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Research Article

A study on nutritional composition and functional properties of wheat, ragi and jackfruit seed composite flour

Shanooba Palamthodi[1]✉, Shriram Shimpi[1], Kanchanlata Tungare[1]

[1] *School of Biotechnology and Bioinformatics, D. Y. Patil Deemed to be University, Plot no-50, Sector-15, CBD Belapur, Navi Mumbai-400614, India*

Abstract

The present research investigation was conducted to analyze the nutritional and functional properties of wheat, ragi and jackfruit seed composite flour. About 11 combinations were made using wheat, ragi and jackfruit seed composite flour with 100% wheat flour as control. 100% ragi and jackfruit flour was also added in the experiments for comparison. The combinations were optimized based on the proximate composition analysis and functional properties. The proximate composition analysis of wheat revealed the fact that jackfruit seed flour contains a higher amount of protein i.e.,13.9 g than wheat and ragi i.e., 11.45 g and 7.8 g respectively. Jackfruit seed flour contains lower fat i.e., 1.44 g as compared to wheat and ragi (2.27g and 1.78 respectively). Also, jackfruit seed flour contains low moisture 6.5% and ash content 0.96% than wheat (6.53% and 0.97%) and ragi (8.76% and 0.98%). The combinations of wheat, ragi and jackfruit seed flour in ratio of 80:10:10, 80:15:5, 70:10:20 and 60:20:20 showed good water and oil absorption capacity and emulsion stability and was found to be significantly different ($p < 0.05$) from the wheat flour alone. Based on nutritional and functional value, we selected 4 combinations for further studies. The selected flour combinations were used to prepare biscuits and muffins against 100% wheat products as control. Sensory evaluation indicated that incorporation of jackfruit seed flour in wheat up to 20%, significantly ($p < 0.05$) enhanced the taste, aroma and texture of biscuits. However, higher levels of jackfruit seed flour contributed to bitter taste in biscuits and thereby the products were rejected by the sensory panel. Further, the optimized biscuits showed superior antioxidant activity. This activity was significantly higher ($p < 0.05$) compared to the control samples. Muffins were prepared with two flour combinations of wheat: ragi: jackfruit seed flour in ratio of 80:10:10 and 80:15:5 owing to its high nutritional and functional property of which, muffins made in ratio of 80: 10:10 showed good taste, texture and aroma when compared to the other sample and the control (100% wheat flour).

Keywords: bakery products, proximate composition analysis, sensory analysis, antioxidant, functional properties

Abbreviations: jackfruit seed flour (J); least gelation concentration (LGC); loose bulk density (LBD); oil absorption capacities (OAC); packed bulk density (PBD); ragi flour (R); randomized block design (RBD); water absorption capacities (WAC); wheat flour (W);

✉*Corresponding author: Dr. Shanooba Palamthodi, School of Biotechnology and Bioinformatics, D. Y. Patil Deemed to be University, Plot no-50, Sector-15, CBD Belapur, Navi Mumbai-400614, India Tel: +91-8169504880 Email: shanooba.pm@dypatil.edu*

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Introduction

Production of baked products such as bread, cakes, buns, doughnuts, muffins and biscuits generally use wheat flour that contains proteins which interact with each other when mixed with water, forming gluten. Due to this gluten content, an acceptable texture and stretchable framework are imparted to the product. An increased consumer demand for healthy and ready to eat products has led to considerable efforts to develop bakery products that combine health benefits with good sensory properties (Dhanimsetti et al. 2016). Composite flours are considered as blends of wheat and other flours for the production of bakery items for being economical and nutritional. Using composite flours for biscuit making has always been a facile strategy in times of wheat scarcity due to climatic or economic constraints, and an easy way of enhancing essential nutrition to human diet (FAO 2006; FAO 1991b). The biscuits available in market prepared from wheat flour (whole/refined) lack lysine and dietary fibre contents thus causing exigency of composite flour to fulfil deficient nutritional status (Tangariya et al. 2018).

Finger millet (*Eleusine coracana*) also known as ‘ragi’ is a popular millet consumed without dehulling in India. It is the principal food grain of the rural population belonging to low-income groups. At present, ragi is usually used for preparation of flour, pudding, porridge and roti (Serrem et al. 2011; Chaturvedi and Srivastava 2008). Ragi is considered to be ideal food for diabetic individuals due to its low sugar content and slow release of glucose/sugar in the body (Kang et al. 2008; Lakshmi et al. 2002). Ragi grain is mixed with milk, water or yogurt and used at breakfast time. The sprouted ragi is used to make baby food and is also frequently consumed by elderly people as it is easy to digest. It contains high fiber, proteins, calcium, B complex vitamins and vitamin E. It is rich in minerals and helps in lowering cholesterol (Misra et al. 2009).

Jackfruit (*Artocarpus heterophyllus*), a member of the family Moraceae, is a popular fruit of the tropics. It grows abundantly in India, Bangladesh, South-East Asia and in the evergreen forest zone of West Africa (Rahman et al. 1999; Burkil 1997). The fruit consists of edible bulbs of yellow-flesh, rind and seeds. It is either eaten directly or processed to chips and snacks for later consumption. Seeds make up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents (Ocloo et al. 2010). As the seed readily germinates, it is difficult to store it with present storage facilities in many underdeveloped countries. As a result, a huge amount of jackfruit seed is wasted without consuming. An efficient way of avoiding this wastage is to blend the seed flour with traditional wheat flour to prepare more nutritious bakery items like breads, cakes, etc. Moreover, jackfruit is rich in nutrients including carbohydrates, proteins, vitamins, minerals, and phytochemicals. Also, the presence of isoflavones, antioxidants, and phytonutrients in the jackfruits indicate that it has high anti-cancer properties (Ranasinghe et al. 2019).

Wheat (*Triticum aestivum*) is a cereal belonging to the family Graminae. The annual world production of wheat exceeds that of any other grain, legume, or food crop. It is consumed worldwide after milling it into flour, primarily in the form of breads, and is a major source of nutrients (FAO 2013). Wheat flour is one of the principal ingredients in bakery products and the cost of wheat flour keeps escalating gradually. Hence, replacing wheat flour with ragi and jackfruit seed flour will make products economical and nutritionally rich. The research studies aiming to expand the utility of both the flours with wheat are highly desideratum. Hence the present research investigation was performed to assess the functional properties of wheat and composite flours followed by development of bakery products and evaluation of the consumer acceptability towards the products.

Materials and Methods

Materials. The jackfruit (*Artocarpus heterophyllus*) seeds were collected from fruit market, Chembur, Maharashtra, India. Commercial wheat (*Triticum aestivum*), and ragi (*Eleusine coracana*) flour was procured from local supermarket, CBD Belapur, Navi Mumbai, India. The entire study was conducted at School of Biotechnology and Bioinformatics, D. Y. Patil Deemed to be University, Navi Mumbai. Instruments used were grinder (Bajaj GX-1), analytical electronic balance (Sky Technology, India), hot air oven (HMG India), centrifuge

(Superspin R- V/FM Plastocraft, India), desiccators (ABG, India) and whipping device (HR3705-300 Watt, Philips, India)

Preparation of jackfruit seed flour. The fresh jackfruit seeds were obtained and cleaned to remove the seed coat manually. The thin brown spermoderm which covers the cotyledon was removed by rubbing the seeds with both the hands. The peeled seeds were then sliced into thin chips and dried at 60-80°C in the dryer. The dried seeds were powdered in a grinder, sieved and packed in polythene pouches and stored in a refrigerator (4°C) for further analysis.

Preparation of composite flour. Composite flour samples were prepared with different quantities of wheat, ragi and jackfruit seed flour as shown in Table 1. All samples were weighed accurately and all the analysis was carried out in triplicates. 100% control to each flour category was also maintained throughout the experiments.

Methods

Moisture content. Three - four g of sample in the dish was subjected to drying at 105°C for 1h in the oven or till the weight of the sample became constant. Sample was then transferred to desiccators and was weighed. Moisture content was calculated to be the difference between fresh and dry weights (Ekunseitan et al. 2016).

Ash content. Dried samples obtained in the process of moisture content determination were heated in a muffle furnace at 550°C for 6 h (Ekunseitan et al. 2016). The percentage of ash was then calculated using the following formula (1):

$$\text{Total ash on dry basis percent} = \frac{(W2 - W)}{(W1 - W)} \times 100 \qquad (1)$$

where:
W2 - weight in g of the dish with the ash
W - weight in g of empty dish
W1 - weight in g of the dish with the dried material taken for test

Fat content. Crude fat was determined by weighing 5 g of each sample wrapped in a filter paper in a Soxhlet apparatus using petroleum ether. This was done each for 4 h. The extracted materials left after the solvent had evaporated were weighed, and the fat content was calculated by considering the difference in the weight of extract and the sample.

Table 1. Percentage combinations of the composite flour along with their 100% control

Sr. No	Product code	W, %	R, %	J, %
1	W_{100}	100	0	0
2	R_{100}	0	100	0
3	J_{100}	0	0	100
4	$W_{90}R_5J_5$	90	5	5
5	$W_{90}R_{10}J_0$	90	10	0
6	$W_{90}R_0J_{10}$	90	0	10
7	$W_{80}R_{10}J_{10}$	80	10	10
8	$W_{80}R_{15}J_5$	80	15	5
9	$W_{80}R_5J_{15}$	80	5	15
10	$W_{70}R_{20}J_{10}$	70	20	10
11	$W_{70}R_{10}J_{20}$	70	10	20
12	$W_{60}R_{20}J_{20}$	60	20	20
13	$W_{60}R_{30}J_{10}$	60	30	10
14	$W_{60}R_{10}J_{30}$	60	10	30

where, W - wheat flour, R - ragi flour, J - jackfruit seed flour

Protein and residual carbohydrate content. Protein in the sample was determined by Morre et al. (2010). The samples were digested by heating with concentrated sulphuric acid (H_2SO_4) in the presence of digestion mixture. The mixture was then made alkaline. Ammonium sulphate thus formed, released ammonia which was collected in 2% boric acid solution and titrated against standard HCL. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor (6.25). Subtracting the sum of fat, protein, ash and moisture content from 100 gave the residual carbohydrate content.

Crude fibre content. A moisture free and ether extracted sample of crude fibre made of cellulose was first digested with dilute H_2SO_4 and then with dilute KOH solution. The undigested residue collected after digestion was ignited and loss in weight after ignition was registered as crude fibre.

pH of the sample. The pH was measured by making a 10% w/v suspension of each sample in distilled water. Each suspension was mixed thoroughly and pH was measured using pH meter (Onuma and Bello 1988).

Functional characteristics of composite flours

Bulk density. Ten g of sample was added in a calibrated 25 ml measuring cylinder and the volume was recorded as the loose volume. The bottom of the cylinder was tapped repeatedly on a firm pad of a laboratory bench until a constant volume was observed. The packed volume was recorded. The loose bulk density (LBD) and packed bulk density (PBD) were calculated as the ratio of the sample weight to the volume occupied by the sample before and after tapping (Amandikwa et al. 2015).

Water and oil absorption capacity. Water and oil absorption capacities (WAC/OAC) for each flour sample were determined by the method of Amandikwa et al. (2015). One g of sample was mixed thoroughly with 40 ml distilled water and oil separately. The sample was then allowed to stand for 30 min at room temperature after which it was centrifuged at 5000 rpm for 30 min. The free water or oil (supernatant) was read directly from the graduated centrifuge tube. The absorbed water or oil was converted to weight (in grams) by multiplying the respective density (water, 1g/ml and sunflower oil, 0.93 g/cm^3). The WAC/OAC was expressed in grams of water or oil absorbed per gram of flour sample.

Emulsion activity. Emulsion activity was determined according to the method of Amandikwa et al. (2015). Two gram of flour sample was blended with 20 ml of distilled water at room temperature for 30 s. After complete dispersion, 20 ml of sunflower oil was added gradually and blended for another 30 s. The blend was centrifuged for 5 min at 1600 rpm. The volume of oil separated from the sample after centrifugation was read directly from the tube. Emulsion activity was calculated as the ratio of the height of emulsion to the total height of the mixture and was expressed in terms of percentage.

Wettability. Wettability for each flour sample was determined as per the method of Onuma et al. (1988). One gram of each sample was placed in a 25 ml of graduated cylinder. A finger was placed over the open end and cylinder was inverted and clamped at a height of 10 cm from the surface of a 600 ml beaker containing 500 ml distilled water. The finger was removed to allow the test material to be dumped, and the time required for the sample to become completely wet was recorded. The measurements were repeated thrice and average value was determined.

Least gelation capacity. The method of Coffmann and Garciaj (2007) was employed with slight modification to estimate least gelation capacity of the flour. The sufficient sample was dispersed in distilled water to make 25 ml of a total volume and protein concentrations of 1, 2, 3, 4, 5 and 6%. The mixture was stirred and the pH was adjusted to 7 with 0.5N NaOH. The mixture was then placed in a blender at high speed for 2 min to ensure complete mixing and was centrifuged for 15 min at 1000 rpm. The series of protein concentrations were heated in a water bath at 80°C for 10 min. After heating, the samples were cooled in an ice bath and the strength of the coagulum was evaluated by inverting the tube. The lowest protein concentration which formed a stable gel (remained in an inverted test tube) was considered the gelation endpoint.

Foaming capacity (whippability). A half g of each sample was blended with 40 ml of distilled water by using a whipping device (HR3705-300 Watt, Philips, India) at high speed (380 rpm) for 2 min. The test was repeated for each sample with blending for 6 min. After blending, each sample was transferred into a 100 ml graduated cylinder. For each sample, triplicate determinations were prepared and average value was recorded. Volumes were recorded before and after whipping and percent volume increased due to whipping was calculated as per protocol suggested by Onuma et al. (1988).

Dispersibility. Ten g of each sample was added in distilled water to reach the volume of 100 ml and was stirred properly. The mixture was allowed to settle for 3 h. The volume of settled particles was subtracted to 100 and differences were recorded as percent dispersibility (Adebowale et al. 2012).

Determination of radical scavenging activity. Four mg of test sample was diluted in 1 ml of methanol. 0.1 ml of sample was then diluted with 9.9 ml of distilled water. 0.5 ml of this sample was further added to 3 ml of DPPH solution. The mixed solution was kept for 30 min at ambient temperature in dark and the absorbance of solution was measured at 517 nm (De Ancos et al. 2002).

DPPH radical scavenging activity (%) =
[1 – absorbance of sample ⁄ absorbance of control] x 100 (2)

Biscuit making process. Wheat flour was blended with ragi and jackfruit seed flours in the ratio of W_{80}:R_{10}:J_{10}, W_{80}:R_{15}:J_5, W_{70}:R_{20}:J_{10}, W_{60}:R_{20}:J_{20} and W_{60}:R_{30}:J_{10} for biscuit production. The biscuit recipe consisted of 100 g of each blend, 45 g of butter, 4.9 ml of vanilla essence, 2.4 g of baking powder, 2.4 g of baking soda and 0.36 g of salt. The ingredients were thoroughly mixed till the dough was formed. The dough was rolled to make biscuits about ¾ inch thickness and was cut with a ½ inch biscuit cutter. All biscuits were placed in ungreased baking sheet and were baked in a preheated oven at 220°C for 12 to 15 min.

Muffin making process. Wheat flour was blended with ragi and jackfruit seed flours in the ratio of W_{80}:R_{10}:J_{10}, W_{80}:R_{15}:J_5 and 100% wheat flour served as a control. The recipe consisted of 150 g of each blend, 200 g of sugar, 200 ml milk, 80 ml of oil, 2.4 g of baking soda, 2.4 g of baking powder, 4.9 ml of vanilla essence and 7.5 g of cocoa powder. The dry ingredients were mixed with wet ingredients using the cut and fold method. After mixing, 4.9 ml of vinegar was added and kept aside for 5 min. After 5 min, muffin molds were filled up to ¾ and kept in the oven at 180°C for 25 min.

Sensory evaluation. Panellist for sensory evaluation consisted of more than 10 judges from different age groups and from both genders. The judges were selected from the faculty, staff and students of School of Biotechnology and Bioinformatics, D. Y. Patil Deemed to be University, Navi Mumbai. Biscuit and muffin samples were served to the panellists and they were asked to rate the appearance (symmetry), color, aroma, mouthfeel, sweetness, hardness, crunchiness and overall acceptability of the product on the basis of 9- point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).

Statistical analysis. The data obtained from the various experiments were expressed as Mean ± SD. Statistical analysis was performed using the software "GraphPad Prism"- version 8. The significance of difference among the groups was assessed using a one-way analysis of variance (ANOVA) test followed by Tukey's honest significant difference (HSD) post-hoc test and Factorial Randomized block design (factorial RBD). The significant difference between the means was tested against the critical difference at 5 % level of significance.

Result and Discussion

Proximate composition analysis. In this research, different properties of composite flours were analyzed using standard procedures (Table 2). The proximate composition analysis is a set of methods to acquire information about the nutritional value of food. The proximate composition of foods includes moisture, ash, lipid, protein and residual carbohydrate content. Proximate composition analysis of the combinations was performed and is represented in Table 2.

The results indicate that there was a significant difference in the chemical composition of the composite flour samples when compared to only wheat flour which served as a control. The moisture content of the flour samples ranged from 6.53% for 100% wheat to 8.4% for $W_{60}R_{10}J_{30}$ samples. These values meet the FSSAI standards for flours or fortified atta of not more than 12-14% moisture in flour blends. The ash content ranged from 0.98 to 1.22%. $W_{80}R_{15}J_5$ showed the highest percentage of ash content due to inclusion of ragi and jackfruit seed flour. The ash content of the composite flours was less than 2% which is acceptable according to FSSAI standards (Table 2). Wheat flour exhibited the highest fat content as compared to ragi and jackfruit seed flour. From sample $W_{90}R_5J_5$ to $W_{60}R_{10}J_{30}$ the percentage of fat increases and then decreases with the addition of wheat and ragi respectively. The percentage of crude fibre increases with addition of ragi and jackfruit seed flour. 100% wheat flour contains only 0.37% of crude fibre as compared to ragi 2.36% and jackfruit seed flour 1.05%. The sample $W_{60}R_{30}J_{10}$ contains 3.5% of crude fibres which is highest amongst all. The addition of jackfruit seed flour in wheat and ragi increases the protein percentage in composite flour by 1.5 to 2%. Sample $W_{80}R_{10}J_{10}$ to $W_{70}R_{20}J_{10}$ showed the highest protein level as compared to others. W_{100} containing 11.45% and sample $W_{60}R_{10}J_{30}$ exhibiting 11.3% showed the lowest protein percentage. The W_{100} and R_{100} flour showed the highest percentage of residual carbohydrate i.e., 78.41% and 78.32% respectively. The J_{100} flour contains 76.15% residual carbohydrates which is lesser when compared to wheat and ragi flour. The carbohydrate content decreases with the decrease in the percentage of wheat flour.

Table 2. Proximate composition analysis of wheat-ragi-jackfruit seed composite flour

Sample, g	Moisture, %	Ashes, %	Fats, g	Crude fibres, g	Proteins, g	Carbohydrates, g	pH
W_{100}	6.53±0.01	0.97±0.01	2.27	0.37	11.45	78.41	6.05±0.01
R_{100}	8.76±0.02	0.98±0.02	1.78	2.36	7.8	78.32	6.70±0.01
J_{100}	6.50±0.07	0.96±0.02	1.44	1.05	13.9	76.15	5.35±0.01
$W_{90}R_5J_5$	6.63±0.01	0.97±0.01	2.13	0.72	11.82	77.73	5.98±0.01
$W_{90}R_{10}J_0$	7.10±0.07*	0.97±0.01	2.25	1.29	12.60	75.79	5.93±0.02
$W_{90}R_0J_{10}$	7.30±0.01*	0.52±0.07*	2.23	1.44	12.00	76.51	6.02±0.01
$W_{80}R_{10}J_{10}$	7.20±0.01*	0.40±0.07*	2.20	0.70	13.95	75.55	5.87±0.01
$W_{80}R_{15}J_5$	5.93±0.01*	1.22±0.01*	2.40	1.24	13.13	76.08	5.80±0.01
$W_{80}R_5J_{15}$	6.96±0.01*	0.98±0.01	2.13	1.37	13.10	75.46	5.94±0.01
$W_{70}R_{20}J_{10}$	7.43±0.01*	0.98±0.02	1.95	1.33	13.60	74.71	5.72±0.02
$W_{70}R_{10}J_{20}$	7.23±0.01*	0.98±0.03	2.20	1.80	11.90	75.89	5.80±0.01
$W_{60}R_{20}J_{20}$	6.10±0.07*	0.98±0.02	1.93	2.10	12.25	76.64	5.68±0.00
$W_{60}R_{30}J_{10}$	7.13±0.02*	0.98±0.03	1.93	3.50	11.95	74.51	5.62±0.02
$W_{60}R_{10}J_{30}$	8.40±0.07*	0.98±0.03	2.20	3.10	11.30	74.02	5.72±0.02

Data is expressed as Mean ± SD. The symbols in the table represents W - wheat flour, R - ragi flour, J - jackfruit seed flour, and * represents statistical significance $p < 0.05$ when compared to W_{100} flour.

Functional properties of flour samples. Functional properties or characteristics are the intrinsic properties that reflect the complex interaction between the composition, structure, confirmation and physicochemical properties of protein with other food components and the nature of environment in which these are associated and measured. Functional characteristics are required to predict how new food components may behave in a specific system (Chandra et al. 2015). The functional properties of a food material determine its application and end use. Therefore, food items with good functional properties can be easily incorporated into other foods and will yield good quality and acceptable end products. Functional properties of blends of wheat, ragi and jackfruit seed flours are presented in Table 3. The loose bulk density of the flour sample varied from sample W_{100} to $W_{60}R_{10}J_{30}$ i.e., 0.28 ± 0.007 ml to 0.4 ± 0.02 ml as shown in Table 3 and was found to be statistically significant ($p < 0.05$) when compared to control. For packed bulk density, $W_{60}R_{30}J_{10}$ sample revealed the highest value of 0.8 ± 0.01 ml while sample W_{100} reported lowest packed density with value of 0.5 ml. The value of bulk density is influenced by the structure of starch polymers whereas loose structure of starch polymers could result in low bulk density. It is a crucial factor considered while handling raw material, process development and packaging in the food industry (Ajanaku et al. 2012).

The composite flour $W_{80}R_{15}J_{5}$ had the highest WAC i.e., 3% and lowest value was recorded for sample $W_{90}R_{0}J_{10}$ and $W_{60}R_{20}J_{20}$ (1.5%) as compared to wheat flour which displayed WAC of 2%. The lowest and highest value of the WAC was found to be significantly ($p < 0.05$) different from control (Table 3). High WAC of composite flours can be used in formulation of some foods such as sausage, dough, processed cheese and bakery products. WAC is important in bulking and maintaining consistency of product (Niba et al. 2001) Sample W_{100} had the highest OAC and lowest value for sample $W_{90}R_{5}J_{5}$, $W_{90}R_{10}J_{0}$ and $W_{70}R_{10}J_{20}$ as compared to wheat control. The OAC of composite flour increases with addition of other flours. Oil gives soft texture and good flavour to food. Therefore, absorption of oil by food products improves mouth feel and flavour retention. The flours in the present study are potentially useful in structural interaction in food specially in improvement of palatability and extension of shelf life particularly in bakery or meat products where fat absorption is desired (Aremu et al. 2007).

The emulsion activity of different flours ranged between 41 and 48%. The emulsion activity for $W_{90}R_{5}J_{5}$, $W_{90}R_{0}J_{10}$, $W_{70}R_{20}J_{10}$ and $W_{60}R_{20}J_{20}$ flour was revealed to be highest i.e. 48 ± 0.05% and $W_{80}R_{10}J_{10}$ sample showed lowest value of 41%. Emulsion activity increases with the addition of ragi and jackfruit seed flour in wheat. Increasing emulsion activity during food processing are primary functional properties of protein in foods such as comminuted meat products, salad dressing, frozen desserts and mayonnaise (Chandra et al. 2015). All composite flours showed relatively good capacity of emulsion activity.

Wettability is a function of ease of dispersing flour samples in water and the sample with the lowest wettability dissolves fastest in water. The time required to reach complete wetness for wheat was 4.48 ± 0.01 min and for sample $W_{60}R_{10}J_{30}$ it required just 1.55 ± 0.01 min. Supplementation of ragi and jackfruit seed flour in wheat significantly ($p < 0.05$) reduced the time of achieving complete wetness (Table 3).

Foam capacity of protein refers to the amount of interfacial area created by protein. Foam is a colloidal of many gas bubbles trapped in a liquid or solid. In our study, the foam capacity of different flours varied from 7 to 30%. The highest foam capacity was observed to be 30% for $W_{90}R_{5}J_{5}$ and $W_{60}R_{30}J_{10}$ and on the other hand flour combination $W_{90}R_{10}J_{0}$, $W_{90}R_{0}J_{10}$, $W_{80}R_{15}J_{5}$, $W_{70}R_{20}J_{10}$ and $W_{60}R_{20}J_{20}$ displayed 27.5% of foaming capacity. The lowest foam capacity was observed in wheat i.e., 7.5% as shown in Table 4. Yasumatsu et al. (1972) have reported that native protein gives higher foam stability than the denatured protein.

Dispersibility is an index that measures how well flour or flour blends can be rehydrated with water (Kulkarni et al. 1991). The dispersibility of W_{100} was revealed to be lower than that of the ragi and jackfruit seed composite flour samples. A dispersibility value for sample $W_{60}R_{10}J_{30}$ was observed to be 58 ± 0.7% which indicates that it can potentially reconstitute to give fine consistency dough during mixing (Falola et al. 2014). Addition of ragi and jackfruit seed flour significantly ($p < 0.05$) increased the dispersibility property of the wheat flour in different combinations.

The least gelation concentration (LGC) is the concentration of the sample that did not fall down or slip when the test tube was inverted. Composite flours formed a gel at a significantly higher concentration (1.25g/25ml) whereas W_{100} and $W_{90}R_{5}J_{5}$ flour formed gel quickly at very lowest concentration (0.75g/25ml) as represented in Table 4. The lower is the LGC, the superior is the gelation ability of the protein ingredient (Akintayo et al. 1999).

Table 3. The functional properties of flour samples

Sample, g	**Bulk density, ml**		**WAC, %**	**OAC, %**	**Emulsion activity, %**	**Wettability, min**
	Loose	Packed				
W_{100}	0.28±0.007	0.50±0.00	2.00±0.07	3.67±0.02	46±0.02	4.48±0.01
$W_{90}R_5J_5$	0.33±0.007*	0.58±0.01	2.00±0.06	1.83±0.03*	48±0.05*	2.59±0.01*
$W_{90}R_{10}J_0$	0.37±0.007*	0.66±0.01*	2.00±0.09	1.83±0.06*	47±0.04*	4.27±0.02
$W_{90}R_0J_{10}$	0.33±0.007*	0.58±0.01	1.50±0.01*	2.29±0.04*	48±0.03*	3.42±0.02*
$W_{80}R_{10}J_{10}$	0.33±0.02*	0.57±0.01	2.50±0.02*	2.75±0.05*	41±0.50*	2.52±0.06*
$W_{80}R_{15}J_5$	0.38±0.01*	0.71±0.01*	3.00±0.03*	2.75±0.09*	43±0.07*	3.17±0.04*
$W_{80}R_5J_{15}$	0.33±0.007*	0.66±0.007*	2.00±0.03	2.75±0.07*	44±0.70*	3.10±0.05*
$W_{70}R_{20}J_{10}$	0.37±0.007*	0.71±0.01*	2.00±0.05	2.29±0.05*	48±0.03*	2.24±0.06*
$W_{70}R_{10}J_{20}$	0.37±0.02*	0.66±0.007*	2.00±0.04	1.83±0.05*	45±0.05*	2.40±0.03*
$W_{60}R_{20}J_{20}$	0.38±0.007*	0.66±0.07*	1.50±0.01*	2.75±0.06*	48±0.08*	2.37±0.07*
$W_{60}R_{30}J_{10}$	0.40±0.03*	0.80±0.01*	2.00±0.02	2.75±0.03*	46±0.09	4.26±0.04
$W_{60}R_{10}J_{30}$	0.40±0.02*	0.76±0.01*	2.00±0.03	2.29±0.08*	42±0.08*	1.55±0.01*

Data is expressed as Mean ± SD. The symbols in the table represents W - wheat flour, R - ragi flour, J - jackfruit seed flour, WAC- water absorption capacity, OAC- oil absorption capacity and * represents statistical significance $p < 0.05$.

Table 4. The functional properties of flour samples

Sample	**Foaming capacity, %**	**Dispersibility, %**	**Least gelation concentration, %**
W_{100}	7.5 ± 0.05	48 ± 0.06	3 ± 0.03
$W_{90}R_5J_5$	30.0 ± 0.03*	49 ± 0.03*	3 ± 0.01
$W_{90}R_{10}J_0$	27.5 ± 0.05*	51 ± 0.02*	4 ± 0.07*
$W_{90}R_0J_{10}$	27.5 ± 0.07*	48 ± 0.08	5 ± 0.40*
$W_{80}R_{10}J_{10}$	22.5 ± 0.80*	51 ± 0.40*	4 ± 0.01*
$W_{80}R_{15}J_5$	27.5 ± 0.01*	50 ± 0.30*	5 ± 0.05*
$W_{80}R_5J_{15}$	25.0 ± 0.05*	56 ± 0.01*	4 ± 0.08*
$W_{70}R_{20}J_{10}$	27.5 ± 0.08*	53 ± 0.04*	6 ± 0.90*
$W_{70}R_{10}J_{20}$	25.0 ± 0.02*	54 ± 0.09*	5 ± 0.01*
$W_{60}R_{20}J_{20}$	27.5 ± 0.01*	51 ± 0.05*	5 ± 0.09*
$W_{60}R_{30}J_{10}$	30.0 ± 0.04*	53 ± 0.04*	6 ± 0.05*
$W_{60}R_{10}J_{30}$	25.0 ± 0.05*	58 ± 0.70*	4 ± 0.04*

Data is expressed as Mean ± SD. The symbols in the table represents W - wheat flour, R - ragi flour, J - jackfruit seed flour, WAC- water absorption capacity, OAC- oil absorption capacity and * represents statistical significance $p < 0.05$.

DPPH radical scavenging activity. The antioxidant activity of the wheat flour was found to be 16.02% because wheat has been known to contain hydroxycinnamic acid derivatives, which demonstrated antioxidative activities. The sample $W_{80}R_{10}J_{10}$ and $W_{80}R_{15}J_5$ revealed highest antioxidant activity whereas sample $W_{70}R_{10}J_{20}$ and $W_{60}R_{20}J_{20}$ showed lowest (Fig. 1). Ferulic acid was reported to be the predominant phenolic acids accounting for approximately 57-77% in wheat. This acid possesses lower antioxidant capacity (Zhou et al. 2004). Wheat flour possessed the lowest amount of ferulic acid, so this can be attributed to its relatively low antioxidative activity (Liyana-Pathirana et al. 2006). The loss of scavenging ability could be attributed to the loss of some phenolic compounds, because the temperature used during baking is known to cause the destruction of some phenolic acids. Therefore, the decrease in DPPH scavenging abilities of sample $W_{70}R_{10}J_{20}$ and $W_{60}R_{20}J_{20}$ probably differed due to concentration of different flours with varying phenolic contents. Albeit all the concentration as represented in Fig. 1 was found to have significantly ($p < 0.05$) higher scavenging activity when compared to control.

Sensory evaluation of composite flour biscuits. Biscuits were subjected to a panel of trained judges comprising male and female using 9-point Hedonic rating scale. Sensorial attributes viz., colour, flavour, taste, crispiness, texture and overall acceptability are shown in Fig. 2. Overall acceptability was calculated by taking the average of all the scores of sensorial attributes.

Biscuits were prepared with five different types of combination and 100% wheat sample as control. The control biscuits were noticed to be whiter than the rest and biscuits up to 30% ragi and jackfruit seed flour replacement made very little difference in color. While, biscuits with 40% ragi and jackfruit seed flour incorporated biscuits were darker shade than the rest.

Aroma is another attribute that influences the acceptance of baked goods even before they are tasted**.** The aroma of control biscuits recorded the highest value of 9 and 10% incorporated ragi and jackfruit seed flour biscuits documented the value of 8 for their good aroma. The 20% ragi and jackfruit seed flour based biscuits documented the value 7 i.e., moderately liked. The 30% and 40% incorporated ragi and jackfruit seed flour biscuits recorded the value of 8 and 7 for their aroma respectively. The taste of 10% incorporated ragi and jackfruit seed flour biscuits recorded the similar value of 7 as that of control biscuits. Further, the 20 and 30% incorporated ragi and jackfruit seed flour biscuits recorded the value of 8 and 7 i.e., very much liked and moderately liked. The 40% incorporated ragi and jackfruit seed flour biscuits recorded the value of 6 i.e., slightly liked.

Colour is an important sensory attribute of any food because of its influence on acceptability. The old adage that the eye accepts the food before the mouth is very true. The brown colour resulting from Maillard reaction is always associated with baked goods. The color and appearance of control biscuits recorded the highest value of 9. The 10 and 20% incorporated ragi and jackfruit seed flour biscuits recorded the value of 8 and 9 respectively. The 30 and 40% incorporated ragi and jackfruit seed flour biscuits recorded the value of 7 and 8 respectively.

According to the texture scores of biscuits with 10% ragi and jackfruit seed flour biscuits recorded the similar value of 8 as that of control for their good texture profile. The 20 and 30% incorporated ragi and jackfruit seed flour biscuits recorded the value of 7 and 8 respectively. The 40% incorporated ragi and jackfruit seed flour biscuits recorded the value of 6 i.e., slightly liked.

The overall acceptability of biscuits showed that the control biscuits scored the highest overall acceptability value of 8 i.e., liked very much. The 10, 20, 30, and 40% incorporated ragi and jackfruit seed flour biscuits scored between 7 - 7.5 i.e., moderately liked.

Sensory evaluation of composite flour muffins. The aroma of control muffins recorded the highest value of 9 whereas 15% incorporated ragi and jackfruit seed flour biscuits documented the value of 8 for their good aroma (Fig. 3). The 20% ragi and jackfruit seed flour based muffins scored the value of 7 i.e. moderately liked. The taste of control sample recorded value of 8 whereas 15% incorporated ragi and jackfruit seed flour muffins scored value of 7.5. The taste for 20% incorporated ragi and jackfruit seed flour muffins scored 8.5 i.e., very much liked. The color and appearance of control biscuits recorded the value of 8 but surprisingly 15 and 20% incorporated ragi and jackfruit seed flour recorded the value of 8 and 8.5 i.e., liked very much. The texture of control muffins was similar to 15% incorporated ragi and jackfruit seed flour muffins documented the value of 7.5. As compared to control, the 20% incorporated ragi and jackfruit seed flour muffins scored well i.e., 8 (Fig. 3).

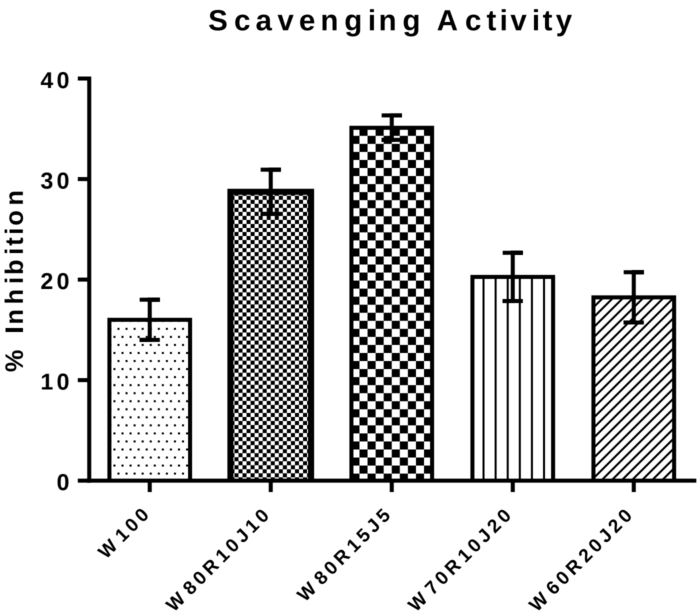

Figure 1. Scavenging activity displayed by the combination of composite flours

Data is expressed as Mean ± SD. The symbols in the table represents W - wheat flour, R - ragi flour, J - jackfruit seed flour, and all the composite flour was found to have significantly ($p < 0.05$) different scavenging activity when compared to control i.e., W_{100}

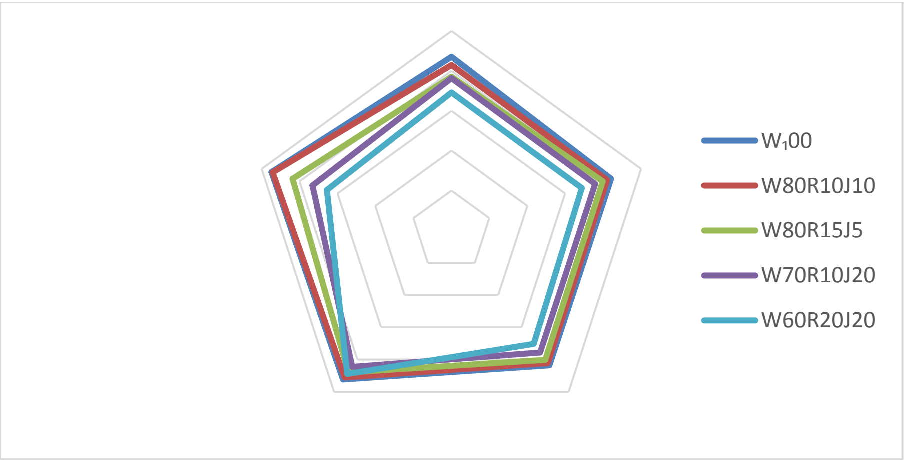

Figure 2. Sensory evaluation of composite flour biscuits

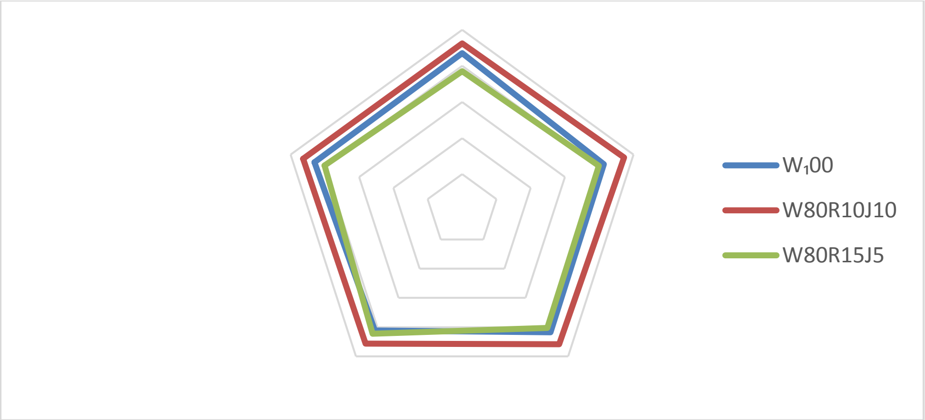

Figure 3. Sensory evaluation of composite flour muffins

Conclusions

Composite flour is a blend that is created to satisfy specific functional characteristics and nutrient composition. Composite flours containing wheat and other flours have proven of practical uses and are being utilized in many parts of the world to improve the nutritional and functional properties of flour. From the results obtained, it can be concluded that incorporation of ragi and jackfruit seed flour in wheat flour up to 30%, will enhance the quality of the flour. The composite flours developed can replace 100% wheat flour in production of various snacks with better nutritional quality and functionality. The sensory quality of ragi and jackfruit seed based composite flour biscuits decreased with increase in incorporation level of jackfruit seed flour. The incorporation above 30% in biscuits was not acceptable based on sensory quality parameter. It was observed that 5, 10, 15 and 20% ragi and jackfruit seed flour incorporated biscuits showed good taste, aroma and texture and were not significantly different with control with respect with sensory qualities. For making muffins the sample $W_{80}R_{10}J_{10}$ showed very good aroma, color and texture due to the incorporation of fermented jackfruit seed flour as compared to sample $W_{80}R_{15}J_{5}$.

References

Adebowale A.A., Adegoke M.T., Sanni S.A., Adegunwa M.O., Fetuga G.O. Functional properties and biscuit making potentials of sorghum-wheat flour composite. *American Journal of Food Technology*, 2012, 7(6): 372-379. https://doi.org/ajft.2012.372.379

Ajanaku K.O., Ajanaku C.O., Edobor-Osoh A., Nwinyi O.C. Nutritive value of sorghum ogi fortified with groundnut seed (*Arachis hypogaea* L.). *American Journal of Food Technology*, 2012, 7(2): 82-88. https://doi.org/ajft.2012.82.88

Akintayo E.T., Oshadi A.A., Esuoso K.O. Effect of NaCl, ionic strength and pH on the foaming and gelation of pigeon pea (*Cajanus cajan*) protein concentrate. *Food Chemstry*, 1999, 66(1): 51-56. https://doi.org/10.1016/S0308-8146(98)00155-1

Amandikwa C., Iwe M.O., Uzomah A., Olawuni A.I. Physico-chemical properties of wheat-yam flour composite bread. *Nigerian Food Journal*, 2015, 33(1) 12-17. https://doi.org/10.1016/j.nifoj.2015.04.011

Moore J.C., De Vries J.W., Lipp M., Griffiths J.C., Abernethy D.R. Total protein methods and their potential utility to reduce the risk of Food protein adulteration. *Comprehensive Reviews in Food Science and Food Safety*, 2010, 9(4): 330-357. https://doi.org/10.1111/j.1541-4337.2010.00114.x

Aremu M.O., Olaofe O., Akintayo E.T. Functional properties of some Nigerian varieties of legume seed flour concentration effect on foaming and gelation properties. *Journal of Food Technology [Iran]*, 2007, 5(2): 109-115. Available at: https://www.sid.ir/en/journal/ViewPaper.aspx?ID=334968

Burkill H.M. The useful plants of West Tropical Africa. In: Royal Botanic Gardens, Kew (Second Edition) (Families M-R Ed), Volume 4. University Press of Virginia, Charlottesville, VA, 1997. pp. 648, Print ISBN: 978-0-94-764364-5, ISBN 10: 0947643567, ISBN 13: 9780947643560 https://books.google.bg/books/about/The_Useful_Plants_of_West_Tropical_Afric.html?id=3WWKQgAACAAJ&redir_esc=y

Chandra S., Singh S., Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food Science and Technology*, 2015, 52(6): 3681-3688. https://doi.org/10.1007/s13197-014-1427-2

Chaturvedi R., Srivastava S. Genotype variations in physical, nutritional and sensory quality of popped grains of amber and dark genotypes of finger millet. *Journal of Food Science and Technology*, 2008, 45(5): 443-446.

Coffman W.C., Garciaj V.V. Functional properties and amino acid content of a protein isolate from mung bean flour. *International Journal of Food Science & Technology*, 1977, 12(5): 473-484. https://doi.org/10.1111/j.1365-2621.1977.tb00132.x

De Ancos B., Sgroppo S., Plaza L., Cano M.P. Possible nutritional and health related value promotion in orange juice preserved by high-pressure treatment. *Journal of the Science of Food and Agriculture*, 2002, 82(8): 790-796. https://doi.org/10.1002/jsfa.1093

Dhanimsetti S., Kothakota A., Ranasalva N., Bodhankar H.B., Chavan P.D. Development of composite flour bread and its effect on physical, sensory and nutritional characteristics. *International Journal of Agriculture Sciences*, 2016, 8(57): 3110-3114. Available at: https://bioinfopublication.org/include/download.php?id=BIA0003275

Dhingra S., Jood S. Effect of flour blending on the functional, baking and organoleptic characteristics of bread. *International Journal of Food Science & Technology*, 2004, 33(2): 213-222. https://doi.org/10.1046/j.0950-5423.2003.00766.x

Ekunseitan O.F., Obadina A.O., Sobukola O.P., Omemu A.M., Adejungwa M.O., Kajihausa O.E., Adebowale A.- R., Sanni S.A., Sanni L.O., Keith T. Nutritional composition, functional and pasting properties of wheat, mushroom, and high-quality cassava composite flour, *Journal of Food Processing and Preservation*, 2017, 41(5): e13150. https://doi.org/10.1111/jfpp.13150

Falola A.O., Olatidoye O.P., Adesala S.O. Amusan M. Modification and quality characteristics of cocoyam starch and its potential for Chin-Chin production. *Pakistan Journal of Nutrition*, 2014, 13(12): 768-773. https://doi.org/pjn.2014.768.773

FAO. FAO statistics series no-102, Food and Agriculture Organisation of the United Nation, Rome. 1991. Available at: http://www.fao.org/3/a-t0496e.pdf

FAO. A cassava industrial revolution in Nigeria. FAO Corporate document repository. 2006. Available at: http://www.fao.orga//docrep/007/y5548e/y5548e06htm. (Accessed 05/12/11)

FAO. FAO, Statistical year book. Rome: Author, 2013. Available at: http://www.fao.org/docrep/018/i3107e/i3107e03.pdf

Kang R.K., Jain R., Mridula D. Impact of indigenous fibre rich premix supplementation on blood glucose levels in diabetics. *American Journal of Food Technology*, 2008, 3(1): 50-55. https://doi.org/ajft.2008.50.55

Kulkarni K.D., Kulkarni D.N., Ingle W.M. Sorghum malted and soybean weaning food formulation: preparation, functional properties and nutritive value. *Food Nutrition Bulletin*, 1991, 13(4): 1-7. https://doi.org/10.1177/156482659101300401

Lakshmi Kumari P., Sumathi S. Effect of consumption of finger millet on hyperglycemia in non-insulin dependent diabetes mellitus (NIDDM) subjects. *Plant Foods for Human Nutrition*, 2002, 57(9): 205-213. https://doi.org/10.1023/A:1021805028738

Liyana-Pathirana C.M., Shahidi F. Importance of insoluble-bound phenolics to antioxidant properties of wheat. *Journal of Agricultural and Food Chemistry*, 2006, 54(4): 1256-1264. https://doi.org/10.1021/jf052556h

Misra A., Rastogi K., Joshi S.R. Whole grains and health: Perspective for Asian Indians. *Journal of the Association of Physician of India*, 2009, 57(2): 155-162. Available at: https://www.japi.org/s264a4a4/whole-grains-and-health-perspective-for-asian-indians

Niba L.L., Bokanga M.M., Jackson F.I., Schlimme D.S., Li B.W. Physico-chemical properties and starch granular characteristics of flour from various Manihot esculenta (cassava) genotypes. *Journal of Food Science*, 2002, 67(5): 1701-1705. https://doi.org/10.1111/j.1365-2621.2002.tb08709.x

Ocloo F.C.K., Bansa D., Boatin R., Adom T., Agbemavor W.S. Physico-chemical, functional and pasting characteristics of flour produced from jackfruits (*Artocarpus heterophyllus*) seeds. *Agriculture and Biology Journal of North America*, 2010, 1(5): 903-908. https://doi.org/10.5251/abjna.2010.1.5.903.908

Okezie B.O., Bello A.B. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. *Journal of Food Science*, 1988, 53(2): 450-454. https://doi.org/10.1111/j.1365-2621.1988.tb07728.x

Rahman M.A., Nahar N., Mian A.J., Mosihuzzaman M. Variation of carbohydrate composition of two forms of fruit from jack tree (*Artocarpus heterophyllus* L) with maturity and climatic conditions. *Food Chemistry*, 1999, 65(1): 91-97. https://doi.org/10.1016/S0308-8146(98)00175-7

Ranasinghe R.A.S.N., Maduwanthi S.D.T., Marapana R.A.U.J. Nutritional and health benefits of jackfruit (*Artocarpus heterophyllus* Lam.): A review. *International Journal of Food Science*, 2019, Volume 2019, Article ID 4327183. https://doi.org/10.1155/2019/4327183

Serrem C.A., de Kock L.H., Taylor J.R.N. Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. *International Journal of Food Science & Technology*, 2011, 46(1): 74-83. https://doi.org/10.1111/j.1365-2621.2010.02451.x

Tangariya P., Sahoo A., Awasthi P., Pandey A. Quality analysis of composite flour and its effectiveness for *Chapatti* formulation. *Journal of Pharmacognosy and Phytochemistry*, 2018, 7(4): 1013-1019. Available at: https://www.phytojournal.com/archives/2018/vol7issue4/PartQ/7-3-288-705.pdf

Yasumatsu K., Sawada K., Moritaka S., Mikasi M., Toda J., Wada T., Ishi K. Whipping and emulsifying properties of soybean products. *Agricultural and Biological Chemistry*, 1972, 36(5): 719-727. https://doi.org/10.1080/00021369.1972.10860321

Zhou Z., Robards K., Helliwell S., Blanchard C. The distribution of phenolic acids in rice. *Food Chemistry*, 2004, 87(3): 401-406. https://doi.org/10.1016/j.foodchem.2003.12.01