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(Research Article)

Microbial phenolic and sensory properties of the complementary food produce flour from malted rice, soybean and pumpkin pulp

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Abstract

The study aimed to assess the phenolic, microbiological, and sensory aspects of a supplemental food made from malted rice, soybean, and pumpkin pulp. Paddy rice was steeped in water, germinated, kilned, winnowed, and dehulsked before being dried and milled. While to make soybean flour, the seeds were while pumpkins were washed, skinned, and chopped. The fiber and seeds were removed before slicing, then blanched, crushed, and sieved before being oven dried. The phenolic, microbiological, and sensory characteristics of the supplemental food were assessed. The results showed 1.12 to 2.25% phenolic content and $1.3x10^3$ to 8.3×10^2 cfu/g overall viable count. Mold counts range from 0.0 x 10 cfu/g to 1 x 10 cfu/g. The study indicated that malted rice, soybean, and pumpkin pulp flour blends produce an excellent sensory rating, are inexpensive in cost, and are ready to eat complementary foods.

Keywords: Phenolic; Malted rice; Soybean flour; Pumpkin flour; Complementary foods

1. Introduction

Around six months of age, an infant should start consuming foods besides breast milk or formula. This is because breast milk or formula can't supply all of the minerals required for newborn development, including iron, zinc, and energy. However, breast milk has important nutrients for growth improvement and should be continued until 12 months and beyond for as long as the baby and the mother want. The World Health Organization refers to complementary foods as any meal that differs from breast milk, implying that baby formulas and follow-on formulae (human milk substitutes, HMS) are considered complementary foods, which could be confusing given that many young children receive HMS from the time they are born (Agostonic et al., 2008). Infants require supplemental foods for the second half of their first year of life for nutritional as well as developmental reasons, as well as to assist them transition from milk to family cuisine. Breast milk's ability to meet macronutrient and micronutrient needs declines as neonates learn to chew and acquire an interest in foods apart from milk (Fewtrell et al. 2015). Malted rice flour is made by drying germinated or sprouted rice and grinding it into a powder. The malting method preserves enzyme activity and allows infants to pre-digest starchy

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foods (Price and Motis 2009). Soybean is one of the most abundant and inexpensive protein sources, and it is a staple in many people's and animals' diets across the world. Soybeans contain no starch, making them a great protein source for diabetics. It is also utilized as a high-protein meat substitute in newborn and vegetarian meals (Anonymous 1, 2021).Soybean is a high protein source (35-40%). The soybean seed has the highest nutritional value of any plant food consumed worldwide (Kure et al., 1998).

Pumpkins can be ground into flour, resulting in a longer shelf life. Pumpkin flour is used to improve wheat and make porridge because of its delicious flavor, sweetness, and brilliant yellow-orange color (Nakazibwe et al., 2019). Pumpkin is a nutritious and beneficial meal high in phenolic compounds, carotenoids, and vitamins, with nutritional value changing by variety (Tamer, 2010; Guz et al., 2018). Pumpkin contains a high concentration of vitamin A and carotenoids which impart pumpkin its orange color and are converted to vitamin A in the human body. Pumpkin is also an antioxidant and contains vitamin C, which defends the human body against oxidative damage (Anon 3, 2021). Production and evaluation of supplementary foods made from pumpkin pulp, soybeans, and malted rice would improve the nutritional properties and overall health of consumers, particularly infants and other vulnerable groups, while also introducing variety into diets.

Locally cultivated ingredients can be mixed to create composite flour (Emojorho et al., 2024, Emojorho et al., 2023). Composite flour derived from grains, legumes, or tubers has been proven to be more nutritionally dense than flour prepared from a single food crop (Emojorho et al., 2023b). By using composite flour, we may reduce our reliance on wheat imports for baked goods production, save foreign exchange, and engage our youth in productive activities (Anene et al., 2023; Aphiar et al., 2024). Poor eating habits, foods with low calorie and nutrient density, inadequate nutrient bioavailability, limited food access, inappropriate processing methods, and microbial contamination are the leading causes of malnutrition (UNICEF 1990). Protein-energy malnutrition affects both rural and urban populations in Nigeria.This is owing to stringent economic measures, insufficient food production and supply, mainly protein and micronutrient-rich foods. This study aims to address the issue of malnutrition. The study's overall goal was to create and assess the microbiological and sensory aspects of a supplemental diet made from malted rice, soybean, and pumpkin pulp flour mixes.

2. Materials and Methods

2.1. Raw materials

Paddy rice, soybean seeds and pumpkin fruit.

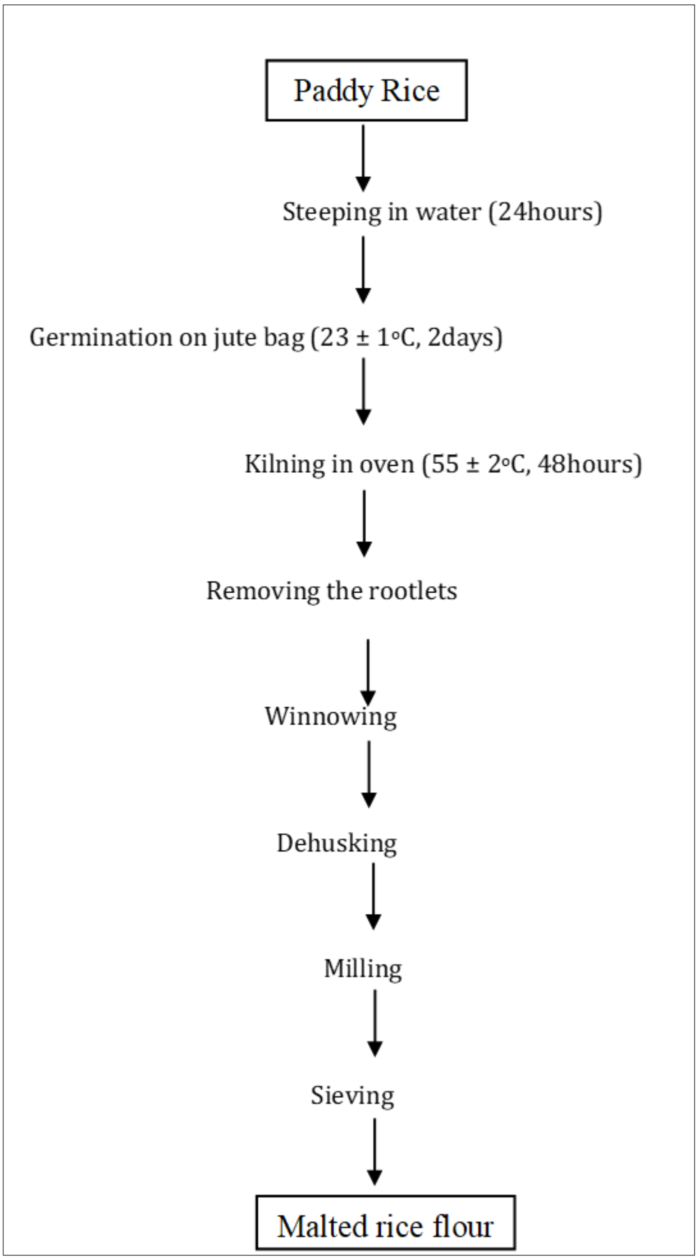
2.2. Sample procurement

The grains of paddy rice used for the research was obtained from Abakiliki rice mill in Ebonyi state while the freshly harvested pumpkin fruit and soybean seeds were locally sourced and purchased from Nsukka market, Nigeria. All the reagents used were sourced and procured from a certified chemical reagent dealer all in Nsukka.

2.3. Sample preparation

Processing of malted rice flour

According to Kunze (2005), the rice was malted with minimal modifications based on barley malting protocols. First, the unhusked grains were selected to remove dirt and contaminants. To avoid fermentation, the rice was steeped at room temperature for 24 hours, with the water changed twice: once after two hours and again after four hours. Following steeping, the grains were removed from the soaked water and couched (heaped) in jute bags sterilized with dry heat and sealed with the same material. Water was applied to the cotton layers once each day until the seeds germinated. The rice germinated at 23oC ± 1 and was harvested after two days. Kilning was performed in a standard oven at 55oC ± 2 for 48 hours. Rice malt was repeatedly spun to aerate and produce uniform, regulated heat. Kilned was manually de-rooted by rubbing it with our hands before being winnowed to remove rootlets and dust. They were then dehusked, processed, sieved to a fine powder, and packed. Figure 1 shows a flow diagram for the production of malted rice flour.



Source: Osuji *et al.*, 2020

Figure 1 Processing of paddy rice to malted rice flour.

2.4. Processing of soybean powder

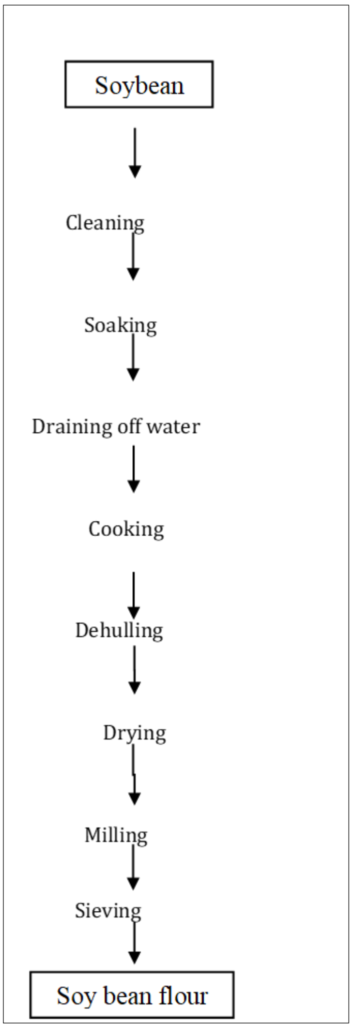
The first steps in soybean product preparation include cleaning (get rid of foreign material, splits, and deformed beans) and dehulling the beans to remove the cotyledon. Dehulling can be done dry or wet (INTSOY- University of Illinois, 2008).

The steps to prepare soybean powder are listed below:

2.4.1. Cleaning the soybean.

- Soak and dry (soak for 4hours and drain water).
- Boil the soaked soybean for 4hours and leave in the boiled water overnight so that the hull absorbs enough water for easier removal.
- Drain out water and dehull the soybean.
- Oven dry at the lowest temperature of the oven.

- Mill to obtain a fine powder.
- Sieve after milling to obtain a smooth flour (the sieved out can be milled and sieved again)

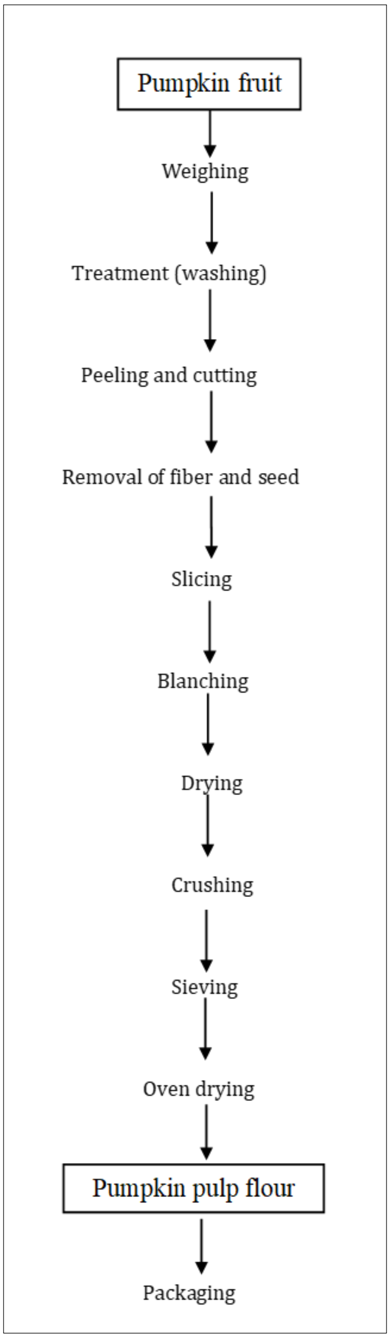


Source: ADP (2008).

Figure 2 Processing of soybean to soybean powder

2.5. Processing of pumpkin pulp flour

The procedure by Cerniauskiene et al. (2014) was used to turn pumpkin pump into flour. The ripened ripe fruit was used, weighing between 0.7kg and 1kg. They were completely cleaned with water and carefully dried. Following cleaning, the pumpkin fruits were peeled and chopped with knives, the fibers and seeds were taken out, the pulp and peel were cut into 4.5-5.5 mm thick pieces, and the pumpkin slices were immersed in water at 88-92°C to boil and blanche for 4-5 minutes before being scooped up and drained. Each sample was subsequently dried at 60°C in the laboratory drying oven, with the moisture content of the dried pumpkin slices kept below 5%.The materials were ground and sieved to yield a high-quality powder.The powder was sterilized in an oven at 80°C for two hours and stored in a freezer at -18±2°C in sealed containers until testing.



Source: Hansini, 2020.

Figure 3 Processing of pumpkin pulp flour

Table 1 Production and Formulation Ratio of Complementary Food

	Rice (%)	Soybean (%)	Pumpkin (%)
Sample A	50	40	10
Sample B	50	30	20
Sample C	50	25	25
Sample D	50	20	30
Sample E	50	10	40

2.6. Determination of total phenol

The method described by Bana and Gupta (2015) was used.

2.6.1. Microbial analysis

- Total viable count

The method by Harrigan and McCance (1976), was employed.

- Mould count

The Pour Plate Method, described by Harrigan and McCance (1976), was also used.

2.6.2. Sensory Evaluation

According to Ihekoronye and Ngoddy (1985), complementing meal samples were assessed on a 9-point Hedonic scale for color, taste, texture, mouthfeel, aftertaste, and overall acceptability, with 1 indicating extreme dislike, 5 indicating neither like nor dislike, and 9 indicating intense liking, by 20-person Panelist drawn at random from the Food Science and Technology Department at the University of Nigeria.

2.7. Experimental Design and Data analysis

The acquired data was treated to one-way analysis of variance (ANOVA) using a completely randomized design, according to Gomez and Gomez's (1985) approach. Significance level of ($P < 0.05$).

3. Results and Discussion

Pictorial representation of pumpkin, soybean and malted rice used in production of complementary food.

Figure 4 Fresh Pumpkin Fruit

Figure 5 Dried pumpkin pulp

Figure 6 Paddy heaped in jute bag for malting

Figure 7 Malted rice during drying process

Figure 8 Soybean flour

Figure 9 Malted Rice flour

3.1. Phenol content of complementary food from malted rice, soybean and pumpkin pulp flour

The results (Table 2) demonstrate the phenol content of a supplemental food made from malted rice, soybean, and pumpkin pulp flour.

Table 2 Phenol content of blends of malted rice, soybean and pumpkin pulp flour

Samples	Phenol (%)
MRSPF1	$2.07^{b}\pm0.04$
MRSPF2	$1.12^{d}\pm0.18$
MRSPF3	$1.16^{d}\pm0.04$
MRSPF4	$2.25^{b}\pm0.02$
MRSPF5	$1.64^{c}\pm0.08$
RF	$0.85^{e}\pm0.08$

PF	$0.24^{f}\pm0.01$
SF	$5.20^{a}\pm0.08$

Values are means ± standard deviation for duplicate determinations. Means in the same column with different superscripts are substantially different at p < 0.05. Key: MRSPF1= Blends of 50% malted rice flour, 40% soymilk flour, 10%pumpkin pulp flour; MRSPF2= blends of 50% malted rice flour, 30% soybean flour, 20% pumpkin pulp flour; MRSPF3= blends of 50% malted rice flour, 25% soybean flour, 25% pumpkin pulp flour; MRSPF4= blends of 50% malted rice flour, 20% soybean flour, 30% pumpkin pulp flour; MRSPF5= blends of 50% malted rice flour, 10% soybean flour, 40% pumpkin pulp flour; RF= 100% malted rice flour; PF= 100% pumpkin pulp flour; SF= 100% soybean flour

The phenolic content ranged between 1.12 and 2.25%. Sample MRSPF4 had the greatest phenol concentration (2.25%), whereas sample MRSPF2 had the lowest (1.12%). There was no significant difference ($p < 0.05$) between samples MRSPF1 and MRSPF4, as well as between samples MRSPF2 and MRSPF3. The sample MRSPF5 was considerably different. These values are lower than those obtained by Hagos et al. (2018) for weaning meal, which ranged from 4.5 to 11.1 mg/100 grams. A study found that eating flavonoid-rich foods protects humans against diseases caused by oxidative stress.

3.2. Microbial analysis of the complementary food from malted rice, soybean and pumpkin pulp flour

The results (Table 3) demonstrate the total viable count and mould count of the supplemental food made from malted rice, soybean, and pumpkin pulp flour.

The viable count varied from 1.3×103 to 8.3×102 cfu/g. MRSPF3 had the greatest total viable count, while MRSPF2 had the lowest total viable count of any of the samples. This could be due to the higher moisture level of the product, as pumpkin flour had the greatest moisture content of any raw item used. The overall viable count increased in proportion to the concentration of pumpkin pulp flour.

The mold count varied from 0.0 ×10 cfu/g to 1.0 ×10 cfu/g. MRSPF1 has traces of mould spores, whilst the other samples show no growth.

Table 3 Total viable count and Mould count of blends of malted rice, soybean and pumpkin pulp flour

Sample	**Dilution factor**	**TVC (Cfu/g)**	**Mould count (Cfu/g)**
MRSPF1	10^{-1}	1.6×10^{3}	1.0×10
MRSPF2	10^{-1}	1.3×10^{3}	0.0 ×10 (no growth)
MRSPF3	10^{-1}	8.3×10^{2}	0.0 ×10
MRSPF4	10^{-1}	6.3×10^{2}	0.0 ×10
MRSPF5	10^{-1}	4.5×10^{2}	0.0 ×10

3.3. Sensory Evaluation of Complementary Food from Malted Rice, Soybean and Pumpkin Pulp Flour

Table 4 displays the sensory score of a complementary food made from malted rice, soybean, and pumpkin pulp flour. There was no noticeable difference in color, appearance, flavor, mouthfeel, aftertaste, or consistency between them.

The hue of the complimentary food varied from 6.30 to 7.05 in the sample. The sample having 50:30:20 malted rice, soybean, and pumpkin pulp flour received the greatest score (7.05), whereas sample MRSPF2 had the lowest sensory score for color (6.30). There was no significant ($p < 0.05$) variation in sensory color among the samples. This could be due to the blending ratio, which includes malted rice flour in 50% of the overall blends.

The sensory score for appearance indicated no significant ($p<0.05$) difference, ranging from 6.20 in sample MRSPF4 to 6.85 in sample MRSPF3. The sample with the best appearance (6.85) consisted of 50:25:25 malted rice, soybean, and pumpkin pulp flour. This is most likely due to the sample's equal blend of soybean and pumpkin pulp flour, which served to brighten the color and make it more appealing.

The complementary food texture varied from 6.05 in sample MRSPF1 to 7.15 in sample MRSPF3. There was no significant difference ($p < 0.05$) between sample MRSPF2 and sample MRSPF3, nor between sample MRSPF4 and MRSPF5, but sample MRSPF1 differed considerably from the other samples. This could be due to the high mixing ratio of soybean flour. The texture smoothened slightly as soybean flour was reduced with increased pumpkin pulp flour.

Aroma of the complementary food varies from 5.50-7.05. Sample MRSPF3 (50:25:25) ranked the highest while sample MRSPF1(50:40:10) ranked the lowest which was significantly ($p<0.05$) different from samples MRSPF2, MRSPF3, MRSPF4 and MRSPF5. This could be as a result of the higher ratio of soybean flour which is known to have a characteristic volatile compound that gives it its distinct flavor.

The taste of the complementary food varies from 5.6 in sample MRSPF1 to 6.55 in sample MRSPF2, it was observed that there is no significant ($p<0.05$) difference between the samples. The preference in taste of the complementary food increased as the pumpkin pulp flour increased, while the soybean flour decreased. This is as a result of the sweet taste and high sugar content of pumpkin pulp.

The mouthfeel of the complementary food varied from 5.95 in sample MRSPF1 to 6.80 in sample MRSPF3. However, there was no observed significant ($p<0.05$) difference in the blends. The sample with the highest value as regards to mouthfeel contained 50:25:25 of malted rice, soybean and pumpkin pulp flour while the sample with the least value contained 50:40:10 of malted rice, soybean and pumpkin pulp flour. The quantity of rice and pumpkin contributed greatly to this preference because rice and pumpkin has a smooth texture which is the basic parameter in mouthfeel.

The blend showed no significant ($p<0.05$) difference in the aftertaste of the complementary food which varied from 5.85 to 6.60 in sample MRSPF1 and MRSPF3 respectively. The sample with the highest value contained 50:25:25 of malted rice, soybean and pumpkin pulp flour while the one with the least value contained 50:40:10 of malted rice, soybean and pumpkin pulp flour. An increased percentage of soybean flour could be as a result of this effect.

The consistency of the complementary food showed no significant ($p<0.05$) difference between them. This varied from 6.30 in sample MRSPF1 to 7.05 in sample MRSPF5. The sample with the highest consistency contained 50:10:40 of malted rice, soybean and pumpkin pulp flour, while the one with the least consistency contained 50:40:10 of malted rice, soybean, and pumpkin pulp flour. It was also observed that as the soybean content reduced the consistency increased with increased pumpkin pulp flour. The consistency increased as a result of higher percent of pumpkin pulp flour while the malted rice flour remained constant.

The overall acceptability of the supplemental food varied between 6.25 in sample MRSPF1 to 7.25 in sample MRSPF3. There were significant ($p<0.05$) differences in the blends of the sample where sample MRSPF1 differ significantly from sample MRSPF3 and samples MRSPF2, MRSPF4 and MRSPF5 showed no significant difference between them. The sample that was most preferred was sample MRSPF3 which contained 50:25:25 of malted rice, soybean and pumpkin pulp flour, while the one with the least preference was sample MRSPF1 which contained 50:40:10 malted rice, soybean and pumpkin pulp flour. The panelist preference could be as a result of the distinct color, appearance, texture, aroma, taste, mouthfeel, aftertaste and consistency of the complementary food which they are not used to.

Table 4 Sensory scores of complementary food from blends of malted rice, soybean and pumpkin pulp flour

Samples	Color	Appearance	Texture	Aroma	Mouthfeel	Aftertaste	Consistency	Overall acceptability
MRSPF1	6.60^{a}±1.42	6.30^{a}±1.26	6.05^{b}±1.35	5.50^{b}±1.35	5.95^{a}±1.50	5.85^{a}±1.13	6.30^{a}±1.41	6.25^{b}±1.01
MRSPF2	7.05^{a}±0.99	6.60^{a}±0.99	6.95^{a}±1.27	6.85^{a}±1.26	6.40a±1.18	6.35^{a}±1.30	6.75^{a}±1.25	6.90^{ab}±1.11
MRSPF3	6.95^{a}±1.23	6.85^{a}±0.98	7.15^{a}±1.18	7.05^{a}±1.27	6.80^{a}±1.57	6.60^{a}±1.46	6.90^{a}±1.44	7.25^{a}±1.11
MRSPF4	6.30^{a}±1.65	6.20^{a}±1.67	6.85^{a}±1.22	6.65^{a}±1.59	6.45^{a}±1.66	6.30^{a}±1.55	6.95^{a}±1.23	6.65^{ab}±1.49
MRSPF5	6.70^{a}±2.07	6.60^{a}±1.84	6.90^{a}±1.29	6.65^{a}±1.59	6.40^{a}±2.03	6.25^{a}±1.83	7.05^{a}±1.46	6.80^{ab}±1.54

4. Conclusion

This study demonstrated that a reasonable, acceptable, low-cost, microbially safe, and ready-to-eat supplemental food product prepared from malted rice, soybean, and pumpkin pulp flour may meet the needs of babies and early children. Mothers might utilize this to feed their newborns and toddlers during supplemental feeding times. According to this study, providing babies and children with complementary food products made from nourishing and locally available food components could help reduce malnutrition, which is common among newborns and children in Nigeria and other poor nations. Malted rice, soybeans, and pumpkin should be made available and promoted to communities and other developing nations. Furthermore, more research should be conducted on the blending ratio of this product in order to create a product that meets up to 100% of the daily requirement for all nutrients missing in babies.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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