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Chemical and Physical Properties of Taro Flour and the Application of Restructured Taro Strip Product

Sirima Chinnasarn and Rachada Manyasi

Department of Food Science, Burapha University, Thailand

Abstract: Native and pregelatinized (pregel) taro flours were produced to use as major ingredients for making the taro strip product. The yields of native and pregel taro flours were 20 and 19%, respectively. Carbohydrate was the main composition of both flours. In addition, ash and fiber represented other important groups of component. The gelatinization temperature of native flour was 80.3°C and the peak viscosity was 153 BU. Pregel flour showed the lower of both gelatinization temperature (66.7°C) and peak viscosity (123 BU). The optimum formulation of taro strip product contained native taro flour, pregel taro flour and rice flour at the amount of 60, 10 and 30 %, respectively. The product was formed into a strip having 0.5 cm. thickness and 6 cm. length and was fried at 180°C for 60 seconds. The obtained product quality was improved by varying the amount of baking powder at 0, 1, 3 and 5 % (flour basis). The compression force value of product increased as the amount of baking powder increased. The product added with 3 % baking powder (flour basis) had the highest overall acceptability score. Final product contained 6% protein, 16.4% lipid, 3.7% ash, 3.2% crude fiber and 71% carbohydrate.

Key words: Taro flour · Pregelatinized taro flour · Modified taro flour · Pasting characteristic · Restructured taro strip · Formulation development

INTRODUCTION

Taro (*Colocasia esculenta*) is one of carbohydrate rich sources while its properties remain to be determined. Taro is an important food staple of developing countries in Africa, the West Indies, the Pacific region and Asia. The corms are generally used as the main starch in meals, however, snacks are prepared from taro in numerous countries and are either sweet or salty, moist or crisp [1]. The food industry utilises some tubers and roots for their flour and starch products, however, there is no taro flour in the market. Taro has been reported to have 70-80 % starch with small size granules, which result in high digestibility, so it is used in preparation of infant foods in Hawaii and other Pacific islands [2]. The starch granules of taro starch were small and polygonal, with an average diameter of 1.3-2.2 μm [3]. This flour could be advantageous in the preparation of myriad products by the food development industry. The effects of using taro flour as partial substitution of wheat flour in balady bread (Egyptian bread) making on the organoleptic properties and chemical composition of the produced bread were investigated by [4]. They found that the substitution of wheat flour with taro flour in bread making with substitution level up to 10 % did not adversely affect the quality properties of the bread and produce bread similar to that produced from wheat flour in the rheological and organoleptic properties. To make taro flour more versatile in its application, the functional properties of native flour may also be improved by the modification techniques.

Pregelatization is one of the physical methods used to modify starch. This method affects physicochemical and functional properties of flour significantly [5]. Due to starch granule disruption, pregelationized flour can absorb water and increase viscosity immediately even with cold water. Therefore, it can create binder properties to obtain uniform matrix instantly when added into water [6-8]. The solubility of modified starch from taro was studied by [9]. It was found that the heat-moisture treated starch was more soluble than raw starch. In addition, it was reported that pregelatinized and heat moisture treated rice flours had lower pasting temperature and peak viscosity as compared to native flour [8]. The research report of [10] revealed that the texture and sensory score

Corresponding Author: Sirima Chinnasarn, Department of Food Science, Burapha University, Tambon Saensook, Aumphur Muang, Chonburi, 20131, Thailand.
Tel: 6638-103137, Fax: 6638-393492, E-mail: sirimac1@gmail.com.

of restructured jackfruit chip product could be enhanced by adding pregelatinized jackfruit seed flour in the formulation. Results showed that the product with pregel flour had lower hardness, more crispness and higher overall acceptability score as compared to the original product.

In Thailand, the popularity of snack product including restructured potato chip or strip products is increasing. The possibility of using starchy staples for snack making depends on the physical and chemical properties of the product. Native taro flour and pregelatinized taro flour could be alternative sources of major raw materials for restructured product making. In this study, the aims were to investigate native and pregelatinized taro flour properties. In addition, the restructured taro strip product was developed by using both flours as main ingredient. Then, the physical properties, chemical properties and sensory characteristics of the strip were investigated.

MATERIALS AND METHODS

Materials: Fresh taro corms, rice flour and other ingredients used in restructured taro strip product were purchased from the local market (Talard Nongmon) in Chonburi province, Thailand. The project had been done in the Department of Food Science, Faculty of Science, Burapha University, Thailand.

Preparation of Native Taro Flour: Fresh taro corms were peeled, washed, sliced and soaked in 0.1% Sodium metabisulfite for 1 hour. Taro slices were dried in a hot air oven at 65°C for 7 hours. The chips were ground and sieved through a 100-mesh sifter to obtain native taro flour.

Preparation of Pregelatinized Taro Flour: Fresh taro corms were also peeled, washed, sliced and soaked in 0.1% Sodium metabisulfite for 1 hour. Then, the slices were cooked in boiling water at 100°C for 5 minutes. Taro chips were dried in a hot air oven at 65°C for 7 hours. The chips were ground and sieved through a 100-mesh sifter to obtain pregelatinized taro flour (pregel taro flour).

Restructured Taro Strip Processing: Mixture design was applied to generate the various formulae under the constraint of native taro flour 25-60%, pregel taro flour 0-10% and rice flour 25-40%. Then, the formulation was optimized. As a result, 5 formulae were studied. The sensory evaluations of products were conducted by 30 panelists, using a Ranking test where one is the most preferred and five is the least preferred.

Restructured taro strips were produced by mixing native taro flour, pregel taro flour and rice flour with 15% moltodextrin, 1% lecithin, 13% shortening, 1.8% salt, 3.5% sugar and 75%water. The percentage of all ingredients was calculated on flour basis. After mixing, the dough was sheeted and cut into 0.5 cm. thickness and 6 cm. length to obtain restructured taro strips. The strips were fried at 180°C for 60 seconds.

The product obtained from Ranking test was compared to the ideal product profiles using Ratio Profile Test (RPT) with unstructured 10 cm line scales. Sensory evaluation by 30 panelists for 4 attributes (crispness, saltiness, sweetness and brown color) was carried out to develop the most acceptable product.

The final formulation of restructured taro strip product was obtained from the 9-point hedonic scale for 6 attributes (appearance, color, odor, taste, texture and overall acceptability) where nine is like extremely and one is dislike extremely. Sensory evaluations were conducted by 30 panelists, consisting of Department of Food Science, Burapha University.

Chemical Analysis: The proximate composition of taro corms, native taro flour, pregel taro flour, rice flour and restructured taro strip product was determined following the official method of analysis [11].

Pasting Characteristics: Gelatinization temperature and pasting characteristics of taro flour and pregel taro flour at 6% slurry concentration were conducted by using a Brabender Viscoamylograph (TP 100, Germany).

Physical Measurements: Color of samples were determined by a Handy Colorimeter (BYK Gardner Handy Colorimeter, Germany) in L*, a*, b* color scale. The texture was performed at room temperature by using a TA-XT2 Texture Analyzer (Surrey, UK) fitted with a three point bend rig (HPD/3PB) probe.

Statistical Analyses: Triplicate samples were analyzed for each property. Data were assessed by analysis of variance (ANOVA). Duncan's multiple range test was used to compare the means from each treatment.

RESULTS AND DISCUSSION

Chemical and Physical Properties of Native and Pregel Taro Flours

Proximate Composition: Native and pregel taro flours were produced. The yields of native and pregel taro flour were 20 and 19%, respectively. The proximate composition of taro corms, native taro flour, pregel taro flour and rice

Table 1: Average proximate composition of taro corms, native taro flour, pregel taro flour and rice flour

	Percentage (dry basis)			
Composition	Taro corms	Native taro flour	Pregel taro flour	Rice flour
Protein	10.88 ± 0.02	8.52 ± 0.07	8.33 ± 0.08	7.05 ± 0.04
Fat	0.18 ± 0.02	0.11 ± 0.01	0.10 ± 0.02	0.09 ± 0.02
Ash	3.42 ± 0.06	3.13 ± 0.08	2.79 ± 0.06	0.19 ± 0.03
Crude fiber	3.38 ± 0.04	2.15 ± 0.04	2.30 ± 0.05	0.22 ± 0.01
Carbohydrate *	82.14 ± 0.14	86.08 ± 0.20	86.48 ± 0.21	92.46 ± 0.09

*Carbohydrate = 100-(Protein+Fat+Ash+Crude fiber).

Table 2: Pasting characteristics of native and pregel taro flours

Pasting properties	Native taro flour	Pregel taro flour
Gelatinization temperature (°C)	80.30 ± 0.00	66.70 ± 5.94
Peak viscosity (BU)	153.00 ± 4.24	123.00 ± 2.83
Initial viscosity at 95°C (BU)	144.00 ± 2.83	123.00 ± 2.83
Final viscosity at 95°C (BU)	116.00 ± 1.41	123.00 ± 2.83
Initial viscosity at 50°C (BU)	157.00 ± 2.83	160.50 ± 0.71
Final viscosity at 50°C (BU)	155.00 ± 2.83	161.00 ± 1.41

flour is presented in Table 1 as a dry weight basis. Results showed that carbohydrate composed mainly of taro corms, was the most important chemical component in both native and pregel taro flours while the fats was very limited. The chemical composition levels of both flours were comparable. Ash and fiber represented other important groups of component in native and pregel taro flours. Ash values ranged from 2.79% (pregel flour) to 3.13% (native flour) and fiber values ranged from 2.15% (native flour) to 2.30% (pregel flour). Both values were higher compared to those of rice flour (0.19% ash and 0.22% fiber). These results are in agreement with those reported by [12]. They found that raw and blanched taro flours had higher fiber contents than wheat flour.

Pasting Characteristics: The gelatinization temperature and pasting behavior of native and pregel taro flours studied by using a 6% slurry concentration are given in Table 2. Pregel flour showed the lower of gelatinization temperature and the decrease of peak viscosity. Due to the fact that when starch granule was heated with water, it went through some changes both physical and chemical such as swelling, granule rupture, crystallinity loss and amylose leaching [13]. If pregelatinization caused granule swelling or disruption, it could cause pregel flour to absorb water and raise viscosity instantly [6-7]. Consequently, when the pregel flour was reheated, it caused a decrease in paste viscosity, leading to thinning of the slurry [14]. The same result was observed by [8] who determined the characterization of pregelatinized rice flour. They found that pregelatinization of rice flours showed the lower of pasting time, pasting temperature and the decrease of peak viscosity. The results also showed the viscosity decrease from 144 to 116 BU of native flour at 95°C while it was constant for the pregel flour. This may be because the disruption of starch granule in native flour slurry just occurred resulting in the thinning paste when it was held at 95°C for 20 minutes. After holding at 95°C, slurry was cooled down to 50°C. Loss of starch granule integrity and the destruction of crystallinity resulted in its cold soluble properties by creating high viscosity at low temperature for both flours. The results are similar to those of taro flour obtained by [15] and those of native and pregel rice flours obtained by [5]. Aprianita *et al.* [15] found that the viscosity of taro flour increased from 265.8 cP to 487.4 cP when the slurry was cooled down to 50°C. As well as, Lai [5] found that the viscograph of all rice flour samples showed the increase of cold viscosity when the temperature was cooled down from 95°C to 35°C.

Restructured Taro Strip Processing

Formulation Development: Five formulae obtained from Mixture design and Ranking score are presented in Table 3. Ranking score of five formulae showed a significant difference ($p \leq 0.05$). Results showed that panelists preferred a formulation 2 the most. Hence, the optimum ingredient contained native taro flour, pregel taro flour and rice flour at amount of 60, 10 and 30%, respectively. The Ratio Profile Test revealed that the intensity rating of saltiness, sweetness and brown color attributes for this formulation were close to those of the ideal product profile, as showed in Table 4, but the intensity rating of crispness was lower. The panelists gave a commentary that the product was not crispy.

Table 3: Five formulae obtained from Mixture design and Ranking score

Formulation	Percentage			Ranking score
	Native taro flour	Rice flour	Pregel flour	
1	60	40	0	106[ab]
2	60	30	10	70[c]
3	40	50	10	114[a]
4	50	50	0	84[b]
5	53	42	5	76[bc]

[a, b, c] different letters in the same column indicate significant differences ($p \le 0.05$)

Table 4: The intensity rating of crispness, saltiness, sweetness and brown color attributes of the formulation 2 using Ratio Profile Test (RPT)

Attributes	S (Sample)	I (Ideal)	Ratio of S/I
Crispness	3.64 ± 0.90	6.56 ± 0.93	0.55 ± 0.10
Saltiness	3.83 ± 0.97	4.13 ± 0.92	0.93 ± 0.12
Sweetness	3.73 ± 0.86	4.22 ± 0.92	0.89 ± 0.10
Brown color	4.75 ± 0.91	4.50 ± 0.94	1.06 ± 0.12

S = the intensity rating of restructured taro strip product from the 10 cm line scale

I = the intensity rating of the ideal product

Table 5: Effect of baking powder on physical characteristics of restructured taro strip

Baking powder (% flour basis)	Compression force(N)	L*[ns]	a*[ns]	b*[ns]
0	1.36 ± 0.06[d]	44.48 ± 0.14	14.61 ± 0.17	24.65 ± 0.14
1	3.60 ± 0.09[c]	44.45 ± 0.17	14.60 ± 0.16	24.60 ± 0.19
3	6.54 ± 0.06[b]	44.40 ± 0.10	14.72 ± 0.12	24.61 ± 0.16
5	9.42 ± 0.08[a]	44.30 ± 0.16	14.75 ± 0.14	24.58 ± 0.19

[a, b, c, d] different letters in the same column indicate significant differences ($p \le 0.05$)

[ns] non significant differences ($p > 0.05$)

Table 6 Effect of baking powder on sensory score of restructured taro strip (9-point hedonic scale)

Baking powder (% flour basis)	Appearance	Color[ns]	Odor[ns]	Flavor[ns]	Texture	Overall acceptability
0	7.27 ± 0.69[a]	7.40 ± 0.67	6.97 ± 0.72	6.73 ± 0.64	5.07 ± 1.23[c]	6.07 ± 0.91[c]
1	7.10 ± 0.66[ab]	7.43 ± 0.63	7.00 ± 0.64	6.87 ± 0.73	6.17 ± 1.32[b]	6.70 ± 0.88[b]
3	7.00 ± 0.74[ab]	7.23 ± 0.57	6.83 ± 0.65	7.03 ± 0.72	7.57 ± 0.90[a]	7.33 ± 0.76[a]
5	6.77 ± 0.77[b]	7.17 ± 0.70	6.80 ± 0.71	6.93 ± 0.78	7.20 ± 1.03[a]	6.93 ± 0.87[b]

[a, b, c] different letters in the same column indicate significant differences ($p \le 0.05$)

[ns] non significant differences ($p > 0.05$)

Crispness attribute was chosen to be improved by varying the amount of baking powder at 0, 1, 3 and 5% (flour basis). Physical properties and sensory evaluation were determined to obtain the final formulation. Physical characteristic of restructured taro strip showed in Table 5 represent color and texture parameters. There were not found a significant difference among treatments for L*, a* and b* values. In data represents influence of baking powder on the texture of the strips. The compression force value increased as the amount of baking powder increased. This could probably be because thermal decomposition causes baking powder alone to act as a raising agent by releasing carbon dioxide at frying temperatures resulting in the expansion of product volumn with more crispness [16]. The mixture for restructured taro strip using this method can be allowed to stand before frying without any premature release of carbon dioxide. In addition, Table 6 showed sensory score for appearance, color, odor, taste, texture and overall acceptability of restructured taro strip. Color, odor and taste were not found to be significantly different ($p > 0.05$). The product added with 3% baking powder (flour basis) had the highest overall acceptance score ($p \le 0.05$). Hence, 3% of baking powder was the optimum amount added in this product.

The final formulation of restructured taro strip product contained 60% native taro flour, 10% pregel taro flour, 30% rice flour, 15% moltodextrin, 1% lecithin, 13% shortening, 1.8% salt, 3.5% sugar, 75% water and 3% baking powder. The chemical quality of the final product was analyzed. Protein, lipid, ash, crude fiber and carbohydrate content were 5.98, 16.38, 3.74, 3.22 and 70.69% (dry weight basis), respectively.

CONCLUSIONS

In this experiment, native and pregel taro flour could be used as a suitable source of carbohydrate. They also showed a higher value of fiber than that of rice flour. Pregel taro flour showed the decrease of the pasting temperature and peak viscosity as comparing with native taro flour; however, its viscosity could be retained over the high temperature. This study has also demonstrated that native and pregel taro flours could be considered as a good functional ingredient for snack food product such as making restructured taro strips.

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