isolation and enumeration of the total Coliform were performed by MPN method. The Most Probable Number (MPN) method using MacConkey broth (Harrigen and MacCance, 1976) is a statistical, multi-step assay consist of the presumptive, confirmed and completed phases. In the assay, serial dilutions of selescted sample are inoculated into broth media. From the gas positive (fermentation of lactose) tubes, the other 2 phases of the number of organisms can be estimated from the statistical tables. Typically only the first 2 phases were performed in Coliform analysis for E.coli microorganism (Speck, M. L. 1976). Staphylococcus aureus of the food sample was examined according to APHA-1999.

III. RESULTS

A. Chemical composition of baby food powder

The datafor chemical compositioni.e. moisture, ash, protein, fat, total dietary fiber, carbohydrate vitamins , minerals and also ALA, DHA and EPA have been presented in the following manner (table 3)

B. Shelf life of baby food powder

The shelf life of baby food powder was studied for three months at ambient conditions. No significant changes in ash, protein, fat, carbohydrate, DHA, ALA and EPA except moisture were observed. All the analysis was performed in triplicate and the values were given in average (Table 3). The moisture content of the baby food powder was significantly increased from 2.55 to 3.69 g/100g and carbohydrate also increased from 82 to 84.55g/100g. The ash, fat, sugar, dietary fiber and energy value slowly decreased during storage period.

C. Functional properties of baby food powder

The functional properties of baby food powder such as water absorption capacity (WAC), bulk density (BD), solubility, swelling power and were analyzed and the results are given in Table 4.

The baby food powder show the following functional properties such as water absorption capacity, bulk density, solubility and swelling power were 115.37(ml/g), 0.57(g/ml-1), 57.412(%), 14.29(gg-1) respectively.

D. Micronutrient analysis of baby food powder

The micronutrient content of baby food powder such as vitamin, mineral and trace metal e.g. vitamin sodium, potassium, iron, magnesium, calcium were analyzed and the result are given in Table 5.

The results indicate that the vitamin A and vitamin C content of baby food powder sample T1was 2800µg and 3252 µg. the sodium, potassium, iron, magnesium, calcium content were 220.4, 250, 8.9, 5.9, 451.3(mg/100g) respectively. Sample T2 contain the amount of Vitamin A and vitamin C were 2550and 3489 µg. . Sample T3 contain the amount of Vitamin A and vitamin C were 2115and 3199µg. The mineral content of sample T2 such as sodium, potassium, iron, calcium and magnesium was 204, 350, 6.5, 470 and 4.6mg/100g respectively and sample T3 contain 197, 245, 6.9, 501and 6.1mg/100g respectively.

E. Microbiological analysis of baby food powder

The distribution of the micro-organisms and their amount of occurrence in the baby food powder during storage period for three months (APHA-1999) were shown in Table 6. Comparative microbiological load of baby food powder has shown in table for three months. Microbial findings of E. coli count, total Coliform count and presence of Staphylococcus aureus per gram were absolutely nil/g or <10 cfu/gm in the baby food powder analyzed, but the yeast and mold count may be increase due to increasing moisture after few days which ranges from <1 to 100 cfu/gm .(table 6)

F. Sensory Evalution of baby food powder

The results of the sensory evaluation performed on reconstituted weaning food made from warm milk and baby food powder . It was served to 5 members of testing panel who were asked to mark the paste on the basis of color, flavor, taste, texture and overall acceptability using a point hedonic scale where 1= dislike extremely and 9= like extremely as reported by Larmond .

In sensory attributes colour of the sample T1, T2, T3 the score were 8.6, 8.4, 5.2 was observed. In sensory attributes Taste of experimental sample ,T1, T2, T3 the 9, 6.6, 4.8 was observed. In sensory attributes Appearance of experimental sample T1, T2, T3 the score was 8.4, 5.6, 4.8 was observed. In sensory attributes overall acceptability of sample T1, T2, T3 the score was 8.64, 6.72, 4.72 was observed.

IV. DISCUSSION

The weaning period is the most critical phase of infant's life. During the period mother's milk is not generally adequate to cover the all nutritional requirements and also support body growth. Weaning foods is generally introduced between the ages of 6 months to 3 years old as breastfeeding is discontinued. While breastfed infants are able to maintain adequate growth through their 6th month, additional nutrients are required to complement or, in some cases, replace breastfeeding completely. A weaning food should be accessible to the baby and should be adequate in protein, fat, carbohydrates, vitamins and minerals, DHA,ALA and EPA to alleviate protein-energy malnutrition. It is an essential element in the care of baby in the developing countries where malnutrition is prevalent [World Bank, 2005 study was performed as a result of the high price of commercial baby foods which cannot be afforded by many of low income families.]Commercial baby food was unable to meet the infant baby nutritional requirement. To meet these requirements, we tried to develop a highly nutritive baby food power enriched with locally available indigenous raw materials such as different cereals, pulses, dry fruits and omega-3 capsule in our laboratory and analyzed its nutritional composition and hygienic aspect.

The carbohydrates content of the sampleT1 was 82g/100g, whereas sample T2 contains 84g/100g and sample T3 contain 91g/100g. The RDA of the carbohydrate for infant is 95g/day (IOM, 2005). the protein content (g/100 g dry weight) in the

sample T1 was 13.33g/100g. The low content of protein in the sample T2 was 12.62g/100g and sample T3 was 12.11g/100g, where the RDA of protein is 15gm/day for baby over 1 year (IOM, 2005). According to the Indian Council of Medical Research (1981), the recommended optimal protein - calorie requirement for the pre-schoolers is 7.1% in the total mixed diet. The result indicated that the baby food powder sampleT1 has higher protein content than sample T2 and T3 but it was adequate in protein content for weaning purposes because it supply 108% protein of RDA for infant. The sample T1 contained comparatively lower amount of fats than the sample T2. Food sample with high fat content is more liable to spoilage than one with a lower fat content (Oduro et al., 2007). The ash content of the product gives an idea of the mineral content, although sample T1 had low ash contents (1.61g/100g) than the sample T2 and T3. Fiber containing food is the better for maintaining good health but, infants do not get benefit from a high fiber intake and therefore fiber levels must be controlled in children's foods. In this study, the sample T1 contained the lowest amount of fiber compared to the sample T2 and T3. However,very high dietary fiber content has been reported to impair protein and mineral digestion and absorption into human subjects (Whitney EN, Hamilton EMN, Rolfes SR, 1990). The percent of protein derived calorie ranged from 11.96 to 14.25(%) in sample T2and T3 whereas sample T1 was 10.91(%). This implies that the products would supply the needed energy to meet infant baby growth demands. Baby body require daily 70-100 mg/100gm DHA for proper growth of brain and good vision. Sample T1 contain 240mg/100gm. So it can full-fill daily requirements of DHA . it also contain 44mg/100gm ALA and 360mg/100gm EPA.

According to Singh (2001), water absorption capacity (WAC) is the ability of a product to associate with water under a condition where water is limited. The water absorption capacity of sample T1 was 115.37 (g/100g) .The significance of a low WAC of the supplementary diets is that it will have lower water absorption which is desirable for making thinner gruels with high caloric density per unit volume (Elkahalifa et al., 2005). The bulk densities of the formulation was 0.57 g/cm3 reported for yam (Hsu et al., 2003). Bulk density is the measure of heaviness of flour (Adejuyitan et al., 2009) and an important parameter that determines the suitability of flours for the ease of packaging and transportation of particulate foods (Shittu et al., 2005) as well as for infant formulations. According to Nelson-Quartey et al. (2007), low bulk density flours are favorite in infant food preparation. The low bulk density of baby food powder therefore suggests they could be good for infant health. Solubility is an index of protein functionality such as denaturation and its potential applications. The solubility of baby food powder was 57.41 % and swelling power was 14.21gg-1. According to the WHO (2003), appropriate complementary diet is one which produce a gruel or porridge that is the neither too thick for the infant to consume nor so thin that energy and nutrient density are reduced. In this study the baby food powder had moderate solubility and low swelling power, which make it good as a weaning food. Thus it can be inferred that the functional properties of the formulated diet will provide appropriate complementary diet in terms of texture, dietary bulkiness.

Sodium concentration was highest in the sample T1(220.4mg/100 g) and lowest in the sample T2 and T3 which was 204mg/100g and 197mg/100g. The Na concentrations in the cerelac were within the range (96.78–411.32 mg/100g) specified in the Codex Alimentarius standard for weaning foods (FAO/WHO, 1994). Potassium, just like sodium , is an electrolyte essential in the homeostatic balance of the body fluids. The concentration of K in sample T1 was 250 and sample T2 was 350mg/100g, whereas 245mg/100g in the sample T3. The RDA of K for infant is 700mg/day (IOM, 2005) which was higher than the baby food powder . So the potassium content will be fortified in future by adding premix. Magnesium is a micronutrient that used for bone mineralization, teeth maintenance, building up of proteins, enzyme activities, normal muscular contractions and also transmission of nerve impulses. Magnesium concentration was generally lower in the baby food powder than the commercial weaning foods. Concentration of Mg in the sample T1 was 5.9mg/100g. An iron concentration in the sample T1 was 8.9 mg/100 g; while in the sample T2 and T3 the concentration was In range of 6.5-6.9 mg/100 g. The RDA of iron for infant baby is 10mg/100g (IOM, 2005). Thus the high iron content of sample T1 compared to other sample can meet the 80% RDA of iron for infant. Calcium is an essential micronutrient in infants and young children for building bones and teeth, functioning of muscles and nerves, blood clotting and for immune defense (Whitney et al. 1990). The concentration of Ca was highest (sample T2 contain 470 and sample T3 contain 501mg/100 g) in the commercial weaning products and was moderate (451.3mg)/100 g) in the sample T1. According to the Codex Alimentary standards (FAO/WHO, 1994) Calcium concentration in weaning foods should not be lower than 435.51 mg/100 g of the dry food. So the formulated baby food fulfills 75% RDA of calcium for infants

storage stability tests was used to estimate the shelf-life of the products developed. The shelf life of baby food powder was studied for three months at ambient conditions. No significant change in protein, fat, carbohydrate, ash, dietary fiber and energy values were observed except moisture (Table 2). Moisture content was slowly increased during storage period from 2.55 to 3.69 (g/100g). High moisture content in foods has been shown to encourage microbial growth (Temple VJ, 1996). The fungus count increased during storage period due to little high moisture. The overall bacteriological status of the baby food powder was observed to be satisfactory. It was found that the baby food powder contained <10 cfu/gm microbial load in the sample which is in a normal range. The total Fungal Counts was <10 (cfu/gm) at 1st month, which was become 50 cfu/gm at 2nd month and 100 cfu/gm at 3rd month due to moisture retention during storage period. A food product for consumption should have microbial count below 1× 105 cfu/ml. The formulated food sample was found to contain no Coliform Count. However, yeasts and moulds, coliform group and Staphylococcus aureus were found to be totally absent in the baby food powder. The low counts of the examined baby food powder indicated adequate thermal process, good quality of raw materials and as a result of the good different processing conditions under which the production of formulas was carried out. The microbiological results suggested that the baby food powder are suitable to be submitted for sensory evaluation by babies and adult panelists.

Overall acceptability scores for the sample T1and the sample T2 and T3 were almost similar. Members also commented on additional attributes of the foods such as the child's preference or after-taste discomforts, and suggested price and purchase intent and sample T1 was accepted. It has been shown that functional properties would produce a more physically balanced and acceptable products which will be cheaper and readily available. Further studies are necessary to determine the longevity of the product and economics of large scale production.

Table 3: Physico-Chemical properties of baby food powder sample

Nutrients	Sample T1	Sample T2	Sample T3
Moisture (%)	2.55	2.67	2.44
Ash (%)	1.61	1.78	1.52
Protein(%)	13.33	12.62	12.11
Fat(%)	13.22	19.64	8.89
Carbohydrate(%)	82	84	91
Dietary fiber(%)	8.22	9.84	8.94
DHA(mg)	240	180	120
ALA (mg)	44	132	44
EPA (mg)	360	270	180

Table-4: Functional Properties of Baby Food powder

Property	Baby food powder
Water absorption capacity (ml/g)	115.37
Bulk density (g/cm3)	0.57
Solubility (%)	57.412
Swelling power (gg -1)	14.29

Table 5: Micronutrient Analysis of Baby Food Powder

Vitamin / minerals	Sample T1	Sample T2	Sample T3
Vitamin Aμg	2800	2550	2115
Vitamin Cμg	3252	3489	3199
Na(mg/100g)	220.4	204	197
K(mg/100g)	250	350	245
Fe(mg/100g)	8.9	6.5	6.9
Ca(mg/100g)	451.3	470	501
Mg(mg/100g)	5.9	4.6	6.1

Table 6: Microbiological Analysis of Baby Food Powder

Test Parameter	1 month	2 month	3 month
Total Coliform(MPN/gm)	Absent	Absent	Absent
E.coli (MPN/gm)	Absent	Absent	Absent
Yeast and mold (cfu/g)	<10	50	100
Staphylococcusaureus(cfu/gm)	Absent	Absent	Absent

CONCLUSION

The present investigation was undertaken for ":- Development of Baby Food Powder Fortified With Omega-3. ", for proximate, sensory, physio-chemical and microbiological analysis.

Low cost local food ingredients were used to prepare a low cost baby food powder to meet the nutritional requirements of growing infant. Sensory attributes was done at the same period of time. According to the sensory attributes all different treatments were accepted. Results obtained were satisfactory and the baby food powder showed good quality characteristics on pH,Moisture,, Ash, Fat, Protein,carbohydrates , DHA and EPA .The overall acceptability was found with T1 sample which contain essential requirments for baby growth. The baby food powder was found nutritionally rich and safe in microbial point of view comparable to imported baby foods. This baby food could be an alternative of imported baby foods to meet the nutritional requirements of infants. T1 containing protein , carbohydrate and fat in baby food powder was found most acceptable in the terms of sensory as well as physiochemical scores compare to other sample T2 and T3.

Baby food powder can be stored for 3 months due to absence of coliforms and yeast and mould was also lower, and it can be recommended as health food for baby over 1 year due to its lower fat content . baby over 1 year require 70-100mg of DHA.

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