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Comparative proximate composition and functional properties of flour and composites from breadfruit (*Artocarpus altilis)* (Parkinson) Fosberg

Awolola, G.V., Oluwaniyi [*], O. O., Aremu, T. A. and Oladapo, B. O.

Department of Industrial Chemistry, University of Ilorin, Ilorin, Nigeria.

Abstract

Artocarpus altilis commonly known as breadfruit, its usage is limited due to the high moisture content of the fresh fruit thus making storage difficult, hence the need for conversion into more storable product with increased versatility. *A. altilis* was processed to obtain breadfruit flour and the flour produced was mixed in different ratio (100:0; 80:20; 60:40; 40:60; 20:80; 0:100) with wheat flour to obtain composites. The proximate and functional characteristics of the composites were evaluated and compared with the whole (breadfruit) flour and wheat flour. The results of the proximate analysis showed that the fiber, ash and moisture contents increased significantly (P<0.05) with increase in the breadfruit flour substitution while the protein content increase was not significant. Wheat flour has the highest carbohydrate, total energy and fat contents and the values decreased significantly (P<0.05) with increase in breadfruit flour substitution. The bulk density, solubility and the water binding capacity also decreased with increase in the breadfruit flour substitution while the swelling power increased significantly (P<0.05). These findings indicate that breadfruit is a potential source of highly nutritious flour and can possibly serve as an alternate source of flour for diabetic patients and for individuals that are sensitive to wheat flour.

Keywords: *Artocarpus altilis,* breadfruit flour, substitution, proximate analysis, functional characteristics.

1. Introduction

Artocarpus altilis, otherwise known as breadfruit, is a traditional starch-rich crop belonging to the Mulbery family (Moraceae). It is a tropical fruit and the tree produces fruit twice in a year, from March to June and from July to September with some fruiting throughout the year (Zerega, *et al.,* 2006). The genus *Artocarpus* (Moraceae) comprises of approximately 50 species and is widely distributed in tropical and subtropical regions (Jones *et al.,* 2011). Among

*Corresponding Author: Oluwaniyi, O. O.
Email: laraoluwaniyi@yahoo.com

the Yorubas of South-West Nigeria, breadfruit is known as "*gbere*" while it is "*ukwa*" to the Ibos of South Eastern Nigeria (Ragone, 2006a).

The breadfruit is usually eaten boiled, roasted or fried, having a potato-like taste, and is used to prepare several delicacies in Nigeria including breadfruit porridge and pounded breadfruit (which is taken with soup like pounded yam) (Morton 1987). Its high carbohydrate content also suggests that it can be made into flour and be used to replace wheat flour in baking and confectionaries (Adebayo *et al*., 2008; Adebowale *et al*., 2005). *Artocarpus camansi* (breadnut) is a close relative of the breadfruit and the seeds can be roasted, canned or processed into soup, paste, butter flour or oil (Ragone, 2006b).

Apart from the nutritional benefits derived from breadfruit, extracts and isolated compounds from various parts of the plant have been reported to be biologically active (Amarasinghe *et al.,* 2007; Boonlaksiri *et al*., 2000; Jagtap and Bapat, 2010: Somashekhar *et al.,* 2013). In spite of the nutritional and health/ medicinal potentials of the breadfruit, there are only a few scientific information available on the utilization of breadfruit thus it remains a grossly under-utilized plant.

This work therefore sets out to explore the possibility of preparing composites of wheat and breadfruit flour and characterizing the composites. This will hopefully lead to an increase in the usefulness and consumption of breadfruit.

2. Materials and Methods

Collection and processing of Breadfruit

The fruits of breadfruit were obtained from Flower Garden Area, G.R.A. Ilorin, Kwara State, Nigeria. The breadfruit sample was washed, sliced, air-dried and pulverized. The pulverized sample was sieved to obtain a fine sample of breadfruit flour. Wheat flour was purchased from Ipata market, Ilorin, Kwara State. Nigeria. The samples were kept in air-tight containers prior to further analysis.

Preparation of the Breadfruit flour: wheat flour sample composite

Breadfruit flour and wheat flour were mixed in different ratio w/w (0:100, 20:80, 40:60, 60:40, 80:20 and 100:0). The composites obtained were stored in polythene bags for further analysis.

Proximate Analysis

Standard methods of Association of Official Analytical Chemists (AOAC, 2000) were used to determine the moisture content, ash content, crude fat content, crude protein content, carbohydrate content of the fruit, flour and composites. All determinations were carried out in triplicates. Moisture content was determined by heating 2 g of sample to a constant weight in a crucible placed in an oven and maintained at 105 °C. Ash was determined by the total incineration of 2 g sample in a muffle furnace maintained at 550 °C for 5 – 6 hours. Crude fat was obtained by exhaustively extracting 2 g of sample in a Soxhlet extractor for 4 hours using n-hexane as the extractant. Protein content was determined by the Kjeldahl method and calculated by multiplying the nitrogen content obtained from the digestion, distillation and titration of 2 g sample by a factor of 6.25. Crude fiber determination was done by digesting 2 g of sample successively with H_2SO_4 and NaOH and then incinerating the residue in a muffle furnace at 550 °C for 5 hours. Total carbohydrate content was estimated by subtracting the sum of percentages of all the nutrients already determined from 100 (AOAC, 2000).

Total Energy

The gross food energy was estimated according to the method of Osborne and Voogt, (1978) using the following equation:

$$FE = (\%\ C_P \times 4) + (\%\ CHO \times 4) + (\%Fat \times 9), \quad (1)$$

where FE is Food Energy (in gm calories), C_p is crude protein, CHO is Carbohydrates.

Glutelin determination

Breadfruit flour-wheat flour defatting

Breadfruit flour-wheat flour mixture with particle size <0.5 mm was obtained and defatted with n-hexane at a solid/liquid ratio of 1:10 (w/v) for 2 hrs at room temperature in three cycles. The defatted flour was placed in a fume hood for 24 hrs to evaporate residual n-hexane.

Protein fractionation and quantification (Tounkara *et al*., 2013)

Proteins were extracted from the composite based on their solubility at room temperature (25°C) using water, 5% NaCl, 70% ethanol and 0.1 M NaOH. The defatted flour was extracted with 50 ml distilled water with stirring for 4 hours and centrifuged at 3,000 rpm x g for 30 min to obtain the albumin fraction (supernatant). The residue obtained after this step was extracted with 50 ml of 5% NaCl to obtain the globulin fraction. Thereafter the residue was extracted with 50 ml of 0.1 M NaOH for 1 hr to obtain the glutelin fraction. All the extractions were done in duplicates. The glutelin fraction was then precipitated at pH 3.5 and washed with distilled water. The determination of protein in the fraction was done using a micro-Kjeldahl method (AOAC, 2000).

Determination of the Functional properties

Water-binding capacity (WBC) determination

Water binding capacity was determined using the modified method of Soni *et al*. (1985). 2.5 g of each sample was suspended in 30 ml distilled water at 30 °C in a centrifuge tube, stirred for 30 min intermittently and then centrifuged at 3000 rpm for 10 min. The supernatant was decanted and the weight of the gel formed was recorded. The water binding capacity (WBC) was then calculated as:

$$WBC = \frac{Gram\ bound\ Water\ (g)}{Weight\ of\ the\ Sample(g)} \times 100.$$

Bulk density determination

The bulk density of the flour was determined by placing 2 g of sample in a 50-mL graduated cylinder with gentle uniform tapping during filling. The volume of the flour was measured. The bulk density was calculated as mass by volume in grams per milliliter (g mL^{-1}). The average of three determinations is reported (Medcalf and Gilles, 1965):

$$\text{Percentage} = \frac{Mass\ of\ the\ Sample\ (g)}{Volume\ of\ the\ Sample\ (ml)} \times 100.$$

Solubility and swelling power determination

2 g of the sample was placed into a pre-weighed centrifuge tube. 40.0 ml of distilled water was then added and stirred. The mixture was placed on a water bath thermostatically controlled at 85 °C with continuous stirring for 30 min, cooled to room temperature and then centrifuged at 2,200 rpm for 15 min. The supernatant was poured into a pre-weighed crucible and then placed in the oven to evaporate. The solid residue in the crucible was weighed and the difference in weight calculated as percentage solubility. The paste in the tube was then weighed and the swelling power determined by the following equation (Leach *et al.*, 1959):

$$\text{Percentage Water Solubility Index} = \frac{Weight\ of\ Residue\ (g)}{Weight\ of\ Sample\ (g)} \times 100,$$

$$\text{Percentage Swelling Power} = \frac{Weight\ of\ the\ Wet\ Mass\ of\ Sediment\ (g)}{Weight\ of\ Sample\ (g)} \times 100.$$

Statistical analysis

The statistical significance of the observed differences among the means of triplicate readings of experimental results was evaluated with the analysis of variance (ANOVA), while means were separated using Duncan's Range Test at P< 0.05 using the statistical package for the social sciences, IBM SPSS statistics 20.

3. Results and Discussion

Proximate analysis

The results of the proximate analysis of the samples are presented in Table 1.

Table 1: Proximate composition of the flour blends

Parameters %	A	B	C	D	E	F
Protein	7.448±0.415[a]	7.847±0.115[a]	7.914±0.755[a]	7.980±0.345[a]	8.047±0.230[a]	8.113±0.502[a]
Crude fibre	0.183±0.104[a]	0.217±0.126[ab]	0.433±0.126[bc]	0.467±0.076[c]	0.650±0.050[c]	1.067±0.225[d]
Moisture	11.350±0.132[a]	12.383±0.153[b]	12.550±0.180[bc]	12.717±0.104[c]	12.450±0.161[bc]	12.550±0.229[bc]
Fat content	5.150±0.050[c]	5.067±0.076[c]	4.917±0.058[b]	4.850±0.050[ab]	4.833±0.029[ab]	4.767±0.029[a]
Ash	1.033±0.076[a]	1.183±0126[ab]	1.350±0.132[bc]	1.483±0.104[c]	1.683±0.104[d]	1.683±0.076[d]
Carbohydrate	74.702±0.380[c]	73.286±0.375[b]	72.870±1.115[ab]	72.520±O.345[ab]	72.170±0.304[b]	71.837±0.201[a]
Total Energy	374.800±0.361[e]	370.283±0.851[d]	367.083±1.960[c]	365.500±0.520[bc]	364.217±0.362[ab]	362.550±1.249[a]
Dry matter	88.500±0.132[c]	87.617±0.153[b]	87.450±0.180[ab]	87.283±0.104[a]	87.367±0.160[ab]	87.450±0.229[ab]
Glutelin	2.860±0.305[e]	2.727±0.230[cd]	2.394±0.200[cd]	2.261±0.230[c]	1.330±0.305[b]	0.732±0.305[a]

Breadfruit flour=BF; Wheat flour=WF; A=100WF:0BF; B=80WF:20BF; C=60WF:40BF; D=40WF:60BF; E=20WF:80BF; F=0WF:100BF. Data are average of triplicate values ± SD. Mean value with different superscript in the same row are significantly different ($P < 0.05$).

Moisture content of foods gives an indication of the available dry matter. A significant difference ($P < 0.05$) was observed in the moisture content values between whole wheat flour and other variants but no significant difference (P >0.05) among the four intermediate composites and breadfruit flour (Table 1). Moisture content results ranged between 11.350 ± 0.132% - 12.550±0.229%, increasing as the level of substitution with breadfruit flour increases. This increase in moisture content is an indication that there will be a reduction in the shelf-life and storage potentials of the breadfruit flour and composites. Higher moisture content in flours have been reported to enhance spoilage through creating favorable conditions for microbial proliferation as well as enhance enzymatic deterioration (Oduro *et al.,* 2009). However, the moisture contents of the flours were within acceptable levels (10-14%) for flours (Butt *et al.,* 2004). The difference in the values obtained were minimal, showing no significant difference (P<0.05) among the composites and may not have adverse effect on the quality attributes of the products and the value of the moisture content can be decreased by application of a better drying technique to remove more moisture from the raw breadfruit.

The ash contents of the whole flour and flour blends were significantly different. The ash content increased gradually as the percentage breadfruit in the blends increased. This implies that breadfruit is higher in minerals than wheat hence the more breadfruit flour in the blend, the higher the mineral content. This is in agreement with the previous findings by Morton (1987) and Ragone (1997). Therefore, increase in the substitution of breadfruit flour in wheat flour will improve the nutritive value of the breadfruit flour blend especially the mineral content.

Fat content varied significantly among all the flour samples with a gradual reduction being observed as the breadfruit flour component increases. The values ranged from 4.767±0.029 % – 5.150±0.050% (Table 1). Fat plays a significant role in the shelf life of food products and as such relatively high fat content could be undesirable in baked food products. This is because fat can promote rancidity in foods, leading to development of unpleasant and odorous constituents (Ihekoronye and Ngoddy, 1985), thus the reduced fat content of the breadfruit flour is desirable.

Plant proteins are very important in human nutrition especially in countries that are less privileged and is an important component that determines the rheological properties of composite flours. The protein contents of the samples increase slightly with increase in the level of breadfruit substitution and the values ranged from 7.448±0.415 % – 8.113±0.502 % (Table 1). The increment is minimal and there were no significant differences ($P > 0.05$) in the protein contents of the samples. This was similar to the work of Bhandary and Amadi (2004). Proteins are one of the macronutrients and it is an alternate energy source when other energy sources are in short supply (Bailey, 2008). Additionally, food protein is needed to make vital hormones, important brain chemicals, antibodies, digestive enzymes, and necessary elements for the manufacture of DNA. Some proteins are involved in structural support, while others are involved in bodily movement, or in defense against germs (Bailey, 2008). The prepared breadfruit flour blends can be considered a good source of protein because they provide more caloric value of protein than the wheat flour.

The fiber contents of all samples ranged from 0.183±0.104 % - 1.067±0.225 %. The fiber contents for the various samples varied significantly ($P < 0.05$). Breadfruit has relatively higher crude fiber than wheat and this could explain the result obtained for the different blends of flour. This observation is in support of the findings of Olaoye *et al*. (2007). Fiber cleanses the digestive tract by removing potential carcinogens from the body and prevents the absorption of excess cholesterol. Additionally, fiber adds bulk to the diet and prevents the intake of excess starchy food (Mensah *et al.,* 2008). The adequate intake of dietary fiber can therefore lower the serum cholesterol level, risk of coronary heart disease, hypertension, constipation, diabetes as well as colon and breast cancer (Ishida *et al.,* 2000; Rao and Newmark, 1998).

Carbohydrates are essential for the maintenance of life in both plants and animals and also provide raw materials for many industries. The carbohydrate content of the samples decreased significantly ($P < 0.05$) with increase in breadfruit flour. 100% wheat flour had the highest percentage, although the differences between the other blends were not quite appreciable. High percentage of carbohydrate content in all the flour blends suggests that the blends are a good source of energy. This is similar to the work by Oladunjoye *et al.* (2010) who established that mature breadfruit is a good source of carbohydrate with starch constituting more than 60% of the total carbohydrate.

The total energy content of the blends decreased from the wheat flour to the breadfruit flour significantly ($P < 0.05$). This reduction in total energy is attributed to the decrease in fat and carbohydrate contents since these are 2 of the 3 contributors to the calorific value of foods. Gluten is responsible for the elasticity and extensibility of the flour dough and is a mixture of prolamins and glutelins. The results indicated that the glutelin content decreased significantly ($P>0.05$) with increase in breadfruit flour. Although the breadfruit flour may not produce a flour of high quality in terms of extensibility and elasticity, however the breadfruit flour blend will be highly recommended for individuals that are allergic to high gluten in food.

Functional properties

The functional properties of the samples are presented in Table 2. The bulk density decreased with increase in the level of breadfruit substitution. Wheat flour has the highest bulk density and the value differed significantly ($P<0.05$) from the value obtained for breadfruit flour (Table 2). The bulk density is a function of particle size and as such particle size is inversely proportional to bulk density (Anandharamakrishnan, 2017). Particle size differences may be the cause of variations in bulk density of the flours. In addition, particle size influences the package design and could be used in determining the type of package material required. Higher bulk density is desirable since it offers greater packaging advantage as greater quantity of flour can be packed within a constant volume. The bulk density of the flours could be used to determine their handling requirement, because it is the function of mass and volume. Bulk density is also important in infant feeding where less bulk is desirable. Since the whole breadfruit flour was the least dense (Table 2), it would occupy greater space and therefore would require more packaging material per unit weight and so could have high packaging cost; however, breadfruit flour would be easier to transport as it is lighter. The low bulk density of breadfruit flour could be an advantage in the use of the flour for preparation of complementary foods.

Table 2: Results of functional properties of the flour blends.

Properties (g/ml)	A	B	C	D	E	F
Bulk density	0.725±0.029[c]	0.675±0.026[bc]	0.669±0.045[bc]	0.645±0.000[ab]	0.620±0.041[ab]	0.600±0.010[a]
Swelling power	18.733±2.372[a]	21.217±0.379[b]	23.333±0.451[bc]	24.750±0.755[c]	28.200±1.805[d]	29.967±0.569[d]
Solubility	20.817±0.284[f]	19.683±0.257[e]	17.333±0.293[d]	14.617±0.306[c]	12.367±0.660[b]	9.717±0.351[a]
Water absorption capacity	115.783±9.364[e]	111.050±8.298[cd]	105.967±6.562[cd]	98.517±6.005[bc]	90.317±6.137[ab]	79.567±7.061[a]

Breadfruit flour=BF; Wheat flour=WF; A=100WF:0BF; B=80WF:20BF; C=60WF:40BF; D=40WF:60BF; E=20WF:80BF; F=0WF:100BF. Data are average of triplicate ± SD. Mean values with different superscripts in the same column are significantly different ($P < 0.05$)

The solubility of the flours varied between 9.717±0.351 and 20.817±0.284% with drastic, significant reduction in solubility as the breadfruit flour component increases. On the other hand, the swelling power of the flours varied between 18.733±2.372 and 29.967±0.569% with an increase in the swelling power as the percentage breadfruit flour increases. The high swelling power suggests that breadfruit flours could be useful in food systems where swelling is required such as in snack production and bakery.

The water binding capacity of the blends decreased from the wheat flour to the breadfruit flour significantly ($P < 0.05$). The whole wheat flour has the highest water binding capacity of 115.783±9.364% and the least value was recorded in breadfruit flour 79.567±7.061%. Water absorption capacity represents the ability of the products to associate with water under conditions when water is limiting such as dough and pastes (Giami *et al.*, 1992). The result of this study therefore suggests that breadfruit flour and its composites may not be very desirable in which hydration is required to improve handling features.

4. Conclusion

This study has shown that breadfruit can make good flour and that it contained high levels of protein, ash, minerals and fibres. In addition, breadfruit flour influenced the chemical composition and functional properties of the wheat-breadfruit flour blends which could be an advantage for industrial use. It has also shown that combination of wheat flour with breadfruit flour would greatly improve the fibre content and protein nutritional quality of wheat flour. This would be of nutritional importance in most developing countries such as Nigeria, where people can hardly afford high proteinous foods because of their costs. The low glutelin content in the breadfruit flour blend may be a disadvantage because gluten improves the toughness and elasticity of baked products, thus, breadfruit may not produce excellent baked products as compared with wheat flour; however, the flour is highly recommended for people that are allergic or sensitive to gluten. The high crude fiber content of breadfruit flour and its composites is also highly desirable nutritionally because crude fibre has been reported to reduce symptoms of chronic constipation, heart diseases associated with high cholesterol, diverticular disease and risk of colon cancer. Thus, breadfruit flour may be especially beneficial to diabetic patients who need to reduce their carbohydrate intake and increase their crude fibre intake.

References

Adebayo, S. A., Brown-Myrie, E. and Itiola, O. A. (2008): Comparative disintegrant activities of breadfruit starch and official corn starch. *Powder Technology*. **181**(2), 98-102.

Adebowale, K. O., Olu-Owolabi, B. I., Olawunmi, E. K. and Lawal, O. S. (2005): Functional properties of native, physically and chemically modified breadfruit (*Artocarpus altilis*) starch. *Industrial Crops and Products*. **21**(3), 343-351.

Amarasinghe, N. R., Jayasinghe, L., Noriyuki, H. and Yoshinori, F. (2007): Chemical constituents of the fruits of *Artocarpus altilis*. *Biochemical Systematics and Ecology*. **36**, 323-325.

Anandharamakrishnan, C. (2017): *Handbook of Drying for Dairy Products*. Wiley- Blackwell, UK.

AOAC. (2000): *Official Method of Analysis of AOAC*. 17th edition. Association of Official Analytical Communities, Arlington, VA, U.S.A.

Bailey R. (2008): The Role of Proteins in the Body. About.com Guide to Biology.

Bhandary, C. S and Amadi, E. C. (2004): Proximate Composition of Fortified pasta from blends of the African breadfruit (*Treculia africana*) Flour and Wheat (*Tritiumdurum*) Semolina. In: Proceedings of the 29th Annual Conference of Nigerian Institute of Food Science and Tech. (NIFST). 56.

Boonlaksiri, C., Oonanant, W., Kongsaeree, P., Kittakooz, P., Tanticharoen, M. and Thebtaranonth, Y. (2000): An antimalarial stilbene from *Artocarpus integer*. *Phytochemistry*. **54**, 415-417.

Butt, M. S., Nasir, M., Akhtar, S. and Sharif, K. (2004): Effect of moisture and packaging on the shelf life of wheat flour. *International Journal of Food Safety*. **4**, 1-6.

Giami, S. Y., Bekebain, D. A. and Emelike, N. J. T. (1992): Proximate composition and functional properties of winged bean *(Psophocarpus tetragonolobus)* flour. *Nigerian Journal of Nutritional Sciences*. **13**, 5-8.

Ihekoronye, A. I. and Ngoddy, P. O. (1985): *Integrated Food Science and Technology for the Tropics*. MacMillan Publishers, London.

Ishida, H., Suzuno, H., Sugiyama, N., Innami, S. and Todokoro, T. (2000): National evaluation of chemical component of leaves stalks and stem of sweet potatoes. *Ipomeabatataspoir*. *Food Chemistry*. **68**, 359-367.

Jagtap, U. B. and Bapat, V. A. (2010): Artocarpus: A review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology*. **12**(9), 143-154.

Jones, A. M. P., Ragone, D., Tavana, N. G., Bernotas, D. W. and Murch, S. J. (2011): Beyond the Bounty: Breadfruit (*Artocarpus altilis*) for food security and novel foods in the 21st Century. *Ethnobotany Journal*. **9**, 131-132.

Leach, H. W, McCowen, L. D and Schoch, T. J. (1959): Structure of the starch granule I. Swelling and solubility patterns of various starches. *Cereal Chemistry*. **36**, 534-543.

Medcalf, D. G and Gilles, K. A (1965): Wheat starches. Comparison of physicochemical properties. *Cereal Chemistry*. **42**, 558-568.

Mensah, J. K., Okoli, R. I., Ohaju-Obodo, J. O. and Eifediyi, K. (2008): Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. *African Journal of Biotechnology*. **7**, 2304-2309.

Morton, J. F. (1987): *Breadfruit: Artocarpus altilis fruits of warm climates*. 50-58.

Oduro, I., Larbie, C., Amoako, T. N. E and Antwi-Boasiako, A. F. (2009): Proximate composition and basic phytochemical assessment of two common varieties of *Terminali acatapa* (Indian almond). *Journal of Science and Technology*. **29**, 1-6.

Oladunjoye, I. O, Ologhobo, A. D and Olaniyi, C. O. (2010): Nutrient composition, energy value and residual anti-nutritional factors in differently processed breadfruit (*Artocarpus altilis*) meal. *African Journal of Biotechnology*. **9**(27), 4259-4263.

Olaoye, O. A, Onilude, A. A and Oladoye, C. O. (2007): Breadfruit flour in biscuit making: effects on product quality. *African Journal of Food Science.* **2007**, 20-23.

Osborne, D. R. and Voogt, P. (1987): *Calculations of calorific value in the analysis of nutrients in roots*. Academic press, New York. 239-240.

Ragone, D. (1997): Breadfruit. *Artocarpus altilis* (Parkinson) Fosberg. *Promoting the conservation and use of underutilized and neglected crops*. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy.

Ragone, D. (2006a): *Artocarpus altilis* (breadfruit). *Specific Profiles for Pacific Island Agroforestry*. **2**(1), 1-13.

Ragone, D. (2006b): Eleritch, C. R. Ced *Artocarpus camansi* (breadnut). Retrieved 15/6/2017 from http://www.agroforestry/images/pdfs/A.camansi-breadnut.

Rao, C. V and Newmark, H. L. (1998): Chemo-preventive effect of Squalene on colon cancer, *Carcinogenesis*. **19**, 287-290.

Somashekhar, M., Naira, N. and Basavraj, S. (2013): A Review on Family Moraceae (Mulberry) With a Focus on *Artocarpus* Species. *World Journal of Pharmacy and Pharmaceutical Sciences*. **2**(5), 2614-2621.

Soni, P. L, Sharma, H. W, Dobhal, S. S, Bisen, H. L, Savastva, H. and Gharra, M. W. (1985): The Starch of *Discore aballophyll* and *Amorphophalius companulalus*, *Starch-starke*. **37**, 6-9.

Tounkara, F., Tidjani, A., Camel, L., Guo-Wei, L. and Yong-Hui, S. (2013): Extraction, characterization, nutritional and functional properties of Roselle (*Hibiscus sabdariffa*

Linn) seed proteins. *Songklanakarin Journal of Science and Technology*. **35**(2), 159-166.

Zerega, N., Ragone, D. and Motley, T. J. (2006): *Breadfruit origins, diversity and human facilitated distribution. In Darwin's Harvest: New approaches to the origins, evolution, and conservation of crops.* Motley, T. J., Zerega, N and Cross, H. (Eds). Columbia University Press, New York. 213-238.