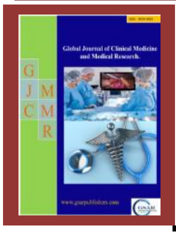


Global Journal of Clinical Medicine and Medical Research [GJCMMR]
ISSN: 2583-987X (Online)
Abbreviated key title: Glob.J.Clinic.Medici.Medica.Res.
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjcmmr-home/

Nutritional Composition and Sensory Acceptability of a pearl millet-Based Complementary Diet Enriched with Soybean, Groundnut, and Dates for Infants and Young Children (6–24 Months)

By

***Sa'eedu Auwal Magaji[1], Bawagana Kyari[1], Anda Susan A.D[2], Haruna Hauwa[3], Osagede Esther Abraham[3], Zafirah Suleiman Abarshi[4], Agboola Fatai O[5], Salisu Shuaibu Lawal[6], Harisu Saleh[6], Jummai Hassan Abdul[7], Sufyanu Lawan Yusuf[8], Hauwa H. Lamimu[1]**

[1]Department of Nutrition and Dietetics, College of Medical Sciences, University of Maiduguri, P.M.B 1069, Borno State, Nigeria.
[2]Department of Home and Rural Economics, College of Agriculture, Science and Technology Lafia, Nasarawa State.
[3]Department of Nutrition and Dietetics, College of Agriculture, Sciences and Technology Lafia, Nasarawa State.
[4]Department of Nutrition and Dietetics, School of Community Health, Plateau State College of Health Technology, Zawan.
[5]Department of Nutrition and Dietetics, Shehu Idris College of Health, Science and Technology Makarfi, Kaduna State.
[6]Department of Nutrition and Dietetics, Federal University of Agriculture, Mubi, P.M.B 2025, Adamawa State, Nigeria.
[7]Department of Medical Biochemistry, Faculty of Basic Medical Sciences, Baze University, Nigeria.
[8]Department of Nutrition and Dietetics, Federal Polytechnic Kabo, Kano State, Nigeria.

Article History

Received: 01/07/2026
Accepted: 08/07/2026
Published: 10/07/2026

Vol – 4 Issue –7

PP: -15-19

DOI:10.5281/zenodo.21318571

Abstract

Complementary foods are foods and liquids other than breast milk or infant formulas required during the second part of the first year of life for both nutritional and developmental reasons and also to enable transition from milk feeding to family foods. In Nigeria, traditional cereal-based gruels (ogi/akamu/pap) are nutritionally inadequate, and recent inflation has further compromised food security, increasing malnutrition among infants and young children. This study evaluated the nutrient composition and sensory properties of a complementary food formulated from pearl millet, soybean, groundnut, and dates at a ratio of 6:3:1:1. Standard AOAC methods were used to determine proximate composition, while texture, taste, appearance, and overall acceptability were assessed using a 6-point hedonic scale. The formulated food contained 418.02 kcal/100 g, with 57.98% carbohydrate, 17.50% protein, 12.90% fat, 5.70% moisture, 4.90% fiber, and 1.02% ash. Sensory evaluation indicated that taste (5.40), texture (5.13), and appearance (5.00) were well accepted. These results demonstrate that nutritionally enhanced complementary foods with satisfactory sensory attributes can be produced by combining nutrient-dense crops such as dates, legumes, and cereals. The inclusion of dates, in particular, improves both palatability and nutrient quality, making this formulation a viable, affordable alternative to traditional gruels for infants aged 6–24 months.

Key words: *Complementary food, nutrients-dense, infant formulas, gruel, malnutrition*

Introduction

Breast milk is universally recognized as the optimal source of nutrition for infants, providing essential nutrients required for normal growth and development during the early months of life. It contains polyunsaturated fatty acids, high-quality proteins, immunological factors, and bioactive components in forms that are highly bioavailable to infants (Ballard and Morrow, 2013). However, after six months of age, breast milk alone becomes insufficient to meet the increasing nutritional demands of the growing infant (Hampson *et al.*, 2019). Consequently, additional foods must be introduced alongside continued breastfeeding, a process referred to as complementary feeding. Complementary feeding typically begins at six months of age and continues up to 24 months or beyond, representing a critical transition from exclusive

*Corresponding Author: **Sa'eedu Auwal Magaji**

breastfeeding to the gradual introduction of family foods (WHO, 2019). During the period of complementary feeding, infants experience rapid physical, physiological, and cognitive development, accompanied by increased nutritional requirements. Complementary foods must therefore be nutritionally adequate, safe, and appropriately processed to meet the child's dietary needs. Ideally, these foods should provide sufficient energy and be rich in high-quality proteins, essential fats, vitamins, and minerals to support optimal growth and development (Cichero, 2016; Koletzko *et al*., 2019). However, inadequate complementary feeding practices and poor dietary quality during this critical stage often contribute to childhood malnutrition.

Childhood malnutrition remains a major public health challenge, particularly in developing countries. Nutrition and health during the first year of life play a crucial role in determining growth and developmental outcomes, and most growth faltering occurs during this period (Shrimpton *et al*., 2001; Semproli and Gualdi-Russo, 2007). Malnutrition, which refers to deficiencies, excesses, or imbalances in nutrient intake, significantly affects infants and young children during the complementary feeding stage. Globally, an estimated 149 million children under five years are stunted, 45 million are wasted, and 38.3 million are overweight (UNICEF, WHO, World Bank *et al*., 2020). The burden of malnutrition is particularly high in developing regions. In Africa, about

12.7 million children under five years suffer from wasting, with 3.5 million experiencing severe wasting (UNICEF, WHO, World Bank *et al*., 2020). West Africa accounts for approximately 4.8 million wasted children, including about 1.1 million who are severely wasted (UNICEF, WHO, World Bank *et al*., 2020).

Nigeria continues to face a substantial burden of child malnutrition. Data from the Nigeria Demographic and Health Survey indicate that among children aged 6–59 months, stunting increased from approximately 37% in 2018 to 40% in 2024, wasting rose from 7% to 8%, and underweight prevalence climbed from 22% to 27% over the same period (Federal Ministry of Health and Social Welfare (FMoHSW) *et al*., 2024). Malnutrition during early childhood can result in serious health consequences, including increased morbidity, mortality, and impaired physical and cognitive development (Wali *et al*., 2019). It also increases susceptibility to infections and other health complications, placing additional strain on healthcare systems (Ruel *et al*., 2013). Furthermore, the long-term consequences of childhood malnutrition, including reduced productivity and increased healthcare costs, pose substantial economic burdens on families, communities, and national economies (Bhutta *et al*., 2013).

In many developing countries, including Nigeria, the high cost of commercially fortified complementary foods limits their accessibility to many households. As a result, many families depend on traditional cereal-based complementary foods such as pap (*ogi*) prepared from maize (*Zea mays*), sorghum (*Sorghum bicolor*), or pearl millet (*Pennisetum glaucum*). Although these foods are widely consumed due to their affordability and availability, they are often nutritionally inadequate, particularly in terms of protein and micronutrient content (Adebayo and Aderiye, 2010). Enhancing the nutritional quality of traditional complementary foods through the incorporation of locally available nutrient-dense ingredients offers a practical and affordable approach to improving infant nutrition.

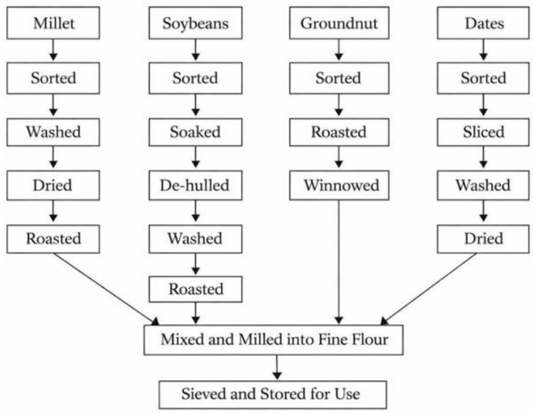
Pearl millet (*Pennisetum glaucum*) provides carbohydrates and essential minerals, while soybean (Glycine max) and groundnut (*Arachis hypogaea*) are rich sources of high-quality proteins and healthy fats. Dates (*Phoenix dactylifera L.*) is also a valuable source of natural sugars, vitamins, and minerals that can enhance both the nutritional quality and sensory acceptability of complementary foods. Therefore, the use of these locally available ingredients in complementary food formulation may contribute to improving the dietary quality of infants and young children. Therefore, this study aimed to formulate and evaluate the nutritional composition and sensory properties of a complementary food developed from pearl millet (*Pennisetum glaucum*), soybean (*Glycine max*), groundnut (*Arachis hypogaea*), and dates (*Phoenix dactylifera L.*) for children aged 6–24 months.

Materials and Methods

Sources of Materials

Pearl millet (*Pennisetum glaucum*), Soybeans (*Glycine max*), Groundnut (*maiborgo*) (*Arachis hypogaea*) and dates (*Dan Shuwarin*) (*Phoenix dactylifera L.*) were purchased from Lafia modern market, Nasarawa state.

Processing of the ingredients into flour and formulation of the complementary food blend The pearl millet was sorted, washed, sun-dried and roasted; the soybeans was sorted, soaked for 12 hours, dehulled, washed, sun-dried and roasted; groundnut was sorted, roasted and winnowed while dates were sorted, sliced to remove seeds, washed and sun-dried. After which all the ingredients were then mixed together at the ratio 6:3:1:1 and milled into fine flour. The flowchart is shown in figure 1.



*Corresponding Author: **Sa'eedu Auwal Magaji**

Fig. 1: Flow chart for the Production of Complementary Food Flour

Chemical composition of complementary food flour

Moisture content, crude fat, total ash, crude fibre, crude protein of the complementary food flour was determined using the AOAC (2010) methods and total carbohydrate was calculated by difference (FAO, 2003) while energy was calculated using the Atwater Conversion factors in Kcal.

Preparation of complementary food

A pot containing the desired quantity of water was placed on the fire and brought to a boil. The complementary food powder was measured into a separate bowl, and water was added gradually while stirring continuously until it completely dissolved and formed a semi-thick paste. Once the water reached boiling point (100 °C), the prepared paste was poured into the pot and stirred over medium heat for at least 4-5 minutes to ensure proper cooking of the complementary food.

Sensory evaluation of the complementary food

Fifteen (15) untrained panelists evaluated the sensory attributes of the formulated samples. Approximately 100 ml of the prepared complementary food was poured into a transparent glass bowl and presented to the panelists for evaluation. The samples were rated based on perceived intensities of standard sensory attributes, namely taste, texture, appearance, and overall acceptability, using a 6-point hedonic scale, where 6 = excellent, 5 = very good, 4 = good, 3 = undecided, 2 = fair, and 1 = poor. Clean drinking water was provided in separate glasses for each panelist to rinse their mouths before and after tasting the sample to minimize carry-over effects.

Statistical analysis

Experiments were conducted in triplicates. The means and standard deviations (SD) were calculated taking all the readings into consideration. Statistical analysis was performed using SPSS (Statistical Package for Social Sciences, version 21.0).

Results and Discussion

Moisture, protein, fat, and carbohydrates constituted the major components of the pearl millet-soybean-groundnut-dates complementary food flour (Table 1), reflecting the combined nutritional contributions of cereals, legumes, and fruit ingredients. The inclusion of roasted soybean is particularly important, as legume fortification has been shown to significantly improve the nutritional quality of cereal-based foods such as *ogi* (Adeyemo and Onilude, 2019). Dates also contribute nutritionally to the formulation due to their high content of natural sugars, dietary fibre, vitamins, minerals, and bioactive compounds including antioxidants and phenolics (Vayalil, 2012). The resulting formulation exhibited balanced macronutrient composition, with carbohydrates (57.98%), protein (17.50%), fat (12.90%), fibre (4.90%), and ash (1.02%), suggesting that the product meets key nutritional criteria for complementary foods. These values align with recommendations that complementary foods should provide balanced protein and energy with adequate micronutrients and moderate fibre levels suitable for infant digestion (Jahan *et al.*, 2021).

The observed protein content of the formulated complementary food (17.50%) indicates that the incorporation of soybean and groundnut effectively enhanced the protein density of the cereal-based blend. This demonstrates that legume fortification can meaningfully improve the nutritional quality of traditionally low-protein cereal-based complementary foods, addressing a common limitation in locally produced weaning foods (Muhammed et al., 2021). While lower than the protein levels reported in some legume-rich formulations (Bassey et al., 2013; Jahan et al., 2021), the value is nevertheless sufficient to contribute substantially to the protein requirements of infants aged 6 - 24 months, a critical period for growth and development (Jabri et al., 2020). The consistency of this result with Saeeda et al. (2009), who reported 17.5% crude protein in a wheat, pea, cabbage, and groundnut blend, further supports the effectiveness of combining cereals with legumes to achieve a nutritionally relevant protein content.

The fat content (12.90%) was relatively higher than that reported in several locally formulated complementary foods (Jahan *et al.*, 2021; Muhammed *et al.*, 2021) and slightly exceeded the recommended minimum of approximately 10% fat for weaning foods (Sajilata *et al.*, 2002). This higher fat level likely resulted from the inclusion of soybean and groundnut, both of which are rich sources of unsaturated fatty acids (Polak *et al.*, 2015). From a nutritional perspective, this is advantageous because dietary fat enhances energy density and supports cognitive development and immune function in infants (Michaelsen *et al.*, 2017). However, higher fat levels may also increase susceptibility to oxidative deterioration and microbial spoilage if storage conditions are inadequate (Laminu *et al.*, 2014).

The carbohydrate content (57.98%) falls within the range reported for locally formulated complementary foods (52.80 - 61.20%) (Jahan *et al.*, 2021), although it is lower than that reported for several commercial complementary products (71.24 - 76.92%) (Jahan *et al.*, 2020). This relatively moderate carbohydrate level may be nutritionally advantageous, as excessive carbohydrate dominance in complementary foods may reduce dietary diversity and energy balance. The energy value (418.02 kcal/100g) further indicates that the formulation provides adequate energy density, which is critical during the complementary feeding period when infants require nutrient-dense foods to meet their increasing metabolic demands (Abeshu *et al.*, 2016).

The fibre content (4.90%) was slightly higher than the value reported by Jahan *et al*. (2021). While excessive fibre can reduce nutrient bioavailability in infants, moderate fibre levels may support gastrointestinal function and contribute to the development of healthy gut microbiota during early life (O'Keefe, 2019). The ash content (1.02%), which reflects the mineral fraction of the food, falls well within the recommended

*Corresponding Author: **Sa'eedu Auwal Magaji**

limit for complementary foods (<5 g/100 g) established by WHO/FAO (2004), indicating that the formulation provides an acceptable mineral contribution to infant diets.

Table 1: Proximate Composition of complementary food powder

Parameters	Composition per 100g
Moisture (%)	5.70±0.01
Crude protein (%)	17.50±0.02
Crude fat (%)	12.90±0.03
Total ash (%)	1.02±0.01
Crude fiber (%)	4.90±0.02
Carbohydrate (%)	57.98±0.01
Caloric Value (Kcal/100g)	418.02±0.39

Values recorded as mean ± SD of triplicate determinations.

The mean sensory scores for texture, taste, appearance, and overall acceptability of the complementary food samples are presented in Figure 2. Taste and overall acceptability recorded the highest ratings, while appearance received comparatively lower scores. Texture, which reflects the mouthfeel and consistency of the product, was also positively rated, indicating that the formulation produced a suitable consistency for infant consumption. The favourable overall acceptability observed in this study is consistent with the findings of Muhammed *et al*. (2021), who reported higher acceptability of formulated complementary food blends compared with the traditional cereal-based product *akamu*. The improved sensory quality of the product may be attributed to the inclusion of roasted soybean, groundnut, and dates, which not only enhanced the nutritional profile but also contributed desirable flavour, texture, and sweetness. Processing techniques applied during formulation may have further enhanced palatability and product stability, as food processing has been shown to improve sensory quality and storage properties of complementary foods (Muhimbula *et al*., 2011; Bintu *et al*., 2019).

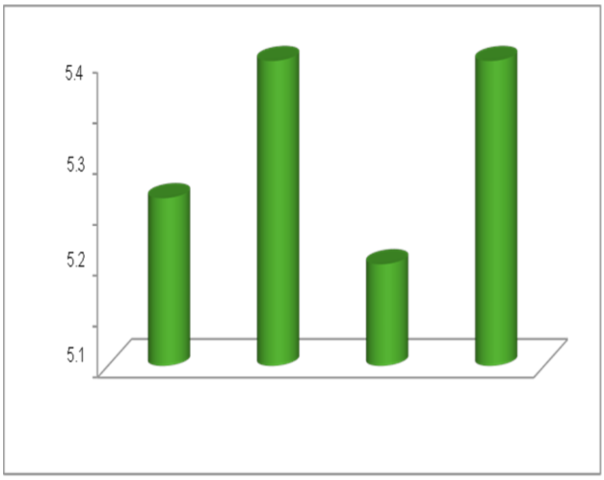


Figure 2: Column graph showing results of 6 - point hedonic scale sensory evaluation of the formulated complementary food blend.

Conclusions

In Nigeria, high costs of commercial complementary foods and the poor nutritional quality of traditional gruels like *ogi/pap* contribute to infant malnutrition. This study shows that a complementary food formulated from pearl millet, soybean, groundnut, and dates provides balanced macronutrients, adequate energy, and acceptable sensory attributes, making it a nutritionally improved and palatable alternative.

References

1. A.O.A.C. (2010). Official Methods of Analysis of Association of Official Chemists.18th Ed., Washington, D.C., USA.
2. Abeshu, M.A., Lelisa, A., Geleta, B., (2016). Complementary feeding: review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries – lessons from Ethiopia. Front. Nutr. 3, 41.
3. Adeyemo S. M. and Onilude A. A. (2018). Weaning food fortification and improvement of fermented cereal and legume by metabolic activities of probiotics Lactobacillus plantarum Article Number - C9A41FF58519. *Afr. J. Food Sci.* 12(10): 254 - 262 https://doi.org/10.5897/AJFS2017.1586
4. Ballard, O., Morrow, A.L., (2013). Human milk composition: nutrients and bioactive factors. Pediatric Clin. 60 (1), 49–74.
5. Bassey, F.I., Mcwatters, K.H., Edem, C.A., Iwegbue, C.M.A., (2013). Formulation and nutritional evaluation of weaning food processed from cooking banana, supplemented with cowpea and peanut. Food Sci. Nutr. 1 (5), 384–391.
6. Bhutta ZA, Das JK, Rizvi A, Gaffey MF, Walker N, Horton S, Webb P, Lartey A, Black RE, (2013). Lancet Nutrition Interventions Review Group, the Maternal and Child Nutrition Study Group.

*Corresponding Author: **Sa'eedu Auwal Magaji**

Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? Lancet. 2013 Aug 3;382(9890):452-477. doi: 10.1016/S0140-6736(13)60996-4. Epub 2013 Jun 6. Erratum in: Lancet. 2013 Aug 3;382(9890):396. PMID: 23746776.

7. Bintu BP, Falmata AS, Maryam BK, Raihatu MA, Chellube Z, Hauwa H and Modu S (2019). Microbial, pH, titratable Acidity, Functional and Sensory Properties of Complementary food blend Blends Formulated from Maize, Cowpea, Bambara nut and Groundnut. Food Sci. Nutr. Stud. 3 (2): 60 – 72
8. Cichero, J.A.Y., (2016). Introducing solid foods using baby-led weaning vs. spoon-feeding: a focus on oral development, nutrient intake and quality of research to bring balance to the debate. Nutr. Bull. 41 (1), 72–77.
9. Food and Agricultural Organization. (2003). *Food and nutrition paper 77: Food energy – Methods of analysis and conversion factors*. FAO.
10. Federal Ministry of Health and Social Welfare [Nigeria], National Population Commission [Nigeria], & ICF. (2024). *Nigeria Demographic and Health Survey 2023–24: Key indicators report*. National Population Commission/ICF.
11. Hampson, G., Roberts, S.L.E., Lucas, A., Parkin, D., (2019). An economicj analysis of human milk supplementation for very low birth weight babies in the USA. BMC Pediatr.
12. Jabri, L., Rosenthal, D.M., Benton, L., Lakhanpaul, M., (2020). Complementary feeding practices and nutrient intakes of children aged 6-24 months from Bangladeshi background living in Tower Hamlets, East London: a feasibility study. *J. Health Popul. Nutr.* 39 (1), 1–15.
13. Jahan SA, , Bisrat FB, Omar FC, Ferdaus JC, Sharmin SKA , Farzana T, (2021). Formulation of nutrient enriched germinated wheat and mung-bean based weaning food compare to locally available similar products in Bangladesh. https://doi.org/10.1016/j.heliyon.2021.e06974.
14. Koletzko, B., Bührer, C., Ensenauer, R., Jochum, F., Kalhoff, H., Lawrenz, B., Zimmer, K.P., (2019). Complementary foods in baby food pouches: position statement from the Nutrition Commission of the German Society for Pediatrics and Adolescent Medicine (DGKJ, eV). Mol. Cell. Pediatr. 6 (1), 1–5.
15. Laminu HH, Sheriff M, Bintu BP and Mohammed AA (2014). Evaluation of the protein Quality of composite meals produced from selected cereals and legumes of infants. *Scholarly J. Agr. Sci*. 4(11): 536 – 542
16. Michaelsen, K.F., Grummer-Strawn, L., Begin, F., (2017). Emerging issues in complementary feeding: global aspects. Matern. Child Nutr. 13, e12444.
17. Mohammed, Z.K., Petrol, B.B., and Ahmad, U (2021). Formulation and nutritional evaluation of a complementary food blend made from fermented yellow maize (Improved variety), soybean and African cat fish meal. *Nig. J. Biotech*.38 (1) : 98-108; DOI: https://dx.doi.org/10.4314/njb.v38i1.12
18. Muhimbula, H.S., Issa-Zacharia, A., Kinabo, J., (2011). Formulation and sensory evaluation of complementary foods from local, cheap and readily available cereals and legumes in Iringa, Tanzania. *Afr. J. Food Sci*. 5 (1), 26–31.
19. O'Keefe, S.J., (2019). The association between dietary Fibre deciency and high-income lifestyle-associated diseases: burkitt's hypothesis revisited. Lancet Gastroenterol. Hepatol. 4 (12), 984–996.
20. Polak, R., Phillips, E.M., Campbell,A., (2015). Legumes: health benets and culinary approaches to increase intake. Clin. Diabetes 17, 198–205.
21. Ruel MT, Alderman H; Maternal and Child Nutrition Study Group (2013). Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? Lancet. 2013 Aug 10;382(9891):536-51. doi: 10.1016/S0140-6736(13)60843-0. Epub 2013 Jun 6. Erratum in: Lancet. 2013 Aug 10;382(9891):506. PMID: 23746780.
22. Saeeda, R., Muhammad N. S., Amer M., Noumann S., Khalid N., and Muhammad A. (2009). Preparation and quality evaluation of nutritious instant baby food from indigenous sources. Pak. J Agri. Res. 22:50–55.
23. Sajilata, G., Singhal, R.S., Kulkarni, P.R., (2002). Weaning foods : a review of the Indian experience. Food Nutr. Bull. 23 (2), 208–226.
24. Semproli, S., & Gualdi-Russo, E. (2007). Childhood malnutrition and growth in a rural area of Western Kenya. *American journal of physical anthropology, 132 3*, 463-9 .
25. Shrimpton R, Victora CG, de Onis M, Lima RC, Blossner M, Clugston G (2001). Worldwide timing of growth faltering: implications for nutritional interventions. Pediatrics., 107 (2001), p. E75
26. UNICEF, WHO, & World Bank Group. (2020). *Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group. joint child malnutrition estimates – 2020 edition*. New York: UNICEF.
27. Vayalil, P.K. (2012). Date fruits (Phoenix dactylifera Linn): an emerging medicinal food. Critical Reviews in Food Science and Nutrition, 52, 249–271.
28. Wali N, Agho K, Renzaho AMN (2019). Past drivers of and priorities for child undernutrition in South Asia: A mixed methods systematic review protocol. Syst Rev. 2019;8(1):1–8. 10.1186/s13643-

*Corresponding Author: **Sa'eedu Auwal Magaji**

019-1112-7

29. WHO/FAO. (2004). Human vitamin and mineral requirements. Report of a joint FAO/WHO consultation, Bangkok, Thailand. Rome: Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO).
30. World Health Organisation (2019). Appropriate complementary feeding. E-Library of evidence for nutrition actions (ELENA). Retrievd from. https://www.who.int/elena/titles/complementary_feeding/en/.

*Corresponding Author: **Sa'eedu Auwal Magaji**