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Production, Viscosity, Microbiological Quality and Sensory Properties of Complementary Food Blends of Improved Rice Cultivars, Soybean and Sorghum Malt

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Abstract: Production methods, viscosity, microbiological quality and organoleptic properties of complementary food formulations from mixtures of improved rice cultivars (broken fractions of FARO 44, FARO 52, NERICA L – 34, NERICA L – 19) and local rice (*yar Mubi*), sorghum malt and soybean (*Glycine max* - *yar Jalingo*) flour blends used for infant formulas were characterized. A 5x2x2 factorial in a completely randomized design comprising 5 rice cultivars, sorghum malt (0.5%) and soybean flour (0, 30%) were used to produce 20 formulations that were evaluated for viscosity, microbiological and sensory properties. Appropriate blends with suitable viscosity for infant feeding were considered as criteria for subsequent studies (70% rice, 30% soybeans with malt). Viscosity of 10% and 20% gruel of rice cultivars, sorghum cultivar, sorghum malt and soybean flours ranged from 1035.33 to 1957.73 cp and 1816.53 to 3024.57 cp, respectively. Gruel prepared with malt had reduced viscosity compared to that where malt was added later. Microbial analysis revealed a total plate count of 2.0×10^6 to 7.2×10^6 CFU/g, an aerobic plate count of 1.76×10^6 to 4.1×10^6 CFU/g and a yeast-mould count of 0.1×10^6 to 0.2×10^6 CFU/g. The bacterial species isolated included *Staphylococcus saprophyticus*, *Staphylococcus epidermidis*, *Bacillus megaterium*, *Bacillus thuringiensis* and *Micrococcus* species. Fungi species isolated included *Rhodotorula* Sp., *Aspergillus* Sp., *Mucor* Sp. and *Alternaria* Sp. Sensory attribute studies of 20 weaning mothers showed no significant (P>0.05) variation compared to conventionally complementary food. Complementary food formulations with a broken fraction of rice basis thus mimicked high-grade conventional complementary rice food (Friso-Gold) in terms of sensory attributes.

Key words: Complementary food, rice, soybean, sorghum, viscosity, microbiological quality

INTRODUCTION

"Weaning foods" and "supplementary foods" refer to foods that are introduced to replace rather than complement breast milk for infants (Anderson *et al.*, 2001). In contrast, complementary foods can be used to complement breast milk when the child reaches six months of age. Complementary foods include breast milk substitutes ("follow-up formula") that are given gradually or fully to infants usually by the age 6 months with the intention of replacing breast milk as the child adapts to solid foods or is weaned (Mosha and Svanberg, 1983; Chibuzo and Ali, 1994 and 1995, Nkama *et al.*, 2001, Nwogwugwu *et al.*, 2012).

In most developed countries, complementary foods are produced using expensive technologies that render these foods unaffordable to most families in developing countries (Mosha and Svanberg, 1983; Gahlawat and Sehgal, 1992; Chibuzo and Ali, 1994 and 95; Thathola and Srivastava, 2002; Badau *et al.*, 2006; Asma *et al.*, 2006; Inyang and Offiong, 2010; Elemo *et al.*, 2011; Nwogwugwu *et al.*, 2012). Low cost materials such as broken fractions of rice together with technologies including malting can be adopted and scaled to produce formulas that will be affordable to economically vulnerable populations (Houston, 1992; Ndindeng *et al.*, 2014; Desikachar, 1980; Mosha and Svanberg, 1983; Gupta and Sehgal, 1990; Gahlawat and Sehgal, 1992; Almeida-Dominguez *et al.*, 1993; Nkama *et al.*, 2001; Thathola and Srivastava, 2002; Badau *et al.*, 2005; 2006; Asma *et al.*, 2006; Elemo *et al.*, 2011). Moreover, toasting of raw materials is commonly used to reduce the presence of anti-nutritional factors in foods (Ory, 1986; Liener, 1989; Salunkle *et al.*, 1992; Iwe, 2003; Badau *et al.*, 2005, 2006). These practices, together with good manufacturing practices, can enhance the bioavailability of nutrients in foods (Dahiya and Kapoor, 1994; Schons *et al.*, 2011; Tripathi *et al.*, 2011), and

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remove pathogens such as *Salmonella, Escherichia coli, Shigella* and other enteric organisms that pose food safety risks for infants (Iwe, 2003; Badau, 2006). Furthermore, these technologies will improve the sensory characteristics and influence acceptability by both mothers and infants (Birch, 1999; Beauchamp and Mannella, 2009; Mannella *et al*., 2009; MacDonald *et al*., 2011).

The objective of the current study was to evaluate the use of low-grade rice (broken fractions of rice cultivars) to produce low cost complementary foods that have acceptability characteristics that are similar to grade one rice-based complementary food (e.g., Friso-Gold).

MATERIALS AND METHODS

Formulation of complementary food flour blends: The weaning food was formulated using broken milled rice fractions from different cultivars (Table 1). The compositions were either broken fractions of rice cultivars alone or a 70:30 mixture of rice and soybeans with or without malt as described by Almeida-Dominguez *et al.* (1993) and Badau *et al.* (2006). All four formulations contained 5.00 g vitamin A-fortified sugar and 0.6 g iodide salt per 100 g. The first two formulations lacked soybeans and malt. The first formulation contained 94.4 g rice cultivar flour, while the second formulation contained 89.40 g rice cultivar flour and 5.00 g "power flour". Power four is prepared from malted sorghum which is rich in enzymes – amylases that break down complex carbohydrates such as starches into simpler sugars, process releasing water trapped in the gelatinous mixture. Power flour makes the gruels more fluid and enables them to be made richer in energy (http://edie.cprost.sfu.ca/gcnet/ISS4-33b.html). The third and fourth formulations contained rice and soybeans at a 70:30 ratio. The third formulation was composed of 66.08 g rice cultivar flour and 28.32 g soybeans. The fourth formulation contained 62.58 g rice cultivar flour, 26.82 g soybean flour, and 5.00 g "power flour." During the mixing process, rice cultivar flours and soybean flours were blended before adding the sugar, salt and finally the "power flour". The mixtures were thoroughly blended to obtain a uniform particle size distribution. The five roasted rice cultivar flours and soybean flours were blended with and without malt flour (Fig. 1). In total, twenty formulations (Table 1) were prepared as described by Badau *et al.* (2006).

Preparation of complementary food gruel: The gruel for the complementary food formulations was prepared by dissolving 40 g in 200 ml of distilled water at 95 °C for 7 min to reconstitute a mixture with a 20% (w/v) concentration. "Power flour" was then added to a final concentration of 5% before or after heating as indicated (Mosha and Svanberg, 1983; Badau eta al., 2005).

Viscosity determination: The viscosity of the developed complementary foods was determined by first preparing the gruel. The slurries of the weaning food formulations mix was prepared by dissolving 40 g in 200 ml and 20 g in 200 ml of distilled water to give 20% and 10% (w/v) concentration respectively. The slurries were heated in water bath (model, HWS26, B. Bran Scientific and instrument company, England) timed to reach a cooking temperature of 95^{0}C for 7 minutes. Then, 5% of "power flour" (Sorghum malt flour) was added before and after cooking of some of the formulations. The viscosity of the weaning foods measured with rotational viscometer {KENEMATICA, AG, Switzeland, Type model Vico STAR + L/Serial : VSCL 110 458 (spindle L2 RPM 6, Cp 0 – 5198.9, and spindle L1 RPM 2.5, Cp 0 – 2543.7)} at appropriate ambient temperature of 32.1^{0}C, Revolution per minutes(RPM) of 2.5 for 10% w/v concentration with spindle L_1 and at 28.9^{0}C, RPM of 6 for 20% w/v concentration using spindle L_2 (Mosha and Svanberg, 1983; Badau *et al.,* 2006).

Sample preparation and microbiological analyses: Complementary food formulation samples were placed in sterile sampling containers and refrigerated prior to microbiological analyses that were carried out as described by Collins and Lyne (1970), Harrigan and McCance (1976), Nkama *et al.* (1994), Badau *et al.* (1999), Badau *et al.* (2001 a,b,c), Fawole (1988), Cheesbrough (2000), Diliello (1982) and Jideani and Jideani (2006).

Preparation of culture media: Potato-dextrose agar, nutrient agar, MacConkey agar and sabouraud agar culture media were prepared according to methods described by Collins and Lyne (1970), Harrigan and McCance (1976), Nkama *et al.* (1994), Badau *et al.* (1999) and Badau *et al.* (2001 a,b,c).

Isolation and identification of bacteria, mould, and yeast: One gram of each of the eight complementary food formulations was resuspended in 9 ml sterile water for a ten-fold dilution that was then further diluted to a 10^6 dilution. Each sample diluent was plated in duplicate using the pour plating technique as described by Harrigan and McCance (1976), Nkama *et al.* (1994), Badau *et al.* (1999) and Badau *et al.* (2001 a, b, c), Singleton (1999) and Cheesbrough (2000). To assess bacterial growth, plates were incubated at 37 °C under aerobic conditions for 24 and 48 h. Plates for fungal growth were incubated at room temperature (32 ± 2 °C) for 72 h. After the incubation period, resulting bacterial and fungal colonies were counted using a digital colony counter. The average colony number obtained from the countable duplicate plates was expressed as colony forming unit per gram

Table 1: Effect of soybean supplementation and sorghum malt on complementary food formulations from mixtures of improved rice cultivars

Formulations	Rice	Soybeans	Sorghum malt	Vitamin A fortified sugar	Iodide salt	Total
Ratio of rice to soybeans (100:0) without malt						
FARO 44	94.40	-	-	5.00	0.60	100
FARO 52	94.40	-	-	5.00	0.60	100
Nerica L-34	94.40	-	-	5.00	0.60	100
Nerica L-19	94.40	-	-	5.00	0.60	100
Local rice	94.40	-	-	5.00	0.60	100
Ratio of rice to soybeans (100:0) with malt						
FARO 44	89.40	-	5.00	5.00	0.60	100
FARO 52	89.40	-	5.00	5.00	0.60	100
Nerica L-34	89.40	-	5.00	5.00	0.60	100
Nerica L-19	89.40	-	5.00	5.00	0.60	100
Local rice	89.40	-	5.00	5.00	0.60	100
Ratio of rice to soybeans (70:30) without malt						
FARO 44	66.08	28.32	-	5.00	0.60	100
FARO 52	66.08	28.32	-	5.00	0.60	100
Nerica L-34	66.08	28.32	-	5.00	0.60	100
Nerica L-19	66.08	28.32	-	5.00	0.60	100
Local rice	66.08	28.32	-	5.00	0.60	100
Ration of rice to soybeans (70:30) with malt						
FARO 44	62.58	26.82	5.00	5.00	0.60	100
FARO 52	62.58	26.82	5.00	5.00	0.60	100
Nerica L-34	62.58	26.82	5.00	5.00	0.60	100
Nerica L-19	62.58	26.82	5.00	5.00	0.60	100
Local rice	62.58	26.82	5.00	5.00	0.60	100

Table 2: Viscosity (Centipoise) of rice cultivars, sorghum cultivar, sorghum malt and soybeans flours

Parameters	10%	20%
FARO 44	1637.03±2.87^{e}	2435.77±1.31^{e}
FARO 52	1957.73±1.16^{a}	3009.73±1.47^{b}
Nerica L-34	1758.10±1.78^{c}	2996.87±2.30^{c}
Nerica L-19	1276.30±2.52^{g}	1956.80±5.76^{g}
Local rice	1279.47±0.67^{g}	1969.27±2.46^{f}
Sorghum cultivar	1822.57±3.43^{b}	3024.57±2.29^{a}
Sorghum malt	1720.57±0.93^{d}	2654.33±5.17^{d}
Whole soybean	1286.97±1.42^{f}	1825.50±3.97^{h}
Soybean bran	1035.33±4.24^{h}	1816.53±3.23^{i}

Each value is a mean±SD of triplicate determinations. Mean values in a column not sharing common superscript letters are significantly ($p<0.05$) different

Table 3: Viscosity (centipoises) of complementary food formulations

Formulations	10% gruel with malt added after	20% gruel with malt added after	20% cold paste with malt
FARO-44	1324.53±0.31^{d}	2640.97±0.57^{c}	2648.13±0.21^{e}
FARO-52	1400.93±1.10^{c}	2650.97±0.32^{a}	2681.10±0.10^{a}
Nerica L-34	1483.57±0.40^{a}	2609.13±0.50^{d}	2653.10±0.20^{b}
Nerica L-19	1435.67±0.06^{b}	2643.20±0.44^{b}	2649.03±0.67^{d}
Local rice	1261.53±0.23^{e}	2650.63±0.55^{a}	2651.80±0.70^{c}

Each value is a mean±SD of triplicate determinations. Mean values in a column not sharing common superscript letters are significantly ($p<0.05$) different as assessed by Duncan multiple range test

Table 4: Total microbial count of complementary food formulations from mixtures of improved rice cultivars as affected by soybean supplementation and sorghum malt

Formulations	Total plate count	Fungal plate count
FARO-44	2.3 x 10^6	0.2 x 10^6
FARO-52	2.8 x 10^6	0.1 x 10^6
Nerica L-34	7.2 x 10^6	0.2 x 10^6
Nerica L-19	2.0 x 10^6	0.2 x 10^6
Local rice	3.1 x 10^6	0.2 x 10^6

Each value is a mean of triplicate determinations

(cfu/g). All pure cultures of bacteria, moulds and yeast were maintained on nutrient agar, and sabouraud dextrose agar slants, respectively. These isolates were refrigerated prior to identification.

The cultural characteristics of discrete bacterial colonies such as colour, shape and pigmentation were observed and noted before microscopic characterization of cell morphology and Gram reaction was carried out on 24 h cultures (Harrigan and McCance, 1976; Singleton, 1999;

Cheesbrough, 2000; Jideani and Jideani, 2006). Biochemical tests were conducted on each isolate. The isolate was inoculated into peptone water and incubated at 37 °C for 24 h. Biochemical tests of starch hydrolysis, catalase activity and sugar utilization were carried out on all isolates. The sugars used were glucose, sucrose, mannose, mannitol, xylose, arabinose, lactose, galactose, starch, maltose and fructose. Voges Proskauer, nitrate reduction, indole and motility tests were carried out using methods described by Collins and Lyne (1970), Harrigan and McCance (1976), Singleton (1999), Cheesbrough (2000). Results obtained from these tests were compared with literature standards using diagnostic tables showing the biochemical reactions identified for many genera and bacterial species (Cowan and Steel, 1961)

Fungal isolates were identified based on cultural and morphological characteristics and were carried out by taking an inoculum from the edge of an isolated colony, placing it on a slide and adding mounting fluid (lactophenol cotton blue). A cover slip was placed atop the sample and the slide was heated with a flame to expel air bubbles. The prepared slide was mounted on a microscope and morphological characteristics and types of spores were noted. Moulds were identified as reported by Gilman (1957), Gaffa and Jideani (2001) and Singh *et al.* (1991)

Sensory evaluation: The taste panellists were served complementary food gruels in white transparent plastic cups and spoons. Participants were asked to rinse their mouth with fresh distilled water between samples. The containers with the samples were coded with three-digit random numbers and were kept far apart to avoid crowding and allow independent judgement (Larmond, 1977; Badau *et al.*, 2006). The panellists were trained in a 6 hr session prior to the commencement of the experiment. Selection of the taste panellists was based on basic requirements, including the ability to be present throughout the evaluation period, interest, willingness, and health (Badau *et al.*, 2006). Many participants were mothers of patients at the paediatric unit of the Specialist Hospital, Yola where the study was conducted. women were overwhelmed because many came from the near-by paediatric unit of the Specialist Hospital, Yola where the research took place. The gruel for the complementary food mixtures was served to 20 weaning mothers who used a 9-point hedonic scale to rank the gruels on sweetness, texture, colour, aroma and overall acceptability (Larmond, 1977).

Statistical analysis: Data were subjected to analysis of variance as described by Steel and Torrie (1980), Gomez and Gomez (1983), and Mead *et al.* (1993), and means were separated by Duncan's Multiple Range Test (DMRT) at 5% significance level (Duncan, 1955).

RESULTS AND DISCUSSION

Viscosity of rice cultivars, sorghum cultivar, sorghum malt and soybeans flours: The viscosity of rice and sorghum cultivars as well as sorghum malt and soybeans flours showed significant ($p < 0.05$) variation at 10 and 20% concentrations (w/v) (Table 2). The highest viscosity value was recorded for the sorghum cultivar, followed by FARO 52 and the lowest in soybean, followed by whole soybeans. Gruel made from soybean, LOCAL rice and sorghum malt appeared to have lower viscosity in terms of appearance compared to other cultivars. Meanwhile, soybean and sorghum malts had a smoother consistency. Determination of the 20% (w/v) concentration of FARO 52 and NERICAL-34 was difficult due to their inconsistency, and these mixtures had a thickness that might arise from the use of insufficient water for preparation.

Viscosity of complementary food formulations: The viscosity values (centipoises) of complementary food formulations also showed significant ($P < 0.05$) variation both at 10 and 20% (w/v) concentrations (Table 3). Formulations containing malt showed significantly ($P < 0.05$) reduced viscosity, while higher viscosity values were recorded for formulations containing soybeans relative to those without soybeans. Viscosity of complementary foods is an important functional property, especially if viscosity is reduced after preparation of complementary food gruel. Researchers recommend that the viscosity of infant formulas range between 1000 and 3000 centipoises (Mosha and Svanberg, 1983). As such, we incorporated malt into some of the complementary food formulations to assess the extent by which malt reduced viscosity and increased nutrient or energy density. According to Mosha and Svanberg, 1983 and Almeida-Dominguez et al. 1993, only formulations containing 70% rice and 30% soybeans with malt have suitable viscosity and composition for infant feeding. Therefore, rejection and acceptance of formulations for subsequent study were based on these criteria and those formulations that did not meet these requirements were not evaluated further.

Total microbial count of complementary food formulations: For weaning food formulations (70% rice and 30% soybeans with malt), the total plate count ranged from 2.0×10^6 to 7.2×10^6 cfu/g and the yeast-mould count ranged from 0.1×10^6 to 0.2×10^6 cfu/g (Table 4). The highest total plate count for bacteria and yeast-mould counts were recorded for 70% NERICAL-34 + 30% soybeans with malt (7.2×10^6 and 0.2×10^6 cfu/g, respectively). Meanwhile, 70% FARO-52 + 30% soybeans with malt had the lowest yeast–mould count of 0.1×10^6 Cfu/g.

Table 5: Distribution and frequency of bacteria in complementary food formulations from mixtures of improved rice cultivars as affected by soybean supplementation and sorghum malt

Formulations	*S. saprophyticus*	*S. epidermidis*	*B. megaterium*	*B. thuringiensis*	*Micrococcus* sp.
FARO-44	+ve (7)	+ve (10)	+ve (1)	+ve (1)	+ve (4)
FARO-52	+ve (3)	+ve (17)	+ve (1)	+ve (1)	+ve (6)
Nerica L-34	+ve (5)	+ve (46)	+ve (6)	+ve (1)	+ve (14)
Nerica L-19	+ve (4)	+ve (9)	+ve (1)	+ve (2)	+ve (4)
Local rice	-v (0)	+ve (28)	-ve (0)	-ve (0)	+ve (3)
Total	19(11%)	110 (63%)	9 (5%)	5 (3%)	31 (18%)

Table 6: Distribution and frequency of fungi in complementary food formulations

Formulations	*Rhodotorula* sp.	*Penicillium* sp.	*Cephalosporium* sp.	*Aspergillus* sp.	*Mucor* sp.	*Alternaria* sp.
FARO-44	+ve (1)	-ve (0)	+ve (1)	+ve (2)	-ve (0)	+ve (1)
FARO-52	+ve (2)	-ve (0)	-ve (0)	-ve (0)	+ve (1)	-ve (0)
Nerica L-34	+ve (1)	-ve (0)	-ve (0)	+ve (2)	-ve (0)	-ve (0)
Nerica L-19	+ve (2)	+ve (1)	-ve (0)	-ve (0)	+ve (1)	-ve (0)
Local rice	+ve (1)	-ve (0)	-ve (0)	+ve (2)	-ve (0)	-ve (0)
Total	7 (39%)	1 (6%)	1 (6%)	6 (33%)	2 (11%)	1 (6%)

Table 7: Sensory scores for complementary food formulations

Formulations	Consistency	Flavour	Taste	Colour	Texture	Overall acceptance
FARO-44	6.90±1.92[ab]	6.05±2.19[b]	5.85±1.69[b]	6.75±1.97[ab]	6.15±2.06[ab]	6.60±1.74[b]
FARO-52	6.85±1.98[ab]	6.15±1.95[b]	5.85±2.32[b]	6.15±1.93[b]	5.80±1.82[b]	6.30±1.98[b]
NERICA L-34	7.30±1.49[ab]	7.00±1.17[ab]	5.40±1.60[b]	6.00±1.97[b]	5.35±2.46[b]	6.60±1.70[b]
NERICA L-19	6.35±1.69[b]	6.20±1.51[b]	6.05±1.67[b]	6.80±1.74[ab]	5.25±2.10[b]	6.55±1.36[b]
Local rice	6.15±2.11[b]	6.15±1.35[b]	5.60±2.14[b]	6.95±1.47[ab]	6.05±2.37[ab]	6.70±1.78[b]
Friso gold (Control)	7.95±1.32[a]	8.00±1.65[a]	7.30±1.84[a]	7.50±1.61[a]	7.25±1.86[a]	8.20±1.24[a]

Each value is a mean±SD scores of twenty weaning mothers used as panellists. Mean values in a column not sharing common superscript letters are significantly ($p<0.05$) different as assessed by Duncan multiple range test

Distribution and frequency of bacteria in complementary food formulations: The distribution and frequency of bacteria in complementary food formulations (70% rice and 30% soybeans, malt) was based on the morphological and biochemical characterization of species including *S. saprophyticuss*, *epidermidis, B. megaterium, B. thuringiensis*, and *micrococcus SP* (Table 5). *S. saprophyticus, S. epidermidis* and *micrococcus SP* are Gram-positive cocci, which are common laboratory agents that are resistant to adverse conditions such as dehydration and desiccation (Cheesbrough, 2000, Jideani and Jideani, 2006). These organisms may have been introduced into the food formulations through various operations via their association with laboratory utensils, equipment and air in the area where the complementary food was prepared (Cheesbrough, 2000; Jideani and Jideani, 2006); similarly, *B. Megaterium* is thermoduric in nature (Prescott, 1996; Jideani and Jideani, 2006). These bacteria likely were present in the starting materials following harvest and survived through storage and roasting during processing. The bacterial distribution among the formulations was: *S. epidermidis*, 63%, *micrococcus SP*, 18%, *S. saprophyticusin,* 11%, *B. megaterium,* 5% and *B. thuringiensis,* 3%. These organisms were distributed among all complementary food formulations tested except for the LOCAL RICE (70% rice + 30% soybeans with malt), which showed the presence of only *S. epidermidis* and *micrococcus SP*. All these bacteria species play a significant role in food spoilage. However, their association with foods, especially complementary foods, has not been implicated in food-borne infections (Ihekoronye and Ngoddy, 1985; Iwe, 2003)

Distribution and frequency of occurrence of fungi in complementary food formulations: Based on the cultural and morphological characterization of fungal isolates, species present in the weaning food formulations were *Rhodotorula SP, penicillium SP, cephalosporium SP Aspergillus SP, mucor SP and Alternaria SP* (Table 6). These organisms were likely introduced during the malting process of sorghum into sorghum malt, since malting is known to encourage mould and yeast growth (Hough, 1992). The distribution of fungi among complementary food formulations (70% rice +30% soybeans with malt) was: *Rhodotorula SP,* 39%, *Aspergillus,* 33%, *mucor SP,* 11%, while *penicillium SP, cephalosporium SP* and *alternaria SP* occurred in 6% of samples. *Rhodotorula SP* was the only fungi found in all weaning food formulations. These organisms are regarded as saprophytic fungi, which are involved in food spoilage, but are less important for medical mycology because they are non-pathogenic. These fungi require high moisture levels and moderate room temperatures for growth, but they grow more slowly than bacteria. Nonetheless, they may be able to grow and produce spores as well as mycotoxins after their

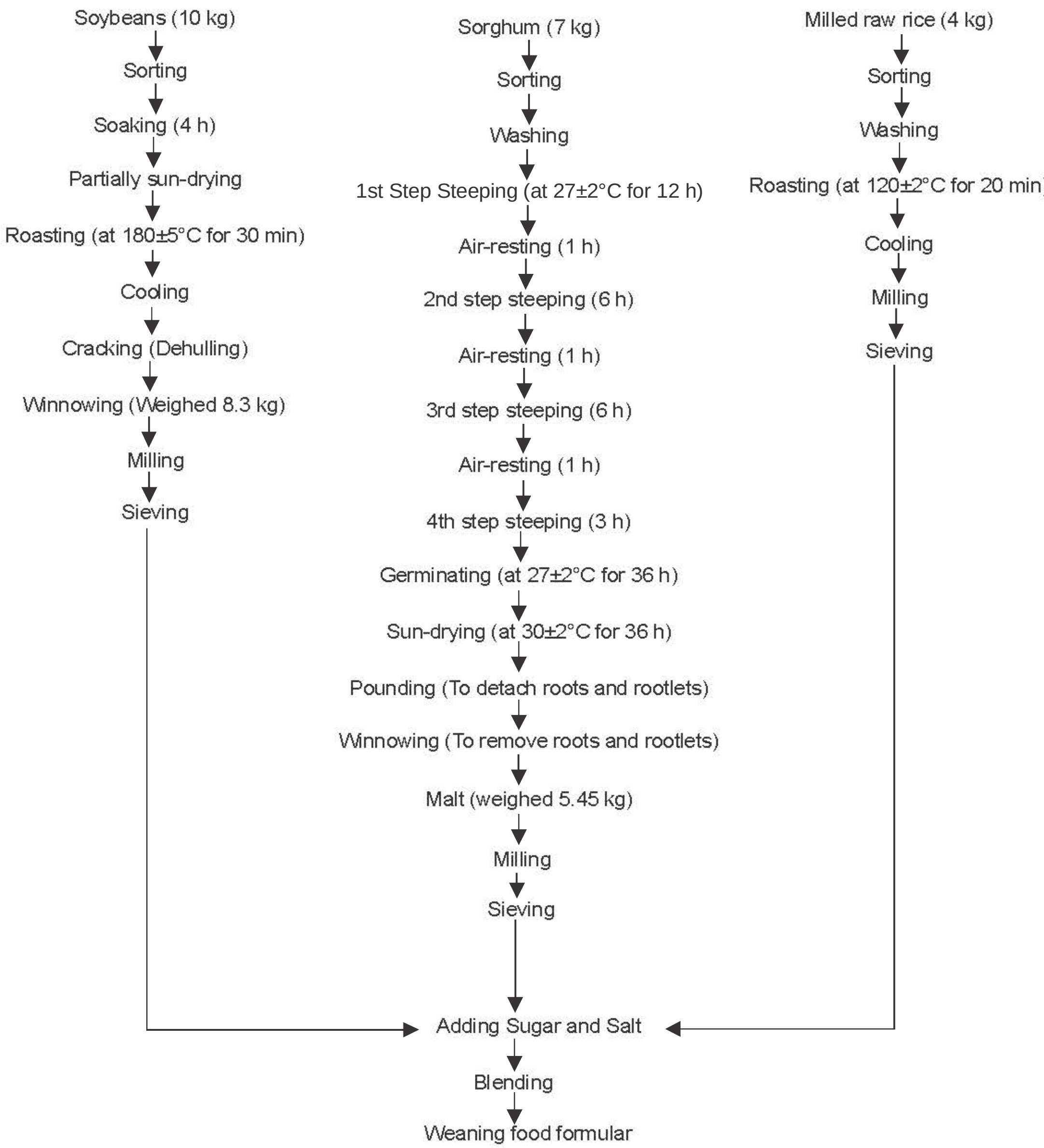

Fig. 1: Production of complementary food formulations from mixtures of improved rice cultivars and soybean (Adapted from Badau *et al*. (2005) with slight modification)

introduction into food (Ihekoronye and Ngoddy, 1985; Prescott, 1996; Cheesbrough, 2000). The low moisture level of the formulations is unfavourable for proliferation of fungi, especially saprophytic fungi, and may explain why the cfu values for yeast and moulds were lower than those for bacteria.

Sensory scores for complementary food formulations: The result of sensory evaluation of the complementary food formulations (70% rice + 30% soybeans with malt) showed no significant (P>0.05) (P < 0.05) difference in sensory scores, but differed from the commercial complementary food (Friso-Gold) in terms of taste and overall acceptance (Table 7). Notably, the Friso-Gold formulation included sugar sweeteners and vanilla flavouring, which may have contributed leading to its higher rating than the complementary foods that lacked significant amounts of sweeteners and flavouring. Indeed, aroma and taste had a prominent effect on the ratings given by the panellists.

Conclusion: The complementary food formulations produced from broken fractions of rice, which have low market value, mimic high-grade rice-based complementary foods (e.g., Friso-Gold used here as a control). There were no pathogenic microorganisms such as *Salmonella*, *Escherichia coli,* or *Shigella* in the formulations. No significant variation was seen in sensory attributes between broken rice formulations and conventional complementary foods, except for taste and overall acceptance. Therefore, addition of soybeans and sorghum malt improved the viscosity and sensory characteristics as well as the nutritional quality of rice-based complementary foods, which also had minimal microbiological loads. Further study will be needed to determine the feasibility of producing these formulations at a large scale for commercial distribution. Because large-scale production, especially in developing countries, would require significant financial investment and marketing efforts, small-scale production of these formulations could be an alternate approach, particularly given financial considerations. We therefore recommend that production of low-cost complementary foods using inexpensive technology such as malting and low-cost materials such as broken fractions of rice ("second head," "screenings" and Brewers" rice) should be adopted as they will increase product availability and affordability and in turn improve national economies due to better nutrition early in life. Small-scale entrepreneurs should also be encouraged to establish intermediate companies for complementary food production using broken rice fractions, soybeans and sorghum malt. This approach will provide employment opportunities and improve the nutritional status of vulnerable groups.

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REFERENCES

Almeida-Dominguez, H.D., S.O. Serna-Saldivar, M.H. Gomez and L.W. Rooney, 1993. Production and nutritional value of weaning foods from mixtures of pearl millet and cowpeas. Cereal Chem., 7: 14-18.

Anderson, A.S., C. Guthrie, E.M. Alder, S. Forsythe, P.W. Howies and F.L.R. Williams, 2001. Rattling the place: reaons and rationales for early weaning. Health Edu. Res., 16: 471-479.

Asma, M.A., E.B. Elfadil and A. ELTinay, 2006. Development of weaning food from sorghum supplemented with legumes and oil seeds. Food and Nutr., Bull., 22: 26-34.

Badau, M.H., I.A. Jideani and I. Nkama, 2005. Production, acceptability and microbiological evaluation of weaning food formulations. J. Trop. Pediatr., 52: 166-172.

Badau, M.H., I.A. Jideani and I. Nkama, 2006. Rheological behaviour of weaning food formulations as affected by addition of malt. Int. J. Food Sci. Technol., 41: 1222-1228.

Badau, M.H., A.M. Adeniran, I. Nkama and S.S. Baba, 1999. Bacteriological quality of various fresh meat sold in Maiduguri, Nigeria. J. Arid Agri., 9: 133-141.

Badau, M.H., O.L. Imhoede and I. Nkama, 2001a. Production, acceptability and bacteriological quality of kunun zaki in Maiduguri, Metropolis. Nig. J. Basic Appl. Sci., 10: 67-82.

Badau, M.H., A.M. Adeniran and I. Nkama, 2001b. Fungi associated with various fresh meat sold in Maiduguri market, Nigeria. Science Forum: J. Pure Appl. Sci., 4: 255-262.

Badau, M.H., G.O. Salami and A.L. Kassum, 2001c. Microbiological assay of ingredients, contact surfaces and stages in 'akara' processing at three locations in Maiduguri, Nigeria. Agro-Science: J. Trop. Agri. Food, Environ. Ext., 2: 42-49.

Beauchamp, G.K. and J.A. Mennella, 2009. Early flavour learning and its impact on later feeding behaviour. J. Paediatr. Gastroenterol. Nutr., 90: 780S-788S.

Birch, L.L., 1999. Development of food preferences. Anim. Rev. Nutr., 19: 14-62.

Cheesbrough, M., 2000. District laboratory practice in tropical countries, part 2, Cambridge lowprice edition, Cambridge University Press, USA.

Chibuzo, E.C. and H. Ali, 1994-1995. Sensory and physicochemical evaluation of millet- groundnut blend as weaning food. Ann. Borno, 11/12 (1994-95): 181-190.

Collins, C.H. and P.M. Lyne, 1970. Microbiological Methods. Laboratory techniques series. Uni. Park Press.

Cowan, S.T. and K.J. Steel, 1961. Diagnostic tables for the common Medical bacteria. J. Hygiene, Cambridge, 59: 352- 361.

Dahiya, S. and A.C. Kapoor, 1994. *In vitro* and *in vivo* availability of iron from home processed supplementary foods. J. Food Sci. and Technol., 31: 122-125.

Desikachar, H.S.R., 1980. Development of weaning foods with high coloric density and low hot paste viscosity using traditional technologies. Food and Nutr., Bull., 2: 21-23.

Diliello, L.K., 1982. Methods in food and dairy Microbiology, A.V. publishing CO. Inc. Westport Connecticut, USA.

Duncan, D.E., 1955. Multiple range and Multiple f-tests. Biometrics. 11: 1-42.

Elemo, G.N., B.O. Elemo and J.N.C. Okafor, 2011. Preparation and nutritional composition of a weaning food formulated from germinated sorghum (Sorghum bicolor) and steamed cooked cowpea (Vigna Unguiculata Malp). Am. J. Food Technol., 6: 413-421.

Fawole, M.O., 1988. Laboratory Manual of Microbiology, Spectrum Books Ltd, Ibadan.

Gaffa, T. and I.A. Jideani, 2001. Sensory evaluation of different levels of Cadaba farinose (Dangarafa) in kunun zaki and determination of its position among other saccharifying agents. J. Food Sce. Tech., 38: 405-406.

Gahlawat, P. and S. Sehgal, 1992. The influence of roasting and malting on the total and extractable mineral contents of human weaning mixtures prepared from Indian raw materials. Food Chem., 46: 253-256.

Gilman, T.C., 1957. A Manual of Soil Fung. Revised 2nd edi. The IOWA State Univ, Press, Annes, IOWA, USA.

Gomez, A.K. and A.A. Gomez, 1983. Statistical procedure for Agric. Res. second edition, John Willey, New York.

Gupta, C. and S. Sehgal, 1990. Development, acceptability and nutritional value of weaning mixtures. Plant Foods for Hum. Nutr., 41: 107-116.

Harrigan, W.F and M.E. McCance, 1976. Laboratory methods in food and Dairy Microbiology, Academic press London-New York-San. Francisco.

Hough, J.S., 1992. The biotechnology of malting and brewing, Cambridge University press, Trumpington Street, Cambridge.

Houston, D.F., 1992. Rice chemistry and technology, American Association of Cereals Chemist.Inc, St. Paul, Minnesota.

Ihekoronye, A.I. and P.O. Ngoddy, 1985. Integrated Food Science and Technology for the Tropics. Macmillan Education Ltd, London and Oxford.

Inyang, C.U. and E.E. Offiong, 2010. Effect of storage temperature on microbial safety of Ogi. Nigeria Food J., 28: 85-92.

Iwe, M.O., 2003. The Science and Technology of Soybeans Chemistry, Nutrition, Processing, Utilization, Rojoint Communications Services Ltd. Umahia, Nigeria.

Jideani, V.A. and I.A. Jideani, 2006. Laboratory manual of food bacteriology, Amana Printing and Advertising Ltd. Kaduna-Nigeria.

Larmond, E., 1977. Laboratory methods for sensory evaluation of food, Canadian Government Publishing Centre, Ottawa, Canada.

Liener, I.E., 1989. Legumes, Chemistry, Technology and Human Nutrition, Marced dekker, Inc. New York.

MacDonald, A., S. Evans, B. Cochrane and J. Willdgoose, 2011. Weaning infants with phenylketonuria: a review. J. Hum. Nutr. Diet., 25: 103-110.

Mead, R., R.N. Curnow and A.M. Hasted 1993. Statistical methods of agriculture and experimental biology, Chapman and Hall, London.

Mennella, J.A., C.A. Foretell, L.K. Morgan and G.K. Beauchamp, 2009. Early milk influence taste acceptance and liking during infancy. Am. J. Clin. Nutr., 90: 780-788.

Mosha, A.C. and U. Svanberg, 1983. Preparation of weaning foods with high nutrient density using flour of germinated cereals. Food Nutr., Bull., 5: 10-14.

Ndindeng, S., D. Mapiemfu, W. Fantong, V. Nchinda, Z. Ambang and J. Manful, 2014. Postharvest adaptation strategies to the effects of temperature variations and farmer-miller practices on the physical quality of rice in Cameroon. Am. J. Climate Change, 3: 178-192.

Nkama, I., F.N. Dagwanna and W.B. Ndahi, 2001. Production, proximate composition and consumer acceptability of weaning foods from mixtures of pearl millet, cowpea and groundnut. J. Arid Agric., 11: 165-169.

Nwogwugwu, N.U., J.N. Ogbulie, E.C. Chinakwe, I.N. Nwachukwu and N.N. Onyemekara, 2012. The microbiology and proximate assay of a novel weaning food-"DUPAP". J. Microbiol. Biotechnol. Res., 2: 298-304.

Ory, R.L., 1986. Plant proteins: applications, biological effects and chemistry. ACS Symposium series 312, developed from a symposium sponsored by the division of agricultural and food chemistry at the 190th meeting of the American Chemical Society, Chicago, Illinois.

Prescott, L.M., 1996. Microbiology, Third edition, McGraw Hill companies, Inc. New Delhi.

Salunkhe, D.K., J.C. Chavan, R.N. Adsule and S.S. Kadam, 1992. World oil seeds, chemistry, technology and utilization. An AV book Published, Van Nostrand reinland, New York.

Schons, P.F., F. Ries, V. Battestin and G.A. Maced, 2011. Effect of enzymatic treatment on tannins and phytate in sorghum (*Sorghum bicolor*) and its nutritional study in rats. Int. J. Food Sci. Technol., 46: 1253-1258.

Singleton, P., 1999. Bacteria in biology, biotechnology and medicine 4th edition, John Willey and sons Ltd.

Singh, K., J.C. Frisvad, U. Thrane and S.B. Mathur, 1991. An Illustrated Manual on Identification of some Seed-borne Aspergilli, Fusaria, Penicillia and Mycotoxins. Ryvangs Alle 78, DK-2900 Hellerup, Denmark.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of statistics. McGraw Hill book Co. New York, USA.

Thathola, A. and S. Srivastava, 2002. Physico-chemical properties and nutritional traits of millet-based weaning food suitable for infants of the Kumaon hills, Northern India. Asia Pacific J. Clin. Nutr., 11: 28-32.

Tripathi, B., K. Platel and K. Srinivasan, 2011. Double fortification of sorghum (*Sorghum bicolor* L. Moench) and finger millet (*Eleucine Coracana* L. Gaertn) flours with iron and zinc. J. Cereal Sci., 55: 195-198.