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Effect of Taro *(Colocasia esculenta)* Enrichment on Physicochemical and Textural Properties of Cake

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Abstract

Taro is a plant widely produced in tropical areas for its underground corms and it is used mainly as a vegetable. Its physicochemical, sensory properties and health benefits led to its use in value-added products. The cake is a high value-added bakery product and it needs a lower amount of gluten protein, therefore, taro flour (TF) was supplemented in wheat flour (WF) at different levels (10, 20, 30 and 40%). In connection with this, the incorporation of taro flour into wheat-based products has been reported to increase their nutritional and textural quality. The taro-supplemented cake showed higher mineral and fiber content, however, reduced caloric value. It was observed that taro supplementation reduced gluten and protein content and had higher oil and water binding capacity, therefore suitable for cake preparation. Taro cake had improved texture and sensory characteristics in comparison to wheat cake. It can be concluded that addition of taro for cake preparation improves nutrition and quality characteristics, therefore, it can be recommended to use taro for cake preparation.

Keywords: Cake; Taro; Textural properties; Sensory properties; Flour enrichment; Composite flour

1 Introduction

When a crop is being considered for food, nutritional value and consumer acceptance are the key factors for selection or rejection. The nutritional value of food depends upon its nutritional contents. As far as consumer acceptance is concerned, tubers of (*Colocasia esculenta*, commonly known as taro or cocoyam, are an important food of several developing countries in Africa, West Indies, Pacific region and Asia (Nip, Whitaker & Vargo, 1994). Large servings of taro corms can become a significant source of dietary protein, especially if taken more than once a day. Taro is also a good source of thiamin, riboflavin, iron, phosphorus and zinc and a very good source of vitamin B6, vitamin C, niacin, potassium, copper, and manganese. Taro also contains greater amounts of vitamin B-complex than whole milk (Soudy, Delatour & Grancher, 2010). In addition, taro is especially useful to persons allergic to cereals and can be consumed by children who are sensitive to milk. For supplying nutrients, the taro tubers are considered a good source of carbohydrates and potassium. Taro is also a tuber that is very rich in carbohydrates, ranging between 73 to 80% which is mainly starch, 77.9%, and 1.4% crude fiber, dry

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matter basis. Because of its high carbohydrate content, this tuber represents one of the main sources of energy in many parts of the tropics and sub-tropics providing about a third of the food intake of more than 400 million people in these areas (Huang, Chen & Wang, 2007).

Nowadays, zinc deficiency is widespread and affects the health and well-being of populations worldwide; since taro is one of the few non-animal sources of zinc, its utilization should, therefore, be pursued to help in the alleviation of zinc deficiency which is associated with stunting (Rana et al., 2018). However, despite the wide application and great potential of taro as a chief dietary source of carbohydrate and other essential nutrients, its usage is often limited by its anti-nutrient contents which are either potentially toxic or may limit the bioavailability of nutrients (Hambidge, 2000). Processing of food like noodles and cookies from taro helps in reducing its anti-nutrient content which can help improve its production and utilization potential (SPC, 2006).

The market of novel plant-based foods Is gaining popularity, such as spices and herbs (Sharma, Kaushik, Sharma, Sharma et al., 2016; Sharma, Kaushik, Sharma, Chouhan & Kumar, 2016) and also serve as source of vitamins (Kaushik, Chawla, Kumar & Kumar, 2017; Kaushik, Sachdeva, Arora & Gupta, 2015; Sachdeva, Kaushik, Arora & Palaniswamy, 2015) and minerals (Kaushik, Sachdeva & Arora, 2015; Sachdeva, Kaushik, Arora & Kapila, 2015). Cereals are the main economic crops from plants and several bakery products are prepared from them like snacks (Sharma, Khatkar, Kaushik, Sharma, Sharma et al., 2017), noodles (Kaushik, Chawla, Kumar, Janghu & Lohan, 2018) rusk (Lohan, Kaushik, Bansal & Gandhi, 2020), cookies (Kumar, Khatkar & Kaushik, 2014) and so on. Bakery products are widely consumed and are becoming a major component of the global food market (Kaushik et al., 2018). Kumar et al. (2014) utilize taro as a potential substitute for wheat flour in cake. Cake is one of the most common bakery products consumed by nearly all levels of society. This is mainly due to its ready-to-eat nature, availability in different varieties and affordable cost. The development of bakery foods enriched with fiber is an important contribution to a broader supply of food products with beneficial health effects. In addition, cakes have a relatively constant place in our diet for a long time and their continuous popularity has encouraged the development of newer and more attractive products that are available on the market today. It is often a dessert of choice for meals at ceremonial occasions, particularly wedding anniversaries and birthdays (Srivastava, Sanjeev & Kumar, 2002). Taro has wide medicinal properties, significant amounts of vitamin A, vitamin C, and other phenolic cell reinforcements. The present study was undertaken to develop and evaluate cake enriched with taro in different proportionate mixtures with wheat (10, 20, 30 and 40 %). The physical characterization and sensory qualities of taro flour and wheat flour cake are reported in this work.

2 Materials and Methods

The taro was obtained from the local market of Solan, Himachal Pradesh, India. A fine part of the taro was scraped, washed, shredded into 1 cm^3 cubes and dried in a mini tray drying oven (Maro Scientific Works Pvt. Ltd., New Delhi, India) for 48 h at 50 ^oC. Dried cubes were milled using a roller-mill (Chopin Laboratory CD-1 mill, France) as per the method described by Kaushik et al. (2017). To obtain uniform particle size, taro flour was sieved through a 60 mm mesh sieve. The taro flour was then packed in an air-tight plastic container for future use. All chemicals used were AR grade.

2.1 Chemical composition of TF and WF and their proportionate mixture

Standard methods of AOAC (2005) were used to determine Moisture (AOAC - 925.10), fat (AOAC - 2003.05) by soxhlet extraction and ash (AOAC - 923.03) by combustion. Protein (AOAC - 960.52) was determined by the micro Kjeldahl method. Petroleum ether, sodium hydroxide, sodium hydroxide, and ammonium borate chemicals were used in the preparation of TF. All chemicals were from Loba Chemical Company.

Table 1: Proportions of ingredients in cake formulations

Ingredients	**Formulations** **Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
Egg (g)	80	80	80	80
Butter (g)	40	40	40	40
Water (ml)	18	18	18	18
Sugar (g)	24	24	24	24
Taro Flour (g)	10	20	30	40
Wheat Flour(g)	90	80	70	60

2.2 Physical characterization of TF and WF

The characterization of TF and WF bulk density was determined by the method described by Kaur and Singh (2005). Water solubility index was determined by the method described by Anderson, Conway, Pfeifer and Griffin (1969). Water-holding capacity and fat-binding capacity were determined by the method described by Kaushik, Kumar, Sihag and Ray (2015), sodium dodecyl sulfate sedimentation was determined by the method described by Axford, Mcdermott and Redman (1978), wet and dry gluten content were determined by the method described by Kaushik, Kumar et al. (2015). Color parameters of flour were measured with a Lovibond, Tintometer Colorimeter MODEL F (The Tintometer Ltd., United Kingdom) on the basis of L*, a* and b* values (Bouaziz et al., 2016). The TF and WF were mixed in four ratios 10:90, 20:80, 30:70 and 40:60 and named them as sample 1, sample 2, sample 3 and sample 4, respectively.

2.3 Textural analysis of dough and extracted gluten

Dough samples were calculated by the texture profile analysis (TPA) method using a TMS Texture Analyzer (Food Technology Corporation, Sterling, Virginia, USA) equipped with a 1000 (N) load cell, and a 0.05 (N) detection range. A sample of dough was removed into a molded Nalgene polypropylene tube (5 cm height) that was placed in a fixture to hold it in place under the texture analyzer. An acrylic cylindrical probe was used to compress the sample to 50% of its original height (40 mm) at a speed of 10 mm/s. The equipment was interfaced with a computer, which controls the instruments and analyzes the data, using the software supplied by Texture Technologies Corp. Textural parameters (hardness, cohesion, springiness, adhesion, and chewiness) were calculated from the TPA curves. The hardness is the peak power of the primary pressure cycle, stickiness is the separation of the recognized tallness of the item on the second pressure determined by the first pressure separation, cohesiveness and adhesiveness were resolved.

2.4 Preparation of Cake

The cake was prepared according to Ceserani, Kinkton and Foskett (1995), flour blend 100 g, fine powder sugar 24 g, egg 80 g, butter 40 g, and water 18 ml Table 1. The sugar was added to the butter and beaten for 3 min. Eggs were beaten and added gradually to the mixture and whipped for 2 min. The TF was incorporated in WF at different concentrations (10, 20, 30 and 40%) over a period of 7 min. with good creaming between the additions. Cake samples were put in the baking oven (Electric 2 Deck 4 Tray Oven, TME-2D-4) at a temperature of 170 ^{o}C for 20-25 min. The cakes were cooled and removed from the pan after 1h. The size of the pan was 5.5×3.5×2 inches. The cakes were packaged in aluminum foil and kept on the shelf until sample analysis in the food laboratory.

2.5 Physical characteristics of cakes

The volume of cakes was measured using the raised displacement method (Rosell, Rojas & de Barber, 2001). Weight, length, width, and height of the cakes were estimated. The textural properties of cakes were estimated by a Texture Analyzer. Cake slices (2.5 cm thick) were placed on the Texture analyzer platform. An acrylic cylindrical probe was used to compress the cake sample up to 50% of its original height at a speed of 10 mm/s. Colors of crust and crumb were measured using the Portable Colorimeter (Lovibond, Colorimeter MODEL F).

2.6 FTIR interpretation

The microstructural changes were verified with the FTIR spectrometer (CARY 630 Agilent Technologies, Santa Clara, California, USA). Microlab Software (Bozeman, Montana, USA) was used to generate data with a resolution of 8 cm-1. The graphs obtained using the FTIR were analyzed using a method described by Lampman, Kriz and Vyvyan (2001).

2.7 Sensory evaluation

The sensory analysis was performed at the Food and Nutrition Laboratory by 35 students and teachers of Shoolini University, from 19 to 37 years old. Judges evaluated the attributes: color, odor, flavor, taste, texture and overall acceptability using a nine-point hedonic scale (where 1 = liked extremely and 9 = disliked extremely). The sensory analysis was conducted at room temperature, and each judge received the samples in white plastic dishes, numbered with random digits (Lohan et al., 2020). Cake samples were left to cool for 4h after baking then samples were cut and subjected to taste panel.

2.8 Statistical analysis

Means (n=3), standard error mean (SEM), linear regression analysis and 95% confidence intervals were calculated using Microsoft Excel 2007 (Microsoft Corp., Redmond, WA) as per Kaushik et al. (2017), Sachdeva, Kaushik, Arora and Palaniswamy (2015) and Sachdeva, Kaushik, Arora and Kapila (2015). Data were subjected to a one-way analysis of variance (ANOVA).

3 Results and Discussion

3.1 Physical and chemical characterization of TF and WF

Physical properties of granular solids play an important role in manufacturing as they determine the application and use of food materials for several food products. Physical properties are important in choosing the flow behavior of their proper handling during the several phases of processing, conveying and storage (Ganesan, Rosentrater & Muthukurnarappan, 2008). The physical properties of the TF and WF are summarized in Table 2. Bulk density is an indication of the porosity of a product and a function of flour wettability without the influence of any compression. It is also a reflection of what the sample can carry if rested directly on another. The bulk density of TF and WF was 0.658 and 0.652 (g/cm^3), respectively. As the concentration of TF increased in mixed flour the bulk density also increased. Njintang et al. (2007) determined a similar bulk density of taro flour (0.645 g/cm^3), however, somewhat higher bulk density (0.745 g/cm^3) was reported by Tagodoe and Nip (1994). Water solubility index was 37.88 and 31.24% for TF and WF, respectively and the results revealed that with the increase in taro concentration, water solubility index also increased. Flours with high water solubility index have been reported to be good constituents in bakery applications as they improve solubility characteristics and lead to the improved freshness of baked products (Ma et al., 2011). Water holding capacity of TF and WF was 7.91 and 6.75% and fat binding capacity of TF and WF was 7.09 and 5.87%, respectively and the different concentrations of TF and WF water holding capacity and fat binding capacity showed increasing order. The high synergic value observed for wheat flour compared to taro flour may be attributed to the differences in amylose content, given the fact that starch with

Table 2: Physical and chemical characteristics of TF and WF

Flour parameters	**Taro flour (TF)**	**Wheat flour (WF)**	**TF/WF(%) 10:90**	**TF/WF(%) 20:80**	**TF/WF(%) 30:70**	**TF/WF(%) 40:60**
Bulk density(g/cm^3)	0.658 ± 0.015^{c}	0.652 ± 0.03^{a}	0.652 ± 0.028^{a}	0.653 ± 0.016^{ab}	0.655 ± 0.014^{b}	0.656 ± 0.026^{b}
Water solubility index (%)	37.88 ± 0.59^{d}	31.24 ± 0.65^{a}	31.54 ± 0.49^{a}	32.56 ± 0.57^{b}	33.86 ± 0.46^{c}	34.17 ± 0.41^{c}
Water holding capacity (g/g)	7.91 ± 0.20^{d}	6.75 ± 0.45^{a}	6.84 ± 0.36^{ab}	7.08 ± 0.29^{b}	7.19 ± 0.65^{bc}	7.30 ± 0.49^{c}
Fat-binding capacity (g/g)	7.09 ± 0.21^{d}	5.87 ± 0.39^{a}	6.12 ± 0.28^{b}	6.22 ± 0.19^{bc}	6.31 ± 0.34^{c}	6.40 ± 0.25^{c}
Moisture content (%)	8.59 ± 0.20^{a}	11.42 ± 0.27^{c}	11.09 ± 0.29^{c}	10.86 ± 0.24^{bc}	10.62 ± 0.34^{b}	10.42 ± 0.31^{b}
Crude Protein (%)	4.55 ± 0.15^{a}	9.56 ± 0.89^{d}	9.06 ± 0.64^{cd}	8.59 ± 0.58^{c}	8.11 ± 0.44^{bc}	7.62 ± 0.59^{b}
Crude Fat (%)	0.65 ± 0.006^{a}	1.56 ± 0.56^{b}	1.48 ± 0.26^{b}	1.39 ± 0.22^{b}	1.25 ± 0.27^{b}	1.13 ± 0.19^{b}
Ash (%)	4.38 ± 0.35^{d}	1.24 ± 0.28^{a}	1.49 ± 0.22^{ab}	1.88 ± 0.18^{b}	2.22 ± 0.14^{b}	2.59 ± 0.24^{c}
Crude Fiber (%)	4.37 ± 0.20^{d}	3.94 ± 0.34^{a}	4.09 ± 0.35^{ab}	4.13 ± 0.37^{b}	4.19 ± 0.31^{bc}	4.23 ± 0.28^{c}
Total Carbohydrates (%)	70.45 ± 2.36^{a}	74.67 ± 2.85^{d}	73.36 ± 2.75^{c}	72.79 ± 2.48^{c}	71.35 ± 2.46^{b}	70.74 ± 2.44^{ab}
SDS Sedimentation (%)	13.45 ± 0.85^{a}	53.02 ± 0.72^{f}	51.35 ± 0.89^{e}	47.06 ± 0.71^{d}	43.28 ± 0.69^{c}	38.55 ± 0.58^{b}
Wet gluten Content (%)	0.00^{a}	30.45 ± 0.28^{f}	28.25 ± 0.48^{e}	26.64 ± 0.59^{d}	24.88 ± 0.66^{c}	21.74 ± 0.51^{b}
Dry gluten Content (%)	0.00^{a}	9.83 ± 0.34^{d}	8.53 ± 0.38^{c}	7.76 ± 0.33^{c}	7.15 ± 0.28^{bc}	6.64 ± 0.24^{b}
Calories (Kilo Calories)	302.6 ± 2.26^{a}	342.48 ± 2.27^{d}	333.16 ± 2.25^{cd}	328.12 ± 2.13^{c}	320.44 ± 2.18^{bc}	315.08 ± 2.14^{b}

Data are presented as means±SEM (n=3).

$^{a-b}$Means within row with different lowercase superscript are significantly different ($p<0.05$) from each other.

Taro flour (TF), Wheat flour (WF)

Table 3: Color characteristics of Taro, wheat and different concentration mixes of flour

Flour	**L***	**a***	**b***
TF	74.59 ± 0.78^{a}	5.81 ± 0.45^{c}	17.22 ± 0.66^{e}
WF	98.19 ± 2.13^{e}	0.49 ± 0.09^{b}	11.13 ± 0.46^{a}
TF/WF (%) 10:90	96.43 ± 2.19^{d}	0.44 ± 0.05^{ab}	15.19 ± 0.54^{d}
TF/WF (%) 20:80	94.71 ± 2.11^{c}	0.42 ± 0.06^{ab}	13.96 ± 0.48^{c}
TF/WF (%) 30:70	93.22 ± 2.16^{b}	0.40 ± 0.03^{a}	12.59 ± 0.41^{b}
TF/WF (%) 40:60	91.79 ± 1.56^{b}	0.38 ± 0.02^{a}	11.88 ± 0.36^{ab}

Data are presented as means±SEM (n=3).

$^{a-b}$Means within row with different lowercase superscript are significantly different ($p<0.05$) from each other.

Taro flour (TF), Wheat flour (WF)

high amylopectin content has been reported to retrograde slowly (Bamidele, Cardoso & Olaofe, 1990). The water absorption capacity indicates the water holding capacity of dough during the processing of different bakery products. The higher water absorption capacity of gluten indicates a high content of starch. Gluten samples varied in all four wheat cultivars which may be due to the difference in drying conditions. The water absorption capacity is considered a critical function of the protein in viscous food like soups, gravies, dough, and baked products mainly bread and cakes (Singh & Singh, 2006). The differences in water absorption are mainly attributed to the greater number of hydroxyl groups which exist in the fiber structure and allow more water interactions through hydrogen bonding (Rosell et al., 2001). Fat binding capacity is an important feature of polysaccharides. It is in part related to the chemical composition, but it is more closely linked to the porosity of the fiber structure than to the affinity of the fiber molecule to oil (Biswas, Kumar, Bhosle, Sahoo & Chatli, 2011). In different concentration of taro and WF the moisture content, crude protein, crude fat, and carbohydrates were present in decreasing order and ash and crude fiber was present in increasing order. Similar results were reported by

Eke, Sanni and Owuno (2009) in banana cake, and See, Noor Aziah and Wan Nadiah (2007) in bread cakes. SDS sedimentation varied between 3.45 to 33.02% respectively, and as the concentration of TF increased, SDS value decreased. The SDS sedimentation volume is a good indicator of wheat flour quality. Present SDS values are in agreement with the values determined by Supekar, Patil and Munjal (2005). The SDS sedimentation value of wheat flours is based on the fact that gluten protein absorbs water and swells considerably when treated with lactic acid. The wet gluten content and the dry gluten content were present in WF 30.45 and 9.83%, respectively and absent in TF. Gluten is an important constituent of wheat because it provides strength to dough and texture to baked wheat products. Higher gluten content in WF is recommended for bread and lower gluten content is found better for biscuits and cookies (Autran, Hamer, Plijter & Pogna, 1997). In a response surface study on gluten extraction from low-grade flour and durum flour, it was found that the protein concentration in protein fractions increased as the water content in the dough increased from 400 to 710 g/Kg (Dik, Yondem-Makascioglu, Aytac & Kincal, 2002). This provides the dry matter of gluten protein present in flour and water absorption capacity of gluten present in flour. However, results determined by Singh and Singh (2006) ranged between 5.9 and 10.1 % of dry gluten yield. Supekar et al. (2005) determined the dry gluten content in the range of 9.4 to 12.7 %. Similar results were reported by Pharande, Dhotre and Adsule (1988).

Color is a significant parameter which includes the physical appearance of the product (Bhandari, Patel & Dong Chen, 2008). Table 3 shows the color values (L*, a* and b*) of TF was ranged between L* 74.59, a* 5.81, b* 17.22 and WF L* 98.19, a* 0.49, b* 11.13 and in different concentrations of TF and WF color values ranged between L* 96.43, a* 0.44, b* 15.19 in TF/WF 10:90%, L* 94.71, a* 0.42, b* 13.96 in TF/WF 20:80%, L* 93.22, a* 0.44, b* 12.41 in TF/WF 30:70% and L* 91.79, a* 0.38, b* 11.88 in TF/WF 40:60%. Kumar et al. (2014) reported similar results for taro cake. They also reported that with substitution of taro carbohydrate, fiber, water absorption index and water solubility index were increased.

3.2 Dough properties

Textural properties of dough, gluten extracted and cake

Textural properties (hardness, cohesiveness, stickiness, and adhesion) were analyzed to assess the effect of the addition of TF to WF on dough quality shown in Table 4. As reported by Carson and Sun (2001), texture analysis is an objective physical examination of baked products and gives direct information on the product quality, while dough rheology tests provide information on the baking suitability of the flour as raw material. Similar results showing increased hardness were found in bread prepared with 10%, 20%, and 30% buckwheat flour (Torbica, Hadnadev & Dapcevic, 2010). Gluten has a significant effect on the consistency of dough, and also affects the structure of molecules in the flour. According to Chang and Liu (1991), the level and structure of protein and starch have an effect on the hydration pattern of flour and modify the consistency of dough. In gluten-free muffins prepared with teff, flour similar results were reported by Tess, Bhaduri, Ghatak and Navder (2015).

Physical characteristics of the cake

The effect of TF incorporation on the physical properties of the cake is summarized in Table 5. Increase in the width and height of the taro cake and dough were affected by the addition of TF in WF. The weight and the volume of the cake were also affected by the addition of TF during formulation. In fact, the weight of the cake after cooking was increased with the addition of TF. The highest weight was exhibited with TF addition at a level of 40%. The volume of cake increased with the addition of TF.

3.3 FTIR interpretation

FTIR is a cheap, fast, reliable, correct and non-destructive method, to find the functional groups present in a sample (Schwanninger, Rodrigues,

Table 4: The textural properties of different types of dough, gluten extract and cake

	Cohesiveness (mm)	Adhesion (N)	Stickiness (N)	Hardness (N)
Textural properties of Dough				
TF (100%)	0.44 ± 0.028^{a}	0.26 ± 0.027^{a}	1.13 ± 0.031^{a}	0.89 ± 0.027^{a}
WF (100%)	0.46 ± 0.033^{a}	0.20 ± 0.026^{a}	0.98 ± 0.034^{a}	0.63 ± 0.029^{a}
TF/WF (%) 10:90	0.46 ± 0.023^{a}	0.22 ± 0.035^{a}	1.00 ± 0.038^{a}	0.67 ± 0.036^{a}
TF/WF (%) 20:80	0.45 ± 0.031^{a}	0.24 ± 0.031^{b}	1.04 ± 0.056^{a}	0.71 ± 0.044^{a}
TF/WF (%) 30:70	0.45 ± 0.025^{a}	0.25 ± 0.029^{a}	1.07 ± 0.064^{a}	0.76 ± 0.042^{b}
TF/WF (%) 40:60	0.44 ± 0.029^{a}	0.26 ± 0.025^{b}	1.09 ± 0.054^{a}	0.81 ± 0.033^{b}
Textural properties of gluten				
TF (100%)	-NA-	-NA-	-NA-	-NA-
WF (100%)	0.18 ± 0.019^{a}	0.12 ± 0.027^{a}	0.41 ± 0.31^{a}	0.39 ± 0.31^{a}
TF/WF (%) 10:90	0.17 ± 0.022^{a}	0.11±0.025 a	0.39 ± 0.28^{b}	0.37 ± 0.29^{a}
TF/WF (%) 20:80	0.16 ± 0.021^{a}	0.10 ± 0.021^{b}	0.37 ± 0.24^{a}	0.36 ± 0.27^{a}
TF/WF (%) 30:70	0.15 ± 0.018^{a}	0.09 ± 0.023^{a}	0.36 ± 0.27^{a}	0.35 ± 0.28^{a}
TF/WF (%) 40:60	0.14 ± 0.020^{a}	0.08 ± 0.022^{a}	0.34 ± 0.25^{b}	0.33 ± 0.26^{b}
Textural properties of cake				
TF (100%)	2.15 ± 0.19^{b}	1.19 ± 0.21^{b}	1.65 ± 0.36^{b}	1.13 ± 0.36^{b}
WF (100%)	2.11 ± 0.16^{a}	1.11 ± 0.19^{a}	1.44 ± 0.34^{a}	0.98 ± 0.27^{a}
TF/WF (%) 10:90 Cake	2.14 ± 0.15^{a}	1.12 ± 0.24^{a}	1.57 ± 0.41^{a}	1.03 ± 0.28^{a}
TF/WF (%) 20:80 Cake	2.13 ± 0.24^{a}	1.14 ± 0.17^{a}	1.59 ± 0.35^{b}	1.05 ± 0.45^{ab}
TF/WF (%) 30:70 Cake	2.12 ± 0.25^{ab}	1.17 ± 0.11^{b}	1.60 ± 0.28^{a}	1.09 ± 0.33^{a}
TF/WF (%) 40:60 Cake	2.11 ± 0.31^{b}	1.18 ± 0.25^{b}	1.63 ± 0.19^{ab}	1.12 ± 0.27^{b}

Data are presented as means±SEM (n=3).
$^{a-b}$Means within columns with different lowercase superscript are significantly different ($p<0.05$) from each other. Taro flour (TF), Wheat flour (WF)

Table 5: Physical characteristics of cakes

	Length (cm)	Width (cm)	Height (cm)	Weight before cooking (g)	Weight after cooking (g)	Volume (cm^3)
TF (100%)	13.6 ± 0.37^{a}	8.5 ± 0.44^{a}	7.0 ± 0.22^{a}	150 ± 0.98^{a}	142 ± 0.89^{a}	809 ± 1.13^{b}
WF (100%)	13.4 ± 0.33^{a}	8.5 ± 0.41^{a}	7.1 ± 0.21^{a}	150 ± 0.92^{a}	144 ± 0.92^{b}	808 ± 1.11^{a}
TF/WF 10%/90%	13.4 ± 0.36^{a}	8.5 ± 0.45^{a}	7.0 ± 0.20^{a}	150 ± 0.95^{a}	143 ± 0.94^{a}	797 ± 1.13^{a}
TF/WF 20%/80%	13.5 ± 0.38^{a}	8.5 ± 0.51^{a}	7.0 ± 0.25^{a}	150 ± 0.87^{b}	142 ± 0.90^{b}	803 ± 1.21^{a}
TF/WF 30%/70%	13.4 ± 0.39^{a}	8.5 ± 0.35^{a}	7.0 ± 0.27^{a}	150 ± 0.75^{b}	141 ± 0.80^{a}	809 ± 1.19^{b}
TF/WF 40%/60%	13.5 ± 0.37^{a}	8.5 ± 0.47^{a}	7.1 ± 0.29^{b}	150 ± 0.90^{a}	144 ± 0.95^{a}	814 ± 1.15^{b}

Data are presented as means±SEM (n=3).
$^{a-b}$Means within row with different lowercase superscript are significantly different ($p<0.05$) from each other.
Taro flour (TF), Wheat flour (WF)

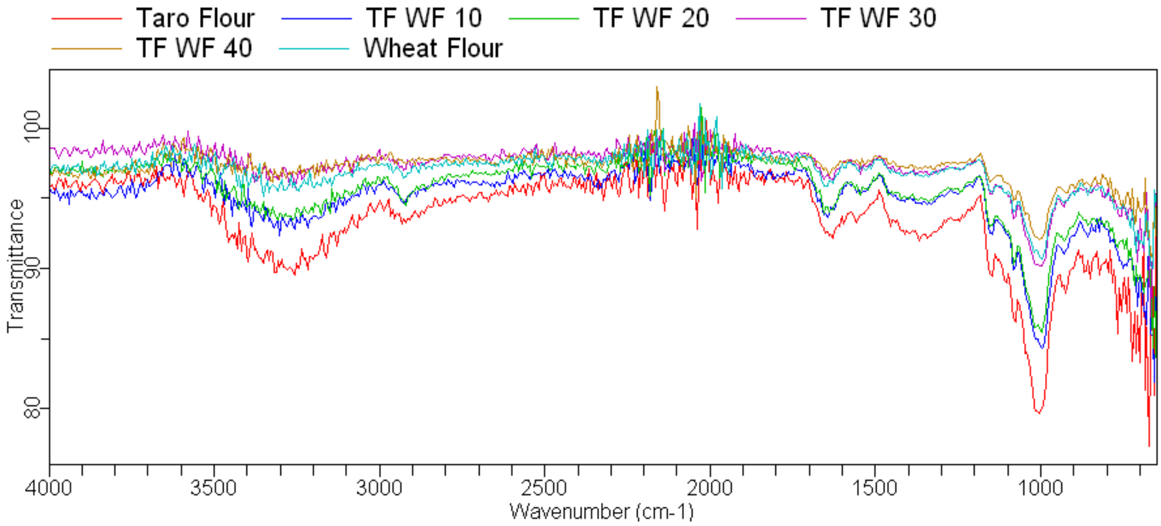

Figure 1: Spectra representation of FTIR analysis of TF, WF and different concentrations of TF and WF

Table 6: Liking scores of cakes prepared with TF

Characteristics	Maximum score	TF (100%)	WF (100%)	TF/WF 10%/90%	TF/WF 20%/80%	TF/WF 30%/70%	TF/WF 40%/60%
Color	10	7.5±0.24^{a}	7.5±0.22^{a}	8.5±0.35^{c}	8.0±0.23^{b}	8.0±0.33^{b}	8.0±0.25^{b}
Texture	10	8.0±0.28^{a}	8.0±0.24^{a}	8.0±0.24^{a}	8.0±0.30^{a}	8.0±0.25^{a}	8.0±0.18^{a}
Taste	10	7.5±0.23^{a}	8.0±0.26b	8.5±0.28^{c}	8.5±0.28^{c}	8.0±0.29^{b}	8.0±0.27^{b}
Odor	10	8.0±0.19^{b}	7.5±0.27^{a}	8.5±0.27^{c}	8.5±0.26^{c}	8.0±0.24^{b}	8.5±0.25^{c}
Overall Acceptability	10	8.0±0.22^{a}	8.0±0.23^{a}	8.5±0.21^{b}	8.5±0.25^{b}	8.0±0.31^{a}	8.0±0.22^{a}

Data are presented as means±SEM (n=3).
$^{a-b}$Means within row with different lowercase superscript are significantly different ($p<0.05$) from each other.
Taro flour (TF), Wheat flour (WF)

Pereira & Hinterstoisser, 2004). To have information about the chemical structure of taro flour and wheat flour, the FTIR spectrum is given in Figure 1. The FTIR spectrum was recorded in the transmission mode between 4000 cm-1 and 500 cm-1 for taro and wheat. The spectrum of biopolyols had characteristic bands of cellulose at 3420, 1163, 1060, and 1033 cm-1. Additionally, the peaks observed at 1714, 1660, 1117, and 1013 cm-1 were related to the functional groups of lignin. The broad band at about 3600-3000 cm1 was related to the characteristic stretching vibration of -OH. The various functional groups present in both TF and WF were (-C=C-O-C) (Ether), (-C-OH) (Phenol) and (-C-OH) (1^o and 2^o Alcohol) and (-C-H) (Alkyl). The presence of these functional groups represents the molecular composition of both TF and WF which further supports the conclusion of no interaction in characteristic functional groups of flour with the ingredients of TF.

3.4 Sensory Evaluation

Table 6 shows effects of adding different concentrations of taro on sensory evaluation of prepared cake. The current study applied the sensory profiling method involving a panel and had a differential rank ordered perception for the four manufactured cake samples. In taste and odor there were significant differences in control and other concentrations. Karaoğlu and Kotancilar (2009) reported no significant difference among samples with and without cake preparation using tapioca starch for liking scores of appearance, color and odor. Samples 10 and 20% TF-added showed the highest taste scores. In order, WF cake showed the lowest scores whereas, 10 and 20% TF-added cake showed highest taste scores. The overall sensory acceptability of TF cake was lowest, whereas, 10% and 20% TF added cake showed the highest scores. According to these results, 10 and 20% TF-added cakes showed higher sensory scores, however, 10% TF-added cake was utilised for further studies.

4 Conclusions

The health benefits of taro are numerous and reported by several papers. Therefore, taro-enriched cake was developed. Most of the physic-chemical properties of taro were different from WF. Enrichment with taro significantly affects textural properties as taro lacks gluten. The composite taro flour at the 40% replacement level showed physical properties similar to wheat cake samples, especially for products from taro-wheat composite flour. The taro-wheat composite flour had the lowest setback and processing stability, which indicated low staling or aging of dough for cake replaced with taro flour. The composite cake would serve as a functional food because of the high trace element content. It can be suggested that other non-cereal products like elephant foot yam and water caltrop will also be tried for cake preparation. For the future, taro will be tried for production of noodles, cookies, bread, buns, pizza base and pan bread.

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