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Solid state fermentation improves the quality of soy-cassava diet

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ABSTRACT

Cassava is used as a staple food in many developing countries despite its low nutrient density. Fortification of cassava diets is needed for the prevention of malnutrition and achievement of food security. Cassava-soybean complementary foods were formulated from natural and solid state fermented cassava complemented with soybean. The proximate composition, physicochemical properties, nutritional quality, and sensory properties of the samples were determined (Table 2). The moisture content (7.51%) and ash (3.81%) content of the solid state fermented (SSF) cassava flour complemented with un-defatted soybean flour was significantly higher ($P < 0.05$) than of the other samples. Solid state fermentation (SSF) led to the highest reduction in viscosity (from 2,855 to 2,052 cPs). Average weight gain and protein efficiency ratio (PER) of experimental animals fed SSF cassava were the highest. The colour and aroma of SSF diets and that of fermented cassava samples were similar ($P > 0.05$). The texture of diets from SSF cassava were inferior ($P < 0.05$) to the other samples. Solid state fermentation of cassava with *Rhizopus oligosporus* and supplementation with soybean can be used to produce a complementary food that is nutrient dense and nutritionally adequate, although the texture of the product might need to be improved.

KEYWORDS

cassava, soybean, solid state fermentation, *Rhizopus oligosporus*, natural fermentation, nutritional quality

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1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a drought resistant subsistence staple crop that is widely consumed in sub-Saharan Africa providing income for small scale farmers (Bayata, 2019). Dietary diversification, nutrition education, food fortification, and bio fortification research efforts are currently being used to improve the nutritional quality of cassava (Bayata, 2019). Since cassava tubers deteriorate very easily (Djabou et al., 2017), it is processed into many food products such as chips, high quality cassava flour, and pasta (Akachukwu et al., 2017). Cassava products are consumed at least once a day in many households in Africa, and intake can reach 940 g/adult (De Moura et al., 2015). The nutrient density of cassava could be improved by solid state fermentation, which encourages the production of secondary microbial metabolites. Bacteria, yeasts, and oleaginous fungi such as *Rhizopus oligosporus* may undertake solid state fermentation (Kumar et al., 2021). For cassava to be used as a complementary food, it requires to be combined with other foods to improve its nutrient density. The present research reports findings on the efforts to improve the nutrient density of cassava as complementary food through solid state fermentation and soybean complementation.

2. MATERIALS AND METHODS

2.1. Flour processing and formulation

Cassava flour was processed according the method of Rose (1982) (Fig. 1). Soybean flour was processed according to the modified Illinois process (Anon, 1987). Soy-cassava composite blends were formulated as shown in Table 1. Table 2 shows the proximate composition of cassava blends.

2.2. Proximate analysis

Protein, fat, crude fibre, moisture, calorie, and ash contents of plant products were determined by standard AOAC methods (2005; methods 978.04; 930.09; 930.05). Carbohydrate was estimated by difference. Sodium, potassium, calcium, magnesium, and phosphorus were determined as described by Pearson (1976).

2.3. Physico-chemical properties

The pH, titratable acidity, and reconstitution time were determined according to the method of James (1995). The viscosity of samples was determined by the method of Mosha and Svanberg (1983). Cyanide content was determined according to the method of Bradbury (2009).

2.4. Determination of nutritional quality of samples

The six cassava-soy blends were evaluated for their nutritional quality using casein control. Seven groups of 21 albino rats were housed in individual cages and fed ad libitum for 28 days with the formulated diets and water. The weight gain/loss and feed intake were monitored daily and was used to calculate the Protein Efficiency Ratio. On days 14–21, faecal matter was collected and used for the calculation of feed digestibility.

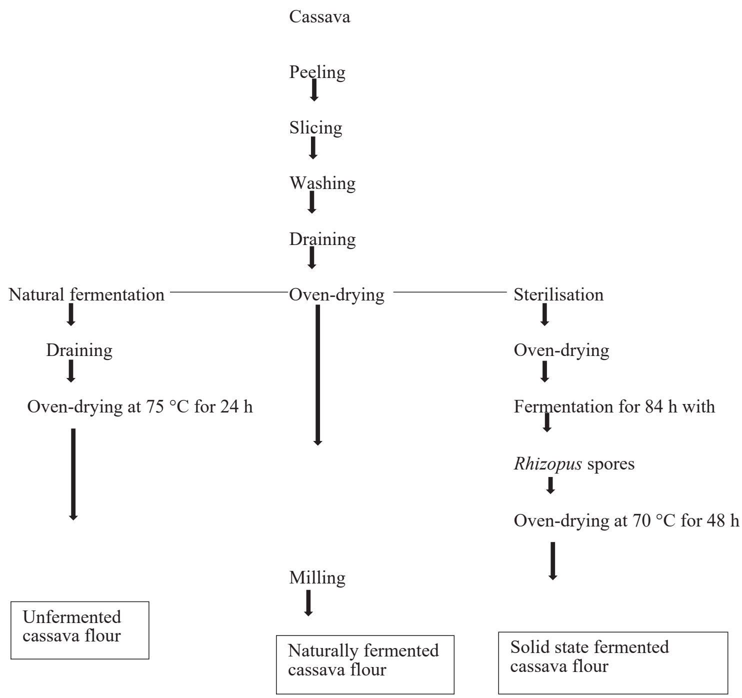

Fig. 1. Preparation of solid state and naturally fermented cassava

Table 1. Soy/cassava composite blends

Treatments for cassava samples (70%)	Treatments for soybean samples (30%)	Sample code
Solid state fermented cassava	Un-defatted soybean	A
Solid state fermented cassava	Defatted soybean flour	B
Naturally fermented cassava	Un-defatted soybean	C
Naturally fermented cassava	Defatted soybean flour	D
Unfermented cassava	Un-defatted soybean	E
Unfermented cassava	Defatted soybean flour	F
Naturally fermented cassava	10% casein	G

2.5. Sensory evaluation

Samples of the composite flour blends were evaluated for taste, flavour, colour texture, and overall acceptability on a nine point intensity scale using 20 panellists. The results were compared using the multiple comparison test of Snedecor and Cochran (1967).

2.6. Statistical analysis

Statistical analyses were conducted on triplicate data generated for proximate composition, nutritional quality, and sensory analysis. Significant means were separated using the one-way analysis of variance.

Table 2. Proximate composition of soy cassava blends

Sample	Moisture (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)	Energy (Kcal g^{-1})
A	$7.51^{a}\pm0.01$	$18.70^{ab}\pm0.33$	$1.69^{d}\pm0.09$	$4.29^{ab}\pm0.10$	$3.81^{a}\pm0.01$	$68.29^{ab}\pm0.39$	363.17^{a}
B	$7.47^{c}\pm0.01$	$20.68^{a}\pm0.92$	$1.98^{a}\pm0.04$	$4.45^{a}\pm0.01$	$4.16^{b}\pm0.01$	$65.70^{ab}\pm0.92$	363.34^{a}
C	$3.62^{c}\pm0.02$	$13.03^{b}\pm0.07$	$9.01^{a}\pm0.15$	$5.39^{b}\pm0.11$	$2.24^{b}\pm0.01$	$72.10^{ab}\pm0.24$	421.61^{a}
D	$3.35^{c}\pm0.02$	$14.00^{b}\pm0.04$	$9.20^{a}\pm0.16$	$5.42^{a}\pm0.59$	$2.87^{b}\pm0.01$	$71.63^{ab}\pm0.18$	425.32^{a}
E	$5.42^{ab}\pm0.01$	$11.01^{bc}\pm0.15$	$3.35^{c}\pm0.62$	$3.75^{bc}\pm0.15$	$1.83^{bc}\pm0.02$	$78.21^{ab}\pm0.13$	387.03^{ab}
F	$5.53^{ab}\pm0.03$	$9.38^{c}\pm0.26$	$4.06^{bc}\pm0.10$	$3.37^{bc}\pm0.33$	$2.12^{b}\pm0.01$	$78.91^{ab}\pm0.35$	389.70^{ab}
G	$1.92^{d}\pm0.01$	$6.61^{cd}\pm0.13$	$2.33^{cd}\pm0.22$	$5.25^{a}\pm0.07$	$0.71^{d}\pm0.01$	$89.24^{a}\pm0.35$	404.37^{a}

Means in the same column with different superscript are significantly different ($P < 0.05$) from one another.
A, B, C, D, E, F, G: Same as in Table 1.

3. RESULTS AND DISCUSSION

3.1. Proximate composition

The solid state fermented cassava (SSF) containing undefatted soy bean flour had the highest moisture (7.51%) and ash (3.81%) contents. SSF containing defatted soy bean had the highest crude protein content (20.68%). The process of solid state fermentation, which involved the inoculation of *Rhizopus oligosporus* in a nitrogen medium, increased the protein content of samples. Although oleaginous fungi like *Rhizopus oligosporus* utilise fats efficiently, the very low fat content of solid state fermented samples needs further scientific verification. The highest crude fibre content ($P < 0.05$) was observed in the sample containing naturally fermented cassava and defatted soy bean flour.

3.2. Physicochemical properties of complementary foods prepared from soy-cassava composite blends

Titratable acidity values were low and ranged from 0.30 to 0.47. The pH value of the solid state fermented sample was the lowest. Solid state fermentation led to the highest viscosity reduction, suggesting that SSF will have higher nutrient density. Reconstitution time was lowest for naturally fermented cassava blended with defatted soybean flour (Table 3).

3.3. Nutritional quality of soy-cassava complementary foods

SSF had a significantly higher average weight gain value than the control. There were no significant differences ($P > 0.05$) in the average feed intake and feed digestibility of all samples. The protein Efficiency Ratio (PER) was highest for SSF samples although there were no significant differences amongst the samples (Table 4). Onabanjo et al. (2008) observed that cassava, soybean, groundnut, and cassava leaf composite blends could meet most of the nutrient requirements of quality complementary foods.

3.4. Cyanide content

The cyanide content of cassava based complementary foods ranged from 3.79 mg kg^{-1} in the solid state fermented cassava to 7.17 mg kg^{-1} in the unfermented cassava. Solid state

Table 3. pH, titratable acidity, and viscosity of soy/cassava blends

Parameters	A	B	C	D	E	F	G
Titratable acidity	0.47±0.08	0.45±0.00	0.37±0.00	0.38±0.01	0.36±0.01	0.36±0.01	0.30±0.01
pH	6.65	6.50	6.93	7.01	7.03	6.93	6.64
Reconstitution Time (sec)	479±0.58	477±0.82	474±0.83	474±0.58	465±0.82	463±0.58	471±0.82
Viscosity (cPs)	2059	2052	2080	2085	2,850	2,855	2,755

A, B, C, D, E, F, G: Same as in Table 1.

Table 4. Nutritional quality of soy/cassava complementary foods

Sample	Average weight gain (g)	Average total feed intake (g)	Adjusted Protein Efficiency Ratio (PER)	Feed digestibility (%)
A	3.53^{a}	8.51	3.30^{a}	95.90
B	4.64^{a}	9.51	3.70^{a}	96.20
C	2.79^{ab}	10.06	3.34^{a}	95.40
D	2.16^{ab}	8.47	2.86^{ab}	95.40
E	2.23^{ab}	10.67	2.98^{ab}	95.30
F	1.34^{b}	8.85	2.54^{ab}	94.10
G	1.41^{b}	8.42	2.50^{ab}	95.30

Means in the same column with different superscript are significantly different ($P < 0.05$) from one another.
A, B, C, D, E, F, G: Same as in Table 1.

fermentation led to the highest reduction in cyanide content. Consuming 50–100 mg of cyanide is associated with acute poisoning. The consumption of lower amounts can cause ataxic neuropathy, eyesight problems, goiter, and cretinism (Tshala-Katumbay et al., 2013).

3.5. Sensory properties

Naturally fermented cassava composite blends had the lowest sensory scores for colour. The solid state fermented blends had the lowest sensory scores for texture. Unfermented soy-cassava

Table 5. Sensory characteristics of soy-cassava complementary foods

Sample	Texture	Colour	Taste	Aroma
A	4.7^{c}	7.5^{b}	7.9^{b}	5.7^{b}
B	4.4^{c}	7.5^{b}	7.7^{b}	5.4^{b}
C	8.3^{b}	4.2^{c}	7.6^{b}	5.4^{b}
D	8.2^{b}	4.1^{c}	7.7^{b}	5.5^{b}
E	8.5^{b}	7.8^{b}	4.2^{c}	4.8^{b}
F	8.2^{b}	7.7^{b}	4.3^{c}	4.7^{b}
G	8.7^{ab}	8.3^{ab}	8.0^{ab}	8.6^{a}

Means in the same column with different superscript are significantly different ($P < 0.05$) from one another.
A, B, C, D, E, F: Same as in Table 1
G: NUTREND.

blends had the lowest scores for taste. Unfermented/un-defatted soy-cassava blend had the lowest sensory score for aroma (Table 5).

4. CONCLUSIONS

Solid-state fermentation by *R. oligosporus* improved the nutrient density of soy-cassava diets making it suitable for complementary feeding of infants and children.

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