Quality analysis of raw jackfruit based noodles

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ABSTRACT
Noodles were extruded as 6 treatments using raw jackfruit bulb flour, jackfruit seed flour and refined flour in different proportion. Different levels of refined wheat flour, jackfruit seed flour and jackfruit bulb flour were added in the ratio (40:30:30, 50:25:25, 50:30:20, 50:40:10, 50:10:40, 50:20:30). This study comprises the quality analysis of the noodles with respect to its cooking quality and physical characteristics. Cooking qualities were analysed with respect to cooking time, cooked weight, cooking loss and water absorption. Physical characteristics like extrusion behaviour, bulk density, true density, swelling index, yield ratio and colour were also analysed. It was observed that cooking and physical quality of noodles was not affected by composition of composite flour. The developed noodles were found to be acceptable. Treatment T6 was observed to have significantly higher yield ratio and significantly lower cooking time.

Key words: Bulk density, Cooking loss, Cooked weight, Extrusion, Noodles, True density, Swelling index, Water absorption.

INTRODUCTION
Jackfruit (Artocarpus heterophyllus L.) a member of the family Moraceae is the largest tree borne fruit in the world. It used to be an integral part of common Indian diet and is commonly known as “Kathal” (Gupta et al., 2011). India is the second biggest producer of this fruit and is considered as the motherland of jackfruit. It is believed to have originated in the rainforests of Western Ghats of India and is cultivated throughout the low lands in South and Southeast Asia (Nandkule et al., 2015). The plant is commonly referred to as 'poor man’s food’ as it is cheap and plentiful during the season. Raw jackfruit is being utilized to a lesser extent only as a vegetable, mainly owing to its cumbersome preparation procedures. Their full potential has not been exploited and utilized. Such under and un-utilized fruits are needed to be evaluated for their nutritive value and potential uses, including processing to convenience foods.

Noodle is a popular food item made from unleavened dough which is stretched, extruded, or rolled flat and cut into variety of shapes by using extrusion technology. This usually cooked in boiling water and salt. Sometimes cooking oil is added. It is widely consumed throughout the world and its global consumption is second only to bread (Jayasena et al., 2008). As the quality of noodles (cooked or uncooked) are generally assessed by its physical and cooking qualities, it is highly imperative to provide these details when developing a noodle from underexploited jackfruit. Raw jackfruit based noodles were extruded with jackfruit bulb flour, jackfruit seed flour and refined wheat flour in various proportions. The treatments were analysed for physical and cooking qualities of low cost jackfruit seed and bulb flour along with refined flour developed noodles.

MATERIALS AND METHODS
The experiment was conducted at the Department of Home Science, College of Agriculture Vellayani, Thiruvananthapuram, Kerala during the year 2013-2015.

Cooking characteristics
Cooking time: Cooking quality of noodles was analysed according to Ojure and Quadri’s method (2012) on unripe banana noodles.

Cooked weight: Cooked weight of a noodles were analysed according to Omeire et al. (2015) on cassava noodles.

Cooking loss: Cooking loss of noodles was analysed according to Ojure and Quadri’s method (2012) on unripe banana noodles and applying the formula-

\[\text{Cooking Loss} (%) = \frac{\text{Dried residue in cooking water}}{\text{Weight of noodles before cooking}} \times 100\]

Water absorption: Water absorption of noodles was analysed according to Ojure and Quadri’s method (2012) on unripe banana noodles and applying the formula-

\[\text{Water absorption} (%) = \frac{\text{Final weight – Initial weight}}{\text{Initial weight}} \times 100\]
Physical characteristics

Extrusion behaviour: This characteristic was analysed for wet (before drying) and dry noodles. The extrusion behaviour of the developed product was ascertained with respect to residence time, uniformity of strands and appearance during extrusion of wet noodles. Uniformity in flow of strands and external appearance during extrusion was rated by technical experts using score card (Karoline, 2004).

The quality of dry noodles was assessed for firmness, shape, uniformity of strands, tensile strength and packaging quality (suitability) subjectively. A five point score card was used for this.

Bulk density: Bulk density was assessed by the formula:

\[
\text{Bulk density} = \frac{\text{Weight of the sample}}{\text{Weight of equal volume of water}} \quad (\text{Okaka and Potter, 1979}).
\]

True density: True density was ascertained from the formula below:

\[
\text{True Density (g/ml)} = \frac{\text{Weight of sample}}{\text{Volume of sample}} \quad (\text{Tapash and Bhaskara, 2006})
\]

Swelling index: The swelling index (SI) of noodles was determined according to the method described by Chen et al. (2002). The swelling index value (SI) was expressed as below:

\[
\text{Swelling Index} = \frac{W_2 - W_1}{W_1}
\]

Where,

- \(W_1\): Weight of cooked noodles
- \(W_2\): Weight of noodles after drying

Yield ratio: Yield ratio of the developed products were analysed using the formula.

\[
\text{Yield ratio} = \frac{\text{Final weight of the product}}{\text{Weight of the raw ingredients}} \quad (\text{Krishnaja, 2014})
\]

Colour: Colour analysis was carried out on noodles using a Minolta spectrophotometer (Japan). The noodle samples after drying at 50°C for 2 hours were powdered using a blender and filled in a petridish of size 60 mm and height 17 mm. The primary colour coordinates ‘L’, ‘a’, ‘b’ values were measured by Minolta spectrophotometer and by granular material cover. From the above primary parameters, the total colour difference and the whiteness index of the powered samples were measured using standard equation as follows.

Total colour difference - \(\sqrt{(L^0 - L)^2 + (a^0 - a)^2 + (b^0 - b)^2}\)

Whiteness index - \(\sqrt{100 - (100 - L)^2 + a^2 + b^2}\)

Where,

- \(L\) = degree of lightness
- \(a\) = degree of redness
- \(b\) = degree of yellowness

\(L^0\) = lightness value of the reference plate - 99.34
\(a^0\) = redness value of the reference plate - 0.03
\(b^0\) = yellowness value of the reference plate - 0.01

Statistical analysis: Statistical analyses of the obtained data were subjected to analysis of variance (ANOVA) using complete randomized design. Critical difference at \((p \leq 0.05)\) was estimated and used to find significant difference, if any.

RESULTS AND DISCUSSION

Cooking time: The Table 1. showed that there was significant difference in cooking time among the developed noodles. It was seen to range from 8.26 to 9.36 min. The result further revealed that among developed noodles \(T_s\) took the least time (8.26 min.) for cooking. The second treatment which took less time for cooking was \(T_3\) (8.38 min) and it was seen to be at par with \(T_s\) (8.26 min). Data further revealed that treatments which contained highest amount of bulb flour took more time for cooking. RF: JFBF: JFSF in the ratio of 50:40:10 took longer time for cooking i.e. 9.36 min. However \(T_s\) (commercial noodles) was observed to take even lesser time (7.16 min) for cooking. Cooking time of commercial noodles was 7.16 min. All the treatments were found to have higher cooking time than control. This should be because refined flour contains starch which gelatinised easily. This variation may also be accommodated to the high fibre content present in \(T_s\) which contained more amount of bulb flour. Ojure and Quadri (2012) standardised unripe plantain flour noodles and reported that the cooking time ranged from 4.5 to 7.62 min. The author also reported that branded noodles (refined flour) had a cooking time of 8.21 to 8.29 min. In another study on banana flour noodles by Rittiruangdej (2011), it was reported that the optimum cooking time of all noodle samples ranged from 13.0 to 14.5 min. Vijaykumar et al. (2009) reported that cooking time of developed noodles from composite flour varied from 15-18 min, which was significantly higher than the cooking time of branded noodles. The cooking times for all the treatments were higher than that of market noodles which was reported to be 8 min. This difference is to be attributed to the incorporation of composite flour in its production as reported by Omeire et al. (2015).

Cooked weight: In this study percentage increase of cooked weight of developed noodles ranged from 100.45 to 140.62. The highest increase of weight (140.62) was obtained for \(T_3\) as reported by Omeire et al. (2015). This difference is to be attributed to the incorporation of composite flour in its production as reported by Omeire et al. (2015).

Weight of the raw ingredients \(\times 100\) \(\frac{\text{Cooked weight}}{\text{Weight of noodles after drying}}\) = \% Increase

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\[
\% \text{Increase} = \left( \frac{\text{Weight of noodles after drying}}{\text{Weight of cooked noodles}} \right) \times 100
\]

The nylon mesh size of 1 mm for sieving the granules was found to be apt for determining the swelling index. The swelling index value of \(T_s\) was lower than that of market noodles which was reported to be 8 min. However \(T_2\) (commercial noodles) was observed to take even lesser time (7.16 min) for cooking. Cooking time of commercial noodles was 7.16 min. All the treatments were found to have higher cooking time than control. This should be because refined flour contains starch which gelatinised easily. This variation may also be accommodated to the high fibre content present in \(T_s\) which contained more amount of bulb flour. Ojure and Quadri (2012) standardised unripe plantain flour noodles and reported that the cooking time ranged from 4.5 to 7.62 min. The author also reported that branded noodles (refined flour) had a cooking time of 8.21 to 8.29 min. In another study on banana flour noodles by Rittiruangdej (2011), it was reported that the optimum cooking time of all noodle samples ranged from 13.0 to 14.5 min. Vijaykumar et al. (2009) reported that cooking time of developed noodles from composite flour varied from 15-18 min, which was significantly higher than the cooking time of branded noodles. The cooking times for all the treatments were higher than that of market noodles which was reported to be 8 min. This difference is to be attributed to the incorporation of composite flour in its production as reported by Omeire et al. (2015).

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Cooking loss (%)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cooking time (min)</th>
<th>Cooked weight (g)</th>
<th>Cooking loss (%)</th>
<th>Water absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;1&lt;/sub&gt;</td>
<td>8.54</td>
<td>23.52 (130.52)</td>
<td>13.05</td>
<td>130.52</td>
</tr>
<tr>
<td>T&lt;sub&gt;2&lt;/sub&gt;</td>
<td>8.43</td>
<td>21.49 (110.49)</td>
<td>15.37</td>
<td>110.49</td>
</tr>
<tr>
<td>T&lt;sub&gt;3&lt;/sub&gt;</td>
<td>8.38</td>
<td>22.64 (120.64)</td>
<td>14.57</td>
<td>120.64</td>
</tr>
<tr>
<td>T&lt;sub&gt;4&lt;/sub&gt;</td>
<td>9.36</td>
<td>24.62 (140.62)</td>
<td>9.13</td>
<td>140.62</td>
</tr>
<tr>
<td>T&lt;sub&gt;5&lt;/sub&gt;</td>
<td>8.55</td>
<td>20.53 (100.53)</td>
<td>15.06</td>
<td>100.53</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt;</td>
<td>8.26</td>
<td>20.45 (100.45)</td>
<td>14.05</td>
<td>100.45</td>
</tr>
<tr>
<td>T&lt;sub&gt;6&lt;/sub&gt; (control)</td>
<td>7.16</td>
<td>19.87 (90.87)</td>
<td>16.20</td>
<td>90.87</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>0.189</td>
<td>0.396</td>
<td>0.044</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(Results are expressed as mean values of three replicates and numbers in parenthesis denote percentage)

Cooking loss: The cooking loss represents the particles that diffused out from the noodles into the cooking medium during cooking. In present study, cooking loss ranged from 9.13 to 15.37 per cent and cooking loss per cent for T<sub>1</sub> was the least (9.13 per cent) among all treatments. It was immediately followed by T<sub>2</sub> with a percentage loss of 13.05 per cent. T<sub>1</sub> had shown highest cooking loss (15.37). Cooking loss of T<sub>6</sub> (control) was higher compared to all treatments (16.20 per cent) at 5% level of significance. Cooking loss of treatments was high but it was lesser than commercial noodles. Non-wheat ingredients leads to discontinuity within the gluten matrix and results in weak dough properties as reported by Manthey <em>et al.</em> (2004). The study further revealed that the treatment which contained highest amount of bulb flour had less cooking loss i.e. T<sub>6</sub>. The reason for low cooking loss may be due to high fibre content in bulb flour and high protein in seed flour. Rittiruangdej <em>et al.</em> (2011) reported that an increased cooking loss with noodles containing banana flour is due to weakening of the protein network by the presence of banana flour. This may have allowed more solids to be leached out from the noodles into the cooking water. These results are in the agreement with the study of Martinez <em>et al.</em> (2007) who reported that partial or complete substitution of durum wheat semolina with fibre material can result in negative changes to pasta quality, including increased cooking loss. Purwandari <em>et al.</em> (2014) reported that cooking loss of noodles with pumpkin and tapioca, ranged from 11.20 – 27.38 per cent whereas cooking loss observed in breadfruit noodle was 12.45 to 17.04 per cent.

Water absorption: Water absorption of noodles was found to be higher and it ranged from 90.87 – 140.62 per cent. The highest water absorption was observed for T<sub>5</sub> (140.62 %) followed by T<sub>1</sub> (130.52 %), T<sub>2</sub> (120.64 %), and T<sub>4</sub> (110.49). The other two treatments, T<sub>3</sub> and T<sub>6</sub>, were seen to be on par with the score of 100.53 and 100.45 per cent respectively. (CD= 0.01% at 5% level of significance) The lowest water absorption 90.87 per cent was recorded by control (T<sub>1</sub>). All other treatments were seen to have higher water absorption than control. Water absorption of noodles was found to be higher in T<sub>1</sub> treatment which contained more amount of bulb flour. In these treatments it was seen that as the concentration of bulb flour increased water absorption increased. Abraham and Jayamuthunagai (2014) reported that JF seed flour has a good ability to bind water. Less water absorption was found in commercial noodles which contained only refined flour. In a study on banana flour noodles Ojure and Quadri (2012), reported that water absorption of noodles ranged from 105.50 to 124.20 per cent. They further reported that branded noodles had water absorption of 111.30 and 112.58 per cent. Several authors reported that the water absorption capacity depends on the behaviour of the protein denaturation, the function of the amylose/amylopectin ratio as well as the chain length distribution of amyllopectin (Kober <em>et al.</em>, 2007).

Physical characteristics

Extrusion behaviour: In the present study residence time of flour was found to be lower in T<sub>1</sub> with 31.05 min. It was also observed that as the concentration of seed flour increased, residence time decreased. This should be the due to higher viscosity of seed flour. Ocloo <em>et al.</em> (2010) reported that JF seed flour had high viscosity. The next higher residence time taken by T<sub>5</sub> (35.16 min) and T<sub>6</sub> (36.98 min) for extrusion. It was immediately followed by T<sub>3</sub> (40.55 min) and T<sub>4</sub> (43.50 min). T<sub>2</sub> took highest residence time (45.11 min) among all the treatments. Table 2. indicates that there were significant differences in residence as it depends on the viscosity of flour. Results of uniformity of strands showed that treatment T<sub>1</sub> obtained the highest score (4.89) which was immediately followed by T<sub>6</sub> with the score of 4.76. These treatments had RF: RJBF: RJSF in the ratio of 50:30:20 and 50:20:30 respectively. Treatment T<sub>3</sub> and T<sub>5</sub> were observed to be on par with the scores of 4.66 and 4.50 respectively. (CD=0.38% at 5% level of significance) T<sub>1</sub> and T<sub>6</sub> scored the lowest values among all (4.35 and 4.10 respectively). From this, it can be concluded that bulb and seed flour in this specific and appropriate combination (20:30) scored better with respect to this parameter. Blending in the right
The proportion of flours is essential for an acceptable product with excellent gluten formation. External appearance during extrusion was evaluated and data revealed that there was no significant difference in appearance during extrusion. The value of sensory scores ranged from 4.04 to 4.66. The highest score was obtained by T_1 (4.66) and it was immediately followed by T_1 with the score of 4.53. This should be due to more of seed flour which was finer as well more white in colour. In a similar study on extruded foods, it was revealed that the formulation with refined flour, tapioca flour and soya flour got the best rating for extrusion behaviour (Karoline, 2004). Firmness determines how the material will withstand during packaging and handling. In the present study with respect to firmness the scores ranged from 4.23 to 4.50. It was found to be higher in T_1 (4.50) which were on par with T_6 (4.48) (CD=0.0294 at 5% level of significance). From the result it was clear that treatment which contains appropriate combination of bulb and seed flour (fibre and starch) had good firmness quality. This is due to the high protein content in seed flour and fibre content in bulb flour. Firmness depends on the degree of gluten development in the noodle. It was reported that firmness of noodles was decided by the internal structures of the cooked product (Edwards et al., 1993). The difference in firmness of noodles was not caused by differences in cooking loss. Protein strength has been proposed that strong gluten in pasta may give a more rigid integrity of cooked pasta by Dexter (1981). They suggested as a possible cause for the difference in surface integrity of cooked pasta by Dexter et al. (1981). They proposed that strong gluten in pasta may give a more rigid but only less flexible structure than weak gluten and that such a structure would be more susceptible to rupture under the stresses of swelling during cooking. Flour protein content has a positive correlation with noodle hardness (Table 3).

Other treatments T_4, T_5, T_2 and T_6 scored 4.42, 4.37, 4.35 and 4.23 respectively. The score for shape of developed noodles was highest for T_6 (4.68) followed by T_1 (4.64), T_5 (4.52), T_4 (4.49) and T_7 (4.13) and respectively. The lowest score was obtained by T_3 (3.86). The score for uniformity of strands ranged from 4.06 - 4.75. The highest score was obtained by T_3 (4.75). The second highest score was obtained by T_4 (4.67). The other two treatments T_2 and T_5 scored 4.53 and 4.44 respectively. T_2 and T_5 scored less and the values were 4.26 and 4.06 respectively. Regarding tensile strength, scores ranged from 4.21 – 4.65. The highest score was obtained by T_1 (4.65) and it was seen to be on par with T_3 (4.58) and T_5 (4.56) respectively. (CD=0.327 at 5% level of significance). This is because these treatments had higher bulb flour. Incorporation of seed flour in the developed noodles had increased the protein content and this may be the reason for higher tensile strength. The lowest score was obtained by T_2 (4.21). Exudate breaking strength is important to both the processor and consumer. If the product has a low breaking strength; it will break easily and disintegrate during packaging and distribution. On the other hand, if the product has a higher breaking strength, the consumer will find the product difficult to bite and to chew (Liu and Maga, 1993). Suitable packaging quality is the ability of the product to withstand microbial contamination, absorption of moisture, gases, heat and dynamic stress (Shivashankaran 2000). In this study all the treatments had good packaging suitability as the result has shown no significant difference in the scores for packaging quality among treatments and all the treatments were found to be on par. Packaging quality was found to be high in the sev comprising of maida, rice flour and soya flour in the combination of 60:30:10 (Karoline, 2004).

### Bulk density:

The treatments exhibited variations in bulk density and the data is presented in Table 4, which ranged from 0.68 to 0.91 g/ml. Bulk density of six different combinations and control revealed that among the 7 treatments bulk density was higher in T_1 (0.91) followed by T_2 (0.90 g/ml) and T_3 (0.86 g/ml) and all these treatments were seen to be on par. (CD=0.40 at 5% level of significance) The lowest bulk density was seen for control samples (0.68 g/ml) among all treatments. Bulk density is generally affected by the particle size and density of the flour. Present study revealed that as the quantity of bulb flour increased, the value

### Table 2: Extrusion behaviour of different combination

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Residence time (min/300g)</th>
<th>Uniformity of strands</th>
<th>External appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_1</td>
<td>35.16</td>
<td>4.40</td>
<td>4.20</td>
</tr>
<tr>
<td>T_2</td>
<td>45.11</td>
<td>4.35</td>
<td>4.23</td>
</tr>
<tr>
<td>T_3</td>
<td>40.55</td>
<td>4.89</td>
<td>4.15</td>
</tr>
<tr>
<td>T_4</td>
<td>43.50</td>
<td>4.66</td>
<td>4.04</td>
</tr>
<tr>
<td>T_5</td>
<td>36.98</td>
<td>4.50</td>
<td>4.66</td>
</tr>
<tr>
<td>T_6</td>
<td>31.05</td>
<td>4.76</td>
<td>4.53</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>1.272</td>
<td>0.355</td>
<td>0.501</td>
</tr>
</tbody>
</table>

(Results are expressed as mean values of two and ten replicates)

### Table 3: Physical characteristics of extruded products

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Firmness</th>
<th>Shape</th>
<th>Uniformity of strands</th>
<th>Tensile strength</th>
<th>Packaging quality (suitability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_1</td>
<td>4.23</td>
<td>4.13</td>
<td>4.06</td>
<td>4.25</td>
<td>4.57</td>
</tr>
<tr>
<td>T_2</td>
<td>4.35</td>
<td>3.86</td>
<td>4.26</td>
<td>4.21</td>
<td>4.59</td>
</tr>
<tr>
<td>T_3</td>
<td>4.50</td>
<td>4.64</td>
<td>4.75</td>
<td>4.58</td>
<td>4.52</td>
</tr>
<tr>
<td>T_4</td>
<td>4.42</td>
<td>4.49</td>
<td>4.53</td>
<td>4.65</td>
<td>4.58</td>
</tr>
<tr>
<td>T_5</td>
<td>4.37</td>
<td>4.52</td>
<td>4.44</td>
<td>4.47</td>
<td>4.53</td>
</tr>
<tr>
<td>T_6</td>
<td>4.48</td>
<td>4.68</td>
<td>4.67</td>
<td>4.56</td>
<td>4.50</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>0.294</td>
<td>0.222</td>
<td>0.381</td>
<td>0.327</td>
<td>NS</td>
</tr>
</tbody>
</table>

(Results are expressed as mean scores of ten replicates)
of bulk density also increased. Control sample had lesser bulk density than the developed treatments. This is due to the big particle size of bulb and seed flour than refined flour. Kumar et al. (2011) reported that the bulk density of chicken meat mince enriched noodles ranged from 0.47 to 0.50g/ml.

**True density:** True density of noodles in Table 4. revealed that there was no significant difference among treatments as well with control. True density means mass per unit volume of grains which does not include pore spaces between granules (Tapash and Bhaskara, 2006). It indicates how much product had expanded after coming from die. In this study true density of treatments ranged from 0.01 to 0.04 and there was significance different from control. True density of T4 was higher (0.4) than all the treatments along with control (0.01). The study revealed that as the concentration of bulb flour increased, true density also increased. This was due to the higher fibre content of bulb flour and higher starch content in seed flour. True density of chicken meat mince enriched noodles ranged from 1.27 to 1.29 as reported by Kumar et al. (2011).

**Swelling index:** Swelling index of noodles(SI) is an indicator of the water absorbed by the starch and protein during cooking, which is utilized for the gelatinization of starch and hydration of proteins. During cooking of noodles, starch absorbs water and swells and the granular structure collapses leading to the leaching of amylose. SI of developed noodles was highest for T1 with a score 1.46 which was followed by 1.35 for T4. Swelling index of control was lower than the experimental samples. Though there was slight difference in the treatments, it was not statistically significant. SI was found to be higher in all treatments though it was highest in T1 which contained higher amount of bulb flour. SI was found to be lower in commercial noodles. According to Cleary and Brennan (2006), increased swelling index values might be related to greater water absorption during cooking due to the high water-binding capacity of fibre. Gopalakrishnan et al. (2011) reported the restricted swelling (low SI values) in the pasta products compared to the reported values of 1.8 - 1.9 for durum semolina pasta which indicates that the added proteins also may be competing with starch for water. Akanbi et al. (2011) reported that swelling index of bread fruit starch with wheat flour noodles ranged from 3.04 to 3.4. Wijesiri et al. (2014) reported that swelling index of rice noodles incorporating drumstick leaves was 2.5 % and also stated that it was higher than control.

**Yield ratio (noodles):** Yield of dried products is directly related to how much water is in the original product. Yield ratio of the different combinations were analysed and the results are presented in Table 5. Yield ratio of different treatments ranged from 0.86 – 0.94 per cent. Results further reveal that T2 having RF: RJB: RJSF in the ratio of 50:20: 30 had the highest value (0.97). The lowest value was obtained by T1 (0.86). Drying removes moisture, as a result the product shrinks and decreases in size and weight, thus requiring less space for storage.

**Colour analysis:** Colour is one of the important parameters used by consumers to evaluate visual quality and is useful for the better marketability of noodles (Asenstorfer et al., 2010). In the present study, colour properties of the noodles were characterised by measuring the primary colour coordinates ‘L’, ‘a’ and ‘b’ and from these values total colour change values and whiteness index values were calculated. The values were observed on 3rd day of preparation. The noodles after drying were found to be different shades of cream colour. L value of treatments ranged from 75.23 to 80.07 and lightness (L value) of T1 was highest (80.07) (Table 6). It was followed for T2, T4 and T5 treatments with value of 77.43, 77.23 and 76.73 respectively. These three treatments were on par with each other. Treatment T3 (75.47) and T6 (75.44) were also on par with each other. Flour protein content had a negative correlation with noodle brightness as reported by Hou and Kruk (1998). The degree of redness or ‘a’ value was less for commercial noodles. Presence of red colour or ‘a’ value was higher in developed noodles and it ranged from 2.12 to 3.07. This is essentially due to jackfruit bulb flour which contains carotenoids pigments. Value for redness (a value) was highest (3.07) for T1 and was immediately followed by T2, T3 and T4 (2.68, 2.64 and 2.59 respectively). The other two treatments T5 and T6 were seen to be on par (2.12 and 2.23 respectively). (CD=0.283 at 5% level of significance)Yellowness of the samples (b value) were analysed and it ranged from 19.43 to 23.27. It was

Table 4: Physical characteristics of noodles

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Bulk density (g/cm³)</th>
<th>True density (g/ml)</th>
<th>Swelling index (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>0.86</td>
<td>0.01</td>
<td>1.35</td>
</tr>
<tr>
<td>T2</td>
<td>0.90</td>
<td>0.01</td>
<td>1.14</td>
</tr>
<tr>
<td>T3</td>
<td>0.91</td>
<td>0.02</td>
<td>1.26</td>
</tr>
<tr>
<td>T4</td>
<td>0.89</td>
<td>0.04</td>
<td>1.46</td>
</tr>
<tr>
<td>T5</td>
<td>0.85</td>
<td>0.01</td>
<td>1.05</td>
</tr>
<tr>
<td>T6</td>
<td>0.78</td>
<td>0.01</td>
<td>1.12</td>
</tr>
<tr>
<td>T7 (Control)</td>
<td>0.68</td>
<td>0.01</td>
<td>1.00</td>
</tr>
<tr>
<td>CD (0.05)</td>
<td>0.040</td>
<td>NS</td>
<td>0.007</td>
</tr>
</tbody>
</table>

(Results are expressed as mean values of three replicates) (NS- not significant)

Table 5: Yield ratio of noodles

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weight of flour (g)</th>
<th>Weight of noodles (g)</th>
<th>Yield ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>300</td>
<td>268.00</td>
<td>0.86</td>
</tr>
<tr>
<td>T2</td>
<td>300</td>
<td>265.72</td>
<td>0.88</td>
</tr>
<tr>
<td>T3</td>
<td>300</td>
<td>287.90</td>
<td>0.89</td>
</tr>
<tr>
<td>T4</td>
<td>300</td>
<td>289.68</td>
<td>0.92</td>
</tr>
<tr>
<td>T5</td>
<td>300</td>
<td>274.28</td>
<td>0.94</td>
</tr>
<tr>
<td>T6</td>
<td>300</td>
<td>279.59</td>
<td>0.97</td>
</tr>
</tbody>
</table>

(Results are expressed as mean values of two replicates)
observed that ‘b’ value was highest in $T_5$ (23.27) followed by $T_4$ and $T_3$ with the score of 22.89 and 22.04 respectively. This was immediately followed by $T_1$ with a score of 21.78. The remaining two treatments $T_2$ and $T_7$ were found to be on par with each other, (19.95 and 19.43 respectively). Among the developed noodles yellowness value was less in commercial noodles and value of yellowness was high in developed noodles due to JF bulb flour which contains higher carotene content as compared to wheat flour. Total colour difference ranged from 27.55 to 33.53 and it was seen to be higher than commercial noodles. Among the developed treatments scores of total colour differences were highest in $T_1$ treatment (33.53) and it was on par with $T_4$ (33.22). The other three treatments showed values that were on par $T_2$ (31.25), $T_6$ (31.16) and $T_7$ (29.94). Treatment $T_2$ scored the lowest value 27.55 among all treatments. The low value of control is because it has only refined flour incorporated. So from the above experiment it can be concluded that addition of many ingredients in noodles increases the total colour difference value. It was analysed that $T_1$ had highest whiteness index (71.71). It was followed by $T_2$, $T_3$ and $T_7$ with score of 69.57, 68.37, and 68.25. These 3 treatments were seen to be on par. The other 2 treatments showed values that were on par with the scores of 66.30 and 66.20 for $T_4$ and $T_5$ combination. There was significant difference in the data. Whiteness index values, though in general increased with increase in concentration of bulb flour, but at higher concentration of the bulb, the manifestation was not observed in $T_5$. Jackfruit bulb and seed have higher minerals content which also might have affected the whiteness of flour. Flour ash content has been rated as one of the important specifications because it affects noodle colour negatively as reported by Hou and Kruk (1998). In a study by Hatcher et al. (2002) it was reported that after being stored for two to five days, fresh noodles had a tendency to darken, which holds true for our observations too. Darkening usually happens due to the protein content of noodles. The higher the protein content, the higher is the tendency for noodles to get darkened after storage and this is attributed to the oxidation process occurring between protein and phenol compounds as reported by Asenstorfer et al. (2010). Colour of developed noodles from composite flour depends on the colour of raw ingredients and their ratio of combination.

CONCLUSION
Raw jackfruit based noodles with different formulations yielded different physical and cooking characteristics. The partial substitution of the noodles with jackfruit bulb and seed flour improved the physical and cooking properties of the noodle during processing. However these properties of noodles were not significantly different from that of control noodle.

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REFERENCES


