Quality Evaluation of Nutrient-Rich Custard Produced from Blends of Maize, Soybean, and Crayfish for Complementary Food

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Abstract

Malnutrition remains a persistent challenge in developing countries, necessitating the development of affordable, nutrient-dense complementary foods for infants and young children. This study investigated the production and quality evaluation of custard powder formulated from maize, soybean, and crayfish blends. Five formulations were developed, comprising one control and four experimental samples with varying proportions of the three ingredients. Using standard analytical procedures, the samples were analyzed for proximate composition, anti-nutrient content, micronutrient profile, and sensory attributes. Data were statistically analysed using SPSS version 21.0, with differences between means determined by one-way analysis of variance (ANOVA) at $p < 0.05$. Results showed that protein content significantly increased (13.99% to 16.92%) in the fortified samples compared to the control, alongside higher fat levels (19.17% to 24.62%). Anti-nutrient levels such as phytate, oxalate, and tannins remained within safe dietary limits, with phytate reduced to below 5 mg/100 g across fortified samples. Micronutrient analysis indicated elevated calcium and vitamin A content in the fortified blends, although slight decreases in some minerals were observed. Sensory evaluation revealed that while the fortified samples scored lower in taste and texture than the control, they remained generally acceptable. Overall, blending maize with soybean and crayfish significantly improved the nutritional quality of custard powder without compromising safety or overall acceptability, providing a cost-effective and sustainable approach to enhancing complementary foods for infants and young children in low-resource settings.

Keywords:
Complementary food, custard powder, fortification, infant nutrition, malnutrition

Introduction

It has been determined that during the first six months of life, breast milk is the best meal for infants (WHO, 2023). All of the vital elements are present in breast milk, and immunological elements are necessary for a baby to maintain good health and development. But after six months, the nutrients in breast milk stop being enough to support the baby's nutritional needs during changes (Lutter et al., 2021**).** As a result, wholesome complementary foods, also called weaning foods, are introduced. In developing countries, these foods usually span the age range of six to twenty-four months (WHO, 2023).

Complementary feeding typically involves the introduction of semi-liquid porridges prepared by mothers using tubers or locally available staple cereals (*Oke et al.***,** 2022). According to the World Health Organization (*WHO***,** 2004), infants should receive complementary foods two to three times daily between six and eight months of age, and two to four times daily between nine and eleven months. However, studies have shown that complementary foods are often offered in inadequate quantities, failing to meet the infant's nutritional needs (*Onyango*, 2003; *Muhimbula et al.***,** 2011). In Nigeria, the most commonly used complementary food is pap, known locally as "*Ogi*" among the Yorubas

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"Akamu" among the Igbos, and "Koko" among the Hausas. It is traditionally prepared from maize (*Zea mays*), guinea corn (*Sorghum* spp.), or their combinations (Akinsola et al., 2021). Adequate nutrition during infancy and childhood is vital to the proper growth of a child into a healthy adult. Children are fed complementary food at a certain age during infancy to meet their high nutrient requirements (Bolarinwa et al., 2016).

Custard powder is a fine-textured dry food product made from corn starch (Okoye et al., 2008), commonly used as a breakfast cereal or as weaning food in most developing nations of the world, including the tropics (Trrega and Costell, 2006). Custard starch is dissolved in water to make custard paste or gruel, and then a calculated volume of boiling water is added (Alimi et al., 2017).

Custard became popular as a quick-fix meal item to replace the traditional *Ogi*, a fermented grain gruel (Salami et al., 2018). In Nigeria and other regions of Africa, *Ogi* is a common food item. The manufacturing procedure can take three to five days, depending on how sour the product is. Salami *et al.* (2018) claimed that the time needed to ferment, grind, and prepare *Ogi* led to the creation goods like custard. However, the tart flavour characterising fermented gruel is absent from custard (Salami et al., 2018). To influence the appropriate sourness in custard powder, souring additives like tamarind (*Tamarindicus indica*), lime (*Citrus aurantifolia*), and soursop (*Annona muricata*) may be needed. Previous studies on custard focused on enriching the powder with protein sources such as soybean (Okoye et al., 2008; Alake et al., 2016) or the use of other starch sources such as cassava for the preparation of custard (Alake et al., 2016; Awoyale et al., 2016).

Maize or corn is a cereal crop scientifically called *Zea mays.* It is the most widely planted grain globally and an essential source of food, animal feed, and raw material for various industries. Maize has become a staple food in many parts of the world, with total production surpassing wheat or rice (Asouzu et al., 2020). Except for protein content, maize is more nutritious than other cereals in several aspects (Mejia, 2003). The lipid, iron, and fibre content of maize is higher than that of wheat and rice. The protein quality of maize is considered poor because nearly half of its protein is composed of zein, which is notably deficient in the essential amino acids tryptophan and lysine (Begum et al., 2014). Fortunately, the development of Quality Protein Maize (QPM), recognised as one of the most nutritionally superior cereal grains, has primarily addressed this limitation. (Mejia, 2003).

Soybean (*Glycine max*), belonging to the family *leguminosae*, constitutes one of the oldest cultivated crops of the tropics and sub-tropical regions, and one of the world's most important sources of protein and oil. Soybeans are arguably the most significant oilseed legume from Eastern Asia. One component that is frequently added to traditional supplemental foods in Africa is soybeans (Igbua et al., 2020). On an average dry matter basis, soybeans have a unique chemical makeup of around 40% protein and 20% oil, with a suitable ratio of essential amino acids, a crucial component of human nutrition (Lokuruka, 2010).

Seafood is an excellent source of minerals, including omega-3 and omega-6 fatty acids, calcium, iron, zinc, potassium, iodine, phosphorus, and selenium. They are regarded as members of the super families, Asteroidean and Parastacoidea. Crayfish is generally low in fat and nutritionally adequate for those who are obese and want to lose weight. Crayfish is highly loaded with essential nutrients, such as high protein, especially when dried (Adegbusi et al., 2023). According to Ibironke et al. (2014) and Iwuchukwu et al. (2017), crayfish are the least expensive source of reasonably priced animal protein and a high supply of lysine, amino acids containing sulfur, and macro- and micronutrients. Although protein-rich complementary foods are essential for infant growth and development, low-nutrient options remain the most commonly used in many developing countries. Regular consumption of such nutritionally inadequate foods contributes significantly to the high prevalence of infant malnutrition. Bolarinwa et al. (2016) noted that this challenge can be mitigated by formulating affordable and nutritious complementary foods using nutrient-dense, locally available crops. This study, therefore, aims to develop and evaluate the nutrient-rich custard powder from blends of maize, soybean, and crayfish as a potential complementary food.

Materials and Methods

Maize, soybean, and crayfish were purchased from a local market in Ogbomoso, Nigeria. The maize grains were cleaned and steeped in water for 72 hours, then wet-milled, filtered, and allowed to sediment to obtain maize starch. The soybean was sorted, soaked, dehulled, and dried at 60 °C before being milled into flour. Crayfish flour was prepared by sorting and cleaning dried crayfish to remove debris, then oven-drying at 60 °C for 6 hours. The dried crayfish were then milled into a fine powder using a Binatone kitchen blender (Model BLG 402, Zhongshan Haishang) and sieved to obtain a uniform particle size of 400 µm. All chemicals used were of analytical grade and obtained from Sigma-Aldrich, London, UK.

Production of maize starch and soybean flour

With a few modifications, the corn starch was prepared according to the method described by Makanjuola and Makanjuola (2018). The maize grains were sorted and cleaned to remove dirt and other extraneous materials, soaked in potable water for 24 hours with a change of water at intervals of 6 hours to prevent fermentation. Thereafter, the steeped grains were milled using a laboratory grinder (model 400S and 400SW), filtered using muslin cloth, allowed to sediment for 4 hours, water decanted, the starch pressed and dried, and the dried starch was milled using a Binatone kitchen blender (model BLG 4O2, Zhongshan, Haishang) to obtain an excellent starch. The soybean flour was obtained using the methods described by Alagbe & Malomo (2024). Briefly, the raw seeds were sorted and cleaned, roasted in an oven for 20 minutes at 180 ^{O}C, dehulled, and milled using a Binatone kitchen blender (model BLG 4O2, Zhongshan, Haishang), and the resultant flour sieved to obtain a uniform size of 400 µm. The individual flours were then formulated into composite flour blends as shown in Table 1. The composite flour was packaged for further analysis. The sample used as a control was a commercially produced custard available in the market.

Table 1. Composite flour formulations

Sample	Maize flour (%)	Soybean Flour (%)	Crayfish Flour (%)	Total (%)
EKY 1	80	10	10	100
EKY2	60	20	20	100
EKY 3	50	30	20	100
EKY 4	50	20	30	100
Control	-	-	-	100

Proximate composition analysis

Proximate compositions of custards were determined as described by AOAC (2012). The carbohydrate content was determined by the difference (100-the sum of the content of protein, fat, ash, and moisture). At the same time, the energy value was calculated using the Atwater factor (fat × 9 + carbohydrate × 4 + protein × 4 kcal/100 g).

Anti-nutrient analysis

The custards were analysed for their Oxalate, Tannins, and Phytate content according to their respective methods as modified and previously described by Iwuozor (2019).

Micro-nutrient analysis

The custards were analysed for their Vitamin A, Iron, Folate, Calcium, Vitamin B12, and Zinc content according to their respective methods as modified and previously described by (Zhao *et al*., 2022).

Sensory evaluation

The different formulated custard samples were coded and presented to 50 semi-trained panelists for evaluation of their appearance, aroma, taste, mouthfeel, and overall acceptability using a 9-point Hedonic scale, where 1 = dislike extremely and 9 = like extremely, as described by Arise et al. (2023).

Statistical analysis

All determinations were carried out in triplicate. Data were subjected to analysis of variance (ANOVA) using SPSS (version 21, Chicago, United States of America). At the same time, means were separated using the Duncan Multiple Range Test (DMRT) at a 5% level of significance ($p < 0.05$).

Results and Discussion

Proximate analysis

Table 2 shows the proximate analysis results of custard produced from blends of maize, soybean, and crayfish for complementary food. The moisture content ranges from 7.15% to 11.21%, with the control having the highest moisture content. This is generally lower than traditional custard powders, which is beneficial for shelf stability. A recent study by Olapade and Aworh (2022) found that moisture content below 10% in complementary foods helps prevent microbial growth and extends shelf life. The energy content increases in all experimental samples compared to the control, ranging from 451.42 to 484.87 kcal/100g. This increase is likely due to the addition of soybeans and crayfish, which are rich in proteins and fats. Adepoju et al. (2023) reported that incorporating protein-rich ingredients like soybean and crayfish into cereal-based complementary foods significantly improves their energy density.

The carbohydrate content decreases in all experimental samples compared to the control. This reduction is expected due to the partial replacement of maize with protein-rich ingredients. Similar trends were observed by Nwosu et al. (2021) when fortifying maize-based complementary foods with legumes and animal proteins. The ash content decreases in the experimental samples, ranging from 0.47% to 1.18%. However, Onyeka & Obeleagu (2023) found that despite lower ash content, fortified complementary foods often have improved mineral bioavailability due to the diverse ingredient profile. Fibre content decreases in all experimental samples compared to the control. While fibre is essential for digestive health, lower fibre content in complementary foods can benefit young children, as Ijarotimi et al. (2022) noted. Moderate fibre levels improve nutrient absorption in infants. Fat content increases significantly in all experimental samples, likely due to the addition of soybeans and crayfish. This increase in fat content can contribute to improved energy density and help absorb fat-soluble vitamins. Adeyeye et al. (2023) highlighted the importance of adequate fat content in complementary foods for optimal infant growth and development. Protein content increased substantially in all experimental samples, with values ranging from 13.99% to 16.92% compared to 9.13% in the control. This improvement in protein content is crucial for complementary foods. A recent review by Okoye and Ani (2022) emphasised the importance of protein-rich complementary foods in preventing malnutrition and promoting healthy growth in infants and young children.

Anti-nutrient content

Table 3 presents the anti-nutrient content of different custard samples, including a control and four experimental samples (EKY 1, EKY 2, EKY 3, and EKY 4). The tannin content ranges from 0.14 to 0.18 mg/100g, slightly increasing in the experimental samples compared to the control. This increase is relatively small and likely due to the addition of soybean containing tannins. A recent study by Adeyemo & Onilude (2023) found that tannin levels below 0.5 mg/100g in complementary foods are generally considered safe and may have some health benefits, such as antioxidant properties. The slight increase in tannin content is not likely to be of concern. Ademola et al. (2022) found that low levels of tannins in complementary foods can have prebiotic effects, promoting the growth of beneficial gut bacteria in infants.

Oxalate content increases in all experimental samples, ranging from 1.02 to 1.24 mg/100g, compared to 0.76 mg/100g in the control, and this increase could be attributed to the soybean added. However, Ogunka-Nnoka et al. (2022) reported that oxalate levels below 2 mg/100g in complementary foods are unlikely to pose significant risks to mineral absorption in infants and young children. While there is an increase in oxalate content, the levels are still within a safe range. However, Nwosu and Nnam (2023) suggest that complementary foods with higher oxalate content should be balanced with adequate calcium sources to prevent potential interference with calcium absorption. Interestingly, the phytate content decreased in all experimental samples, ranging from 2.29 to 2.86 mg/100g, compared to the control (3.91 mg/100g). This reduction is beneficial, as phytates can interfere with mineral absorption. Adeola and Oladunmoye (2023) observed that blending cereals with legumes and animal proteins often reduces phytate content due to the complementary effects of different ingredients and processing methods. The reduction in phytate content is a positive outcome of the blending process. Adeyeye and Akingbala (2024) demonstrated that lower phytate levels in complementary foods significantly improve iron and zinc bioavailability, which is crucial for infant growth and development.

Table 2: Proximate composition of custard produced from blends of maize, soybean, and crayfish for complementary food

Variables	Control	EKY 1	EKY 2	EKY 3	EKY 4
Moisture (g)	11.21±0.33^{a}	8.24±0.38^{a}	7.89±0.11^{b}	7.15±0.31^{abc}	8.81±0.34^{c}
Energy (kcal)	433.52±3.62^{a}	451.42±3.13^{a}	484.87±3.50^{ab}	465.54±1.74^{abc}	472.36±2.57^{abc}
CHO (g)	60.64±0.71^{a}	52.80±0.61^{a}	50.95±0.32	52.55±0.96^{c}	50.15±1.57^{ac}
Ash (g)	2.10±0.13^{a}	1.18±0.18^{a}	0.47±0.09^{ab}	0.98±0.07^{b}	1.10±0.06^{b}
Fibre (g)	3.84±0.10^{a}	1.69±0.01^{a}	1.19±0.01^{ab}	1.75±0.03^{bc}	1.96±0.07^{abc}
Fat (g)	13.08±0.02^{a}	19.17±0.51^{a}	24.62±0.55^{ab}	21.02±0.05^{abc}	23.97±0.79^{ac}
Protein (g)	9.13±0.85^{a}	16.92±0.29^{a}	14.87±0.67^{ab}	16.55±0.68^{bc}	13.99±0.46^{ac}

Mean±SD, *EKY 1 = 80% Maize flour + 10% Soybean flour + 10% Crayfish flour; EKY 2 = 60% Maize flour + 20% Soybean flour + 20% Crayfish flour; EKY 3 = 50% Maize flour + 30% Soybean flour + 20% Crayfish flour; EKY 4 = 50% Maize flour + 20% Soybean flour + 30% Crayfish flour.*

Table 3: Anti-nutrient analysis of custard produced from blends of maize, soybean, and crayfish for complementary food

Variables	Control	EKY 1	EKY 2	EKY 3	EKY 4
Tannin	0.14±0.01[a]	0.18±0.01[a]	0.17±0.01[b]	0.16±0.01[ac]	0.18±0.01[bc]
Oxalate	0.76±0.02[a]	1.02±0.05[a]	1.24±0.03[ab]	1.15±0.02[abc]	1.02±0.03[bc]
Phytate	3.91±0.08[a]	2.85±0.08[a]	2.29±0.07[ab]	2.86±0.07[bc]	2.58±0.07[abc]

Mean±SD**,** *EKY 1 = 80% Maize flour + 10% Soybean flour + 10% Crayfish flour; EKY 2 = 60% Maize flour + 20% Soybean flour + 20% Crayfish flour; EKY 3 = 50% Maize flour + 30% Soybean flour + 20% Crayfish flour; EKY 4 = 50% Maize flour + 20% Soybean flour + 30% Crayfish flour*

Micronutrient composition

Table 4 presents the micronutrient content of different custard samples, including a control and four experimental samples (EKY 1, EKY 2, EKY 3, and EKY 4). The magnesium content ranges from 228.67 to 298 mg/100g, with a slight decrease in the experimental samples compared to the control. Despite this decrease, the levels remain significant. Adeyeye et al. (2023) reported that magnesium is crucial for bone development and enzyme function in infants, and levels above 200 mg/100g in complementary foods are considered beneficial. Iron content decreased in all experimental samples, ranging from 1.28 to 1.74 mg/100g, compared to the control (2.68 mg/100g). While this reduction is noteworthy, Okoye & Ani (2022) found that even lower iron levels can be beneficial if the bioavailability is improved through food matrix modifications, such as adding animal proteins like crayfish. Calcium increased in all experimental samples, ranging from 107.86 to 118.23 mg/100g, compared to the control (96.27 mg/100g). This increase is positive, as Nwosu et al. (2024) noted, who emphasised the importance of adequate calcium in complementary foods for proper bone and tooth development in infants. Vitamin A also increased in most of the experimental samples, ranging from 57.73 to 65.11 µg/100g, relative to the control sample (50.36 µg/100g). This increase is beneficial, as Adepoju and Osagie (2024) highlighted the crucial role of vitamin A in vision development and immune function in infants. The increase in calcium and vitamin A content in the experimental samples is a positive outcome, likely due to the addition of soybean and crayfish. This aligns with findings by Olapade and Aworh (2023), who reported improved micronutrient profiles in cereal-based complementary foods fortified with legumes and animal proteins. Zinc content decreased in the experimental samples, ranging from 5.12 to 7.04 mg/100g, compared to the control (11.50 mg/100g). Despite this decrease, Ijarotimi et al. (2023) reported that zinc levels above 5 mg/100g in complementary foods can still contribute significantly to meeting infants' daily requirements. Folate levels vary across the samples, with some showing a slight decrease. Onyeka and Obeleagu (2023) emphasised the importance of folate in complementary foods for proper cell division and growth in infants, suggesting that even small amounts can be beneficial. Vitamin B12 decreased in the experimental samples, ranging from 0.41 to 1.23 µg/100g, compared to the control (1.57 µg/100g). However, Ademola et al. (2022) noted that adding animal-sourced ingredients like crayfish, even in small amounts, can significantly improve vitamin B12 status in plant-based complementary foods. While some micronutrients show a decrease, the overall profile of the experimental samples suggests a more balanced nutrient composition. This aligns with recent recommendations by Adeyeye & Akingbala (2024) for diverse ingredient selection in complementary food formulations.

Sensory Evaluation

The sensory evaluation of the complementary food samples (Table 5) provides crucial insights into the acceptability of the fortified custard formulations. The control sample scored the highest (8.25), with experimental samples ranging from 6.70 to 7.71. This slight decrease in colour acceptance could be attributed to adding soybeans and crayfish. Adeyeye et al. (2023) reported similar findings when fortifying maize-based complementary foods with legumes, noting that while colour scores decreased, they remained within acceptable ranges. The control sample again scored highest (8.31), with experimental samples ranging from 6.35 to 7.65. This decrease in taste scores aligns with findings by Olapade & Aworh (2023), who observed that adding protein-rich ingredients like soybean and fish powder can alter the taste profile of cereal-based complementary foods. However, they emphasised that taste adaptation occurs over time, especially in infants. The control sample scored significantly higher (8.42) than the experimental samples (5.31 to 6.51). This substantial decrease in flavour scores could be due to the intense flavours introduced by soybeans and crayfish.

Table 4: Micronutrient analysis of custard produced from blends of maize, soybean and crayfish for complementary food

Variables	Control	EKY 1	EKY 2	EKY 3	EKY 4
Magnesium (mg)	298.00±6.31[a]	285.33±7.57[a]	228.67±6.43[ab]	286.67±6.51[bc]	258.0±7.21[abc]
Iron (mg)	2.68±0.01[a]	1.43±0.01[a]	1.29±0.00[ab]	1.74±0.00[abc]	1.28±0.01[ac]
Calcium (mg)	96.27±0.15[a]	115.10±0.10[a]	118.23±0.15[ab]	110.60±0.17[abc]	107.86±0.32[abc]
Zinc	11.50±0.01[a]	7.04±0.01[a]	5.53±0.01[ab]	6.00±0.01[abc]	5.12±0.00[abc]
Vitamin A	50.36±0.79[a]	61.24±0.89[a]	57.82±0.97[ab]	65.11±0.78[abc]	57.73±0.67[ac]
Folate	0.09±0.01[a]	0.07±0.01[a]	0.05±0.01[ab]	0.09±0.01[abc]	0.05±0.01[ac]
Vitamin B12	1.57±0.07[a]	0.96±0.06[a]	0.41±0.07[ab]	1.23±0.08[b]	0.84±0.06[ac]

Values are the mean of triplicate determinations within the same column are not significantly different (P > 0.05)
Key: *EKY 1 = 80% Maize flour + 10% Soybean flour + 10% Crayfish flour; EKY 2 = 60% Maize flour + 20% Soybean flour + 20% Crayfish flour; EKY 3 = 50% Maize flour + 30% Soybean flour + 20% Crayfish flour; EKY 4 = 50% Maize flour + 20% Soybean flour + 30% Crayfish flour*

Table 5: Sensory Evaluation of Complementary Food

Attributes (%)	Control	EKY 1	EKY 2	EKY 3	EKY 4
Colour	8.25±1.71	7.40±1.30	7.71±1.21	7.30±1.42	6.70±1.51
Taste	8.31±1.50	7.65±1.42	7.35±1.51	6.40±1.31	6.35±1.62
Flavour	8.42±1.52	6.45±1.21	6.21±1.21	5.31±1.42	6.51±1.70
Mouth feel	7.11±1.31	6.52±1.40	6.23±1.10	5.35±1.21	5.20±1.24
Smoothness	8.11±1.45	7.34±1.13	7.45±1.20	7.21±1.22	7.01±1.15
Overall acceptability	8.32±1.21	7.47±1.30	7.23±1.42	6.10±1.15	6.51±1.10

Mean±SD, Values are the mean of triplicate determinations within the same column are not significantly different (P > 0.05), *EKY 1 = 80% Maize flour + 10% Soybean flour + 10% Crayfish flour; EKY 2 = 60% Maize flour + 20% Soybean flour + 20% Crayfish flour; EKY 3 = 50% Maize flour + 30% Soybean flour + 20% Crayfish flour; EKY 4 = 50% Maize flour + 20% Soybean flour + 30% Crayfish flour.*

Nwosu et al. (2024) suggested that gradually introducing fortified complementary foods can improve flavour acceptance. Scores ranged from 5.20 to 7.11, with the control scoring the highest. Ijarotimi et al. (2023) noted that adding protein-rich ingredients can affect complementary foods' texture and mouth feel, but emphasised that nutritional benefits often outweigh slight textural changes. All samples scored relatively well (7.01 to 8.11), indicating that the fortification did not significantly impact the smoothness of the custard. This is crucial for infant acceptability, as Onyeka and Obeleagu (2023) highlighted the importance of smooth textures in complementary foods for ease of swallowing and digestion. The control sample scored highest (8.32), with experimental samples ranging from 6.10 to 7.47. While there was a decrease in overall acceptability, the scores for the fortified samples remained above average. Ademola et al. (2022) emphasised that despite slightly lower sensory scores, the nutritional benefits of fortified complementary foods often outweigh minor reductions in organoleptic properties. While the fortified custard samples showed some decrease in sensory scores compared to the control, they remained generally acceptable. Despite the slight decline in sensory scores, the fortified custard samples remain permissible, and the significant improvements in protein quality and micronutrient content far outweigh minor reductions in taste or appearance.

Conclusion

This study investigated the production and quality evaluation of custard produced from maize, soybean, and crayfish blends as a complementary food. The results demonstrated that combining these ingredients can significantly improve the nutritional profile of custard powder compared to traditional maize-based formulations while maintaining acceptable sensory characteristics. These improvements are crucial for meeting the dietary needs of infants and young children during the complementary feeding period. The fat content also increased significantly, which can contribute to improved energy density and aid in absorbing fat-soluble vitamins. Sensory evaluation indicated that while the fortified custard samples showed some decrease in sensory scores compared to the control, they remained generally acceptable. The slight reductions in sensory attributes should be weighed against the significant nutritional improvements observed. Overall, this research demonstrates the potential of using locally available, nutrient-dense ingredients to improve the nutritional quality of complementary foods. The blends of maize, soybean, and crayfish offer a promising approach to addressing malnutrition concerns in infants and young children, particularly in developing countries where commercial infant formulas may be less accessible or affordable.

Recommendations

The recommendations are to:

1. Optimise ingredient composition by testing different maize, soybean, and crayfish ratios, and incorporating other locally available, nutrient-rich foods.
2. To determine real-world effectiveness, evaluate long-term impact on growth, micronutrient status, and health outcomes in infants and young children.
3. Enhance sensory and nutritional quality through processing methods such as fermentation, extrusion, or enzymatic treatments.

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