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Effect of soy supplementation and its stage of inclusion on the quality of ogi – a fermented maize meal

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Abstract

Soybean was incorporated (30:70) at different stages and states in the flow line for ogi production and subjected to sensory, physical, sensory and acceptability tests. Results showed that the soy ogi flours contained 57.7–59.1% carbohydrates, 17.9–18.9% protein, 10.64–11.45% fat, 1.85–2.88% fibre, 2.37–2.75% ash and 17.1–17.5 kJ/g gross energy. These values were significantly ($P < 0.05$) higher than values obtained for ogi. The loose bulk densities of soy ogi flours ranged from 0.47 to 0.68 g/cm^3, and packed bulk densities from 0.75–0.84 g/cm^3, while ogi flours were 0.42 and 0.70 g/cm^3, respectively. The apparent gelatinisation temperature of soy ogi flours varied from 75.2–77.5 °C while ogi flour is 70.5 °C. The peak viscosity of ogi flour (control) is 850 BU. Soy ogi flours had lower values, in the range of 270–460 BU. The index of gelatinisation was highest in ogi flour (620 BU), while soy ogi flours range from 250–490 BU. Ogi flour had the highest reconstitution index (105) while soy ogi samples ranged between 83.06 and 99.12. Batch B (prepared by souring soyflour and ogi slurry together for 24 h) was the most preferred upon sensory evaluation. Acceptability tests carried out on Batch B showed that 79% of the respondents rated it good to excellent; 65% noted that its most appealing factors were taste, flavour and consistency, 34% preferred it to the usual ogi; 65% agreed that it was easy to prepare, while 30% reported the soy ogi was easier to prepare than the usual ogi.
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1. Introduction

Protein malnutrition is a major public health problem in some parts of the world, including Nigeria and the west African sub region (Awake, 2003). This is because diets in these areas are predominantly starchy, the major crops being roots, tubers and cereals. In Nigeria, the usual first weaning food is called pap (a fermented corn meal), akamu, ogi, or koko and is made from maize (*Zea mays*), millet (*Pennisetum americanum*) or guinea corn (*Sorghum* spp) (King & Ashworth, 1987). These grains, especially corn, are of low protein quality. The traditional method of preparation involves steeping in water for one to three days, depending upon variety, urgency of need and the desired sourness, followed by milling and extraction. The soaking and extraction process that the corn is subjected to lowers the nutrient value of ogi further (Aremu, 1993). ogi is commonly reconstituted with boiling water (to form akamu, or allowed to cool to form eko) and consumed, either alone or with bean meal (moinmoin) or bean cake (akara) as accompaniment. People from low-income groups may not consume eggs or fish because of socio-economic factors, taboos or ignorance (Nnanyelugo, 1985), whereas people from high-income groups do (Cherian, 1981). This observation necessitates the need for affordable and acceptable plant protein supplementation. Soybeans have high protein content and are not very expensive.

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Therefore they are an ideal source for protein supplementation of starchy foods (Collins & Falasinu, 1977). There has been considerable interest in the improvement of the nutritional quality of ogi through legume-based supplementation (Akinrele & Bassir, 1967; Akinrele & Edwards, 1971; Alnwick, Moses, & Schmidt, 1988; Ekpenyong, Babatunde, & Oyenuga, 1977; Nkama, 1991). The Federal Institute of Industrial Research, Oshodi (FIIRO), Lagos, Nigeria, pioneered the production of soy ogi using a spray-drying method (Akinrele et al., 1970). In spite of the tremendous improvements recorded with the use of soybeans (Harris et al., 1988; Messina & Barnes, 1991; Peterson & Barnes, 1993), soy ogi is still not popular among the consuming populace in Nigeria, due largely to its perceived inferior taste quality, cost and inaccessibility in open markets. Egounlety and Syarief (1992) reported considerable improvement in the nutritional and sensory properties of ogi supplemented with tempeh powder (fermented soybean). However, the use of tempeh is popular in Oriental countries only. Banigo, Deman, and Duits Chaever (1974), produced soy ogi from dry-milled maize inoculated with a combination of microorganisms. This method has been shown to be capital-intensive with low adaptive index (Adeyemi, 1989). Egounlety and Syarief (1992) showed that the point of inclusion of tempeh powder significantly influenced the taste quality of ogi. Thus there is a need for the production of soy ogi with acceptable taste and nutritional quality with cheap, simple, easy-to-understand-processes for use by people with low technological capabilities. To ensure that the nutritional status of the consuming populace is not compromised, technologies proposed for making soy ogi must be accessible, affordable, environmentally sound and tailored to meet the peculiar and cultural norms of the people. This, no doubt, will go a long way in improving the domestic utilization of soybean and enhance the nutritional status of the ogi-consuming populace.

The objective of this work was to evaluate the effect of different points and states of soybean inclusion on the quality and acceptability of ogi. In addition, we have investigated consumer response to the most preferred soy ogi flour.

2. Materials and methods

2.1. Raw materials

The major raw materials used in this work, mature healthy corn (*Zea mays*) and Soybean (*Glycine max*), were obtained from a local market in Akure and taken to the Crop, Soil and Pest Management laboratory, Federal University of Technology, Akure, for identification. The grains were washed with distilled water, air-dried and collected into separate sterile containers.

2.2. Methods

2.2.1. Processing method

ogi was prepared using the modified traditional method of Aremu (1993). Fig. 1(a) and (b) shows the major unit operations involved in the process. Soybean was incorporated (30:70) at various points as shown in Table 1. The incorporation of soybean at the different points was accompanied by thorough mixing. Thereafter, samples were taken from each blend for proximate analyses, physical analyses, determination of pasting characteristics, sensory evaluation and consumer acceptability.

2.2.2. Proximate analyses

Proximate analyses were carried out on the samples using standard methods (AOAC, 1990). The crude protein ($N \times 6.25$) was determined by the micro-Kjeldahl method (AACC, 1983). The total ash was determined after ashing for 12 h at 550 °C. Total lipids were estimated by petroleum ether extraction. The carbohydrate content was determined by difference. The Gallenkamp bomb calorimeter was used to determine gross energy.

2.2.3. Evaluation of physical properties

The packed and loose bulk densities of the samples were determined as described by Narayana and Narasinga (1984); reconstitution index was determined as described by Banigo and Akpapunam (1987).

2.2.4. Evaluation of pasting characteristics

The pasting characteristics of ogi and soy ogi flours were evaluated using a Brabender visco-amylograph at the Federal Institute of Industrial Research, Oshodi, Lagos, Nigeria. Flour slurry, containing 12% solids (w/w, dry basis), was heated from 30 to 95 °C at a rate of 2.5 °C/min, held at 95 °C for 15 minutes, and cooled at the same rate to 50 °C (Shuey & Tipples, 1982). The pasting performance was automatically recorded on the graduated sheet of the amylogram. The pasting temperatures, peak viscosities, viscosity at 95 °C, stability, cooking times and setback viscosities were read off the amylograph.

2.2.5. Sensory evaluation and consumer acceptability

The soy ogi flours were reconstituted in boiling water and rated on a 9-point hedonic scale by a trained laboratory panel for consistency, colour, taste, aroma and overall acceptability (Data not included). Soy-free ogi sample (Batch E) served as control. Batch B scored highest; hence its flour was selected for the subsequent consumer acceptability test. The product was packed in 1 kg lots in translucent polythene bags; 200 randomly selected households in Akure, Ondo State, Nigeria, were used for the acceptability test. Each participant was gi-

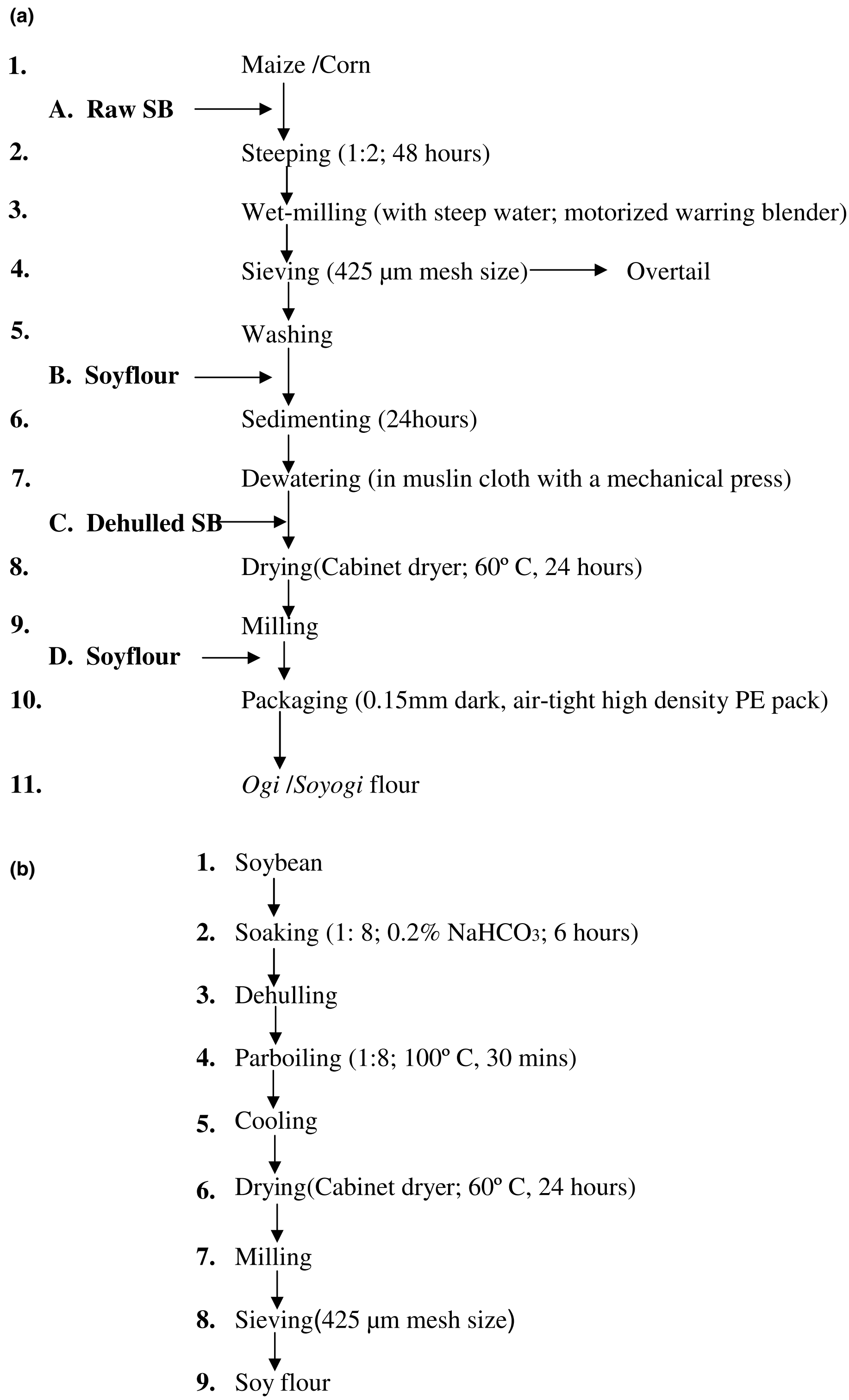

Fig. 1. (a) Flow chart for the production of ogi and soy ogi at different points of soy inclusion. (b) Flow chart for the production of soy flour.

ven a well labelled packet of Batch B soy ogi and one of *ogi* alone. A questionnaire accompanied each sample. The participants were told to prepare (i.e. reconstitute) ogi the usual way, taste it and then respond to the questionnaire.

2.2.6. Statistical analysis

The statistical significance of the observed differences among the means of triplicate readings of experimental results obtained were evaluated by analysis of variance (ANOVA), while means were separated using Duncan's

Table 1
Points of incorporation of soybean into ogi

Batch	Points of incorporation of soybean into ogi flow line	State	Objective
A	Between 1 → 2	Raw soybean (Stage 1)	Steep/ferment together with corn
B	Between 5 → 6	Soyflour (Stage 9)	Souring together with ogi slurry
C	Between 7 → 8	Cooled parboiled and dehulled soybean (Stage 5)	Dry and mill with ogi meal
D	Between 9 → 10	Soyflour (Stage 9)	Homogeneous mixing with ogi flour
E	Nil (Control)	–	–

multiple range test. These analyses were carried out using a GenStat 6.1 (2002) computer programme.

3. Results and discussion

3.1. Chemical composition

Table 2 shows the results of the proximate analyses, of ogi and soy ogi flours. The soy ogi flours are good sources of carbohydrates (57.7–59.1%), protein (17.9–18.9%) and fat (10.64–11.45%). In all the batches, there were significant improvements in the quality of soy-enriched ogi. The protein content of ogi increased significantly with the addition of soybeans. There were significant differences ($P \leqslant 0.05$) in the fibre contents, the protein, the fat, carbohydrate and ash contents. Thus, the proximate composition of soy ogi flours appears to be dependent of the state and point of inclusion of soybeans. The protein was highest in sample C, while the fat and the fibre contents were highest in sample D and the ash content highest in sample A. This work confirms earlier reports by Fashakin, Awoyefa, and Furst (1986) on the beneficial effect of vegetable protein supplementation. With the protein content of the soy ogi flours ranging between 17.6 and 18.6, they would be capable of meeting the RDI of infants fed solely on it (PAG, 1971). About 285–310 g would have to be consumed by an adult weighing 70 kg to meet the daily protein requirement of 55 g (FAO/WHO/UNU, 1985; Robinson, 1987). The energy producing value of the flours is shown in Table 2. The energy values of the soy ogi flours were significantly higher ($P < 0.05$) than the control (14.42 kJ/g) and ranged between 17.1 and 17.53 kJ/g. This may be attributed to the increase recorded in the protein and fat contents of the soy ogi flours. The Atwater factor of fat is 37.8 kJ/g, which is more than twice the value for protein and carbohydrates (16.8 kJ/g). The daily energy requirement for adults ranges from 10,000 to 12,600 kJ, depending on their physiological state. Thus, an adult would require about 600–740 g of the soy ogi flour to meet its minimum daily

Table 2
Proximate composition, energy and physical properties of ogi and soy ogi flours

Component	Batch				
	A	B	C	D	E (Control)
Proximate composition (%)					
Moisture	7.70	7.57	7.18	6.98	6.79
Protein	17.9^{b}	18.3^{b}	18.9^{b}	18.3^{b}	10.5^{a}
Fat	10.78^{b}	10.64^{b}	11.32^{b}	11.45^{b}	5.0^{a}
Carbohydrate	59.1^{b}	58.2^{a}	58.0^{a}	57.7^{a}	78.7^{b}
Ash content	2.75^{b}	2.57^{b}	2.37^{b}	2.72^{b}	1.02^{a}
Fibre	1.85^{a}	2.76^{b}	2.80^{b}	2.88^{b}	1.40^{b}
Gross energy (kJ/g)	17.4^{b}	17.1^{b}	17.2^{b}	17.5^{b}	14.4^{a}
Physical properties					
Loose bulk density (g/cm^3)	0.47^{a}	0.56^{b}	0.65^{b}	0.68^{b}	0.42^{a}
Packed bulk density (g/cm^3)	0.75^{ab}	0.78^{bc}	0.81^{c}	0.84^{c}	0.70^{a}
Reconstitution index	90.2^{b}	99.12^{c}	88.21^{b}	83.06^{a}	105^{d}

Batch	Points of incorporation of Soybean into ogi flow line	State
A	Between 1 → 2	Raw soybean (Stage 1)
B	Between 5 → 6	Soyflour (Stage 9)
C	Between 7 → 8	Parboiled, cooled and dehulled soybean (Stage 5)
D	Between 9 → 10	Soyflour (Stage 9)
E	Nil (Control)	–

Values are means of three replicates.
Values in a row denoted by different superscripts differ significantly at $P < 0.05$.

energy requirement (FAO/WHO/UNU, 1985; Robinson, 1987). However, in practical terms, higher quantities may be required because of the incomplete digestion of energy-giving nutrients in the body, which in turn leads to lower metabolisable energy. Furthermore, unavailable carbohydrate (present naturally in plants) is combusted in the bomb calorimeter, while it is not in the human body. This further widens the energy differential between gross energy and metabolisable energy in foods, necessitating the consumption of higher quantities of the food item than is predicted theoretically.

3.2. Pasting characteristics

Amylographic studies (Table 3) showed that the Brabender viscosities of the soy ogi flours are generally lower than the control (ogi). The apparent gelatinisation temperature (T_a) of ogi flour (Batch E, Control) was the lowest (70.5 °C) while those of soy ogi flours varied from 75.2–77.5 °C. These higher values of treated samples may be due to the buffering effect of fat (from soybean) on the gelling properties of the starch component of the ogi flour which is mainly a carbohydrate food (Egounlety & Aworh, 1991). The peak viscosity (V_p) of ogi flour is 850 BU. The soy ogi flours had lower values, in the range of 270–460 BU. This suggests that the presence and interaction of components, such as fats and proteins (from soybeans) with starch lower its peak viscosity (Egounlety & Aworh, 1991; Svanberg, 1987). However, there were differences in the peak viscosities of the treated samples, with samples A and D having lower values than the rest of the samples. The lower value of sample A must have been due to the effect of fermentation on the soybean which might have denatured the proteins, thus lowering their hydrophilic tendencies, while that of sample D might have been due to the buffering effect of fat in the soy flour on the gelling properties of the starch in ogi flour. High V_p reflects fragility of the swollen granules, which first swell and then break down under the continuous mechanical stirring conditions of the Brabender visco-amylograph. Thus they require careful cooling with good agitation in order to pass through the V_p and achieve a properly cooled paste. However, after a 15 min hold at 95 °C, viscosity was reduced considerably, with the ogi flour having the highest percentage decrease (~50%). There were significant increases in the viscosity of the flours when cooled to 50 °C, with values ranging from 460 to 1060 BU. When held for 15 min at 50 °C, the final viscosities of the soy ogi samples dropped, with sample D having the highest percentage drop (~33%). However, that of the control (ogi) increased. The final viscosity after 15 min is a measure of the stability of the cooked paste (Mazurs, Schoch, & Kite, 1957). It can be concluded from the results obtained that ogi flour (control) is the most stable, followed by sample B, with sample D being the least stable. The extent of increase in viscosity on cooling to 50 °C reflects the retrogradation tendency ($V_c - V_p$) of the products. Of the five flours studied, sample B had the highest retrogradation tendency (300 BU), followed by samples D (250 BU), C (225 BU) and E (210 BU), while sample A had the lowest value. The increase in the index of retrogradation (i.e., set-back value) in soy ogi flours may be due to increased hydrogen bonding during cooling. This increased hydrogen bonding activity may be due to the hydrothermal treatment and the interaction between the polysaccharide and protein (peptide bonds). This leads to the growth of gel micellar regions, and hence increase in index of retrogradation (Hodge & Osman, 1976), making entrapped water more prone to expression. The low apparent viscosity and retrogradation in the soy ogi

Table 3
Pasting characteristics of soy ogi flours

Batch	T_a	V_p	V_a	V_b	V_c	V_f	V_p-V_b	V_c-V_p	V_c-V_a	V_c-V_b
A	77.5	290	290	210	460	400	80	170	160	250
B	75.7	460	450	270	760	750	190	300	300	490
C	76.25	315	310	215	540	420	100	225	125	325
D	75.2	270	265	220	520	355	50	250	255	300
E	70.5	850	825	440	1060	1120	410	210	235	620
Range	70.5–77.25	270–850	265–825	210–440	460–1060	335–1020	50–410	170–300	125–300	250–620

Batch	Points of incorporation of Soybean into ogi flow line	State
A	Between 1 → 2	Raw soybean (Stage 1)
B	Between 5 → 6	Soyflour (Stage 9)
C	Between 7 → 8	Parboiled, cooled and dehulled soybean (Stage 5)
D	Between 9 → 10	Soyflour (Stage 9)
E	Nil (Control)	–

$V_p - V_b$ = Stability during cooking; $V_c - V_p$ = Set-back value; $V_c - V_a$ = Consistency; $V_c - V_b$ = Gelatinisation index; T_a = Gel temperature; V_p = peak viscosity; V_a = viscosity at 95 °C; V_b = viscosity after 15 min at 95 °C; V_c = viscosity at 50 °C; V_f = final viscosity after 15 min at 50 °C. All viscosity values are expressed in BU, Brabender units.

flours after cooling for 15 min at 50 °C is an advantage nutritionally, in that it enhances the production of nutrient-dense product that does not require the addition of water during child/infant feeding (Karlson & Svanberg, 1982; Ljungvist, Mellander, & Svanberg, 1981). In the traditional ogi and maize flour products, it is usually necessary to dilute the products with water before feeding because of their viscous nature. This reduces the energy and nutrient density, resulting in infant malnutrition in areas where starchy foods are the staple diets (Fashakin, 1994). Soy ogi, with low set back viscosity values, will eliminate the need for dilution before feeding, as well as the use of specialised processes, such as germination, enzymatic treatment and extrusion (to reduce the "dietary bulk"). The index of gelatinisation ($V_c - V_b$) was highest in ogi flour (620 BU), followed by sample B (490 BU), with sample A having the lowest value (250 BU). ogi from corn steeped together with soybean had the lowest setback and index of gelatinisation value (170 and 250 BU, respectively). Thus, the presence of protein and fat (which act as surfactants), coupled with fermentation, inhibits the gelatinisation process, thus raising the temperature and retarding the rate of swelling. The mechanism of action is that a complex is formed between the protein-fat matrix of the soy product and the amylose in the starch of ogi. The formation of complex with amylose reduces the tendency of the amylose to associate, gel and retrograde, thus delaying the rate of firming during the heating and the cooling stages (Bourne, Tiffin, & Wenger, 1960; Ghiasi, Varrianco Marston, & Hoseney, 1982).

3.3. Physical properties

The loose bulk density generally increased, with values ranging from 0.47 g/cm^3 (Sample A) to 0.68 g/cm^3 (Sample D). The packed bulk density follows the same pattern. Increase in bulk density is desirable in that it offers greater packaging advantage, as a greater quantity may be packed within a constant volume (Fagbemi, 1999). ogi flour (control) had the highest reconstitution index (105), followed by sample B (99.12) while sample D had the lowest value (83.06). The reconstitution index is a measure of the ability of the flour to associate with water, particularly in products where hydration is required to enhance handling characteristics, such as dough and pastes (Giami & Alu, 1994).

3.4. Sensory properties

Table 4 shows the result of a consumer acceptability test carried out on Batch B. The product was rated good to excellent by about 79% of the respondents; 65% of the respondents noted that the most appealing factors in the soy ogi were its taste, flavour and consistency.

Table 4
Acceptability test[a] of soy ogi flour

Question	Average number of responses	Percentage
General appreciation		
Very poor	0	0
Poor	10	5
Passable	22	11
Good	38	17
Very good	66	33
Excellent	54	29
Abstention	10	5
Preparation		
Easy to prepare	130	65
Difficult to prepare	50	25
Neither easy nor difficult	20	10
Most appealing factor		
Taste	80	40
Flavour	26	13
Colour	20	10
Protein	50	25
Consistency	24	12
Compare with usual ogi		
Better to taste	68	34
Easier to prepare	60	30
Richer	64	32
Not good at all	8	4

[a] Based on responses from 200 randomly selected households in urban Akure, Ondo State, Nigeria.

Only 34% of the respondents preferred the soy ogi to the usual ogi. This may be because of the objectionable beany flavour of the soy supplemented samples. While 65% of the respondents agreed that the soy ogi flour was easy to prepare, 30% noted that the soy ogi was easier to prepare than the usual ogi. This may be due to the decrease in viscosity associated with the use of soybean. The respondents commented that soy ogi was not as white as the usual ogi flour. This may be due to the characteristic yellow pigment in soybean and browning reactions during processing. Thus, to ensure greater acceptability of soy ogi, a balance must be struck between consistency, colour, taste and aroma. The process for the production of batch B (soy ogi prepared by souring soy flour and ogi slurry together for 24 h) provides cheap alternative technology for the production of soy ogi at cottage level. This would go a long way in enhancing the protein status of the consuming populace.

4. Conclusion

This work has shown that 'souring' soy flour and ogi slurry together for 24 h, followed by sedimenting and drying at 60 °C enhanced the qualities and acceptability of soy ogi, and this provides an alternative and a cheaper technology for producing soy ogi, at the cottage level.

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