Production and quality evaluation of tapoica substituted with fermented bambara flour

Sogo James Olatunde[1], Rachel Oluwatoyin Adetola[1], Adewumi Toyin Oyeyinka[2], and Samson Adeoye Oyeyinka[3]

1 – Ladoke Akintola University of Technology, Ogbomoso, Nigeria
2 – Kwara State University, Malete, Nigeria
3 – University of Ilorin, Ilorin, Nigeria

Keywords:

Tapoica
Bambara
Pasting
Fermentation
Cassava

Article history:

Received 07.12.2015
Received in revised form 16.01.2016
Accepted 24.03.2016

Corresponding author:

Samson Adeoye
E-mail:
sartf2001@yahoo.com

Abstract

Introduction. Tapioca grit is a partly gelatinized dried starch obtained from cassava. Fortifying tapioca with fermented bambara flour may be important to improve its nutritional value.

Materials and methods. The pasting, functional, nutritional and sensory properties of tapioca meal fortified with fermented bambara flour at varying levels of 10, 20, 30, 40 and 50% were investigated using standard methods.

Results and discussion. Cabohydrate was the major nutrient in the control tapioca (84%) and the fortified tapioca samples (64-80%). However, with increasing levels of fermented bambara flour, the protein contents of the tapioca meal progressively increased. The higher protein content of the fortified samples is expected since bambara is a good cource of protein. Fortified tapioca meals showed a slight decrease in water absorption capacity but significant increase in swelling power. Increased swelling of the tapioca meal could be due to the effect of heat which may have enhanced starch disruption. Further, the increase in protein content of the fortified samples may also have contributed to their higher swelling power. Peak viscosity of tapioca samples decreased with increasing levels of fermented bambara flour up to 30%, but thereafter increased. This behaviour was attributed to increase in starch content. Cyanide contents of the control tapioca and fortified amples (5.82-6.34 mg/kg) are within the acceptable limits in foods. Tapioca cake fortified with 10% fermented bambara flour compared favourably with the control sample in colour, taste, aroma, consistency and overall acceptability.

Conclusions. Acceptable tapioca meal with improved swelling power and nutritional value can be produced from cassava starch fortified with 10% fermented bambara flour.

Introduction

Cassava (*Manihot esculenta crantz*) is a major food crop in many parts of the world including Nigeria [1]. It is highly perishable, and must be processed immediately after harvest into highly stable products such as tapioca. Tapioca cake is a partly gelatinized dried starch obtained from cassava tubers which appears as flakes of irregular shaped granules [2]. It is consumed in various forms such as soaking and subsequently cooking in water to form meals. Sugar and milk may be added depending on individual preferences. In Africa, tapioca meal is consumed as a convenience food [2, 3]. Cooked tapioca is similar to oatmeal in appearance and taste [4]. However, tapioca meal is nutritionally inferior compared to oatmeal. Further, unlike oatmeal that is widely consumed all over the world, the consumption of tapioca meal seems to be limited to production areas of cassava. Nutritionally, tapioca contains substantially high amount of carbohydrate (78-96%) [4-6] in the form of starch. The protein content of tapioca is very low and may vary between 0.31 and 1.20% depending on the cassava variety [4-6]. Attempts by previous studies to improve the nutritional value of tapioca meal using defatted soybean flour [5] full fat soybean flour [4, 6], spices [7] coconut and banana pulp [8] have proved successful. The protein content of tapioca fortified with 50% full soybean flour was reportedly higher (approx. 37 times) compared to the unfortified control tapioca [6]. In a similar study, the addition of defatted soybean flour at 20% was found to substantially increase the protein content of tapioca meal. [5].

The addition of legume flour to tapioca meal may influence its physicochemical properties including pasting, functional and sensory properties. For instance, with increasing amount of full fat soybean flour, the swelling power of tapioca was reported to decrease significantly, while the water absorption increased [9]. The peak, breakdown, set back and final viscosities of the fortified tapioca meal also decreased with increasing amount of full fat soybean flour [9]. Further, the inclusion of full fat or defatted soybean flour to tapioca meal has been found to increase its overall acceptability [5, 6].

The use of many underutilized legumes including bambara in enriching staple foods is currently being encouraged. Many of these crops have the potential to reduce protein malnutrition especially among communities where their staple is majorly carbohydrate foods. Bambara groundnut (*Vigna subterranea*) is a protein-rich legume (19-25%) [10-13] similar to those of cowpea [14]. It is highly drought tolerant and well adapted to the changing climate. However, bambara remains a neglected and underutilised legume grown mainly for subsistence [11]. In Nigeria, bambara is traditionally used in making puddings and has been fermented for improved nutritional value [15-17]. The use of fermented bambara to fortify tapioca meal may be one of several ways to unlock the potential of this crop and enhance value addition. Therefore, the objective of this work was to enhance the nutritional quality especially protein content of tapioca meal using fermented bambara nut flour.

Materials and methods

Cassava tubers (sweet variety) were obtained from the research farm of Ladoke Akintola University of Technology, Ogbomoso. Bambara grains were purchased from a local market in Ogbomoso, while the innoculum (*R. Oligosporus*) was from the Indonesian Embassy, Lagos Nigeria. All other chemical used in this study were of food grade.

Fermentation of bambara groundnut. Bambara was fermented as described in the literature [18]. The fermented bambara grains were blanched for 20 min, drained and dried at 55°C for 24 h in hot air oven. The dried samples was milled, sieved and used immediately for fortification.

Preparation of the Tapioca cake. Tapioca cake was prepared as previously described [9]. Fermented bambara flour was added at 10%, 20%, 30%, 40% and 50% into the moist cassava starch prior to roasting. Tapioca without bambara flour served as the control.

Pasting and functional properties. The pasting properties of the tapioca mixes were determined using a RVA (3D New port Scientific, Australia). The functional properties including water absorption capacity, swelling capacity and solubility index were determined using previous methods [9]

Chemical composition. The pH of the tapioca cakes were determined using a pH meter, cyanide contents by Bradbury, Egan [19], while moisture, fat and ash contents were determined using standard methods [20]. Protein content was determined by Kjeldahl method (6.25 × N) and total carbohydrate was calculated by difference.

Sensory evaluation. Consumers acceptability of cooked tapioca meal was conducted using semi-trained panelist (N=50) consisting of students in the Department of Food Science and Engineering, Ladoke Akintola University of Technology, Nigeria. Most panelists were between the ages: 18–30 and these were regular consumers of tapioca meal. A 9 point hedonic scale (1- extremely dislike; 9- extremely like) was used.

Statistical analysis. All experiments were conducted in duplicate. Data were analysed using analysis of variance (ANOVA) and means were compared using Fischer's Least Significant Difference Test ($p<0.05$).

Results and discussion

Chemical composition. The major nutrient in unfortified tapioca control and the fortified samples was carbohydrate (Table 1). As expected, the protein content of the tapioca meal progressively increased with increase in the level of the fermented bambara flour (Table 1). Similarly, the fat, ash, crude fibre and moisture content of the tapioca meal increased significantly ($p<0.05$) following the addition of fermented bambara nut flour. The protein contents of tapioca meal containing 50% fermented bambara nut flour was substantially higher (approx. 10 times) compared to the tapioca control. Bambara groundnut is a good source of protein and its inclusion into tapioca meal expectedly increased the protein content of the tapioca mixes. Previous studies similarly reported improvement in the nutritional value of tapioca meal fortified with full fat or defatted soybean flour [5, 6]. However, the protein content (12.07%) obtained in this study for tapioca meal fortified with 50% fermented bambara flour was slightly lower (approx. 1.6 times) compared to those previously reported for tapioca meal fortified with 50% full fat soybean flour [6]. Further, the fat content reported by these authors for the same sample was almost double the fat content in this study. Bambara groundnut is a pulse while soybean is an oil seed with higher protein and fat contents. Thus, the difference in protein and fat contents may be attributed to the higher protein and fat content in soybean compared to those in bambara flour.

Table1

Proximate composition of tapioca-bambara flour mixes (%)

Tapioca	Bambara	Moisture	Protein	Fat	Ash	Crude fiber	CHO
100	0	10.47±0.00^{b}	1.24±0.01^{a}	0.65±0.01^{a}	1.85±0.01^{a}	1.77±0.00^{d}	84.00±0.01^{f}
90	10	10.33±0.01^{a}	3.95±0.01^{b}	1.35±0.01^{b}	2.43±0.01^{b}	1.81±0.01^{b}	80.10±0.02^{e}
80	20	10.47±0.01^{b}	4.75±0.15^{c}	3.76±0.01^{c}	2.62±0.01^{c}	2.12±0.01^{c}	76.26±0.12^{d}
70	30	10.55±0.01^{c}	7.63±0.01^{d}	5.85±0.01^{d}	2.75±0.01^{d}	2.25±0.01^{d}	70.95±0.04^{c}
60	40	10.62±0.01^{d}	10.55±0.00^{e}	6.54±0.01^{e}	2.95±0.01^{e}	2.36±0.01^{e}	66.96±0.02^{b}
50	50	10.54±0.01^{c}	12.07±0.01^{f}	7.46±0.02^{f}	3.11±0.02^{f}	2.41±0.01^{f}	64.39±0.03^{a}

Mean ± SD. Mean with the same superscript within a column are not significantly different ($p<0.05$).

pH and cyanide contents. The tapioca control had pH value slightly lower compared to the tapioca samples containing fermented bambara flour (Fig. 1). However, the difference was not significant. The cyanide contents of tapioca samples varied between 5.82 and 6.34 mg/kg for tapioca meal with 50% fermented bambara flour and the control sample respectively (Fig. 1). These values are within the range previously reported [6]. The cyanide content of the tapioca cake decreased slightly with increase in fermented bambara flour. This is expected since the tapioca which is the source of cyanide in the formulation reduced with increasing concentration of the fermented bambara flour. Tapioca sample containing 50% fermented bambara flour showed approximately 8.2% reduction in cyanide content.

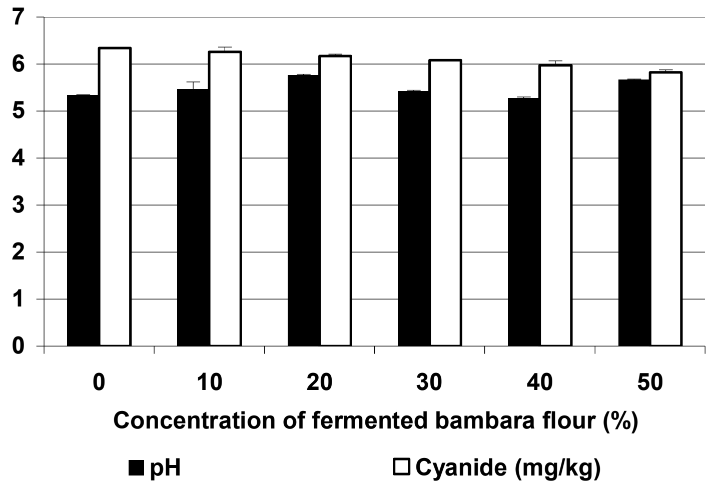

Fig 1. pH and Cyanide content of fortified tapioca
Error bars indicate n=2

Functional properties. Water abortion capacity of tapioca meal showed a minimal decrease with increasing concentration of fermented bambara flour (Fig. 2).

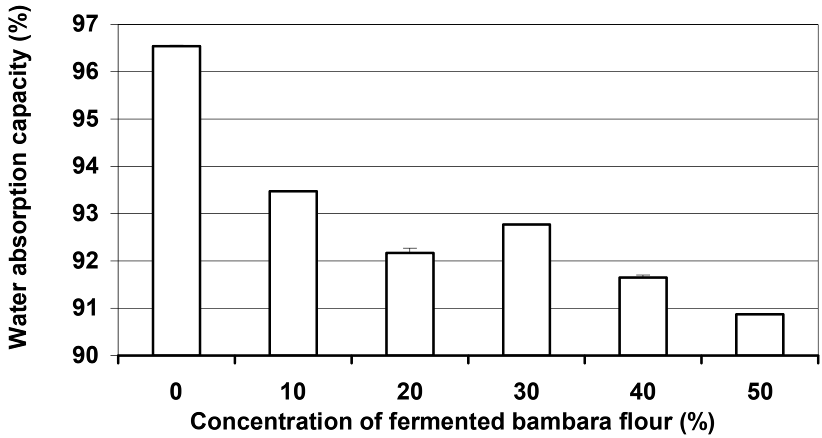

Fig 2. Water absorption capacity of fortified tapioca
Error bars indicate n=2

However, when the tapioca mixes were heated, they showed tangible swelling (Fig. 3). The applied heat may have enhanced starch disruption and subsequent leaching of amylose into the paste. Further, the high protein content of the fortified tapioca (Table 1) could also have contributed to the increased swelling power. Otegbayo, [9] working with tapioca meal reported a reduction in swelling power following the addition of full fat soybean. These authors attributed the reduction in swelling power to possible formation of amylose-lipid complex, which has been found to inhibit swelling in starch [21, 22]. However, in this study, fermented bambara which was used to fortify the tapioca cake are not rich sources of fats when compared to soybean. The lower fats contents of the bambara may have accounted for the relatively higher swelling power of the tapioca mixes when compared to those reported by Otegbayo, [9]. The solubility profile of the tapioca mix fortified with fermented bambara flour followed a similar trend as observed for swelling power (Fig. 3).

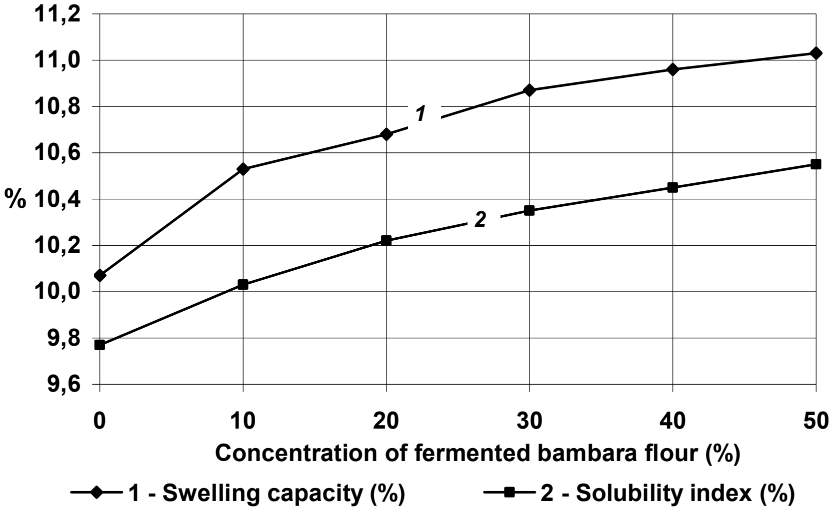

Fig 3. Swelling capacity and solubility index

Pasting. With the exception of pasting temperature (approx. 81°C) which appear similar, other pasting properties of tapioca mixes were significantly ($p<0.05$) influenced by the added fermented bambara flour (Table 2). In general pasting time increased with increasing levels of fermented bambara flour (Data not shown). The peak viscosity also referred to as swelling peak of the control tapioca (163.16 RVU) decreased consistently with increasing level of fermented bambara flour up to 10%, 20% and 30%. However, the peak viscosity tends to increase when the concentration of fermented bambara flour in the tapioca meal reached between 40 and 50%. The increase in peak viscosity may be attributed to high starch content [23, 24]. This seems plausible since the bulk of carbohydrate in bambara grain is starch [11]. The high peak viscosity displayed by 50% substitution implies that the tapioca may be suitable for products requiring high gel strength and elasticity [25]. Previous research on tapioca meal fortified with 50% full fat soybean flour similarly reported reduction in peak viscosity of tapioca [9]. These authors reported approximately 53% reduction in peak viscosity for tapioca fortified with 25% full fat soya bean. In this study, with similar concentration (20%) of added fermented bambara flour, the reduction in peak viscosity was approximately 22%. This value is much lower compared to values reported by the authors working with tapioca meal fortified with full fat soybean [9]. The difference in peak viscosity reduction may be attributed to the higher fat content of soya bean compared to that of bambara flour. This seems plausible since lipids may interact with starch restricting granule hydration and swelling [26]. In addition, the fermentation process may have altered the composition of bambara groundnut flour.

The breakdown viscosity of the tapioca meal varied from 28.16 to 84.25 RVU for the control tapioca and tapioca with 50% fermented bambara flour respectively. High breakdown viscosity is generally associated with poor resistance to thermal disruption. Thus, the higher breakdown viscosities of the fortified tapioca mix suggest that these samples will show higher disintegration during heating.

The control tapioca meal showed higher tendency for starch retrogradation as indicated by its higher setback value of 108.59 RVU compared to the fortified tapioca (40.08-102.96 RVU). Many other authors have reported the reduction in setback value of tapioca fortified with legumes [9].

Final viscosity ranged from 124.31-243.28 RVU for the control tapioca and tapioca with 50% fermented bambara flour respectively. The variation in the final viscosity might be due to the re-association of starch molecules in the samples during cooling.

Table 2

Pasting properties of tapioca-bambara flour mixes

Tapioca	Bambara	PV (RVU)	BDV (RVU)	FV (RVU)	SBV (RVU)	PT (°C)
100	0	163.16±0.01^{c}	28.16±0.01^{b}	243.28±0.42^{f}	108.59±0.02^{e}	80.42±0.01^{b}
90	10	100.48±0.13^{a}	40.91±0.01^{c}	170.07±0.01^{b}	102.42±0.01^{d}	82.26±0.01^{d}
80	20	128.11±0.56^{a}	41.07±0.01^{d}	186.90±0.67^{c}	98.95±0.08^{c}	81.45±0.01^{c}
70	30	128.51±0.02^{b}	22.08±0.00^{a}	229.34±0.01^{d}	102.96±0.06^{f}	80.63±0.04^{b}
60	40	221.59±0.67^{a}	81.66±0.02^{f}	233.01±0.02^{a}	92.56±0.01^{a}	80.75±0.57^{a}
50	50	239.35±0.67^{e}	84.25±0.00^{b}	124.31±0.02^{a}	40.08±0.01^{a}	79.60±0.57^{a}

Mean ± SD. Mean with the same superscript within a column are not significantly different ($p<0.05$).
PV: Peak viscosity, BDV: Breakdown viscosity, FV: Final viscosity, SBV: Setback viscosity, PT: Pasting temperature

Sensory evaluation. In general, tapioca meals fortified with fermented bambara flour had lower ratings compared to the control sample (Table 3). Tapioca cake fortified with 10% fermented bambara flour compared favourably with the control sample in colour, taste, aroma, consistency and overall acceptability. At higher concentrations (>10%) of fermented bambara flour the ratings for the tapioca meal was low when compared to the control. However, since the objective of this study was to improve the nutritional value of the tapioca meal, there may be a need to add some food additives especially to improve the taste. The colour of tapioca is generally accepted to be white in colour so the low rating recorded for the colour of the fortified samples is expected. Previous studies similarly reported lower ratings for aroma when tapioca was fortified with full fat soybean flour [6]. These authors, however, reported higher ratings for taste and overall acceptability, which may be attributed to the higher oil content of the soybean flour used for fortification.

Table 3

Mean sensory scores of tapioca mixes

Tapioca	Bambara	Colour	Taste	Aroma	Consistency	Overall acceptability
100	0	8.46^{cd}	8.40^{cd}	8.20^{cd}	8.60^{c}	8.88^{d}
90	10	7.60^{c}	7.46^{c}	7.53^{c}	8.13^{c}	8.00^{d}
80	20	5.80^{a}	6.40^{b}	5.66^{a}	6.86^{b}	6.00^{b}
70	30	7.13^{c}	5.80^{a}	6.26^{b}	5.73^{a}	6.60^{c}
60	40	5.26^{a}	4.66^{a}	5.20^{a}	5.66^{a}	4.60^{a}
50	50	6.33^{b}	5.40^{a}	6.06^{b}	5.26^{a}	5.46^{b}

Mean with the same superscript within a column are not significantly different ($p<0.05$).

Conclusion

The inclusion of fermented bambara flour improve the swelling power and nutritional value of tapioca cake. Pasting properties of tapioca were significantly affected by fermented bambara flour. Acceptable tapioca meal can be produced using 10% fermented bambara flour. However, higher amounts of fermented bambara flour up to 50% can be used provided that additives to enhance taste and aroma will be added. Fortified tapioca meal could serve as valuable intervention to combat Protein energy malnutrition syndrome in Africa.

References

1. Samuel F., B. Otegbayo and T. Alalade (2012), Nutrient and Anti-nutrient content of soy-enriched tapioca, *Food and Nutrition Sciences*, 2012.
2. Adebowale A.R., L. Sanni S. Awonorin I. Daniel and A. Kuye (2007), Effect of cassava varieties on the sorption isotherm of tapioca grits, *International Journal of Food Science and Technology*, 42(4), pp. 448–452.
3. Falade K.O. and J. Akingbala (2008), Improved nutrition and national development through the utilization of cassava in baked foods, *Using Food Science and Technology to Improve Nutrition and Promote National Development, International Union of Food Science & Technology*, pp. 1–12.

4. Kolapo A.L. and Sanni M.O. (2009), A comparative evaluation of the macronutrient and micronutrient profiles of soybean-fortified gari and tapioca, *Food and Nutrition Bulletin*, 30(1), pp. 90–94.
5. Balogun M., Karim O., Kolawole F., and Solarin A., (2012), Quality Attributes of Tapioca Meal Fortified With Defatted Soy Flour, *Agrosearch*, 12(1), pp. 61–68.
6. Folake O.S., Bolanle O.O., and Titilope A. (2012), Nutrient and Anti-nutrient content of soy-enriched tapioca, *Food and Nutrition Sciences*.
7. Okwu D.E. (2001), Improving the nutritive value of cassava tapioca meal with local spices, *Journal of Nutraceuticals, Functional and Medical Foods*, 3(4), pp. 43–51.
8. Obadina A., Oyewole O., and Olaleye A., (2010), Development and evaluation of fortified tapioca meal with coconut and banana pulp, *Nigerian Food Journal*, 28(2).
9. Otegbayo B., Samuel F., and Alalade T. (2013), Functional properties of soy-enriched tapioca, *African Journal of Biotechnology*, 12(22), pp. 3583.
10. Kaptso K., Njintang Y., Nguemtchouin M., Scher J., Hounhouigan J., and Mbofung C. (2014), Physicochemical and micro-structural properties of flours, starch and proteins from two varieties of legumes: bambara groundnut (*Vigna subterranea*), *Journal of Food Science and Technology*, 52(8), pp. 4915–4924.
11. Oyeyinka S.A., Singh S., Adebola P.O., Gerrano A.S., and Amonsou E.O. (2015), Physicochemical properties of starches with variable amylose contents extracted from bambara groundnut genotypes, *Carbohydrate Polymers*, 133, pp. 171–178.
12. Onimawo I., Momoh A., and Usman A. (1998), Proximate composition and functional properties of four cultivars of bambara groundnut (*Voandezeia subterranea*), *Plant Foods for Human Nutrition*, 53(2), pp. 153–158.
13. Sirivongpaisal P. (2008), Structure and functional properties of starch and flour from bambarra groundnut, *Sonklanakarin Journal of Science and Technology*, 30(1), pp. 51–56.
14. Oyeyinka S., Oyeyinka A., Karim O., Kayode R., Balogun M., and Balogun O., (2013), Quality attributes of weevils (*Callosobruchus maculatus*) infested cowpea (*Vigna unguiculat*a) products, *Nigeria Journa of Agriculture Food and Environment,* 9(3), pp. 16–22.
15. Amadi E., Barimalaa I., and Omosigho J. (1999), Influence of temperature on the fermentation of bambara groundnut (*Vigna subterranea*) to produce a dawadawa-type product, *Plant Foods for Human Nutrition*, 54(1), pp. 13–20.
16. Olanipekun B., Otunola E., Adejuyitan J., and Adeyanju J., (2012), Proximate and fatty acid composition of bambara groundnut (*Voandzeia subterranea* L.) as influenced by fermentation with a combination of Rhizopus oligosporus and R. nigricans, *Journal of Science and Technology*, 2, pp. 77–87.
17. Olanipekun B., Otunola E. and Oyelade O., (2015), Effect of Fermentation on Antinutritional Factors and in Vitro Protein Digestibility of Bambara Nut (*Voandzeia subterranea* L.), *Food Science and Quality Management*, 39, pp. 98–110.
18. Olanipekun B., Otunola E., Adelakun O., and Oyelade O., (2009), Effect of fermentation with Rhizopus oligosporus on some physico-chemical properties of starch extracts from soybean flour, *Food and Chemical Toxicology*, 47(7), pp. 1401–1405.
19. Bradbury J., Egan S., and Lynch M., (1991), Analysis of cyanide in cassava using acid hydrolysis of cyanogenic glucosides, *Journal of the Science of Food and Agriculture*, 55(2), pp. 277–290
20. AOAC, (2000), Official methods of analysis (17th ed.), *Washington DC: Association of official Analytical Chemists*.
21. Tester R.F. and Morrison W.R. (1990), Swelling and gelatinization of cereal starches. I. Effects of amylopectin, amylose, and lipids, *Cereal Chemistry*, 67(6), pp. 551–557.
22. Tang M.C. and Copeland L. (2007), Analysis of complexes between lipids and wheat starch, *Carbohydrate Polymers*, 67(1), pp. 80–85.
23. Osungbaro T.O. (1990), Effect of fermentation period on amylose content and textural characteristics of “Ogi”(a fermented maize porridge), *Journal of Fermentation and Bioengineering*, 70(1), pp. 22–25.
24. Osungbaro T.O. (1990), Effect of differences in variety and dry milling of maize on textural characteristics of ogi (fermented maize porridge) and agidi (fermented maize meal), *Journal of the Science of Food and Agriculture*, 52(1), pp. 1–11.
25. Odedeji J. and Adeleke R. (2010), Pasting characteristics of wheat and sweet potato flour blends, *Pakistan Journal of Nutrition*, 9(6), pp. 555–557.
26. Kim C. and Walker C. (1992), Changes in starch pasting properties due to sugars and emulsifiers as determined by viscosity measurement, *Journal of Food Science*, 57(4), pp. 1009–1013.