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An Analytical Study on Jackfruit Seed Flour and its Incorporation in Pasta.

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ABSTRACT

Jackfruit (*Artocarpus heterophyllus* Lam.) is one of the most popular tropical fruits grown in India. Jackfruit seeds make-up around 10 to 15% of the total fruit weight and have high carbohydrate and protein contents, dietary fibre, vitamins, minerals and phytonutrients. To increase the shelf life, jackfruit seed flour is a better option, so that the analysis had done. Jackfruit seed flour (JSF) was a cheap source of protein (13.49%), ash (2.47%) and carbohydrate (70.73%). The calorific value was 357.665 kcal/100g. It was also rich in potassium (6466 ppm), magnesium (4582 ppm) and sodium (8906 ppm). High water absorption capacity (2.91ml/g), oil absorption capacity (0.884ml/g) and bulk density (0.873g/ml) were recorded for JSF. It had a least gelation capacity of 17%. The addition of JSF at different proportions (5%, 10%, 15% and 20%) to the pasta increased the nutrient content and textural properties. 10% JSF substituted pasta has got the maximum consumer acceptability.

Keywords: Jackfruit, Jackfruit seed, Pasta, Analytical study, shelf life

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INTRODUCTION

The Jackfruit (*Artocarpus heterophyllus* Lam.), believed to have originated from India, is largely cultivated throughout many countries in the Middle East such as India, Burma, Ceylon, Malaya and Southern China[1]. This fruit also grows in African countries such as Uganda and Kenya; as well as in Brazil, Jamaica and the Bahamas.Jackfruit is available in the Indian market in the spring, till summer. The fruit contains large fleshy banana flavoured sweet bulbs which may be crispy or soft and yellow to brownish when ripe [2]. Jackfruit also has been reported to contain antioxidant prenyl flavones. Recently, antioxidant capacity of fruit pulp has been evaluated. However, jackfruit seeds are eaten as boiled or roasted but less popular as vegetable . The seeds are also rich source of carbohydrates and proteins and good source of fibre and vitamins.They are light brown in colour, oval, or oblong ellipsoid or rounded shape, 2-3 cm (0.8-1.2 inch) in length and 1-1.5 cm (0.4-0.6 inch) in diameter. Up to 500 seeds can be found in each fruit. They are recalcitrant and can be stored in cool, humid conditions up to a month[3]. Manganese and magnesium elements have been detected in seed powder [4] Jacalin and artocarpin are the two lectins present in the seeds. Jacalin has been seen to inhibit the herpes simplex virus type 2 and has proved to be useful for the evaluation of the immune status of human immunodeficiency virus 1 (HIV1) infected patients [5].The incorporation of seed flour to deep fat fried products has found to reduce the fat absorption to a remarkable extent[6]. With all these medicinal values and efficient ingredients in value added products the utilization of seed flour in convenience food has a long way to utilize the flour with value addition for marketability and to create employment among rural women for economic empowerment. In recent years pasta has been a popular dish and is also recognized as food product that is low in sodium and fat with no cholesterol and rich source of complex carbohydrate[7].Inclusion of this pasta ensures the consumption of jackfruit, which provides many health benefits especially among school going children and working women[8].

MATERIALS AND METHODS

Materials

Jackfruit Seed Flour

The seeds were collected from the local market, cleaned. The seed coat and brown spermoderm were removed. The seeds were subjected to lye peeling using 3% NaOH for 15 minutes. Then the seeds were washed thoroughly with water and cut into small pieces. The seeds were cooked in boiling water for 1 hour, recommended by A.H. Akinmutimi, to reduce the anti-nutritional factors. The cooked sample was dried in a hot air drier at 60°C for 6-7 hours. The dried seeds were powdered in a mixer grinder, passed through a sieve. The flour was stored in air tight containers.

Wheat flour

Commercially available refined wheat flour (maida) was purchased from local market. All maida samples were stored in air tight containers until further use.

Chemicals

The reagents and chemicals used are of analytical grade (AR) unless and otherwise specified.

Methods

Physico-Chemical Properties

The proximate composition of jackfruit seed flour (JSF) was determined by Association of Official Analytical Chemist (AOAC 2000) methods. The JSF was analysed for moisture using oven drying method, ash by burning in a muffle furnace, protein by Kjeldal method, fat by Soxhlet extraction using petroleum ether(b.p 60-80 ºC), crude fibre by acid and alkali digestion method and carbohydrate by deducting the sum of values of moisture, protein, fat, ash and crude fibre from 100.

Calorific Value

The calorific value was computed by summing up the values obtained by multiplying the values of carbohydrate, crude protein and crude fat with the factors 4, 4 and 9 respectively and expressed as kilocalories per 100 grams of seed flour.

Mineral Composition

The mineral composition of the seeds was determined by Atomic Absorption Spectroscopy method[9].

pH and Titratable Acidity

pH of the JSF was checked by dipping the probe of pH meter in a 10% flour solution. The titratable acidity of the seed flour was expressed in terms of lactic acid by titrating a 10% JSF solution against 0.1 N NaOH using phenolphthalein as indicator.

Functional Properties

Water Absorption Capacity

One gram sample was weighed into 25 ml graduated conical centrifuge tubes and about 10 ml of water added. The suspensions were allowed to stand at room temperature (30 ± 2 °C) for 1 hr. The suspension was centrifuge at 200 x g (2000 rpm) for 30 minute. The volume of water on the sediment was measured and the water absorbed expressed as per cent water absorption based on the original sample weight[10].

Oil Absorption Capacity

One gram sample was weighed into 25 ml graduated conical centrifuge tubes and about 10 ml of refined vegetable oil (Goldwinner brand. Density, 0.91 g/ml) added. The suspension was centrifuge at 200 x g (2000 rpm) for 30 minute. The volume of oil on the sediment was measured and the oil absorbed expressed as percent oil absorption based on the original sample weight[10].

Bulk Density

A graduated cylinder tubes were weighed and flour sample filled to 5 ml by constant tapping until there was no further change in volume. The contents were weighed and the difference in weight determined. The bulk density was computed as grams per milliliter of the sample[11].

Swelling Power

This was determined with the method described by Leach et al 1959. with modification for small samples. One gram of the sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80 °C for 30 min. The mixture was continually shaken during the heating period. After heating, the suspension was centrifuged at 1000 x g for 15 min. The supernatant was decanted and the weight of the paste taken. The swelling power was calculated[12].

Solubility

About 500 milligrams (W1) of jack seed flour was taken in a centrifuge tube and weighed the centrifuge tube with sample (W2) and 20ml (VE) of distilled water was added. Then it was allowed for 30min in a boiling water bath at 100°C. The contents were cooled and centrifuged at 5000rpm for 10min. The supernatant was carefully decanted in a test tube. For percent solubility of seed flour, the dried petriplate was weighed (W4) and 10ml of supernatant (VA) was pipetted into the petriplate. Then it was dried at 105°C in a hot air oven till constant weight was attained and cooled in a descicator and again weighed the petriplate with dry solids (W5).The per cent solubility of the supernatant was calculated.

Gelation Capacity

Least gelation concentrations for raw and heat processed jackfruit flours were determined using the method modified[13]. Flour samples were mixed with 5 ml of distilled water in test tubes to obtain suspensions of 2-20% (w/v) concentration. The test tubes were heated for 1 h in a boiling water bath, cooled rapidly under running tap water and further cooled for 2 h in a refrigerator at 4˚C. The least gelation concentration was regarded as that concentration at which the sample from the inverted test tube did not fall or slip.

Flour Dispersibility

Dispersibility was measured by placing 10 grams of seed flour sample in 100ml stoppered measuring cylinder. Distilled water added to the volume of 100ml, stirred vigorously and allowed to settle for three hours. The volume of settled particles was subtracted from 100 and the difference was reported as percentage dispersibility.

Analysis Of Pasta

Preparation of Pasta Blends

Wheat flour and Jackfruit seed flour(JSF) blends were prepared by replacement method, in the ratio of 100:0; 95:5; 90:10; 85:15; 80:20 (wheat flour/JSF; w/w) to obtain control 5, 10, 15 and 20% blends. Then these blends were extruded and analysed for moisture, protein and ash.

Estimation of Gluten in wheat flour

Gluten in a sample of flour could be estimated by washing the dough free of starch, sugars, water soluble proteins and other minor components, The wet cohesive mass obtained is referred to as wet gluten while the dried product obtained from it is referred to as dry gluten.

Determination of pasting characteristics of wheat flour- JSF blends using Rapid-visco-Amylograph

The Amylograph is a recording viscometer, used to determine the effect of α-amylase activity on the viscosity of starch gel as function of temperature.The Amylograph value provides information on probable effect of α-amylase during pasta processing. Pasting properties of wheat flour-JSF blends were measured using a rapid-visco- Amylograph (RVA Starchmaster2, Newport Scientific, Warriewood, Australia), following the AACC method 22-10A[14] to determine the onset gelatinization temperature, peak viscosity, breakdown and setback values. The viscosity values were reported in terms of Brabender Units (BU).

Pasta processing

Pasta was prepared using wheat flour and different concentrations of JSF (0%, 5%, 10%, 15% and 20% [w/w]).The flour and water were premixed in a Spar mixer at speed 1 (60 rpm) until uniform distribution of water was facilitated. The consistency of the dough depends on the volume of water added and the time of mixing. These two parameters were optimized. Then the premixed dough (300 g) was kept for hydration for fifteen minutes by covering the dough containing bowl with a wet cloth. After that, it was transferred to a laboratory pasta extruder machine (La Monferrina, Model Dolly, Asti, Italy) and further kneaded for 1 min. The dough was then extruded through the brass die for pasta type Rotini and was dried in a hot air drier held at 60˚C for 3 hours. The pasta samples are then allowed to cool at room temperature and then packed in polyethylene covers for storage.

Quality characterization of pasta

Cooking quality determination (cooking loss, cooked weight and water absorption)

25 g (W1) of raw pasta was added to 250 ml of boiling water was cooked for optimum cooking time (The time required for the complete gelatinization of starch). It is defined as the time required for the white opaque core of the strand to disappear. The time was determined by removing a strand from water at 30-s intervals and cutting into two pieces. After cooking the cooked water was drained and the volume was measured. The cooked pasta weight was also noted (W2). Accordingly after cooking and draining, samples were analyzed for water absorption and cooking loss.

Determination of pasta firmness

Firmness of cooked pasta was measured using a universal texture measuring system (TA HD Plus) The cooked pasta stands were analysed for stickiness and firmness by the HDP Pasta Firmness Rig. The stickiness is expressed in gram force whereas firmness in kg-s. A higher value indicates a firmer product.

Microstructure of cooked pasta using Scanning electron microscopy

Scanning electron microscopy can be used to study the changes in structure of pasta that occurred during cooking. It mainly gives an idea about the starch protein interactions that contribute to the quality of pasta products. Cooked pasta samples were kept at freezer for overnight and dried for 5-6 h. Dried samples were packed in polyethylene covers and stored in desiccators, which were further used for microscopic studies.

RESULTS AND DISCUSSION

Jackfruit is considered as poor man's fruit. It is a good source of protein and carbohydrates, the seeds have several potentialities for value addition. The results of the studies on jackfruit seed flour based on physico-chemical and functional properties and the analysis of jackfruit seed flour added pasta are discussed below.

Analysis of Jackfruit Seed Flour

Physico-chemical Properties

It includes the proximate analysis, mineral composition, total starch content, pH & titratable acidity, dietary fibre analysis of the jackfruit seed flour.

Moisture

Moisture provides a measure of the water content of the seed flour and for that matter its total solid content. It is also an index of storage stability of the flour. The moisture content of the seed flour was 7.758% The lower the moisture content of flour, the better its shelf stability and the quality. Moisture content of flour generally is depended upon the duration of the drying process.

Crude Fat

The fat content of the jackfruit seed flour was 2.317% The result is however compared with fat content of jackfruit seeds in literature (0.88%, dry matter basis)[15].Singh et. al. (1991) reported lipid values of 2.2% for Jackfruit seeds. The observed value is however comparable to value reported by Bobbio et.al.(1978), who reported 1.3%. Kumar et. al. (1988) also reported crude lipid content of 2.1-2.5% for jackfruit seeds.

Crude Ash

The percent ash content of the flour was 2.472% .The ash content is the inorganic residue remaining after the organic matter has been burnt away. Ash content of 2.76 – 3.31% (dry matter basis) has been reported for jackfruit seeds. The disparity may be due to varietal differences and the locality.

Crude Protein

The percent crude protein of the flour was 13.49% The value obtained was however lower than that obtained[16]. The difference observed may be contributed by varietal differences, maturation of the seeds and environmental conditions. Bobbio et. al. (1978) reported value of 31.9%. Kumar et. al. (1988) also reported protein content of 17.8-18.3% for jackfruit seeds. Values of 6.34 – 8.57% have also been reported for jackfruit seed flour[17].

Crude Fibre

The percent crude fibre of the flour was 3.25% This value is comparable to value of 3.19% and 3.06% are reported[16]. Crude fibre value of 2.36% was also reported by Tulyathan et. al. (2002). The disparity may be due to varietal differences and the locality[18].

Carbohydrate

The major component of the flour was carbohydrate. The value obtained from the study was 70.713% .This result is comparable to those reported by Singh et al (1991) 74%, Kumar et al(1988) 76.1%, and Tulyathan et al(2002) 81.64%. However, the value obtained is higher than 66.2%, reported [19].

Energy

The caloric value (energy) of the Jackfruit seed flour was 357.66 kcal/100g. This value is comparable with 382.79 kcal/100g reported[20], but is higher than that reported by Akinmutimi (2006) for Jackfruit seed (292 – 313 kcal/100g).

pH and Titratable Acidity

The pH and titratable acidity (as lactic acid) of JSF were 6.02 and 0.574% respectively.It was reported that **t**he pH and titratable acidity (as lactic acid) of the seed flour were 5.78 and 1.12% respectively. pH value gives a measure of the acidity or alkalinity of the flour, while the titratable acidity gives a measure of the amount of acid present in the fruit. The levels of these indices are used to estimate the quality of the flour.

Mineral Composition

The mineral composition of JSF is showed in the . The flour is rich in sodium (8906 ppm), potassium (6466 ppm) and magnesium (4582 ppm), but low in copper(2.20 ppm) and manganese(4.04 ppm). F.C.K.Ocloo et al(2010) studied that the Jackfruit seed flour prepared was rich in calcium (3087 mg/kg), magnesium (3380 mg/kg) and potassium (14781 mg/kg). Akinmutimi (2006) reported values 0.4667% (phosphorus), 67% (iron), 7.05% (copper), 28.85% (manganese), 73.4% (zinc), 0.099% (calcium), 1.21% (potassium) and 0.025% (sodium). The value obtained for potassium is comparable to that reported [21].

Functional Properties

Water Absorption Capacity

The water absorption capacity of the JSF was found to be 2.916 ml/g, . F.C.K.Ocloo et. al. (2010) reported the water absorption capacity for the Jackfruit seed flour was 25% (2.5 ml/g). The value is higher than 2.3 ml/g reported for raw jackfruit flour[22]. Water absorption capacity describes flour – water association ability under limited water supply. The disparities observed could be attributed to the method used as well as the varietal differences. The result obtained shows that the flour has a good ability to bind water. This result suggests that Jackfruit seed flour could be used in bakery industry.

Oil Absorption Capacity

The oil absorption capacity of JSF was 0.884 ml/g. The value is lower than that reported by F.C.K.Ocloo et. al. (2010) 1.7ml/g and 2.8 g/ml reported for raw jackfruit flour (Odoemelam, 2005). Fat absorption is an important property in food formulations because fats improve the flavour and mouthfeel of foods[23]. The disparities observed could be attributed to the method used as well as the varietal differences. The result obtained shows that jackfruit seed flour is a high flavour retainer and may therefore find useful application in food systems such as ground meat formulations.

Bulk Density

Bulk density is depended upon the particle size of the samples. The value obtained from the study was 0.873 g/ml. The value was comparable with 0.80g/cm^3 [24] also reported a bulk density value of raw flour from Jackfruit seeds to be about 0.61g/ml.

Bulk density is a measure of heaviness of a flour sample. It is important for determining packaging requirements, material handling and application in wet processing in the food industry. The value obtained is higher than that reported in literature. Since flours with high bulk densities are used as thickeners in food products, the Jackfruit seed flour studied could be used as a thickener.

Swelling Power

The JSF has a swelling power of 5.264 . The value was comparable with that reported by F.C.K.Ocloo et al(2010) that is 4.77. Swelling power is a measure of hydration capacity, because the determination is a weight measure of swollen starch granules and their occluded water. Food eating quality is often connected with retention of water in the swollen starch granules [25].

Gelation

The least gelation capacity of the jackfruit seed flour was 17%. The value was comparable with the least gelation concentrations for the raw and heat processed jackfruit flour 16% and 18% (w/v), respectively. These variations may be due to variations in the different constituents of the flour such as carbohydrates, lipids and proteins, which have a significant role on functional properties of flour (Abbey and Ibeh,1988). Swelling of starch granules occurs in gelation while heating. Hence jackfruit seed flour is a good gelling agent and thickener, useful in food systems such as puddings, sauces, soups etc [26].

Flour Dispersibility

The flour dispersibility of JSF was 60.33%. The property of dispersibility determines the tendency of flour to move apart from the water molecules and reveals its hydrophobic action. The dispersibility of jack seed flour recorded 30%[27],which was much lower than the documented values of Quality Protein Maize (71.00%) and DMH-2 maize variety (68.70%) as reported[28]. The data on jack seed flour on the above parameter is not available.

Analysis of Pasta

The JSF incorporated pasta were analyzed for its nutrient content, cooking quality, texture, and micro-structural studies.

Gluten content

The gluten content of the wheat flour was analyzed. The dry gluten content was 10.89% whereas wet gluten content was 27.63%. The dough obtained by mixing wheat flour with water possesses the characteristics of plasticity and elasticity is mainly due to the presence of gluten component, which has a significant role in handling the dough as well as its end performance.

Pasting Characteristics

The pasting properties of wheat flour-JSF blends are shown in Fig 1.The gelatinization temperature of control was 95.2°C, found to be same as that of JSF substituted blend; this may be not such competition of starch molecules for hydration and the higher temperature required for breaking the hydrogen bonds in the network and hence facilitating the hydration of the granules.

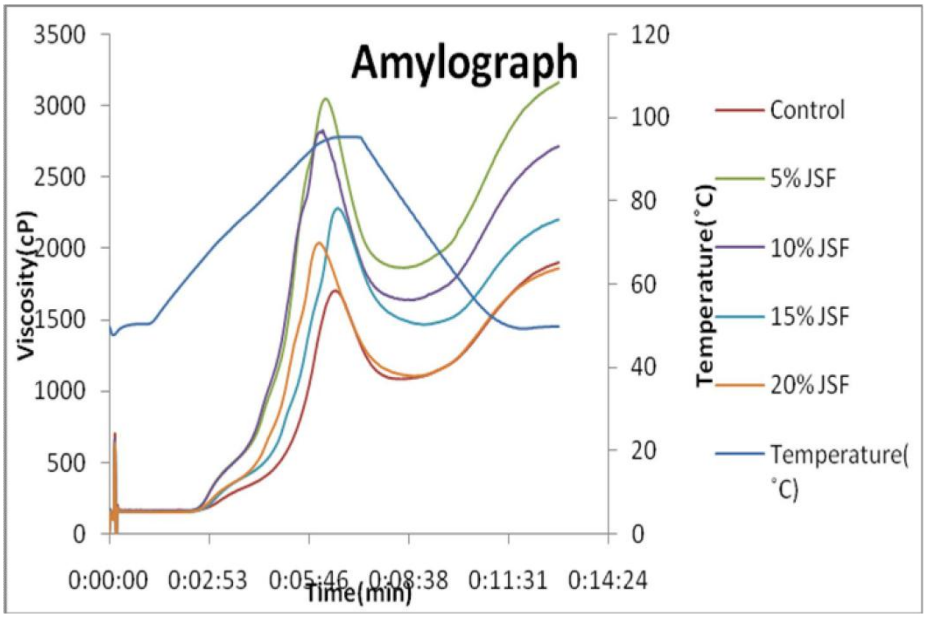


Figure: 1 Pasting Characteristics of wheat flour-JSF blends

Peak viscosity reflects the ability of the starch granules to swell freely before their physical breakdown. The peak viscosity decreases as substitution level is increased which indicates that the presence of JSF does not promote an increment of the capacity of the starch granules to swell.

Hot, cold and final paste viscosities decreases as the substitution level increases from 5% to 20%. The breakdown values increased from 875cP to 1190cP as the level of substitution increases; this indicated that starch granules are becoming, less resistant to thermal treatment and mechanical shear as the level of substitution increases[29].The setback has been reported due to aggregation of the amylose fractions, which leads to reinforcement of swollen granules and fragments by the formation of bonds between them[30]. It was found to be decreasing from Control to 20% JSF. Differences in protein composition are also known to affect pasting viscosities and properties [31].

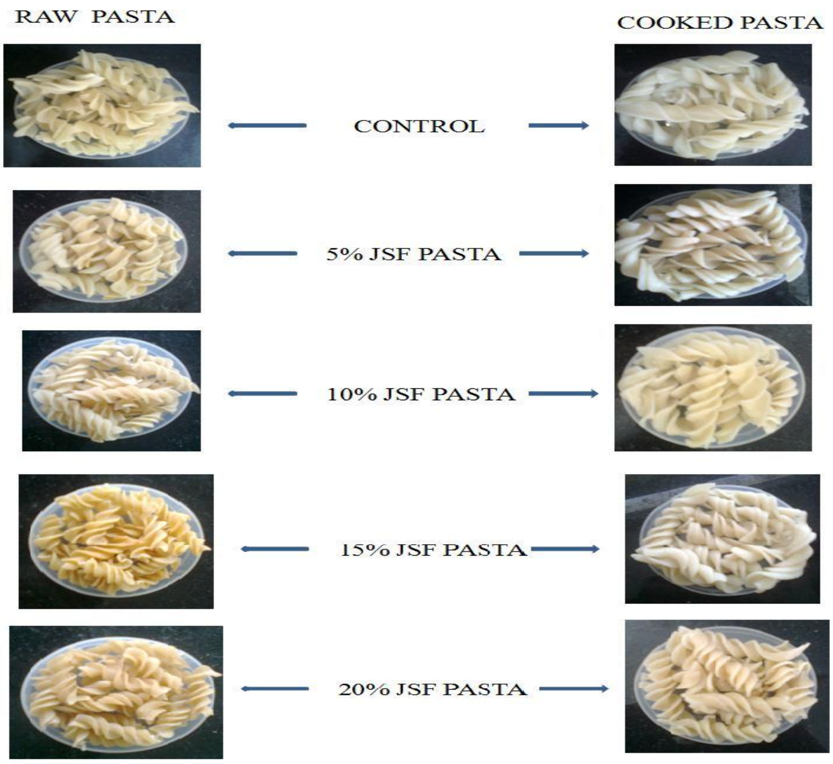
Nutritional Value

The extruded pasta samples were determined for nutritional value in terms of moisture, protein and ash, using AOAC methods and shown in . The moisture content of the samples was comparable with that of the control. But the protein and the ash content of the JSF incorporated pasta was gradually increasing as compared to the control. This is due to the nutritional value of the added jackfruit seed flour. There was not such a big deviation of the nutrient content for the 10%, 15% and 20% JSF pasta, may be due to the availability of the nutrients present in the added flour in lesser amount.

Cooking Quality

The cooking characteristics of jackfruit seed flour supplemented pasta were compared to the control and the results are presented and the photographs of raw and cooked pasta are shown in Fig.2.The ability to form a gluten matrix is unique to wheat flour and semolina and is believed to be the main factor in forming the internal network that holds the pasta together [32]. Cooking quality is indicated by cooking time, cooked weight and cooked firmness. Cooking time of pasta substituted with jackfruit seed flour was comparable to that of control pasta sample.

Figure:2 Samples of Raw and Cooked Pasta



Textural Characteristics

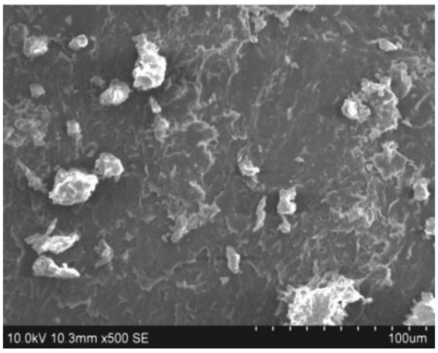
Pasta samples were placed in the platform of TA-HD texture analyzer to determine the stickiness and firmness. The results indicate that substitution with protein affects the firmness of the final product. Pasta firmness can be related to the hydration of starch granules during cooking process and the subsequent embedding of gelatinizing starch granules in a matrix of partially denatured protein.

The JSF substituted pasta had lesser stickiness to that of control except for 10% JSF pasta.It is clear that addition of JSF has increased the firmness of the pasta compared to that of control, maximum for 10% one.

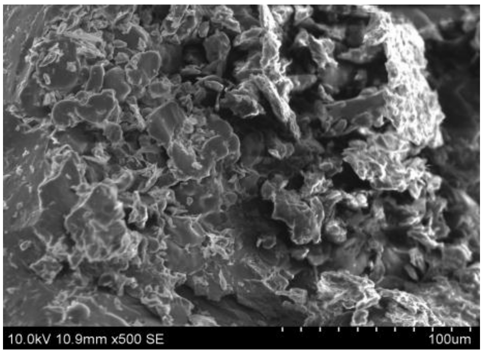
Scanning Electron Micrograph of JSF substituted pasta samples

Microscopy techniques have been used to gain information about size, shape, and arrangement of the particles, which can be further correlated with other pasta characteristics such as texture, cooking behavior, and digestibility [33]. The microstructure of transverse sections of control product was compared with the jackfruit seed flour substituted (at 5%, 10%, 15%, 20% level) rotini pasta Fig 3.

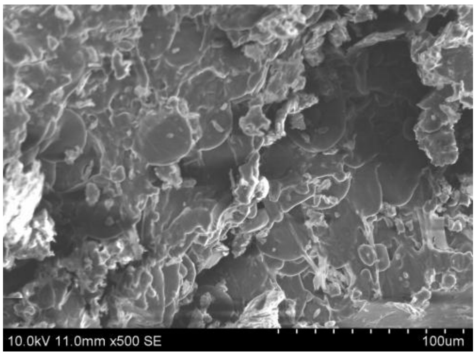
Fig.3 Scanning Electron Micrographs of pasta



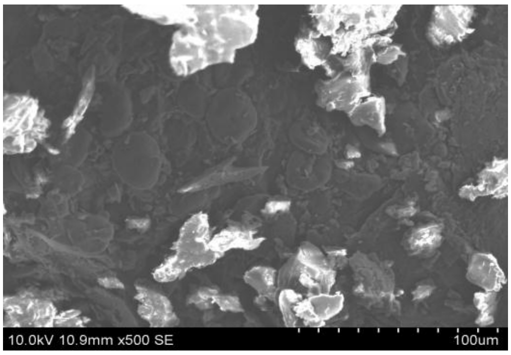
Control



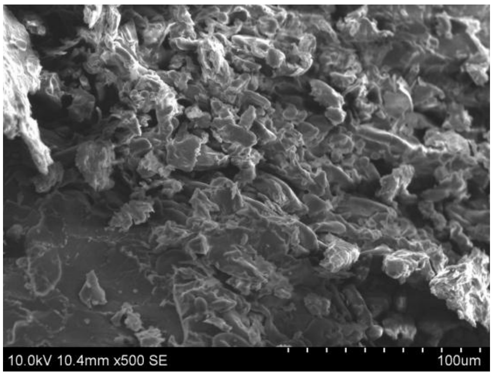
5 %JSF



10 %JSF



15 %JSF



20 %JSF

In Control pasta, wavy like structures were seen. It exhibited a good network due to gluten matrix. Wheat starch granules were seen embedded in the gluten matrix. In pasta with jackfruit seed flour, the starch granules within the pasta appear to be slightly swollen and irregular in size and shape, perhaps indicating the level of gelatinization during the extrusion process [34]. And, 10% JSF pasta reveals good starch and gluten network, with all starch molecules well embedded in the matrix. Higher concentration of JSF in pasta showed more particles in the matrix. None of the molecules is seen outside.

CONCLUSION

In countries with high population where the food requirements are not being fulfilled by seasonal vegetables, jackfruit seeds can be used as a good substitute. As jackfruit seeds have shorter shelf life, they go waste during the seasonal glut. So, the seed flour can be an alternative product, which can be stored and utilized, for value addition. Jackfruit seed flour was found to be rich in proteins, carbohydrates and minerals. The fat content of the seed flour was negligible, making it a good constituent in functional foods which can be consumed safely without any concern of health risk of fat free diet. Therefore, jackfruit seeds could be used in balanced diets. Jackfruit seed flour exhibited good functional properties also. It showed better results for water absorption, oil absorption, swelling power etc., which can be utilized in various food formulations.The incorporation of jackfruit seed flour in pasta at different proportions, increased the nutrient content of the control pasta, but showed similar rheological and cooking qualities. The colour of the pasta has slightly changed due to the addition of JSF, can be clearly seen when compared to the control pasta. The flavour of the jackfruit seed can easily recognised from the 15%, 20% JSF substituted pasta. The firmness of the pasta also increased with the addition of jackfruit seed flour. The 10% JSF substituted pasta showed greater consumer acceptability, in relation to flavour, mouthfeel, appearance, colour and overall quality. So, the pasta incorporated with 10% jackfruit seed flour could be optimized for value added pasta production.

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