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Nutritional Evaluation of Some Complementary Food Mixtures for Weaning Stage

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ABSTRACT

Weaning is a crucial period in an infant's life. Most babies, after 6 months of age, begin to eat semi-solid complementary foods. At this stage, homogenized baby food plays a major role in their nutrition. In developing countries, hidden hunger is one of the major problems due to the lack of micronutrients such as vitamins, especially vitamin A, and minerals such as zinc and iron. Cereal porridge is a common complementary food in developing countries and is usually low in energy and protein, thus increasing protein-energy malnutrition among deprived babies of weaning age. In this context, the current experiment was conducted to form a weaning food (12 mixtures) for babies from six to twenty-four months of age that includes fruits, vegetables, and grains consisting of bananas, kiwi, and pumpkin mixed with beans, rice, date powder, and dried milk. The sensory properties of 12 mixtures were evaluated, and then the four best mixtures were selected. The chemical composition and mineral content were estimated in the four selected formulas in comparison with Cerelac (a commercial sample) as a reference sample. In addition, vitamins, antioxidants, and microbial activity were evaluated. Sensory and chemical analysis showed that weaning food (mixture M4) was the best mixture in terms of sensory properties and chemical composition compared to cerelac.

1. Introduction

Breast milk is the best meal for newborns throughout the first six months of life. Breast milk cannot provide a baby with all the nutrients and calories needed for them to thrive after six months of life. Supplemental feeding is necessary beyond six months of breastfeeding since breast milk cannot supply adequate nutrients and energy for developing children (Udensi et al., 2012). Weaning is the gradual process of introducing solid foods to a baby's diet in addition to breast milk, starting at six months of age, because breast milk alone cannot provide all of the baby's nutritional needs. The baby is gradually weaned into a semi-solid food that is typically described as digestible and has a high energy density and low bulk (Tesby Mohamed et al., 2019). Infants' needs for micronutrients such as iron and zinc increase after six months of breastfeeding, which is why recent emphasis has been placed on breastfeeding for at least six months and then including complementary foods as breastfeeding continues for 18 months or longer (WHO, 2021). Commercial weaning systems are common. They are the results of years of research and development and are usually of foreign origin. However, problems with acceptance, affordability, and accessibility restrict their use locally. As an alternative to conventional weaning foods already available and to develop new nutrient-dense foods for infants, research has recently been conducted into the use of local food crops as sustainable sources (Shegelman et al., 2019 and Twum et al., 2015). While a baby that is exclusively breastfed has protection against diseases and meets all of its nutritional demands, complementary meals also fill in the baby's missing mineral needs and help with the care and feeding of sick or stressed-out babies. (Savarino et al., 2021). This preference for such mixtures results from the complementary effects of the limiting amino acids in cereals and legumes, methionine and lysine, respectively.

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Therefore, reducing undernutrition among children 5 years of age and younger and increasing the value of these traditional food crops would help reduce postharvest waste. Examples of local food crops that could be processed into ready-to-eat nutritious products and made more shelf-stable include bananas, rice, and beans. Cereals, which make up the majority of the diet's calories, are a rich source of B -complex vitamins and adequate sources of methionine and cysteine but low in lysine (Imtiaz et al., 2011; Elhadidy and El-Dreny, 2020 and Elhadidy et al., 2020). Lysine is limited in cereals, but there is an abundance of sulfur-containing amino acids, which are scarce in legumes (Iqbal et al., 2006).

Bananas are one of the best sources of potassium, which is essential for heart function and blood pressure, in addition to being an energy booster. The modest laxative effects of the fruit make it useful to treat infantile constipation. It is believed to help treat diarrhea and dysentery. Bananas are a staple in the diets of undernourished children. Baby food is easy to prepare and very healthy. Potassium, magnesium, calcium, phosphorus, selenium, iron, fiber, vitamins C, A, B2, B6, and E, folic acid, niacin, and pantothenic acid are all found in significant concentrations in mashed ripe bananas. Bananas are utilized in infant food because they are also very easy to digest and rarely produce allergy responses (Kumar et al., 2012).

Kiwi fruit is a rich source of vitamin C, as well as other important nutrients such as vitamins B, E, and K, carotenoids, folate, and the minerals Cu, Mg, and potassium. An increased intake of kiwifruit has been shown to improve mood (Carr et al., 2012).

Pumpkin is used as a food source by humans because it includes a variety of vital components, including vitamins, dietary fiber, pectin, carbs, trace minerals (such as zinc), and beta-carotene. It is rich in beta-carotene, which is responsible for the fruit's vigor and yellow hue. Pumpkin also has antioxidants, unsaturated fatty acids, and plant sterols, all of which are beneficial to human health. (Pasha et al., 2013). The portion of the pumpkin fruit that is most frequently used for food preparation is the flesh (Mujaffar and Ramsumair, 2019).

Broken rice is a by-product of rice milling. Due to its low cost and widespread availability, it has been used to produce rice flour and modified starch, adding value to a variety of industrial applications. Due to its mild flavor, bright white color, fast-absorbing carbohydrates, and hypoallergenic properties, rice flour is a good ingredient for gluten-free recipes (Abdel-Haleem, 2016 and El Hadidy et al., 2022). From a nutritional point of view, rice is a good source of thiamin, riboflavin, niacin, and zinc compared to other nutrients, so it is a good source from a nutritional and economic point of view (Megat Rusydi et al., 2011).

Beans (Phaseolus vulgaris L.) or common Beans are an ideal and basic food for almost all people in the world due to their high protein content, as well as fiber, prebiotics, vitamins B, and other diverse micronutrients. Beans account for 50% of the legumes consumed worldwide (Câmara et al., 2013). Cereals, fruits, legumes, and vegetables have been reported to form a good diet (Kumari and Sangeetha, 2017; Iwanegbe, 2021) and have been recommended for inclusion in weaning foods (UNICEF, 2020).

Date fruits are an inexpensive source of proteins, carbohydrates (70–80% in the form of glucose and fructose), and essential minerals (zinc, copper, selenium, potassium, calcium, magnesium, phosphorus, manganese, and iron). In addition, they are a good source of fiber, vitamins C and E, fatty acids, polyphenols, carotenoids, and flavonoids. Dates are frequently used to manufacture paste, syrup, and juice, which are subsequently utilized in a range of different recipes, including dairy products, baked goods, and confections. Due to their numerous health advantages, dates are referred to as "emerging healthy foods (Majzoobi et al., 2019).

The aim of the present study was to prepare weaning food formulas enriched with vitamins and minerals by using available, cheap, locally available, and natural sources from vegetable fruits (pumpkin, banana, kiwi, and dates). Moreover, the formulas contained a mixture of legumes and cereals to increase the efficiency of protein, in addition to skimmed milk.

2.Materials and Methods

Bananas, kiwis, pumpkin, common beans (*Phaseolus vulgaris),* and dates were bought from local market in Kafrelsheikh, Egypt.

Milk powder was obtained from an Arab dairy company in Egypt. The broken rice was obtained from the Rice Milling Factory in Dakahlia, Egypt. Additionally, El-Gamhouria Substances and Drugs Company in Egypt provided the substances that were employed in the study.

Methods

Preparation of banana powder

The fruits of mature bananas were picked, cleaned, and peeled to obtain pulp. To prevent enzymatic browning, the pulp was separated from the peel, sliced into slices, and treated with 34g/L of ascorbic acid or citric acid in distilled water.

The slices were dried for 6 hours at 60°C in a tray dryer. The dried banana slices were ground into a powder using a food processor, then passed through a 60mm sieve.

The banana powder was packed in aluminum foil pouches for incorporation into the weaning mix in accordance with the method outlined by Bindu et al., (2018).

Preparing kiwi powder

The fresh kiwi, peel was cut into slices, and dried at 45 degrees Celsius for about 6 hours. Then then ground into powder by using a local grinding machine, and samples were placed in plastic containers then stored in the refrigerator at 4°C until use., according to the method of (Inglehart et al., 2002).

Preparation of pumpkin powder

Ripe fruits; following cleaning, the pumpkin pulp was separated from the fibers and seeds, sliced into pieces 2-3mm thick, and then dried at 60°C in the laboratory. The samples were then ground and sifted through a fine screen to create fine powder, which was then placed in plastic containers and stored in the refrigerator at 4°C until use. (Cerniauskiene et al., 2014)

Preparation of common bean powder

White beans were thoroughly cleansed of contaminants before being rinsed with tap water. White bean seeds were steeped in water for six hours at 25 degrees Celsius. After the seeds had soaked for the required amount of time, the hulls were manually removed, and the seeds were boiled in tap water for 15 minutes at 100 degrees Celsius until 50% of the seeds felt mushy to the touch. according to Khattab and Arntfield (2009). Cooked samples were dried for 18 hours at a temperature of 45±5°C, followed by milling and sieving. The samples were placed in plastic containers and stored in the refrigerator at 4°C until use.

Preparation of steamed broken rice flour

Broken rice was cleaned, washed, and steamed. It was dried at 50˚C, milled, sieved (sieve: 0.700µ ˚C.m mesh size), and stored in the refrigerator at 4˚C until use (Hasbullah et al., 2017).

Preparation of date powder

The date was washed to remove any adhering dirt, followed by the removal of the seeds, and the pulp was then oven dried at 55±1°C. The dried date was ground using milling (Stauffer, Germany). The powder samples were placed in plastic containers and stored in the refrigerator at 4°C until use., according to Amin et al. (2019).

Preparation of infant food mixtures

Food formulations were done by blending different components of the food sample in powder form in the appropriate ratios according to their nutrient contributions in order to achieve the desired food balance that meets the nutritional needs of infants between 6 and 24 months. Sample mixing ratios are shown in the Table 1.

The weaning food mixes in the dry form were cooked in warm water (how much gm of mixture in how much ml of water according to the solubility of each mixture) and subjected to sensory evaluation according to Indu and Nazni (2018).

Formulas of food mixtures

Table 1. shows weaning food mixtures consisting of 12 mixtures according to the methods described by Jansen and Harper (1985), with some modifications.

Table 2. presents the best acceptable infant feeding mixtures selected from the 12 mixtures in Table 1. according to sensory evaluation.

Table 1. Ingredients of Baby Food Mixtures

Basic Ingredient	Mixture No.	Mixture Ingredients
Banana (M1)	1	60% Banana + 10% Common beans+ Broken rice 20% +5% Milk powder + 5% Dates powder
	2	60% Banana + 20% Common beans+ 10% Broken rice +5% Milk powder + 5% Dates powder
	3	60% Banana + 15% Common beans + 15% Broken rice + Milk powder 5% + 5% Dates powder
kiwi (M2)	4	60% Kiwi + 10% Common beans + 20% Broken rice + 5% Milk powder +5% Dates powder.
	5	60% Kiwi + 20% Beans + 10% Broken rice + 5% Milk powder +5% Dates powder.
	6	60% Kiwi + 15% Common beans + 15% Broken rice +5% Milk powder +5% Dates powder.
Pumpkin (M3)	7	60% Pumpkin +10% Common beans + 20% Broken rice + Milk powder + 5% Dates powder.
	8	60% Pumpkin + 20% Common beans + 10% Broken rice + Milk powder + 5% Dates powder.
	9	60% Pumpkin + 15% Common beans + 15% Broken rice + Milk powder + 5% Dates powder.
Banana 20% Pumpkin20% Kiwi20% (M4)	10	60% Mix + 10% Common beans + 20% Broken rice + 5% Milk powder +5% Dates powder.
	11	60% Mix + 20% Common beans + 10% Broken rice +5% Milk powder + 5% Dates powder.
	12	60% Mix + 15% Common beans + 15% Broken rice + 5% Milk powder +5% Dates powder.

Table 2. The best accepted baby food mixtures

Mixture No	**Mixture Ingredients**
M1	60% Banana + 20% Beans+ 10% Broken rice +5% Milk powder+ 5% Dates powder.
M2	60% Kiwi + 20% Beans + 10% Broken rice + 5% Milk powder +5% Dates powder.
M3	60% Pumpkin + 20% Beans+ 10% Broken rice +5% Milk powder + 5% Dates powder.
M4	20% Banana + 20% Kiwi + 20% Pumpkin + 20% Beans + 10% Broken rice + 5% Milk powder + 5% Dates powder.

Chemical Analysis

Protein, fat, crude fiber, ash and minerals were determined (AOAC 2012). Total carbohydrate was calculated by difference. Total calories densities of different infant formula samples were calculated according to (Insel et al., 2002).

Energy value = (P*4.0) + (F*9.0) + (C*4.0)

in Kcal/100g of the sample

Where; P=Protein content (%); F=Fat content (%) and C=Available total carbohydrate (%).

Sensory Evaluation

Ten panelists from the Food Technology Research Institute personnel (mothers of children who are weaning) at the Agricultural Research Center "ARC" were asked to sensory evaluate twelve fresh baby food combinations at zero time, as reported by (Metwalli et al., 2011).

Determination ß-carotene

The analyses of carotene was conducted using a modified method from (A.O.A.C 2012).

Determination of Vitamin C

L-ascorbic acid of different baby food mixtures were determined according to the method described in the AOAC (2012). using High Performance Liquid Chromatography (HPLC) Beckman model.

Determination of Vitamin B1, B2, B3, B6 and B9

Vitamins B1 (Thiamin), B2 (Riboflavin), B3 (niacin), B6 (Pyroxidine) and B9 (Folic acid) of different meals were determined according to the method described in the (AOAC 2012). using (HPLC).

Total phenol content (TPC) analysis

Utilized the folin-Ciocalteu technique to calculate the TPC of the extracts. using a gallic acid standard curve, the absorbance was converted to milligrams of gallic acid equivalent per gramme of dry material (mg GAE/ g) according to Agbor et al., (2014).

Total flavonoid content (TFC) measurement: TFC was estimated using a colorimetric approach using the aluminum chloride technique. The results are expressed as milligrams of quercetin equivalent per gramme of dry material (mg QE/g), with quercetin serving as the reference substance for the calculations according to El Ouadi et al. (2017).

Antioxidant activity

The free radical scavenging capacity was evaluated using the DPPH radical scavenging activity method, as recommended by (Abdel-Razek et al., 2017).

Physical properties

1. Bulk density of weaning formulas: Bulk density of weaning formulas were determined by using (Onwuka 2005) method.
2. Water absorption capacity of weaning formulas: Water absorption capacity was calculation by using the method described by (Onwuka 2005).
3. Viscosity of weaning formulas: Viscosity was determined according to (Quinn and Beuchat 1975).

Microbiological Evaluation

All created mixes underwent the following tests: A total bacterial count, yeast and mould were counted using Wehr and Frank (2004). American Public Health Association Methods (on standard plate count agar).

Statistical Analysis

SPSS software (version 26) was employed for the statistical analysis, and Duncan's multiple range tests were employed for mean comparison. To compare between means, Duncan's multiple range tests were performed at the ($P \leq 0.05$) level according to (Mc Clave and Benson 1991).

3. Results and Discussions

Sensory evaluation of different baby food mixtures Sensory

Figure 1. displays the panelists' subjective assessments of the prepared food samples. All examined samples exhibited significant ($p < 0.05$) differences, according to the results. The paniltists found sample M4 to be more acceptable than the other samples, however the nursing mothers found all of the samples acceptable. When compared to the same other created mixtures, a high acceptance rate was seen for the banana, pumpkin, and kiwi mixtures. The results indicated that adding pumpkin to the blends improved the hue. Additionally, the table demonstrates that there are no discernible variations in acceptability between the mixtures M1, M3, and M4 and cerelac, the reference sample. These findings support those of Kumar et al. (2012), who found that children who are malnourished typically eat bananas. Mashed ripe bananas provide a very easy yet nutritious baby meal. Bananas are very easy to digest and hardly cause allergies.

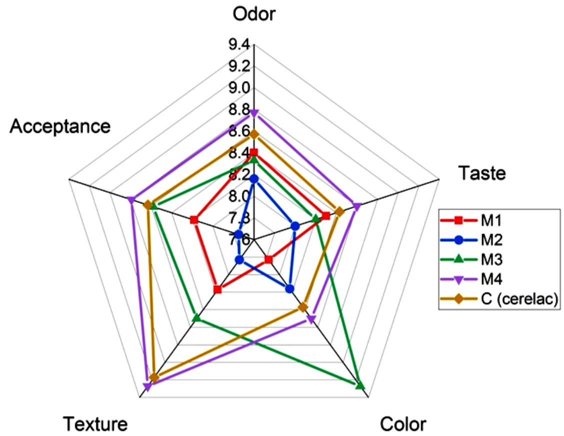

Figure 1. Sensory Evaluation of Baby Food Mixtures

Chemical composition of the basic baby food ingredient

Table 3. provides a summary of the chemical composition of the common beans, broken rice, date palm, banana, pumpkin, kiwi, and milk powder that are the main elements of the prepared baby food mixtures. the results showed that the ranges for protein contents were 5.11 to 23.95%, fat contents were 0.70 to 26.71%, fiber contents were 0.00 to 8.61%, ash contents were 1.03 to 10.26%, carbohydrate contents were 43.96 to 90.39%, and energy value (Kcal/100 g) was 368.09 to 512.28. The highest protein contents were found in common beans, milk powder, and pumpkin; the highest fat content was found in milk powder; the highest fiber content was found in bananas; the highest ash content was found in pumpkins and kiwi; and the highest carbohydrate content was found in broken rice, bananas, and date palm. These results agreed with those of (Al-Barbary et al., 2011). Based on its chemical composition, pumpkin has a high protein and ash level, which could make it a beneficial addition to a diet. It is also added to food goods as a yellow color enhancer and as a source of beta-carotene. (El-Dreny and Elhadidy 2020) reported that rice flour has 7.95% crude protein, 0.67% fat, 0.93% ash, 0.32% fiber, and 90.13% carbohydrates.

Table 3. Chemical composition of the basic baby food ingredient (on dry weight)

Ingredient	Protein%	Fat %	Fiber %	Ash%	*Carbohydrate %	Energy value (Kcal /100 g)
Banana	$5.47^{d} \pm 0.28$	$1.67^{c} \pm 0.08$	$8.61^{a} \pm 0.72$	$2.91^{d} \pm 0.06$	$89.95^{a} \pm 2.24$	$396.71^{bc} \pm 3.34$
Pumpkin	$15.41^{b} \pm 0.78$	$1.73^{c} \pm 0.07$	$6.43^{c} \pm 0.48$	$10.26^{a} \pm 0.45$	$72.73^{c} \pm 1.88$	$368.09^{e} \pm 3.56$
Kiwi	$5.71^{d} \pm 0.28$	$2.54^{b} \pm 0.28$	$8.12^{b} \pm 0.53$	$3.65^{c} \pm 0.12$	$88.10^{b} \pm 1.98$	$398.11^{b} \pm 2.56$
Common Beans	$23.95^{a} \pm 1.25$	$1.39^{e} \pm 0.05$	$2.96^{e} \pm 0.28$	$3.27^{c} \pm 0.28$	$71.39^{d} \pm 1.25$	$393.86^{cd} \pm 2.28$
Broken rice	$7.88^{c} \pm 0.56$	$0.70^{f} \pm 0.02$	$0.34^{f} \pm 0.02$	$1.03^{f} \pm 0.03$	$90.39^{a} \pm 3.28$	$399.41^{b} \pm 3.57$
Date palm	$5.11^{e} \pm 0.34$	$1.52^{d} \pm 0.07$	$4.43^{d} \pm 0.12$	$3.57^{c} \pm 0.08$	$89.73^{a} \pm 2.35$	$392.83^{d} \pm 2.58$
Milk powder	$24.02^{a} \pm 1.56$	$26.71^{a} \pm 1.26$	0g	$4.58^{b} \pm 0.03$	$43.96^{e} \pm 1.09$	$512.28^{a} \pm 4.26$

*Carbohydrate were calculated by difference.
- Means with different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation

Mineral profiles of baby food ingredients

The mineral content of banana, pumpkin, kiwi, common beans, broken rice, and date palm, constituting the base ingredients of the baby food mixtures, is presented in Table 4. Bananas exhibit a significant amount of magnesium, phosphorus, and potassium. Pumpkin demonstrates elevated levels of calcium, magnesium, phosphorus, potassium, and sodium compared to its raw state. Common beans contribute substantial calcium, magnesium, phosphorus, and potassium. Dates offer high sodium, potassium, and zinc alongside other trace minerals. These findings align with those of (Kumar et al. 2012), who reported bananas as rich in fiber, potassium, magnesium, selenium, calcium, phosphorus, and iron. (El-Dreny and Elhadidy 2020) identified the presence of Ca, Mg, K, Mn, and Zn in rice flour. The observed ingredient diversity translates to a baby food composition replete with a diverse spectrum of essential mineral elements, addressing the nutritional needs of infants and young children.

Chemical composition of different weaning food formulas

Weaning food formulas were analyzed for protein, fat, fiber, ash, total carbohydrate, and energy contents. The obtained results are shown in Table 5. These results showed that blends of weaning formulas (M3 to M4) had significantly higher protein values compared with Cerelac; the increase in protein values of M3 and M4 may be due to the high protein contents of pumpkin (15.41%). The results also showed that the weaning food formulas contained a higher percentage of fat and ash compared to cerelac. Also, the percentage of fiber in mixture 4 is significantly higher than that of cerelac. The results also showed that there were significant differences between carbohydrates and calories in the mixtures compared to cerelac. These results are in agreement with those observed by (Adepeju et al., 2016), who developed instant weaning food that contained major nutrients like moisture (4%), protein (16%), fat (9%), fiber (5%), ash (2%), and carbohydrates (64 %.

Table 4. Mineral Contents of the basic baby food ingredient (mg/100g on dry weight)

Minerals	Calcium (Ca)	Magnesium (Mg)	Phosphorus (P)	Potassium (K)	Sodium (Na)	Iron (Fe)	Zinc (Zn)
Banana	32.17^{c}± 0.76	114.67^{c}± 1.53	83.54^{c}± 1.37	1475.57^{c}± 5.38	3.65^{e}± 0.05	21.09^{a}± 1.03	0.70^{c}± 0.01
Pumpkin	150.83^{b}± 0.76	176.00^{a}± 1.63	660.67^{a}± 6.03	2340.50^{a}± 3.03	108^{b}± 2.65	0.12^{e}± 0.01	0.03^{d}± 0.01
Kiwi	25.50^{d}± 0.51	30.67^{d}± 1.25	39.67d^{e}±1.50	331.3^{f}± 2.41	5.27^{de}± 0.07	0.44^{e}± 0.04	0.17^{d}± 0.03
Common Beans	259.33^{a}± 4.03	117.23^{b}± 2.03	301.33^{b}± 2.24	1754.34^{b}± 2.03	74.00^{c}± 3.46	12.67^{b}± 1.22	4.69^{b}± 0.56
Broken rice	17.45^{e}± 0.51	141.12^{b}± 1.53	34.94^{e}± 1.03	372.56^{e}± 0.03	7.33^{d}± 0.65	1.88^{d}± 0.02	1.03^{c}± 0.02
Dates powder	33.67^{c}± 1.53	26.76^{e}± 0.63	42.00^{d}± 1.53	705.34^{d}± 4.03	342.5^{a}± 2.03	3.39^{c}± 0.03	28.67^{a}± 1.24

- Means with different letter in the same column are significantly different at LSD at ($p \leq 0.05$).
- Each value was an average of three determinations ± standard deviation.

Table 5. Chemical composition of different weaning food formulas (on dry weight)

Blends	Protein%	Fat%	Fiber%	Ash%	*Carbohydrate%	Energy value (Kcal /100 g)
M1	9.55^{c}± 0.27	3.80^{b}± 0.28	5.48^{b}± 0.18	3.85^{c}±0.13	82.80^{a} ± 2.53	403.6^{b} ± 3.16
M2	9.74^{c}± 0.19	4.42^{a}± 0.16	5.12^{b}± 0.16	4.27^{b}±0.17	81.57^{b} ± 2.92	405.02^{a} ± 2.88
M3	15.41^{a}± 0.53	3.80^{b}± 0.21	4.51^{c}± 0.03	3.80^{c}±0.23	73.51^{c} ± 2.16	389.88^{d} ± 3.18
M4	14.98^{a}± 0.64	4.63^{a}± 0.39	6.81^{a}± 0.19	7.47^{a}±0.28	72.94^{d} ± 2.08	393.35^{c} ± 2.15
C (Cerelac)	10.45^{b}± 0.48	2.12^{c}± 0.18	5.39^{b} ±0.17	3.35^{c}±0.15	84.08^{a} ± 2.68	397.2^{c} ± 2.16

- M1 Banana 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M2 Kiwi 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M3 Pumpkin 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M4 Banana 20% + Kiwi 20% + Pumpkin 20% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.

Mineral content of different weaning food formulas

The mineral compositions of the formulated baby food mixtures (M1-M4) are detailed in Table 6. Potassium emerged as the most abundant mineral across all formulations, with mixture 4 exhibiting particularly high levels compared to the commercial counterpart, Cerelac. Mixture 3 displayed the highest content for most minerals, excluding calcium, surpassing even Cerelac. This discrepancy could be attributed to Cerelac's potential fortification with naturally sourced calcium salts. Notably, mixtures M1 and M2 boasted the highest iron and zinc concentrations among all tested formulas. Overall, the prepared food samples demonstrated significant provision of key mineral elements crucial for childhood development, encompassing iron, potassium, phosphorus, calcium, sodium, magnesium, and zinc. These elements play vital roles in cognitive development, blood health, bone and tooth formation. Supporting this observation, (Gibson et al., 1998) highlight the importance of complementary foods meeting 50–75% of calcium needs, and 75–100% of phosphorus, zinc, and iron requirements for infants.

Encouragingly, the formulated meals fulfill the daily recommended intakes (DRIs) for calcium (62–78%), phosphorus (46–59%), zinc (83–100%), and iron (71–92%) as per FAO/WHO (1998) guidelines. While falling slightly short of the phosphorus DRI, it's important to consider these formulas as complementary foods intended to supplement breast milk. As advocated by (FAO/WHO 1998), continued breastfeeding significantly contributes to meeting an infant's daily mineral needs. Furthermore, incorporating fruits and vegetables into babies' diets is recommended to ensure holistic fulfillment of daily micronutrient requirements, echoing the findings of (Ma et al., 2019) that highlighted kiwi fruit as a valuable mineral source.

Table 6. Mineral contents of different weaning food formulas (mg/100g on dry weight)

Blends	Calcium (Ca)	Magnesium (Mg)	Phosphorus (P)	Potassium (K)	Sodium (Na)	Iron (Fe)	Zinc (Zn)
M1	$73.23^{d}\pm1.18$	$108.49^{b}\pm 3.14$	$95.34^{d}\pm 2.19$	$1312.51^{b}\pm 4.13$	$35.00^{c}\pm1.14$	$15.03^{a}\pm 1.08$	$8.23^{a}\pm 0.18$
M2	$71.63^{d}\pm1.15$	$58.24^{d}\pm 2.13$	$93.45^{d}\pm 2.14$	$624.98^{d}\pm 3.16$	$35.60^{c}\pm 1.15$	$3.28^{c}\pm 0.18$	$7.88^{a}\pm 0.15$
M3	$146.03^{b}\pm2.75$	$147.57^{a}\pm 3.18$	$460.72^{a}\pm 3.16$	$1834.64^{a}\pm 5.15$	$98.75^{b}\pm 2.24$	$3.12^{c}\pm 0.15$	$7.69^{b}\pm0.22$
M4	$96.69^{c}\pm2.36$	$104.67^{c}\pm 2.68$	$219.48^{c}\pm 2.98$	$1253.33^{c}\pm 4.12$	$35.46^{c}\pm 1.17$	$7.34^{b}\pm 1.18$	$7.34^{b}\pm 0.16$
C	$587^{a}\pm2.88$	-	$395^{b}\pm 2.56$	$630.76^{d}\pm2.96$	$145^{a}\pm 1.17$	$7.5^{b}\pm 0.68$	$4.91^{c}\pm0.01$

- M1Banana 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M2Kiwi 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M3Pumpkin 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M4Banana 20% + Kiwi 20% + Pumpkin 20% + Beans 20% + Broken rice 10% + Powdered milk 5%+Date palm 5%.-C (Cerelac)

The content of phenolic compounds in baby food mixtures

Figure 2. reveals the phenolic content and antioxidant capacity of the formulated baby food mixtures (M1-M4). Total phenolic content varied markedly, with M1 exhibiting the highest concentration at 21.85 mg/g, followed by M2 (15.31 mg/g), M4 (12.54 mg/g), and M3 (10.38 mg/g). Notably, M2 displayed significantly higher levels of flavonoids compared to the other mixtures, containing 130.13 mg/g compared to M1 (24.75 mg/g), M3 (103.25 mg/g), and M4 (99.25 mg/g). This suggests a potential variation in the specific phenolic profiles between the formulations. Further analysis revealed exceptional antioxidant activity across all samples. Mixture M4 demonstrated the highest radical scavenging capacity at 95.76%, followed by M2 (86.50%), M3 (81.11%), and M1 (77.16%). These results support the notion that these formulated baby foods could contribute valuable bioactive compounds with potentially beneficial health effects, aligning with the findings of (Ragab et al., 2019).

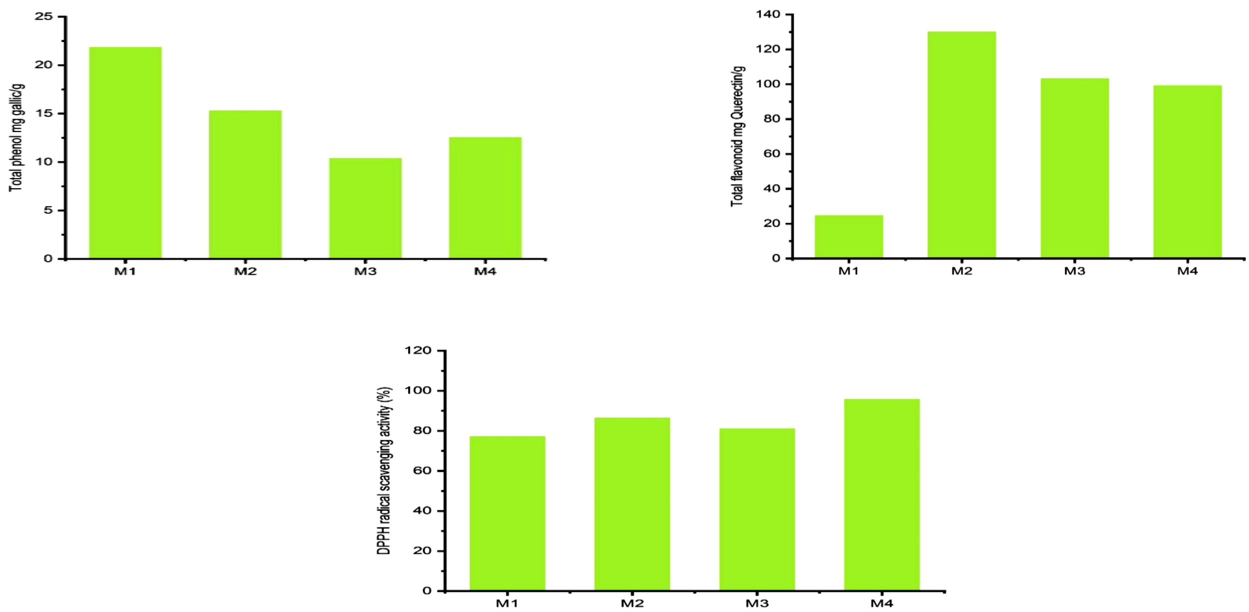

Figure 2. Total phenol compounds flavonoids and antioxidant activity in different baby food mixtures

Vitamin B1, Vitamin B3, Vitamin B6, and Nitamin B9 group content (mg/100 g) in different baby food.

The results obtained from the contents of thiamine B1, niacin B3, pyridoxine B6 and folic acid B9 in the of baby food shown in the Table 7. The M1contents of thiamine B1, niacin B3, Pyroxidine B6, and folic acid B9 were 0.13, 2.36, 0.03, and 14.13 mg/100, respectively. While the M2 contents of thiamine B1, niacin B3, Pyroxidine B6, and folate B9 were 3.21, 0.99, 0.01, and 0.84 mg/100, respectively. The M3 contents of thiamine B1, niacin B3, Pyroxidine B6, and folic acid B9 were 0.09, 0.07, 0.13, and 6.91 mg/100, respectively. While the M4 contents of Thiamine B1, Niacin B3, Pyroxidine B6, and Folic Acid B9 were 1.74, 0.13, 0.63, and 2.58 mg/100, respectively. These results agree with **(Kumar et al., 2013)**. Bananas are rich in pantothenic acid, niacin, folate, vitamins A, C, E, B2, and B6.

Table 7. Vitamin B1, Vitamin B3, Vitamin B6, and Vitamin B9 Group Content (mg/100g) of Different Baby Food Mixtures

Blends	Thiamine (B1)	Niacin (B3)	Pyroxidine (B6)	Folic acid (B9)
M1	0.13	2.36	0.03	14.13
M2	3.21	0.99	0.01	0.84
M3	0.09	0.07	0.13	6.91
M4	1.74	0.13	0.63	2.58

- M1 Banana 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M2 Kiwi 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M3 Pumpkin 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M4 Banana 20% + Kiwi 20% + Pumpkin 20% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.

Vitamin Contents of Mixtures

Table 8. details the beta-carotene, vitamin C, and vitamin E content of the formulated baby food mixtures (M1-M4). M2 demonstrated the highest beta-carotene concentration (97.69 mg/100g), surpassing M1 (82.45 mg/100g), M4 (91.59 mg/100g), and M3 (86.06 mg/100g). Vitamin C levels were highest in M2 (7.70 mg/100g), followed by M1 (4.12 mg/100g), M4 (3.94 mg/100g), and M3 (3.54 mg/100g). Interestingly, M1 exhibited the most abundant vitamin E content (35.1 mg/100g), substantially exceeding M2 (4.62 mg/100g), M4 (16.82 mg/100g), and M3 (27.88 mg/100g). These findings align with observations by Carr et al. (2012), highlighting the potential of fruits and vegetables as valuable sources of antioxidants and key vitamins. This is particularly relevant for kiwi fruit, a prominent ingredient in M1 and M3, which is recognized as a significant contributor to vitamin C intake. As noted by (Rao et al., 2013), kiwi fruit boasts not only abundant vitamin C but also a rich profile of other vital micronutrients like vitamins B, E, and K, carotenoids, and minerals like copper and magnesium. Notably, research by (Kim et al., 2014) suggests that increased kiwifruit consumption may be associated with improved mood, potentially due to the synergistic effects of these micronutrients, especially in individuals with low fruit and vegetable intake. Therefore, incorporating kiwifruit and other antioxidant-rich ingredients into baby food formulations may contribute significantly to infants' nutritional needs and potentially offer additional health benefits associated with these bioactive compounds.

Table 8. Beta Carotene, Vitamins C and Vitamin E Group Content (mg/100g) of Different Baby Food Mixtures

blends	Beta Carotene	Vitamin C	Vitamin E
M1	82.45	4.12	35.1
M2	86.06	7.70	4.62
M3	97.69	3.54	27.88
M4	91.59	3.94	16.82

Physical properties of weaning food formulas

Table 9. presents the physical properties of weaning food formulas (M1 to M4 and Cerelac). The bulk density measurements for all formulas did

not exhibit highly significant differences, with values ranging from 0.76 to 0.90. The highest bulk density was observed for M1, while the lowest was recorded for M4. These findings align with those of (Onuoha et al., 2014). Bulk density is vital for packaging requirements and the consumption of complementary foods. The water absorption capacities of the combinations varied significantly; M2 (90%) and M1 (83%) had the highest capacities, followed by M3 (81%) and M4 (78%), while Cerelac (73%), on the other hand, had the lowest. (Steve and Babatunde 2013) suggested that a lower water absorption capacity and binding capacity in the formulas are desirable for creating thinner gruels with high caloric and nutrient density per unit volume. The findings presented in Table 9. indicated that the viscosities of M1 (1550 cPs), M2 (1500 cPs), M3 (1250 cPs), and M4 (1150 cPs) were higher than those of Cerelac (1050 cPs). Furthermore, Cerelac exhibited lower viscosity compared to the other treatments, and this disparity was statistically significant.

Table 9. Physical properties of the weaning formulas

Samples properties	Bulk Density(g/ml)	Water Absorption Capacity (g/g)	Viscosity (cps)
M1	$0.90^{a} \pm 0.01$	$83^{b} \pm 0.19$	$1550^{a} \pm 4.68$
M2	$0.79^{b} \pm 0.75$	$90^{a} \pm 0.26$	$1500^{a} \pm 5.78$
M3	$0.84^{ab} \pm 0.48$	$81^{b} \pm 0.31$	$1250^{b} \pm 3.47$
M4	$0.75^{c} \pm 0.56$	$78^{c} \pm 0.24$	$1150^{c} \pm 4.65$
C (Cerelac)	$0.76^{c} \pm 0.48$	$73^{c} \pm 0.18$	$1050^{d} \pm 2.36$

Microbiological Testing of the Formulated Baby Food Mixtures

The total bacterial, yeast, and mold counts of the prepared mixtures are shown in Table 10. The results revealed that total bacterial, yeast, and mold counts were not detected at the time of mixture preparation. After 48 hours of storage at a temperature of 5°C, the total bacterial, yeast, and mold counts ranged from 2×10^1 to 6×10^1 and from ND to 3X10 cfu/gm, respectively. However, after 96 hours of storage at 5°C, the total bacterial, yeast, and mold counts ranged from 3×101 to 8×10^1 and from 2×10^1 to 6×10 cfu/gm, respectively.

The formulated baby mixtures were prepared without any heat treatments to prevent the nutritional components from being lost or reduced. Accordingly, the results suggest that feeding freshly prepared mixtures is the best way to get the benefits and ensure the quality and safety of the mixtures.

Table 10. The Total Bacterial and Yeast & Mould Counts of Baby Food Mixtures (cfu/gm)

blends	Zero Time		48 hours		96 hours	
	T.C	Y&M	T.C	Y&M	T.C	Y&M
M1	ND	ND	6×10^1	3×10^1	8×10^1	6×10^1
M2	ND	ND	2×10^1	ND	4×10^1	2×10^1
M3	ND	ND	4×10^1	1×10^1	6×10^1	4×10^1
M4	ND	ND	2×10^1	ND	3×10^1	3×10^1

-M1 Banana 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
-M2 Kiwi 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
-M3 Pumpkin 60% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.
- M4 Banana 20% + Kiwi 20% + Pumpkin 20% + Beans 20% + Broken rice 10% + Powdered milk 5% + Date palm 5%.

4. Conclusion

Weaning is the gradual process of introducing solid foods into a child's diet in addition to breast milk, starting at six months of age, because breastfeeding alone cannot provide all of the child's nutritional needs of protein, fats, minerals, and vitamins. Therefore, weaning foods are prepared using inexpensive, locally available food ingredients such as fruits, vegetables, grains, and legumes to provide for the child's nutritional needs.

Recommendations

1. It is recommended that infants be introduced to this formula alongside continued breastfeeding from 6 months to at least 18 months. This dual approach ensures comprehensive nutrient intake while upholding the immunological and developmental benefits of breast milk.
2. To empower parents and increase accessibility, mothers may consider preparing these complementary foods for their weaning infants. Prioritizing proper hygiene during food preparation can be crucial in preventing foodborne illness and ensuring optimal nutrient availability. This empowers parents with control over ingredients and potentially reduces reliance on commercially produced formulas, which can be costly in some regions.
3. Some food components, like those present in legumes and cereals, can contain anti-nutritional factors that may hamper protein digestibility. Simple processing techniques like cooking, soaking, and roasting can effectively reduce these anti-nutritional factors, enhancing protein bioavailability and maximizing nutritional benefit for infants.

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