Vietnam Journal of Food Control

A Scientific Journal of National Institute for Food Control

Journal homepage: https://vjfc.nifc.gov.vn

Research Article

Effect of ratio of taro (*Colocasia esculenta L.)* on physicochemical properties of snacks

Nhan Minh Tri [1‡], Nguyen Thi Thuy Hong [1,2], Trang Thi Hoang Quyen [1]

[1]*Institute of Food and BioTechnology, Can Tho University, Can Tho city, Vietnam*

[2]*Faculty of Mechanical Engineering, Can Tho University of Technology, Can Tho city, Vietnam*

(Received: 02 Jan 2025; Revised: 06 Mar 2025; Accepted: 18 Mar 2025)

Abstract

Taro root (*Colocasia esculenta* L.) is indeed a valuable food crop, rich in nutrients like starch, sugar, minerals, vitamins, and fiber, especially, mucilage. It acts as a thickening, binding, emulsifying, swelling capacities or foaming agent in food, and pharmaceutical. The aim of the study was to investigate the effects of the ratio of taro mash (15, 25, 35 and 45%), on quality parameters (moisture content, expansion ratio, weight loss, oil absorption, hardness) and color (L, a*, b*) of taro snack. The results showed that, when the percentage of added taro was higher, the expansion of the snack increased and the hardness decreased. There were strong correlation coefficients between quality characteristics (moisture content, expansion ratio, weight loss, oil absorption, hardness, color) with ratio of taro mash. Snack supplemented with taro achieved the best quality when adding 35% taro. This research contributes to developing new products from taro and creating new snack products for consumers.

Keywords: *expansion ratio, hardness, oil absorption, taro snack, weight loss*

1. INTRODUCTION

Taro (*Colocasia esculenta* L.) is a highly nutritious plant, with its root being particularly rich in starch, comprising approximately 70 – 80% of its dry weight. The starch granules in taro are relatively small, making them easily digestible and well-suited for consumption by children and young adults [1]. Additionally, taro is a nutrient-dense crop, containing approximately 2% protein, 10 mg/100 g vitamin C, 32 mg/100 g calcium, 64 mg/100 g phosphorus, and 514 mg/100 g potassium. Given its affordability, the promotion and comprehensive evaluation of taro-based products are of considerable industrial significance. In addition to traditional snacks, quickly processed snacks such as snacks are increasingly popular because they meet requirements such as taste, nutritional value, and reasonable price. Snack is a type of snack that is widely used in the world and is increasingly popular in our country thanks to its delicious taste and variety of types. The snack is crispy, spongy, diverse in processing, easy to store, and has many flavors to choose from, so this dish is not only liked by children but also by adults.

Snacks are made from the main ingredients of wheat, baking powder, combined with spices and additives, then fried in cooking oil. However, wheat is a relatively expensive imported grain and can also trigger a gluten allergy known as Celiac disease [2]. Therefore, taking advantage of the available taro source to replace a part of the wheat in the production of snacks to reduce the gluten content, contributes to creating non-toxic natural colors and aromas for snacks. Besides, Taro is also a source of antioxidant compounds, including phenolics, carotenoids, and ascorbic acid, which are evaluated for scavenging activity using methods such as DPPH (2,2-Diphenyl-1-picrylhydrazyl) [3]. Taro contain rich in mucilage. It acts as a thickening, binding, emulsifying, or foaming agent in food, pharmaceutical, and several other fields of research. Mucilage can be extracted from several living organisms and has excellent functional properties, such as water-holding, oil-holding, and

[*]*Corresponding author: Nhan Minh Tri (E-mail: nhanmtri@ctu.edu.vn)*

https://doi.org/10.47866/2615-9252/vjfc.4460

swelling capacities [4]. Moreover, taro mucilage has unique rheological properties and gives much potential for use as a food binder and stabilizer, in addition to producing gelling properties and increased viscosity [5, 6]. Colloids are one of the properties of mucilage. Colloids contribute to glucose metabolism, slow down the reabsorption of undesirable components of the diet such as cholesterol, reduce total and LDL cholesterol in the blood, reduce insulin and blood glucose levels after eating, buffer excessive acid in the stomach, prevent constipation. In addition, it also helps to increase the water holding capacity of food, increasing the stability, texture and gelation of food [7]. The production of snacks supplemented with taro also contributes to the diversification of products made from taro. Therefore, this research was carried out in order to find out the process in snack processing, contributes to the production of high quality, high nutrional value, diversify products from snacks to serve consumers and at the same time increase the value of current taro raw material. Therefore, to fully exploit the potential of taro in the food industry, further research is needed to explore its physicochemical properties, functional applications, and processing techniques. The development of innovative taro-based products can not only enhance its commercial value but also provide sustainable and nutritionally rich alternatives to conventional staple foods. This study aims to contribute to the growing body of knowledge on taro by evaluating its nutritional composition, functional characteristics, and industrial applications, thereby supporting the advancement and wider adoption of taro-based food products.

2. MATERIALS AND METHODS

2.1. Materials

The primary ingredients used in the preparation included freshly harvested taro roots (Colocasia esculenta), cultivated at Lap Vo Farm, Dong Thap Province, Vietnam. The taro roots were collected at the maturity stage of five months. The specific taro variety utilized was Cao, characterized by a corm weight ranging from 500 to 800 g and a relatively purple flesh. In addition to taro, other key ingredients incorporated into the formulation included wheat flour with an 11% protein content (Baker’s Choice), modified starch (E1412), which was sourced from Vietnam, and extra refined sugar obtained from Bien Hoa, Vietnam.

2.2. Preparation of snack

The cleaned taro slices were steamed at 90℃ for 3 minutes. The taro slices were dried until 8% of moisture content. The dried sliced was ground and passed through a sieve with a mesh size of 0.105 mm. Taro was incorporated at ratios of 15, 25, 35, and 45% of wheat flour. The modified starch content remained constant at 20% of the wheat flour. The flour mixture also included sugar (2%), salt (1%), MSG (1.2%), baking powder (1%), and citric acid (1%). Water was added to the flour mixture to achieve a dough with a moisture content of 36%. The dough was kneaded and rolled six times to achieve a smooth texture. Noodling was done with a noodle maker (AKS YTD220 from Taiwan) to produce noodles with a thickness of 0.2 cm and a width of 0.6 cm. The noodle strands were cut into 5 cm lengths to shape the snack.

2.3. Physiochemical characteristics affecting on snack’s quality

The moisture content, or water content, was assessed by subjecting the ground sample (5 g) to heat in an oven set at 105℃ for 24 hours, employing the specified method AOAC, following Luigi's method (2004) [8]. The oil absorption of the snack was determined based on the method by Smith *et al*. [9], measuring the dry weight before and after frying. Weight loss was determined by the mass difference pre- and post-frying, following Lane *et al*.'s method (1982) [10]. The expansion ratio was determined by the volume change ratio before and after frying, following Yu's analytical method (1991) [11].

2.4. Texture profile of analysis

Texture analysis was conducted using a TA-XT2 Texture analyser connected to a computer, equipped with a “share blade”, rectangular attachment for cutting (70 mm x 3 mm). The velocity of the head with the attachment was 25 mm/min with a 50 kg load cell. The measurements were taken for determining maximum force (hardness) necessary to cut one slice of taro snack [12]. Each measurement was conducted on 10 taro snack. The distance at break is an indication of fracturability of the product.

2.5. Color measurement

Color parameters (L, a, b) were evaluated using a Hunterlab SAV colorimeter. The instrument underwent standardization before each measurement using both a white and a black ceramic plate. Samples were scanned at four different locations, and the L, a, b values were determined as the average of five measurements at each location [13].

2.6. Data analysis

The data were subjected to statistical analysis, which involved performing an Analysis of Variance (ANOVA), calculating Pearson correlation coefficients, and determining means using Duncan's multiple range tests at a significance level of $p < 0.05$. Significant differences were represented by varying letters. These statistical analyses were carried out using Statgraphic Centurion 15.

3. RESULTS AND DISCUSSIONS

3.1. Effect of taro's ratio on moisture, expansion, hardness, weight loss, and oil absorption of snack

After adding different ratios of taro mash, the doughs were prepared according to **Figure 1**. The snack samples were determined for moisture content, expansion ratio, texture, weight loss and oil absorption. The texture profiles were showed in **Figure 1**.

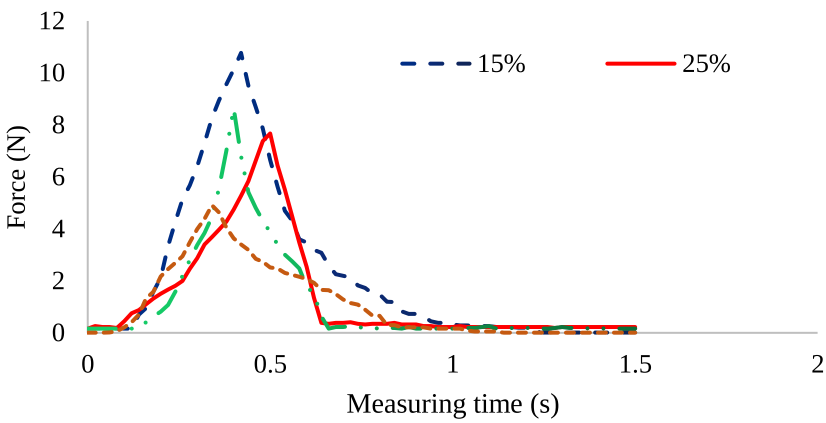


Figure 1. *Texture profile of snacks with different taro ratio addition*

Figure 1 showed that the hardness of snack was affected by the ratio of taro, the hardness of snacks decreased when the ratio of taro increased from 25% to 45%. The highest hardness was 10.77N when snack was added 25% taro and the lowest hardness was 4.91N when snack was added 45% taro. During the processing of taro snack products, the taro ratio was changed so the quality of the snack was also changed. All of the data were statistically analyzed and shown in **Table 1** and **Table 2**.

Table 1 shows that, when the taro ratio increased from 15% to 45%, the weight loss of snack gradually decreased from 11.95% to 2.99 %. The expansion ratio of the snack increased from 51.34% to 65.98%. The oil absorption rate gradually increased from 23.10% to 31.47%.

Table 1. *Effect of taro addition ratio on snack quality*

Taro's ratio (%)	Moisture (%)	Expansion (%)	Hardness (N)	Weight loss (%)	Oil absorption (%)
15	4.16 ± 0.47^a	51.34 ± 3.49^c	10.77 ± 0.88^a	11.95 ± 1.36^a	23.10 ± 0.97^c
25	3.30 ± 0.14^b	57.56 ± 1.51^b	7.67 ± 1.31^b	6.38 ± 0.86^b	28.32 ± 0.71^b
35	2.50 ± 0.06^c	59.53 ± 2.67^b	6.80 ± 0.93^b	3.61 ± 0.21^c	31.10 ± 0.08^a
45	2.56 ± 0.05^c	65.98 ± 2.33^a	4.91 ± 0.75^c	2.99 ± 0.53^c	31.47 ± 0.41^a

Note: The data are expressed as the mean ± standard deviation of thrice replicates. The samples in the same column that have related superscript letter(s) are not significantly different while those with different superscripts are significantly different (Tukey's test, $P < 0.05$).

The higher the percentage of taro, the higher the amount of free sugar and fiber. The most important sugar in taro is sucrose, but fructose, maltose, glucose and raffinose are also present [11], which prevents the gluten in the wheat from being tightly bound, less elastic, so the ability to link between starch molecules also decreases, so the quality of the wheat was reduced. Hardness decreased from 10.77 N to 4.91 N. Compared with the study of [14] for shrimp crackers supplemented with purple sweet potato, also shows that when adding more potatoes, the snack's hardness decreases.

3.2. Effect of taro's ratio on colors (L, a*, b*) of snack

Color values (L, a*, b*) of snack under the addition of taro's ratio are shown in **Table 2** below:

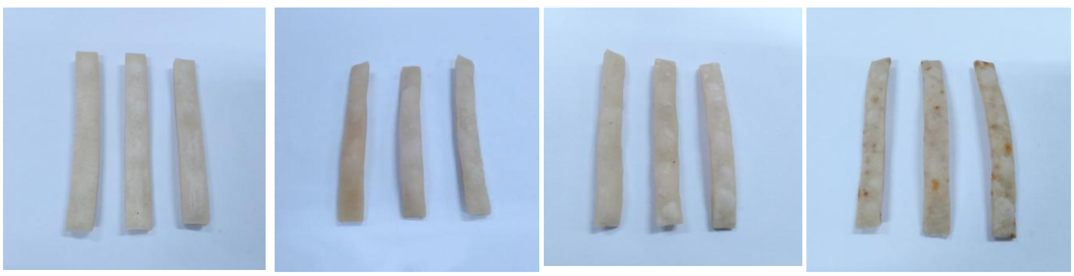
Table 2. *Effect of taro's ratio on colors (L, a*, b*) of snack*

Taro's ratio (%)	L*	a*	b*
15	67.39 ± 1.28^{a}	1.51 ± 0.53^{c}	21.54 ± 1.02^{a}
25	62.20 ± 0.42^{b}	3.93 ± 0.13^{b}	19.51 ± 0.72^{b}
35	63.32 ± 2.12^{b}	9.17 ± 0.49^{a}	12.03 ± 1.01^{c}
45	61.56 ± 1.84^{b}	9.42 ± 0.69^{a}	11.35 ± 1.32^{c}

The data are expressed as the mean ± standard deviation of thrice replicates. The samples in the same column that have related superscript letter(s) are not significantly different while those with different superscripts are significantly different (Tukey's test, $P < 0.05$).

Table 2 shows that the brightness L of the snack decreased from 67.39 to 61.56 if taro was added at an increasing ratio. At the same time, the value of a* also increased from 1.51 to 9.42. This result is similar to the research of [15] on the effect of purple sweet potato addition on snack quality. The b* value decreased from 21.54 to 11.35. Taro contains sugar (fructose and glucose), which contributed Maillard reaction causing darker color [14]. Additionally, the natural pigmentation of taro contributed to the color variation of the fried snack.

Statistical results show that snack products with the additional ratio of taro 35% have appropriate swelling, crispy texture (not too hard and not too soft) and good color, so it was chosen as the optimal treatment for the next experiment.



15% 25% 35% 45%

Figure 2. *Snack color when adding taro at the ratio of 15, 25, 35 and 45%*

3.3. Evaluation of the relationship between the indicators and the ratio factor of additional taro

Table 3 presents the Pearson correlation coefficients used to analyze the relationships between the properties of the deep-fried wheat-taro snack. The results indicate that the taro ratio exhibited a negative correlation with hardness, suggesting that an increased taro content resulted in reduced hardness, thereby enhancing crispiness. Previous research has also reported that taro contributes to improved texture and flavor in bread [16].

Additionally, the expansion ratio demonstrated a negative correlation with both hardness and moisture content, implying that as the expansion ratio increased, the hardness and moisture content of the snack decreased after frying. Furthermore, moisture content was positively associated with hardness, indicating that snacks with higher moisture content exhibited lower hardness. Lastly, oil absorption was positively correlated with the expansion ratio, meaning that greater oil absorption led to increased expansion of the snack.

Table 3. *Correlation coefficient ® between indicators and additional taro ratio factor*

	Taro's ratio	**Moisture content**	**Expansion ratio**	**Weight loss**	**Oil absorption**	**Hardness**	**L**	**a***
Moisture content	-0.89***							
Expansion ratio	0.91***	-0.79**						
Weight loss	-0.92***	0.91***	-0.80**					
Oil absorption	0.92***	-0.94***	0.80**	-1.00***				
Hardness	-0.91***	0.86***	-0.86***	0.91***	-0.91***			
L	-0.70*	0.73**	-0.61*	0.74**	-0.75**	0.74**		
a*	0.95***	-0.91***	0.80**	-0.92***	0.93***	-0.84***	-0.59*	
b*	-0.93***	0.87***	0.80**	0.89***	-0.89***	0.79**	0.54	-0.98***

*Note: ***: P < 0.001; **: 0.001< P < 0.01; *: P < 0.05*

4. CONCLUSION

The ratio of taro was negatively related to hardness so the more taro was added, the hardness was smaller meaning crispy. Ratios of taro were positively related to the oil absorption rate gradually increased. On the other hand, the ratio taro the weight loss of snacks. The brightness L of the snack decreased if taro was added at an increasing ratio. At the same time, the value of a* also increased. The b* value decreased. The taro ratio was changed so the quality of the snack was also changed. In addition, the statistical results also showed many high correlation coefficients (p < 0.001) between the snack properties (moisture content, expansion ratio, weight loss, oil absorption, hardness, color) with taro's ratio. Snack products with the additional ratio of taro 35% have appropriate swelling, crispy texture (not too hard and not too soft) and good color, so it was chosen as the optimal treatment for the processing of taro snack products.

REFERENCES

[1]. K. Pragati, V. Kumar, and H. K. Sharma. "Utilization Of Taro (Colocasia Esculenta): A Review," *Journal of Food Science and Technology*, vol. 52, no. 1, pp. 7 – 40, 2015, doi: 10.1007/s13197-013-0933.

[2]. Jeffrey Butterworth and Louis Los, "Coeliac disease," *Medicine*, vol. 47, no. 5, pp. 314-319, 2019, doi: 10.1016/j.mpmed.2019.02.003.

[3]. R. M. Nguimbou, N. Y., Njintang, H. Makhlouf, C. Gaiani, J. Scher and C. M. F. Mbofung, "Effect of Cross-Section Differences and Drying Temperature on the Physicochemical, Functional and Antioxidant Properties of Giant Taro wheat," *Food and Bioprocess Technology*, vol. 6, no. 7, pp.1809 -1819, 2013, doi: 10.1007/s11947-012-0846-1.

[4]. M. M. Tosif, A. Najda, J. Klepacka, A. Bains, P. Chawla, A. Kumar, and R. Kaushik, "A concise review on taro mucilage: Extraction techniques, chemical composition, characterization, applications, and health attributes," *Polymers*, vol. 14, no. 6, pp. 1163, 2022, doi: 10.3390/polym14061163.

[5]. Y. Njintang, T. Boudjeko, N. Tatsadjieu, E. Nguema-Ona, J. Scher, and C. Mbofung, "Compositional, spectroscopic and rheological analyses of mucilage isolated from taro (*Colocasia esculenta L. Schott*) corms," *Journal of Food Science and Technology*, vol. 51, no. 5, pp. 900-907, 2011, doi: 10.1007/s13197-011-0580-0.

[6]. P. Kaushal, and H. K. Sharma, "Convective dehydration kinetics of noodles prepared from taro (*Colocasia esculenta*), rice (*Oryza sativa*) and pigeonpea (Cajanus cajan) flours," *Agricultural Engineering International: CIGR Journal*, vol. 15, no. 4, pp. 202-212, 2013.

[7]. P.C. Njoku and C.C. Ohia, "Spectrophometric Estimation Studies of Mineral Nutrient in Three Cocoyam Cultivars," *Pakistan Journal of Nutrition*, vol. 6, no. 6, pp. 616-619, 2007, doi: 10.3923/pjn.2007.616.619.

[8]. AOAC International, "*AOAC 967.21 IFU Method No 17. The Association of official chemists 18th ed. Arlington*", USA, 2004.

[9]. L. M. Smith, A. J. Clifford, R. K. Creveling, and C. L. Hamblin, "Lipid content and fatty acid profiles of various deep-fat fried foods," *Journal of American Oil Chemistry Socciety*, vol. 62, pp. 996–999, 1985, doi: 10.1007/BF02935700.

[10]. R. H. Lane, H. Nguyen, S. W. Jone and V. C. Midkiff, "The Effect of Fryer Temperature and Raw Weight on Yield and Composition of Deep-Fat Fried Chicken Thighs," *Poultry Science*, vol. 61, no. 2, pp. 294-299, 1982, doi: 10.3382/ps.0610294.

[11]. S. Y. Yu, "Acceptability of fish crackers (keropok) made from different types of flour," *ASEAN Food Journal*, vol. 6, no. 3, pp. 114-116, 1991, doi: 10.1111/j.1365-2621.1990.tb01075.x.

[12]. P. M. Bahram, M. T. Mohammadi, and S. M. Razavi, "Effect of deep-fat frying on sensory and textural attributes of pellet snacks," *Journal of Food Science Technology*, vol. 51, no. 12, pp. 3758-66, 2014, doi: 10.1007/s13197-012-0914-6.

[13]. M. K. Krokida, V. Oreopoulou, Z. B. Maroulis and D. Marinos-Kouris, "Colour changes during deep fat frying," *Journal of Food Engineering*, vol. 48, no.3, pp. 219-225, 2001, doi: 10.1016/S0260-8774(00)00161-8.

[14]. M. Rosarlo, A. Vinas and K. Lorenz, "Pasta Products Containing Taro (*Colocasia Esculenta* L. Schott) And Chaya (*Cnidoscolus Chavamansa* L. Mcvaugh)," *Journal of Food Processing Preservation*, vol. 23, pp. 1-20, 1999.

[15]. Bui Thi Thuy Nga, "Survey of some factors affecting the quality of purple sweet potato shrimp crackers," Master's thesis in post-harvest technology, Can Tho University, 2016 (in Vietnamese).

[16]. G. Abera, W. K. Solomon, and G. Bultosa, "Effect of drying methods and blending ratios on dough rheological properties, physical and sensory properties of wheat-taro flour composite bread," *Food Science Nutrition*, vol. 5, no. 3, pp. 653-661, 2016, doi: 10.1002/fsn3.444.