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Assessment of Proximate Composition of Rice-Sesame Composites Formed from Fermented and Sprouted Rice and Sesame Seed

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ABSTRACT

This study investigated the proximate composition and calorific value of fermented and sprouted rice-sesame composites formulated at varying ratios. Significant differences ($P < 0.05$) were observed across moisture, ash, crude protein, crude fiber, crude fat, carbohydrate contents, and energy values among the blends. The 50:50 rice-to-sesame ratio (FR50S50 and SR50S50) exhibited the highest moisture (10.62–11.70%), ash (1.89–1.99%), fat (11.52–15.42%), protein (24.39–25.35%), crude fiber (1.25–1.31%), and calorific values (397.76–422.06 Kcal/100 g), indicating enhanced nutritional quality with balanced seed proportions. Conversely, blends with higher rice content (FR90S10 and SR90S10) showed lower values in these parameters but higher carbohydrate content (71.38–73.08%) compared to pure rice (R100, 85.16%). These findings demonstrate that incorporating sesame seeds, particularly at equal ratios with rice, significantly improves the nutritional profile of fermented and sprouted rice-based composites, suggesting their potential as nutrient-dense functional food ingredients.

1. Introduction

The nutritional quality of food is a critical factor in addressing global health challenges, particularly in developing regions where staple foods like rice and sesame play a significant role in the diet. Rice (Oryza sativa) is a primary source of carbohydrates for over half of the world's population, providing essential energy and serving as a dietary staple in many cultures (Huang et al., 2016).

In contrast, sesame (Sesamum indicum) is recognized for its high oil content, rich in unsaturated fatty acids, and its abundance of essential nutrients, including vitamins and minerals (Kumar et al., 2017). The combination of these two ingredients, particularly through processes such as fermentation and sprouting, has garnered attention for its potential to enhance nutritional profiles and the bioavailability of nutrients.

Fermentation is a traditional method that not only preserves food but also improves its digestibility and nutritional value. This process is facilitated by microorganisms that break down complex carbohydrates

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and proteins into simpler, more bioavailable forms (Nout & Kiers, 2005). Fermented foods have been associated with various health benefits, including improved gut health, enhanced immune function, and increased nutrient absorption (Marco et al., 2017). The fermentation of rice, for instance, has been shown to increase the levels of B vitamins and bioactive compounds, making it a more nutritious option compared to unfermented rice (Huang et al., 2016).

Similarly, sprouting has been recognized for its ability to enhance the nutritional composition of grains and seeds. The process of sprouting activates enzymes that break down anti-nutritional factors, such as phytic acid, which can inhibit the absorption of essential minerals (Bhat et al., 2018).

Additionally, sprouting has been shown to increase protein content, improve amino acid profiles, and enhance the bioavailability of vitamins and minerals (Domokos et al., 2023).

The combination of fermented and sprouted rice with sesame seeds could lead to a composite food product that is not only rich in macronutrients but also beneficial for health. The assessment of proximate composition encompassing moisture, ash, protein, fat, fiber, and carbohydrate content is essential for understanding the nutritional value of food products (AOAC, 2019).

Proximate analysis provides a comprehensive overview of the nutritional components of food, allowing for the evaluation of its potential health benefits. In the context of developing functional foods, understanding the proximate composition of a composite formed from fermented and sprouted rice and sesame seeds is crucial for determining its suitability as a dietary supplement or a healthier food option. When combined with the carbohydrate-rich profile of rice, this composite could provide a balanced source of energy and essential nutrients.

Furthermore, the incorporation of fermented and sprouted ingredients may enhance the overall digestibility and absorption of these nutrients, making the composite more beneficial for consumers. In addition to the nutritional benefits, the development of a composite food product from fermented and sprouted rice and sesame seeds aligns with contemporary dietary trends that emphasize whole foods and functional ingredients.

This study aims to evaluate the proximate composition of a composite formed from fermented and sprouted rice and sesame seeds, providing insights into its potential as a functional food. By elucidating the nutritional benefits of this composite, we can contribute to the development of healthier food options that align with contemporary dietary needs and preferences. The findings of this research could have significant implications for food scientists, nutritionists, and consumers alike, promoting the use of traditional food processing methods to enhance the nutritional quality of staple foods.

2. Literature review

As consumers become more health-conscious, there is a growing demand for food products that not only satisfy hunger but also contribute to overall well-being (Bennett et al., 2019). The proposed composite could serve as a versatile ingredient in various culinary applications, from snacks to meal replacements, catering to diverse dietary preferences and needs.

Research has shown that the combination of rice and sesame can yield a product with enhanced nutritional properties. For instance, sesame seeds are known to be a rich source of calcium, magnesium, and iron, which are essential for bone health and metabolic functions (Kumar et al., 2017).

3. Materials

Sampling of materials

The paddy rice (FARO 52) and sesame variety (NCRIBEN 04E) was obtained from National Cereals Research Institute (NCRI), Badeggi, Niger State.

The rice samples were manually cleaned to remove shaft before milling to obtain brown rice whereas the sesame samples were kept until required.

Chemicals and reagents

All chemicals and reagents used were of analytical grade, products of British Drug House (BDH) and Mayer/Baker grades. The chemicals used include sodium hydroxide, hydrochloric acid, sulphuric acid, perchloric acid, cupric sulphate and ammonium thiocyanate among others.

Equipment

The equipments used in this study include attrition mill (RM 100 model), amino acid analyzer (Beckman system 6300 Model), rice de-huller (satake Tokyo M3), extruder (Duisburg, DCE-330 model), muffle furnace (carbolite, Bamford, S302AU) among others.

Methods

Fermentation of rice

A modified method of Jeygowri et al., (2015) was adopted for the fermentation of the rice samples. Brown rice was soaked in warm water for 30 minutes to obtain uniform hydration. Fermentation was carried out by soaking brown rice in sterile distilled water (24 hours) at an ambient temperature **(37 ± 2 ℃)**. After the fermentation, the water in the container was drained and the fermented brown rice was air dried before transferring into an oven where the moisture content was reduced to 12 % before milling into flour and sieved through a laboratory sieve of 80 mesh size, packaged in polyethylene bags until required for further experiment.

Fermentation of sesame seed

The sesame seeds were de-hulled and fermented using the method described by Akusu et al., (2019) with little modifications. The seeds were boiled in hot water for 6 hours and cooled. The cooked seeds were placed in a plastic container with a tight lid and sealed. The samples were allowed to ferment at room temperature (37 ± 2 ℃) for 7 days and oven dried at 105 °C for 12 h to bring an end to fermentation. The seeds were defatted using hydraulic press and milled to obtain fermented sesame flour and stored in a glass container.

Sprouting of rice and sesame seeds

The seeds were germinated as described by Akusu et al, (2019). The seeds were sorted to remove stones and other extraneous materials. They were thereafter soaked for 2 h to achieve hydration then rinsed, drained and spread thinly on jute sack for germination to take place. The germination process was closely monitored to prevent discontinuity of germination and mould growth which was achieved by constant wetting and intermittent uniform spreading of the germinating seedlings. Sprouting was carried out for 7 days. The sprouted seedlings were thoroughly rinsed with water, drained, derooted, dried in a hot air oven set at 60 ºC for 6 h and the sesame seeds were defatted using hydraulic press before milling using a laboratory blender to pass through a 0.5 mm sieve and stored in plastic bags until required for further analysis.

Composite flour formulation

Five composite flour blends were formulated from fermented and sprouted samples and coded as: FR90S10, FR80S20, FR70S30, FR60S40 FR50S50 and SR90S10, SR80S20, SR70S30, SR60S40 and SR50S50. They were prepared by mixing varying proportions of fermented rice-defatted sesame flour for both fermented and sprouted samples. The control was 100% untreated rice (R100) as shown in table 1.0.

The different rice-sesame formulations were subjected to extrusion cooking using a small scale laboratory single screw extruder. The moisture content of the flour was determined and adjusted to 25 % according to the methods described by Anuonye et al., (2012). Feeds were manually introduced at a speed of 30 rpm which insure that the flight of the screw was filled and avoiding accumulation of feed in the hopper. Desired barrel temperature (120 ℃) was maintained by in-build thermostat and a temperature control unit. Experimental samples were collected as steady state was achieved. The extrudates were dried overnight after extrusion at 60°C in an oven and crushed using a small scale laboratory blender into powder forms then stored in a desiccator till required for analysis and sensory evaluation.

Analyses of Extrudates

Determination of proximate composition

Proximate composition

The proximate composition analysis was determined using the standard method of (AOAC 2010), while the total carbohydrate was obtained by difference.

Statistical Analysis

The results obtained from the analyses were subjected to Analysis of Variance (ANOVA) and Statistical Package for Social Sciences (SPSS) version 16.0. All data were analysed at 95% confidence interval and values were considered statistically significant at $P<0.05$.

Table 1.0. Percentage Composition for Rice and Sesame Composite Flours

Composite	Rice Flour	Sesame Flour
FR90S10	90	10
FR80S20	80	20

Composite	Rice Flour	Sesame Flour
FR70S30	70	30
FR60S40	60	40
FR50S50	50	50
SR90S10	90	10
SR80S20	80	20
SR70S30	70	30
SR60S40	60	40
SR50S50	50	50
Control (R100)	100	-

FRS: Fermented Rice-Sesame SRS: Sprouted Rice-Sesame R100: Untreated rice Extrusion cooking experiment
Source: Authors experimental design (2025)

4. Results and discussion

The proximate analysis of fermented and sprouted rice-sesame composites revealed substantial compositional variability influenced by the ratio of rice to sesame seeds. Moisture content was significantly higher in the 50:50 and 50:60 blends (FR50S50 and SR60S40), which could be attributed to the hydrophilic nature of sesame seeds and the fermentation/sprouting processes that enhance water retention Sunday et al. (2019). Higher moisture in these blends may favor enzymatic activities during fermentation and sprouting, potentially improving digestibility and bioavailability of nutrients.

Ash content, an indicator of total mineral content, was significantly elevated in blends with balanced rice-sesame ratios, particularly in FR50S50 and SR50S50. This suggests that sesame seeds contribute appreciable mineral elements, enhancing the composite's micronutrient density. The lower ash values in FR90S10 and SR90S10 reflect the dominance of rice, which is comparatively lower in mineral content Makinde and Oyeleke (2012).

Crude fat content showed a marked increase with higher sesame inclusion, consistent with sesame's known lipid richness. The fat content peaked at 15.42% in FR50S50 and 11.52% in SR50S50, indicating that sesame seeds significantly enrich the lipid profile of the blends. This enhancement is nutritionally beneficial, providing essential fatty acids and improving energy density. Motashari & Mousavi (2024).

Protein content followed a similar trend, increasing significantly with sesame addition. The highest protein contents observed in FR50S50 (24.39%) and SR50S50 (25.35%) underscore sesame seeds' role as a valuable plant protein source. Fermentation and sprouting likely contributed to protein quality improvement by reducing antinutritional factors and enhancing amino acid availability Amanda et al., (2022).

Crude fiber content was also highest in the equal proportion blends, which may improve gastrointestinal health and aid in glycemic control. The lower fiber in rice-dominant blends aligns with rice's inherently low dietary fiber content Aderonke et al. (2022)

Carbohydrate content was inversely related to sesame proportion, with the highest carbohydrate levels found in pure rice (R100) and rice-dominant blends (FR90S10 and SR90S10). This reflects the dilution effect of sesame seeds, which are lower in carbohydrates but richer in fats and proteins Elleuch et al., (2011).

Calorific values correlated positively with fat and protein contents, peaking in the 50:50 blends. The higher energy density of these composites suggests their suitability as nutrient-dense food formulations, which could be particularly advantageous in addressing malnutrition or energy deficiency, Solomon (2005).

Table 4.1. Proximate composition of fermented and sprouted rice-sesame Composite

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	CHO (%)	Energy Value (Kcal)
FR90S10	8.72±0.01d	0.61±0.01d	6.92±0.15e	10.26±0.01e	0.40±0.01c	73.08±0.04a	395.64±0.04e
FR80S20	9.39±0.02c	1.32±0.14c	9.10±0.08d	12.91±0.14d	0.87±0.02b	66.41±0.01b	399.18±0.12d
FR70S30	9.48±0.01c	1.35±0.01c	12.17±0.01c	15.38±0.01c	0.89±0.04b	60.73±0.01c	413.97±0.02c
FR60S40	9.70±0.14b	1.49±0.01b	13.34±0.15b	21.68±0.01b	0.98±0.01b	52.81±0.14d	418.02±0.02b
FR50S50	10.62±0.01a	1.89±0.03a	15.42±0.01a	24.39±0.04a	1.25±0.01a	46.43±0.04e	422.06±0.20a
SR90S10	10.72±0.01c	1.08±0.01d	4.51±0.14e	11.60±0.14e	0.71±0.01d	71.38±0.02a	372.51±0.04e
SR80S20	10.57±0.02c	1.19±0.14c	6.73±0.01d	14.85±0.14d	0.79±0.02c	65.87±0.01b	383.45±0.12d
SR70S30	10.94±0.01b	1.47±0.01b	8.80±0.14c	19.17±0.01c	0.97±0.07b	58.65±0.01c	390.48±0.01c
SR60S40	11.70±0.14a	1.96±0.01a	10.45±0.15b	20.55±0.01b	1.29±0.01a	54.04±0.01d	392.41±0.02b
SR50S50	11.66±0.01a	1.99±0.03a	11.52±0.01a	25.35±0.04a	1.31±0.01a	48.17±0.01e	397.76±0.14a
R100	8.67±0.01	0.46±0.04	1.56±0.14	3.85±0.01	0.30±0.01	85.16±0.04	370.08±0.01

Values are expressed as mean ± Standard Deviation. Values with different superscripts on the same column are statistically different at P<0.05. FRS = Fermented Rice/Sesame, SRS = Sprouted Rice/Sesame, R100 = Rice, Subscripts = percentage substitution

Source: Laboratory experiment 2025

5. Conclusions

The study demonstrates that fermenting and sprouting rice-sesame composites, especially at balanced ratios, significantly enhances their nutritional quality. These findings support the development of functional foods leveraging traditional processing techniques and seed blending to improve dietary nutrient profiles. Future research should explore bioavailability, sensory attributes, and potential health benefits to fully harness the value of these composites.

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