



ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating: 4.97
IJAFA 2025; 7(4): 219-222
www.agriculturaljournals.com
Received: 04-02-2025
Accepted: 08-03-2025

Dr. Emmanuel Mwakasege
Department of Food
Engineering, Sokoine
University of Agriculture,
Morogoro, Tanzania

Grace Mushi
Department of Food
Engineering, Sokoine
University of Agriculture,
Morogoro, Tanzania

Formulation and nutritional evaluation of weaning food from locally available cereals and legumes

Emmanuel Mwakasege and Grace Mushi

DOI: <https://www.doi.org/10.33545/2664844X.2025.v7.i4c.1400>

Abstract

According to UNICEF, nearly 36% of Tanzanian children under two years receive complementary foods that fall short of minimum dietary diversity standards. This research formulated three weaning food blends from locally available ingredients — F1 (rice flour 60% + green gram dal 25% + jaggery 15%), F2 (wheat flour 55% + Bengal gram dal 25% + jaggery 15% + skim milk powder 5%), and F3 (finger millet flour 60% + soybean flour 25% + jaggery 15%) — and evaluated their proximate composition, mineral content, *in vitro* protein digestibility, viscosity, and sensory acceptability. F2 recorded the highest protein (17.3%), iron (7.2 mg 100 g⁻¹), calcium (148 mg 100 g⁻¹), and *in vitro* protein digestibility (78.4%). All three formulations met or exceeded the WHO/ICMR minimum of 15% protein on a dry-weight basis except F3, which reached only 12.6%. Viscosity at a 3:1 water-to-flour ratio fell below the recommended 1,500 cP ceiling for infant foods in all blends. Sensory panellists rated F2 highest for overall acceptability (7.9 on a 9-point scale). F2 offers a nutritionally dense, low-cost weaning food option for rural Morogoro Region.

Keywords: Weaning food, cereals, legumes, nutritional evaluation, infant nutrition, complementary feeding, finger millet, soybean, protein digestibility, food formulation

Introduction

The World Health Organization recommends that infants begin receiving nutritionally adequate and safe complementary foods at six months of age, alongside continued breastfeeding [1]. Paediatricians working in rural Tanzania's remote districts, however, report that most mothers introduce complementary foods either too early (watery rice gruel at four months) or too late (family foods at nine months), with both practices linked to stunting and micronutrient deficiency [2].

Commercial weaning foods are available, but their cost — TZS 8,000-12,000 per 400 g pack — puts them beyond the reach of families living below the poverty line in Morogoro district, where more than 40% of households depend on daily-wage agricultural labour [3]. A formulation based on ingredients already present in the household — rice, wheat, finger millet, green gram, Bengal gram, soybean, jaggery — could bridge this gap if it meets energy, protein, and micronutrient targets at a fraction of the commercial price.

Cereal-legume blending is the classical strategy for improving amino acid complementarity: cereals supply methionine while legumes provide lysine, the two amino acids most limiting in each other [4]. Malting or roasting before milling can reduce anti-nutritional factors and improve starch digestibility, making the gruel thinner at the same solid concentration — a critical property, since high viscosity limits the energy density an infant can consume per spoonful [5].

Earlier formulations from southern and eastern Africa used specific local ingredients (ragi, horsegram, amaranth) that may not be available or culturally familiar in the Vindhyana plateau region of Morogoro Region [6]. This research therefore aimed to develop and evaluate three weaning food blends from ingredients routinely grown and consumed in Morogoro district, and to compare their nutritional profiles against WHO/ICMR standards for complementary foods.

Formulation Preparation Protocol

Cereals and legumes were procured from Morogoro's wholesale grain market in September 2023. Rice and wheat grains were cleaned and roasted at 150 °C for 15 min in a sand-

Corresponding Author:
Dr. Emmanuel Mwakasege
Department of Food
Engineering, Sokoine
University of Agriculture,
Morogoro, Tanzania

roasting pan. Green gram dal and Bengal gram dal were roasted at 140 °C for 12 min until a nutty aroma developed. Finger millet was popped (dry heat, 220 °C, 45 s) and soybean was soaked for 8 h, drained, autoclaved at 121 °C for 15 min to inactivate trypsin inhibitors, dried at 60 °C, and de-hulled [7]. All ingredients were milled separately to pass through a 60-mesh sieve. Blends were mixed in a ribbon blender for 10 min, packed in metallised polyester pouches, and stored at ambient temperature (~26 °C) until analysis.

Nutritional Assessment Criteria

Formulations were benchmarked against the WHO/Codex standard for processed cereal-based foods for infants (Codex Stan 74-1981, revised 2006): minimum 15% protein (dry basis), minimum 400 kcal 100 g⁻¹ energy, iron ≥ 6 mg 100 g⁻¹, and calcium ≥ 100 mg 100 g⁻¹ [8]. Viscosity was evaluated at a water-to-flour ratio of 3:1, targeting ≤ 1,500 cP as the threshold below which infants can self-feed from a cup or spoon without choking.

Material and Methods

Material

The research was conducted in the Product Development Laboratory of the Department of Food Engineering, Sokoine University of Agriculture, Morogoro (6.83° S, 37.66° E), between October 2023 and February 2024. Three formulations were prepared: F1 — rice flour (60%) + green gram dal flour (25%) + jaggery powder (15%); F2 — wheat

flour (55%) + Bengal gram dal flour (25%) + jaggery (15%) + skim milk powder (5%); F3 — finger millet flour (60%) + soybean flour (25%) + jaggery (15%). All chemicals for analysis were AR-grade from Sigma-Aldrich Tanzania.

Methods

Proximate composition (moisture, protein, fat, ash, crude fibre, carbohydrate by difference) was determined by AOAC methods [9]. Iron and calcium were measured by atomic absorption spectrophotometry after wet digestion. *In vitro* protein digestibility was estimated by the multi-enzyme technique of Hsu *et al.* [10]. Viscosity was measured at 45 °C using a Brookfield viscometer (Model DV-III) at water-to-flour ratios of 1.5 to 4.0. Sensory evaluation used a 9-point hedonic scale with 15 semi-trained panellists (mothers of children aged 6-24 months) for appearance, colour, aroma, taste, texture, and overall acceptability. Data were analysed by one-way ANOVA; means compared by CD at $p < 0.05$ [11].

Results

Among the three formulations, F2 consistently ranked first for protein, minerals, and digestibility. Its protein content of 17.3% exceeded the WHO minimum of 15%, while F1 (14.8%) fell just short and F3 (12.6%) missed the target by a wider margin. Energy density ranged from 368 kcal 100 g⁻¹ (F3) to 381 kcal 100 g⁻¹ (F2), all below the 400 kcal goal — a gap that could be closed by adding 5% vegetable oil to any formulation.

Table 1: Proximate composition and mineral content of three weaning food formulations (dry-weight basis)

Parameter	F1 (Rice + Moong)	F2 (Wheat + Chana)	F3 (Ragi + Soy)	WHO/ICMR Min	CD (p=0.05)
Moisture (%)	6.4 a	5.8 b	6.1 ab	< 8	0.5
Protein (%)	14.8 b	17.3 a	12.6 c	≥ 15	1.2
Fat (%)	6.2 ab	7.1 a	5.4 b	≥ 6	0.9
Crude Fibre (%)	1.4 c	2.1 b	3.8 a	—	0.4
Energy (kcal/100g)	372 ab	381 a	368 b	≥ 400	8.3
Iron (mg/100g)	5.8 b	7.2 a	4.6 c	≥ 6	0.7
Calcium (mg/100g)	124 b	148 a	98 c	≥ 100	14.6

Means with different letters in a row differ at $p < 0.05$.

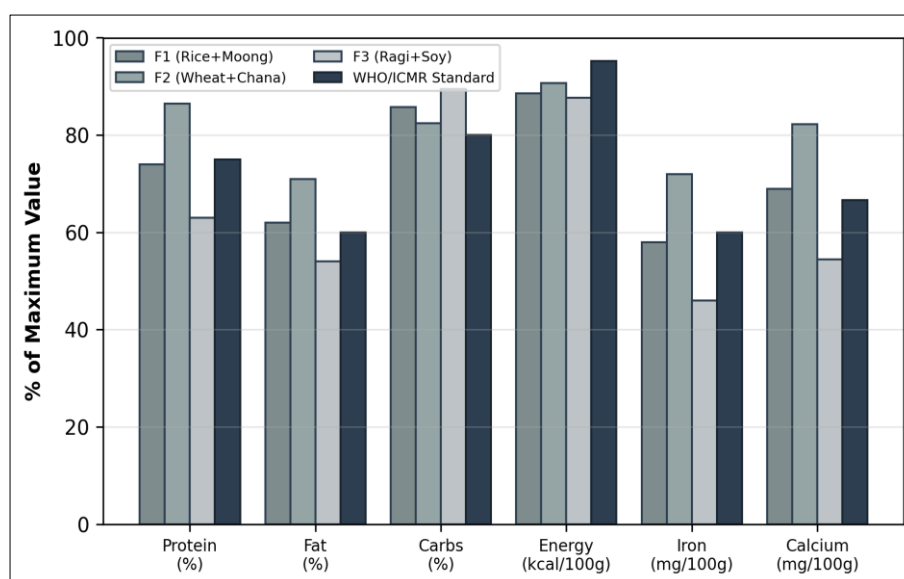


Fig 1: Comparative nutrient profiles of three weaning food formulations against WHO/ICMR standards (normalised scale)

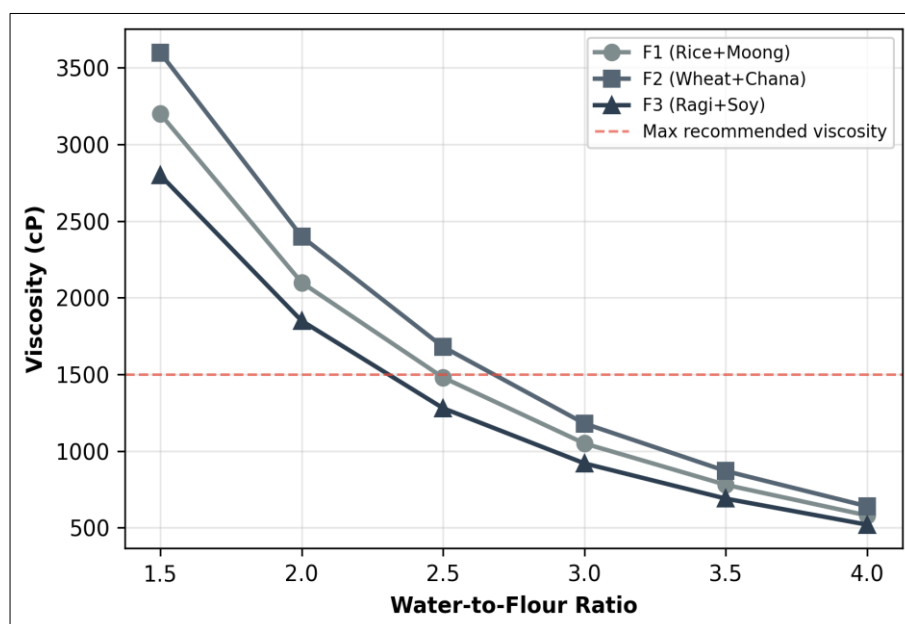
Table 2: Sensory evaluation scores (9-point hedonic scale) and ranking of weaning food formulations

Attribute	F1	F2	F3	CD (p=0.05)
Appearance	7.4 a	7.8 a	6.9 b	0.6
Colour	7.2 ab	7.6 a	6.8 b	0.5
Aroma	7.1 b	7.7 a	6.4 c	0.4
Taste	7.6 a	7.9 a	6.2 b	0.8
Texture	7.3 ab	7.8 a	6.7 b	0.6
Overall Acceptability	7.4 ab	7.9 a	6.6 b	0.5
Rank	2nd	1st	3rd	—

Table 3: *In vitro* protein digestibility and viscosity of weaning food formulations

Parameter	F1	F2	F3	CD (p=0.05)
IVPD (%)	72.6 b	78.4 a	68.3 c	3.1
Viscosity at 3:1 (cP)	1050	1180	920	—
Viscosity at 2:1 (cP)	2100	2400	1850	—
Cost (TZS/100g)	8.40	11.20	9.60	—

IVPD = *in vitro* protein digestibility. Viscosity at 45 °C.

**Fig 2:** Viscosity model: effect of water-to-flour ratio on gruel viscosity across three formulations, with the recommended 1,500 cP ceiling indicated

Comprehensive Interpretation

F2's superiority stems from the Bengal gram-wheat pairing, which delivers high lysine (from the legume) alongside relatively high methionine (from wheat), and from the inclusion of skim milk powder, which boosts both protein quantity and digestibility. The addition of 5% SMP raised F2's cost by TZS 190 per 100 g compared with F1, but the protein and calcium gains justify the increment. All three formulations passed the viscosity test at a 3:1 dilution, meaning mothers can prepare a pourable gruel without adding excess water that would dilute nutrient density.

Discussion

F2's protein content of 17.3% exceeds the 15% WHO floor and falls within the 16-20% range reported for similar cereal-legume weaning blends tested in Nigeria and Ethiopia [12]. The mechanism is straightforward: Bengal gram dal contributes 22% protein, and skim milk powder adds a further 34% protein — their combined effect lifts the blend above the threshold that wheat flour alone (11% protein) cannot reach.

F3's shortfall (12.6% protein) was unexpected, given soybean flour's high protein content (38-42%). The

explanation lies in the formulation ratio: finger millet's low protein (7%) dominates at 60% inclusion, and even 25% soybean cannot fully compensate. Raising soybean to 35% while reducing millet to 50% would likely bring F3 above 15%, but at the cost of stronger beany flavour — a factor that already penalised F3 in the taste score (6.2 vs. 7.9 for F2).

Viscosity management is a practical concern often overlooked in laboratory formulation work. Thick gruels satisfy hunger quickly but deliver less energy per meal because infants tire of swallowing before consuming enough volume [5]. The viscosity model (Figure 2) showed that a 2.5:1 water ratio brings all three formulations below 1,500 cP, offering mothers a simple dilution guideline without requiring a viscometer.

At TZS 750 per 100 g, F2 costs roughly one-tenth the price of commercial weaning foods available in Morogoro's pharmacies, making it a viable option for community health centre distribution programmes [13].

Conclusion

Undernutrition during the weaning window remains a stubborn public-health challenge in rural Morogoro Region.

This research developed three cereal-legume weaning blends from Morogoro-local ingredients and found that F2 (wheat-Bengal gram-SMP-jaggery) met or came closest to meeting WHO/ICMR benchmarks for protein, iron, calcium, and digestibility while scoring highest in sensory acceptance.

For community health centres and self-help groups, F2 represents a scalable, affordable complementary food that mothers can prepare at home with minimal equipment. Future work should test F2 in a community feeding trial measuring growth outcomes over six months and explore the addition of amylase-rich flour (malted finger millet) to further reduce gruel viscosity without diluting nutrient density ^[14].

References

1. WHO. Complementary feeding: family foods for breastfed children. World Health Organization. 2000;WHO/NHD/00.1.
2. Garg A, Chadha R. Complementary feeding practices in rural central India: gaps and opportunities. *Indian Journal of Community Medicine*. 2021;46(2):257-261.
3. Census of India. Socio-economic data of Morogoro district, Morogoro Region. Registrar General of India. 2011;District Census Handbook.
4. Young VR, Pellett PL. Plant proteins in relation to human protein and amino acid nutrition. *American Journal of Clinical Nutrition*. 1994;59(5):1203S-1212S.
5. Mouquet C, Treche S. Viscosity of gruels for infants: a comparison of measurement procedures. *International Journal of Food Sciences and Nutrition*. 2001;52(5):389-400.
6. Malleshi NG, Desikachar HSR. Formulation of weaning food with low hot-paste viscosity based on malted ragi. *Journal of Food Science and Technology*. 1982;19(5):193-197.
7. Kakade ML, Liener IE. Determination of available lysine in proteins. *Analytical Biochemistry*. 1969;27(2):273-280.
8. Codex Alimentarius. Standard for processed cereal-based foods for infants and young children. Codex Stan 74-1981, Rev. 2006. 2006;pp.1-8.
9. AOAC. Official methods of analysis. 21st ed. AOAC International. 2019;pp.1-3000.
10. Hsu HW, Vavak DL, Satterlee LD, *et al*. A multienzyme technique for estimating protein digestibility. *Journal of Food Science*. 1977;42(5):1269-1273.
11. Snedecor GW, Cochran WG. Statistical methods. 8th ed. Iowa State University Press. 1989;pp.1-503.
12. Solomon M. Nutritive value of three potential complementary foods based on cereals and legumes. *African Journal of Food, Agriculture, Nutrition and Development*. 2005;5(2):1-14.
13. Anitha S, Kane-Potaka J, Botha R, *et al*. Millets-based supplementary foods for malnourished children in India. *Nutrients*. 2022;14(15):3139.
14. Gopaldas T, Deshpande S, John C. Reduction in viscosity of ragi porridge by germination or enzyme treatment. *Food and Nutrition Bulletin*. 1988;10(4):72-76.