Development and physico-chemical evaluation of protein rich cookies using underutilized *Curcuma angustifolia* starch

Dr. Namrata Ankush Giri, Anjudas, Dr. MS Sajeev and Dr. T. Krishnakumar

Abstract

*Curcuma angustifolia* is one of the Indian tribal minor tuber crop found growing wild in northeast and western coastal plains and hills containing highly nutritious and easily digestible starch which is especially recommended for children. The study was conducted with the objective of utilizing the under exploited tribal tuber crop *Curcuma angustifolia* starch by processing it into protein-energy rich functional cookies which is highly suitable for tribal communities. The basic ingredients under this study were *Curcuma angustifolia* starch, pearl millet flour and refined wheat flour whereas the functional ingredients were used as protein sources as whey protein concentrate (WPC), bengal gram flour (BF) and soy flour (SF). The level of *Curcuma angustifolia* starch was standardized based on experimental trials and incorporated up to 25% in formulation of functional cookies. It is used as source of energy in cookies. The level of protein rich functional ingredients were used as 5%, 10% and 15%. Raw materials were analyzed for chemical properties. Also the produced cookies were evaluated for physical, chemical, minerals content and sensory characteristics. The results indicated that spread ratio and expansion ratio of functional cookies decreases as the level of functional ingredients increases. Textural characteristics like breaking hardness of functional cookies were increased as the level of functional ingredients increases. Results indicated that protein-energy rich functional cookies for tribal people with highest overall sensory acceptable score can be prepared using a whey protein concentrate (15%). Protein rich functional cookies containing 15% whey protein concentrate along with other ingredients was found most sensory acceptable by the panelists and it provides protein 8.24%, fibre 3.33%, carbohydrate 57.3% and energy 481.37 Kcal.

Keywords: Protein rich, cookies, *Curcuma angustifolia*, Physical properties, Nutritional composition

Introduction

Curcuma species is a minor tuber crop found widely all over south India and many other tropical areas with adequate rainfall. Although highly nutritious and high in medicinal properties, the usage of curcuma species is limited to tribal hamlets and traditional medicinal preparations [1]. Curcuma is reported to be used as a source of an easily digested starch, which is rather similar to that of arrowroot in India, it is utilized on a cottage industry basis for the preparation of invalid and valid foods [2]. *Curcuma angustifolias* most commonly found growing wild in India, especially in the northeast and western coastal plains and hills. Such areas include the states of Maharashtra, Madhya Pradesh, Andhra Pradesh, Himachal Pradesh, Orissa, Chhattisgarh, Tamil Nadu and Kerala. This species can also be found in Burma, Laos, Nepal, and Pakistan [3].

In some part of India *Curcuma angustifolia* is used as weaning food for babies. The starch obtained from the rhizomes is given to babies three – four times a day after boiling in water or milk. This preparation is given as a traditional food for babies. Sometimes it is used as replacement of mother’s milk. This may be due to the high content of total soluble protein, reducing sugar and total free amino acids in this species. The starch of *tikhar* is used for the preparation of many sweet meals and herbal dishes like *halwa, barfi, jalebi* etc. It is used specially during fast.

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Farmers also prepare herbal drink “sarbat” through tikhur starch during summer due to its cooling effect [4]. Tikhur is found as a primary ingredient in cakes, fruit preserves, biscuits, and puddings [5].

Tikhur rhizomes are used as appetizer reducing burning sensations and stomach pains, removal of stone from kidney, useful for ulcer patient [6] and rhizome pulp is used for treatment of headache as well as it gives cooling effect [7]. The rhizome pulp is a remedy for fever, joint pains and leucorrhoea. The starch obtained from the rhizomes is highly nutritious and easily digestible, therefore, it is recommended for infants, weak children. The starch of tikhur is used for the preparation of many sweet meals and herbal dishes like halwa, baati, jalebi etc. It is used specially during fast. Farmers also prepare herbal drink “sarbat” through tikhur starch during summer due to its cooling effect [8]. The rhizome of the tikhur is light bitter, demulcent, non irritating, nutritive and fragrant. Rhizome pulp is used as a remedy for headache, joint pains, jaundice and leucoria [9], essential oil of tikhur rhizome is used against tape worm [9].

Cookie type biscuits are widely consumed due to their long shelf life and crisp texture [10, 11]. Cookies are made traditionally from wheat flour using a number of ingredients such as sugar, chocolate chips, peanut butter etc. [12]. Functional cookies have been attempted by various researchers using several types of alternative non-wheat flours such as flour, buckwheat flour, cassava flour, quinoa flour etc. [13-15]. India is one of the largest biscuit producers of the world and the bakery industry has been projected to grow annually at the rate of 15-17% [16]. Being one of the most acceptable snack foods by both children and adults cookies/biscuits could be considered as the best vehicle for nutritional supplements. Whey protein concentrate (WPC) is extensively used as a functional component, in order to improve the protein content, exclusive of increase in energy value from fat [17]. It is reported that, it have more biological value and amino acid score [18]. WPC is added to different food preparations as a best source of protein in order to prevent malnutrition and obesity [19, 20]. Singh et al. [21] reported that, WPC is an effective ingredient in cake preparation as an egg solids replacer useful for people allergic to egg. WPC is having 70% proteins and utilized for the preparation of protein rich foods and in ice cream, yoghurt, and soft drink etc. [19, 20]. It was reported that, whey ingredients also help to increase batter viscosity and crumb structure of muffins and provide tender texture in biscuits by holding moisture for longer time [22].

The incorporation of chickpea flour increased the protein, mineral, fat and indigestible compound content of the pasta, but total starch content was not affected. Starch hydrolysis was lower in both types of pasta than in white bread, but the difference was greater in the case of pasta made with chickpea flour [23]. Kaur et al. [24] analyzed the sensory, nutritional and glycemic properties of biscuits from cereal such as oats and barley and soybean and chickpea combinations for diabetic patients. Biscuits made from these cereal pulse combinations were highly acceptable and were chosen for nutritional analysis. The results of nutritional analysis showed increased protein (11.72 g/100 g), crude fiber (1.5 g/100 g) and ash content (4.68 g/100 g) and decreased content of carbohydrates (47 g/100 g) in blend containing refined wheat flour, barley and soy flour (25:50:25).

Considering the health value of Curcuma angustifolia tubers and being underutilized crop coupled with the need to expand the utilization potential of Curcuma angustifolia through the development of value added products, the present study aimed at the development of functional cookies using Curcuma angustifolia starch.

Materials and methods

a. Materials

Curcuma angustifolia starch, wheat flour, pearl millet flour, Bengal gram flour, whey protein concentrate, soy flour, refined sugar, hydrogenated fat and baking powder were procured from the local market of Trivandrum city.

b. Methods

1. Preparation of cookies: Composite flours blends were prepared by using Curcuma angustifolia starch, wheat flour and pearl millet flour. However the functional ingredients were added as Bengal gram flour, whey protein concentrate and soy flour at the level of 5%, 10% and 15%. The formulations for the preparation of cookies comprised Curcuma angustifolia starch powder and pearl millet flour incorporated at constant rate in the ratio of 1:08. Whereas wheat flours was substitute with protein rich ingredients such as whey protein concentrate (WPC), Bengal gram flour (BF) and soy flour (SF) at the level of 5%, 10% and 15% while the control cookies were made from 100% refined wheat flour. The formulation for the preparation of cookies is given in Table 1. Cookies were prepared by creaming methods for making cookies dough. The ingredients (g) used in preparation of tara flour based gluten free cookies were gluten free flour blends-100g, powdered sugar-32g, fat-40g, baking powder-1g and guar gum-0.5g. Cookies dough was prepared in a spiral dough mixer and sheeted to a thickness of about 5mm approximately, cut into round shape of 30mm diameter and then transferred to baking tray and baked at 165°C for 20 min. Cookies, after attaining room temperature, were packed in airtight plastic containers and evaluated for different physico-chemical parameters [25, 26].

Table 1: Formulation of protein rich cookies incorporated with Curcuma angustifolia starch

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Curcuma angustifolia starch</th>
<th>Wheat flour (WF)</th>
<th>Pearl millet flour</th>
<th>Whey protein concentrate (WPC)</th>
<th>Bengal gram flour (BF)</th>
<th>Soy flour (SF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>--</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>5% WPC</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>10% WPC</td>
<td>25</td>
<td>45</td>
<td>20</td>
<td>10</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>15% WPC</td>
<td>25</td>
<td>40</td>
<td>20</td>
<td>15</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>5% BF</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>--</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>10% BF</td>
<td>25</td>
<td>45</td>
<td>20</td>
<td>--</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>15% BF</td>
<td>25</td>
<td>40</td>
<td>20</td>
<td>--</td>
<td>15</td>
<td>--</td>
</tr>
<tr>
<td>5% SF</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>--</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>10% SF</td>
<td>25</td>
<td>45</td>
<td>20</td>
<td>--</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>15% SF</td>
<td>25</td>
<td>40</td>
<td>20</td>
<td>--</td>
<td>--</td>
<td>15</td>
</tr>
</tbody>
</table>


2. Physical properties

Cookies were evaluated for physical characteristics including diameter (mm), thickness (mm) and spread ratio. Diameter and thickness were measured with the help of digital vernier caliper whereas spread ratio of cookies was calculated by dividing values of diameter (D) by the thickness (T) value \(^{[27]}\). Ten cookies samples were considered for determination of physical properties of cookies.

3. Textural properties

The textural properties of cookies were determined using Food texture analyzer [TA-HDi]; Stable Micro System (U.K.). Breaking test was used to determine hardness and toughness of cookies. The individual cookie was placed over two points of the blade. The blade was attached to the crosshead of the instrument. The size of probe used was 5mm. The peak force from the resulting curves was considered as breaking hardness of the cookie and the area under the peak force was considered as breaking toughness. Settings were kept for the texture analysis as: Pre test speed-10mm/sec. Test speed-1mm/sec, Post test speed-1mm/sec, Distance at-50% and Starin-50%.

4. Proximate composition

Moisture, protein, fat, ash, crude fiber and minerals (Mn, Cu, Zn and Fe) content of different samples of cookies were determined as per standard methods \(^{[28]}\). Minerals content of cookies was determined by using atomic absorption spectrophotometer. Total carbohydrates value was calculated by subtracting the total of moisture, protein, fat, crude fiber and ash content from 100. Total calories were calculated by multiplying protein, carbohydrates and fat content by the factors 4, 4 and 9 respectively.

5. Sensory characteristics

Sensory evaluation of cookies was done by group of 15 panel members selected from diverse category of staff at ICAR-CTCRI. Samples were served with three digit code numbers. Panelists were instructed about the evaluation procedure. Sensory attributes like appearance, colour, aroma, taste, texture and overall acceptability for all cookies samples were evaluated using nine point hedonic scales. The grades for hedonic scale were: like extremely 9, like very much 8, like moderately 7, like slightly 6, neither like nor dislike 5, dislike slightly 4, dislike moderately 3, dislike very much 2, dislike extremely 1 \(^{[29]}\).

6. Statistical analysis

Results were expressed as mean of triplicate analyses. A one way analysis of variance and Duncan’s test were used to establish the significance of differences among the mean values at the 0.05 significance level. The statistical analyses were performed using SAS 9.3 software \(^{[30]}\).

### Table 2: Physical properties of protein rich cookies incorporated with *Curcuma angustifolia* starch

<table>
<thead>
<tr>
<th></th>
<th>Weight(g)</th>
<th>Diameter(cm)</th>
<th>Thickness(cm)</th>
<th>Spread ratio</th>
<th>Expansion ratio</th>
<th>Hardness(N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>11.9±0.5a</td>
<td>41.85± 0.3a</td>
<td>5.06± 0.3e</td>
<td>8.26±0.5a</td>
<td>0.97±0.3a</td>
<td>40.6±0.5c</td>
</tr>
<tr>
<td>5% WPC</td>
<td>11.2±0.4f</td>
<td>24.2±0.3c</td>
<td>7±0.5</td>
<td>3.46±0.5g</td>
<td>0.86±0.3f</td>
<td>35.6±0.39c</td>
</tr>
<tr>
<td>10% WPC</td>
<td>11.5±0.1b</td>
<td>24.5±0.3b</td>
<td>6.4±0.5b</td>
<td>3.83±0.3f</td>
<td>0.87±0.3c</td>
<td>43.5±0.15b</td>
</tr>
<tr>
<td>15% WPC</td>
<td>11.0±0.1f</td>
<td>24±0.5c</td>
<td>7±0.5a</td>
<td>3.43±0.5g</td>
<td>0.86±0.5f</td>
<td>48.7±0.83a</td>
</tr>
<tr>
<td>5% BF</td>
<td>11.2±0.5f</td>
<td>22.8±0.3e</td>
<td>4.6±0.5</td>
<td>4.96±0.5c</td>
<td>0.95±0.5b</td>
<td>17.4±0.34j</td>
</tr>
<tr>
<td>10% BF</td>
<td>11.28±0.3e</td>
<td>22.7±0.3e</td>
<td>5.6±0.5d</td>
<td>4.05±0.3d</td>
<td>0.94±0.5c</td>
<td>23.6±0.84g</td>
</tr>
<tr>
<td>15% BF</td>
<td>11.43±0.2d</td>
<td>23.6±0.3d</td>
<td>5.9±0.3c</td>
<td>4.0±0.3d</td>
<td>0.90±0.2d</td>
<td>37.1±0.81d</td>
</tr>
<tr>
<td>5% SF</td>
<td>11.23±0.2f</td>
<td>22.9±0.3e</td>
<td>4.5±0.5</td>
<td>5.09±0.3b</td>
<td>0.95±0.2b</td>
<td>19.3±0.40h</td>
</tr>
<tr>
<td>10% SF</td>
<td>10.99±0.1g</td>
<td>22.5±0.2f</td>
<td>5.5±0.3d</td>
<td>4.09±0.5d</td>
<td>0.94±0.1c</td>
<td>29.3±0.44f</td>
</tr>
<tr>
<td>15% SF</td>
<td>11.47±0.2c</td>
<td>23.5±0.2d</td>
<td>5.9±0.3c</td>
<td>3.98±0.5e</td>
<td>0.90±0.5d</td>
<td>21.5±0.70h</td>
</tr>
</tbody>
</table>

* Values are given in mean ± standard deviation of three independent determinations. Values in column followed by the same letter are not significantly different at \(p \leq 0.05\) as measured by Duncan’s test using SAS

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Results and discussion

1. Physical properties

The physical properties of cookies incorporated with *Curcuma angustifolia* starch powder fortified with protein sources is mentioned in Table 2. The physical properties of protein rich cookies such as diameter, thickness, spread ratio and expansion ratio indicated that the diameter, spread ratio and expansion ratio decreased proportionately with increase in the level of fortification of WPC, BF and SF in cookies incorporated with *Curcuma angustifolia* starch powder (Table 2). On the contrary, thickness of cookies increased significantly with increase in protein rich ingredients from 5% to 15% addition in cookies. This indicated that replacement of wheat flour with protein sources (WPC, BF and SF) resulted in reduction in lateral expansion of cookies, while it led to increased vertical expansion. Increase in thickness of cookies led to a reduction in the spread ratio (D/T) and when compared to a spread ratio of 8.26 for control cookies, very low spread ratio of 3.43 was observed in cookies made from protein sources. Decrease in spread ratio of biscuits has been reported in biscuits made from wheat flour fortified with functional additives such as defatted soy flour, cassava-soybean mix, chick pea, bran etc. \(^{[13, 31-35]}\). Singh et al. \(^{[36]}\) found that high protein biscuits made from wheat-legume blends had low spread ratio. The poor spread ratio of biscuits made from composite flour might be associated with the altered elastic behavior of the dough. Mcwatters \(^{[37]}\) attributed the spread ratio depression in biscuits made from composite flours to an increase in the relative quantity of hydrophilic additives, which compete for water in the dough.

Breaking hardness of protein rich cookies varied between 19.33N to 48.73N (Table 2). The fortification of WPC leads to increase in hardness of cookies as compared to rest of the treatments. WPC fortified cookies showed higher hardness even than control when added more than 5%. Lowest hardness was recorded in cookies fortified with SF. Similar results were reported by other researchers also \(^{[38, 39]}\). It might be due to the gluten miming properties of WPC in cookie dough. This was probably caused by changes in the rheological properties of the dough of cookies due to the presence of fiber, minerals etc. in pearl millet flour and other flours. Rheological properties such as water absorption capacity, dough development time and dough stability time, have been reported to change in whole wheat dough as a result of iron and zinc fortification \(^{[40]}\). Singh et al. \(^{[35]}\) obtained hardness value of 26.97 N for biscuits made from refined wheat flour and found that defatted soy flour fortification enhanced the hardness. Although brittleness is preferred to some extent by the consumers, too brittle products could result in packaging problems. However, subsequent sensory evaluation studies reported in the present study showed that cookies with 15% WPC had high acceptability.
2. Proximate composition and mineral content
Proximate composition including moisture, ash, protein, fat, carbohydrates and energy value of protein rich cookies incorporated with *Curcuma angustifolia* starch is presented in Table 3. Moisture content of cookies varied in between 2.86 to 5.38%. The increase in the level of fortification of protein ingredients from 5 to 15% resulted to increase in the per cent of moisture content. The moisture content of protein fortified cookies found on higher side compared to control. It might be due the higher water binding capacity of WPC, BF and SF. Giri and Sakhale [26] observed that the water content was raised from 3.53 to 4.83% and found higher WPC fortified GF cookies.

Protein content of WPC, BF and SF fortified cookies was significantly superior to that of control. The protein content of cookies fortified with WPC, BF and SF resulted to increase in protein content from 6.73% to 10.69%, 8.95% and 9.37% respectively. The percent increase in protein content was observed as 58.84, 32.98 and 39.22 with addition of WPC, BF and SF respectively as compared to control. Comparable outcome were reported by Munaza et al. [41] in WPC fortified biscuits. Sathe et al. [42] reported that substitution of wheat flour with soy flour in crackers leads to increase in protein content. Giri and sakhale [26] also found that increase in protein content of gluten free cookies when sweet potato was substituted with WPC. They also observed that the high protein level was related with the water binding capacity of soy flour. The increase in level of protein content of cookies with fortification of WPC, BF and SF is also represented in Fig.1

There was somewhat increase in ash and fiber content of cookies fortified with protein sources which might be due to the fortification of WPC, SF and BF in cookies. Giri and Sakhale [26]; Gallagher et al. [43] also reported the biscuits fortified with whey protein concentrate and casein found high in ash content. Control cookies had low crude fiber content (2.20%) as compared to 2.23-3.44% in the protein fortified cookies. The fat content of protein fortified cookies was observed from 22.03 to 25.66% compared to control. The SF fortified cookies had higher fat content as compared to rest of the treatment. Obvious, it has been due to high content of fat in SF compared to WF. The significant decrease and increase in carbohydrate and calorie content of protein rich cookies were noted respectively. The increase in protein and fat content leads to decrease in carbohydrate content and increase in energy value of cookies. These results are in agreements with Giri et al. [25].

Table 3: Proximate composition of protein rich cookies incorporated with *Curcuma angustifolia* starch

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Crude fibre (%)</th>
<th>Ash (%)</th>
<th>Protein (%)</th>
<th>Carbohydrate (%)</th>
<th>Energy (Kcal/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.29±0.19d</td>
<td>22.03±0.08d</td>
<td>2.20±0.0d</td>
<td>1.17±0.03e</td>
<td>6.73±0.40e</td>
<td>64.58±0.38a</td>
<td>483.51±0.1c</td>
</tr>
<tr>
<td>5% WPC</td>
<td>4.49±0.25b</td>
<td>23.44±0.29c</td>
<td>2.35±0.45c</td>
<td>1.14±0.06e</td>
<td>7.97±0.04d</td>
<td>60.61±0.48c</td>
<td>485.28±0.2c</td>
</tr>
<tr>
<td>10% WPC</td>
<td>5.38±0.47a</td>
<td>24.53±0.38b</td>
<td>2.42±0.15b</td>
<td>1.50±0.03c</td>
<td>8.91±0.00c</td>
<td>57.26±0.51c</td>
<td>485.45±0.3c</td>
</tr>
<tr>
<td>15% WPC</td>
<td>5.51±0.35a</td>
<td>24.55±0.15b</td>
<td>2.45±0.36b</td>
<td>1.55±0.18c</td>
<td>10.69±0.15a</td>
<td>55.25±0.96g</td>
<td>484.71±0.13d</td>
</tr>
<tr>
<td>5% BF</td>
<td>2.86±0.05c</td>
<td>23.07±0.04c</td>
<td>2.23±0.21d</td>
<td>1.18±0.08e</td>
<td>7.77±0.03d</td>
<td>62.89±0.35b</td>
<td>490.27±0.5a</td>
</tr>
<tr>
<td>10% BF</td>
<td>3.31±0.44d</td>
<td>23.73±0.29c</td>
<td>2.56±0.03b</td>
<td>1.27±0.14c</td>
<td>8.21±0.07c</td>
<td>60.92±0.14c</td>
<td>490.09±0.5a</td>
</tr>
<tr>
<td>15% BF</td>
<td>4.44±0.09b</td>
<td>24.49±0.14b</td>
<td>3.44±0.29a</td>
<td>1.33±0.01d</td>
<td>8.95±0.08c</td>
<td>57.35±0.13c</td>
<td>485.61±0.49c</td>
</tr>
<tr>
<td>5% SF</td>
<td>3.32±0.25d</td>
<td>24.26±0.21b</td>
<td>2.43±0.36b</td>
<td>2.55±0.04b</td>
<td>7.50±0.15d</td>
<td>59.94±0.84d</td>
<td>488.1±0.33b</td>
</tr>
<tr>
<td>10% SF</td>
<td>3.83±0.14c</td>
<td>25.56±0.26a</td>
<td>2.49±0.28b</td>
<td>3.11±0.11a</td>
<td>8.22±0.02c</td>
<td>56.79±0.14f</td>
<td>490.09±0.5a</td>
</tr>
<tr>
<td>15% SF</td>
<td>3.83±0.12c</td>
<td>25.66±0.22a</td>
<td>2.53±0.31b</td>
<td>3.32±0.08a</td>
<td>9.37±0.06b</td>
<td>55.29±0.50g</td>
<td>489.58±0.1a</td>
</tr>
</tbody>
</table>

*Values are given in mean ± standard deviation of three independent determinations. Values in column followed by the same letter are not significantly different at p ≤ 0.05 as measured by Duncan's test using SAS

Fig 1: Protein content of *Curcuma angustifolia* incorporated cookies fortified with WPC, BF and SF

It was found that minerals such as manganese (Mn), cooper (Cu), iron (Fe) and zinc (Zn) were significantly higher in protein fortified cookies as compared to control (Fig. 2). Copper content ranged from 0.25 to 0.53 mg/100 g in protein enriched cookies. Iron content ranged from 1.37 to 3.55 mg/100g in the protein fortified cookies, when compared to only 0.35 mg in the control cookies. Similarly, manganese and zinc content ranged from 0.22 to 0.77 mg/100g and 3.34 to 4.25 mg/100g respectively which was higher than 0.008 mg/100g of manganese and 2.3 mg/100g of zinc present in control cookie. Minerals such as magnesium and copper have been associated with several vital enzyme activities and biological functions in the body [44, 45]. The minerals content of protein rich cookies fortified with WPC, BF and SF at the level of 5 to 15% is graphically represented in Fig. 2.
3. Sensory evaluation

The records regarding sensorial properties of cookies incorporated with *Curcuma angustifolia* starch and fortified with WPC, BF and SF is given in Fig. 3. Mean sensory scores for different sensorial characteristics of protein enriched cookies were more than minimum acceptable score of 6 (Fig. 3). It was observed that cookies were prepared using different level of protein sources: WPC, BF and SF at the level of 5 to 15% were accepted by the panelists.

The data revealed in Fig. 3 that cookies with 15% WPC obtained highest scores of texture (8), taste (8.5) and overall acceptability (8.95) as compared to control and other treatments. It was found that, the score for cookies fortified with BF and SF were reduced for texture, mouth feel and taste due to beany flavor of SF and particular taste of BF as compared to control and WPC fortified cookies. Cookies fortified with WPC were more preferred than cookies fortified with SF and BF. Based on panel score, it was investigated that, the cookies with 15% WPC was found most acceptable with regards to overall acceptability. Based on sensorial score of WPC fortified samples, the cookies containing 15% WPC was found overall acceptable, considered as standardized. Sathe *et al.* [42] documented parallel findings that, protein rich crackers could be prepared by substituting refined wheat flour with soy and groundnut flours at 15% level. Singh *et al.* [35] also state that WPC might be fortified up to 15% level in cookies without disturbing their overall quality. The maximum mean score for different sensory characteristics of cookies developed using 25% *Curcuma angustifolia* starch, 40% wheat flour, 20% pearl millet flour and 15% WPC indicated the commercial scope for manufacturing of good quality protein rich cookies which can be consumed by people with protein deficiency and malnutrition problem.

Fig 3: Sensory evolution of protein fortified cookies incorporated with *Curcuma angustifolia* starch

Conclusions

Nutritional and physico-mechanical evaluation of cookies showed that *Curcuma angustifolia* starch could be successfully utilized along with other flours such as wheat and pearl millet and fortification with whey protein concentrate for the development of protein enriched cookies which could be help to combat protein deficiency and malnutrition. The protein rich cookies coupled with the high content of minerals such as copper, zinc, iron and manganese could be added advantage for cookies. Based on the high scores for all the sensory parameters, it could be concluded that cookies containing 25% *Curcuma angustifolia* starch, 40% wheat flour, 20% pearl millet flour and 15% WPC was the best combination for making cookies. The fortification of 15% WPC in cookies resulted in 58.84% rise in proteins of the cookies.

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