

Product development of tortilla chips from white glutinous corn and cassava starch with addition of sodium bicarbonate

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Abstract. Tortilla chips, a popular corn-based snack originating from Mexico, are the focus of this research due to their potential for nutritional enhancement and improved sensory qualities. The study explores the use of white glutinous corn, tapioca, anchovy flour, and sodium bicarbonate to create a product with better texture, flavor, and nutritional value. The anchovy addition aimed to increase its flavor and calcium content. The experimental design of the research was Completely Randomized Design (CRD) Factorial Type with two factors, namely the proportion of white corn flour: tapioca (90:10, 80:20, 70:30) and the addition of sodium bicarbonate (0.2%, 0.4%, 0.6%). The data was analyzed by analysis of variance and further tested used Duncan's Multiple Range Test. The best treatment is tortilla chips made from proportion of white corn flour: tapioca flour (70:30) with the addition of sodium bicarbonate (0.2%). These tortilla chip had the characteristics as follow: water content of 8.89%, ash content of 6.00%, protein content of 11.02%, fat content of 4.64%, starch content of 60.40%, amylose content of 12.25%, amylopectin content of 48.15%, total dietary fiber content 4.71%, calcium content 493.85 mg/100gr; and it was preferred by panelist in term of color, aroma, taste and texture

1 Introduction

Tortilla chips are the most popular corn-based snack with the characteristics of a yellow color, crunchy, thin, easily crushed [1] and known as corn chips and are a typical food from Mexico [2]. Corn-based snacks such as tortilla chips have become the focus of food research because they can be modified in terms of raw materials and production processes to increase nutritional value and physical-sensory quality.

Previous Tortilla research usually used yellow corn flour as the main ingredient. This research was focused on product development of tortilla chips from white corn flour, tapioca, anchovy flour, spices and sodium bicarbonate. White corn was chosen as the object of this research because it has unique characteristics that differentiate it from other corn varieties. Snack food made from white corn flour with a high amylopectin content have a crunchier texture than products made from flour with a high amylose content. This is caused by amylopectin's ability to expand during the gelatinization process, so that the resulting product has a crunchy texture after baking.

White corn is a type of glutinous corn. The advantage of white corn is that it is rich in functional food components, namely dietary fiber, starch, amylose and amylopectin. The amylose content in white corn tends to be lower than yellow corn. The starch content in white corn is around 73% with amylose content of 27.04% and amylopectin of 45.96% [3].

Tapioca (cassava starch) is often used in the food industry as an auxiliary ingredient such as a binder, filler, or substitute for some of the main flour. Tapioca has good binding characteristics, white color, and sweet flavor [4]. The use of tapioca in the formulation of tortilla chips has the potential to expand the variety of ingredients and increase cost efficiency as well as physical characteristics such as crispness or density. Starch has a contribution in creating crispy tortilla chips texture, brightness of product color, and adhesive power [5].

Addition of anchovy flour aimed to increase calcium levels and improve the texture/firmness of the snack. The puffing level of tortilla chips is also influenced by food additives (BTP), namely the expanding agent in the form of sodium bicarbonate. Adding NaHCO₃ can prevent the formation of a hard-textured final product and increase swelling and crispness [6].

Previous research using yellow corn flour showed that the best treatment was the proportion of corn flour: sago flour (95:5) with the addition of 2.5% rebon shrimp flour which produced tortilla chips with a water content of 6.04%; ash content 2.56%; protein content 6.91%; fat content 3.62%; starch content 60.54%; hardness 356.17gf [7].

Other research showed that the best treatment for simulated chips was the proportion of taro:tapioca (80:20) with the addition of 2% NaHCO₃ which produced simulated taro chips with a water content of 11.27%, starch 52.38%, crude fiber 2.39%, yield

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62.57%, swelling volume 143.33, breaking strength 2.92 N/cm². The hedonic test results showed crunchiness score 3.95 (like), color score 4.00 (like), and taste score 3.55 (somewhat like) [8].

Anchovy is a small type of marine fish which can be used as source of animal protein and minerals in the development of innovative food products. The addition of anchovies which are rich in calcium can provide increased calcium levels as well as improved texture such as firmness in snacks. This shows that ion interactions in forming calcium bridges play a very important role in helping texture formation [9].

Until now there has been no research combining anchovies in white corn tortilla chips. The concept of using anchovies as an additional ingredient in crunchy snacks such as tortilla chips is very promising, both for increasing protein and mineral content, for example calcium. In research on the development of white corn tortilla chips enriched with anchovies, anchovies are a constant factor that plays a role in increasing the taste and nutritional content of tortilla chips.

2 Materials and methods

2.1 Materials

Raw materials for making tortilla chips include white corn purchased from farmers in Tuban, tapioca flour, sodium bicarbonate, anchovies, salt, water, garlic powder, refined sugar, margarine, ground pepper, and mineral water purchased at Wonokromo Market, Surabaya, and chemical reagents for chemical analysis. The tools used in making the product are a stove, cabinet dryer, blender, 80 mesh sieve, scales, dough com, baking pan, spoon, knife, oven, and glassware for analysis.

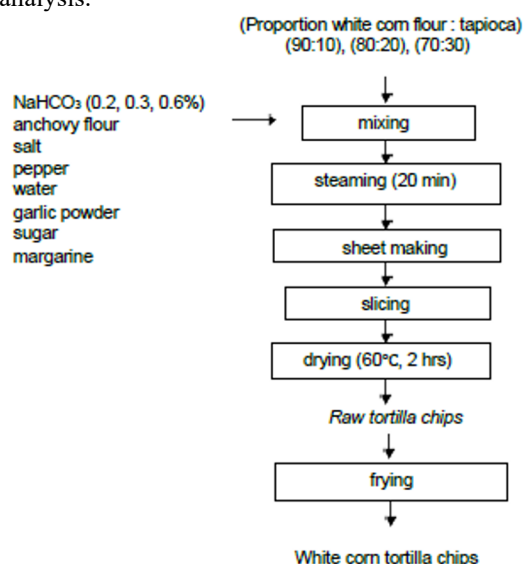


Fig 1. Flow chart of tortilla chips production

2.2 Methods

The procedure of tortilla chips making included mixing all ingredients, steaming (90oC, 30 min), sheet making (± 2 mm of thickness), slicing, drying (60oC, 2 hrs) and

frying (150-160oC, 8 sec) (Fig. 1). The raw materials (white corn flour, tapioca and anchovy flour) were analyzed for chemical composition). The tortilla chips were analyzed for moisture, protein, starch, amylose, amylopectin [10] and hedonic scale scoring of color, aroma, taste, and texture [11] using 25 panelists and the data was analyzed by nonparametric Friedman Test. The product from the best treatment was analyzed for dietary fiber [10] and Calcium content [12].

The experimental design used in this research was completely randomized design factorial pattern with 2 factors and 3 replications. Factor 1 was the proportion of white corn flour: tapioca (90:10, 80:20, 70:30 w/w) and Factor 2 was NaHCO₃ addition (0.2, 0.4, 0.6% of flour weight). The data was analyzed using analysis of variance. If a significant difference were found, it was further tested using Duncan's Multiple Range Test (DMRT).

3 Results and discussion

3.1 Chemical characteristics of ingredients

Previously, the researcher conducted initial test on the ingredients of Tortilla chips, namely white corn flour, cassava starch (tapioca) and anchovy flour.

Table 1. Chemical composition of white corn flour, tapioca and anchovy flour

Chemical content	White corn flour	Tapioca	Anchovy Flour
Moisture (%wb)	7.37±0.09	9.80±0.07	13.46±0.25
Ash (%wb)	0.55±0.11	1.83±0.19	17.68±0.12
Protein (%wb)	8.77±0.20	0.19±0.24	61.28±0.23
Fat (%wb)	0.75±0.15	0.07±0.17	5.07±0.13
Starch (%wb)	71.96±0.10	85.74±0.08	-
Amylose (%wb)	15.72±0.14	13.72±0.16	-
Amylopectin (%wb)	56.24±0.10	72.02±0.12	-
Calcium (mg/100g)	na	na	6915

na: not analyzed

The study found that white corn flour had higher protein (8.77%) and fat (0.75%) content compared to tapioca flour, which had a higher starch (85.74%) and amylopectin (72.02%) content, which were needed as a binding agent in making tortilla chips. While powdered anchovy was noted for its high protein (61.28%) and calcium (6915 mg/100g) levels, making it a valuable addition for enhancing the nutritional profile of the tortilla chips. Based on the research results of Nuraini [9], anchovy flour has an ash content of 14.86%, a protein content of 70.16%, a fat content of 4.55%, and a calcium content of 6179.95 mg/g. Another researcher [13] stated that anchovy flour has a calcium content of 3219 mg/100 g.

3.2 Chemical characteristics of tortilla chips

The results indicated that increasing the proportion of tapioca led to higher moisture content due to its water-

Table 2. Chemical characteristics of tortilla chips made from proportion of white corn flour:tapioca and NaHCO₃ addition

Proportion of white Corn flour:tapioca (%w/w)	NaHCO ₃ addition (%)	Moisture (%wb)	Starch (%wb)	Protein (%wb)	Amylose (%wb)	Amylopectin (%wb)
90:10	0,2%	4.67 ^g ±0.04	58.42 ^c ±0.04	13.67 ^a ±0.07	13.32 ^a ±0.13	45.10 ^e ±0.17
	0,4%	4.45 ^h ±0.07	58.62 ^c ±0.06	14.26 ^a ±0.27	13.21 ^a ±0.04	45.41 ^c ±0.07
	0,6%	4.09 ⁱ ±0.04	58.88 ^c ±0.12	14.26 ^a ±0.19	13.27 ^a ±0.11	45.61 ^c ±0.05
80:20	0,2%	6.90 ^d ±0.01	59.57 ^b ±0.14	12.68 ^b ±0.21	13.27 ^b ±0.20	46.30 ^b ±0.14
	0,4%	6.76 ^e ±0.06	59.82 ^b ±0.09	13.27 ^b ±0.27	12.53 ^b ±0.27	47.29 ^b ±0.06
	0,6%	6.28 ^f ±0.11	59.84 ^b ±0.07	13.13 ^b ±0.29	12.44 ^b ±0.29	47.40 ^b ±0.22
70:30	0,2%	8.89 ^a ±0.06	60.40 ^a ±0.05	11.02 ^c ±0.12	12.25 ^c ±0.17	48.15 ^a ±0.12
	0,4%	8.52 ^b ±0.02	60.54 ^a ±0.02	11.30 ^c ±0.15	12.16 ^c ±0.28	48.38 ^a ±0.16
	0,6%	8.35 ^c ±0.07	60.63 ^a ±0.12	10.84 ^c ±0.12	11.73 ^c ±0.20	48.90 ^a ±0.07

*different superscript in the same column show significant different based on DMRT (p≤0.05)

binding properties. Conversely, higher sodium bicarbonate levels resulted in lower moisture content, as CO₂ released during baking facilitated water evaporation. This is in accordance with the statement by Kurniasari [14] that starch has a high water binding ability because the number of hydroxyl groups contained in starch is high, so water is difficult to evaporate during drying. However, the higher the NaHCO₃ added to the dough, the more water will be bound, but during the baking process CO₂ gas is released and the process of releasing the bound water is easier. This is in accordance with Harahap [15] who stated that the higher the concentration of sodium bicarbonate, the lower the water content because the higher the amount of CO₂ produced from sodium bicarbonate can release water from the material.

The protein content of the chips decreased with more tapioca, while starch content increased (Table 2). This is in accordance with the data in Table 1 where the protein content of white corn flour (8.77%) is higher than the protein content of tapioca flour (0.19%) so that formulations with more white corn flour produce products that have relatively higher protein levels. The standard nutrition of corn-based snacks such as tortilla chips refers to snack food quality requirements in SNI 01-6630 (2002) [16]. All formulations of tortilla chips have protein content ranging from 11.05-14.06% which exceeds the minimum protein content of snack food (5%).

The lower the proportion of white corn flour and the higher the proportion of tapioca flour, the higher the starch content of tortilla chips, this is because the starch content in corn flour (71.96%) is lower than tapioca flour (85.74%). Meanwhile, the lower the proportion of white corn flour and the higher the tapioca flour, the lower the amylose content of the product and the higher the amylopectin content of the product, this is because the amylose content in white corn flour is 15.72% higher than tapioca flour at 13.72%, while the amylopectin content in white corn flour (56.24%) is relatively low compared to tapioca flour (72.02%) (Table 1). Based on Hersoelistyorini's statement [17], amylopectin levels can affect the crispness of the product, the higher the amylopectin levels in the product, the higher the product's crispness level. This is because amylopectin is

correlated with an increase in the puffing process in the product, so that the resulting food product has crunchy, light, porous and crunchy properties.

Table 3. Average hedonic score of color, aroma, taste and texture of tortilla chips made from proportion of white corn flour:tapioca and NaHCO₃ addition (using Non Parametric Friedman Test)

Proportion of white Corn flour : tapioca (%)	NaHCO ₃ addition (%)	Hedonic score			
		Color	Aroma	Taste	Texture
90:10	0,2%	3.72	3.48	3.88	3.96
	0,4%	3.00	3.52	3.72	3.84
	0,6%	2.88	3.64	3.48	3.76
80:20	0,2%	3.52	3.44	3.64	3.84
	0,4%	3.36	3.48	3.28	3.24
	0,6%	2.92	3.48	3.20	3.20
70:30	0,2%	3.76	3.44	4.16	3.88
	0,4%	3.36	3.52	3.76	3.52
	0,6%	3.28	3.84	3.64	3.20

The result showed that the more tapioca flour added, the tortilla chips had a browner color and were more liked by the panelists, while the addition of more sodium bicarbonate produced tortilla chips which were less liked by the panelists (Table 3). The color change that occurs is caused by the Maillard reaction during the frying process of tortilla chips. This Maillard reaction occurs because of the high carbohydrate content in tapioca flour. The carbohydrate content in tapioca flour is higher than white corn flour, so when heated it causes the color of the tortilla chips to change to brown as the proportion of tapioca flour increases. Based on Ridhani's [18], the Maillard reaction is a reaction that occurs between carbohydrates containing reducing sugars and primary amine groups which will produce a brown color.

The taste preference score for tortilla chips increased along with increasing the proportion of white corn flour. This is thought to be because the taste of white corn flour influences the taste and aroma of the tortilla chips that the panelists prefer. It is because white corn flour contains protein and fat, which can increase

the umami taste of Tortilla. According to Gozali [19] the addition of corn flour improves the taste and aroma of the corn flour produced, so the more corn flour added, the more pronounced the corn taste will be.

Table 2 showed that the reduce of white corn flour porportion decreased texture preference of panelists or the higher the proportion of white corn flour, the higher the texture preference score. It is because white corn flour provides the right and crunchy tortilla texture, the higher the proportion of tapioca and sodium bicarbonate, the more crunchy of the tortilla texture and liked by the panelists. The level of crispiness of tortilla chips is influenced by the amylopectin content of the raw material.

The selection of the best treatment for tortilla chips is based on analysis of water content, protein content, starch content, amylose content, amylopectin content, as well as organoleptic test in the term of color, aroma, taste and texture preference. The best treatment for tortilla chips is combination treatment of white corn flour:tapioca (70:30) and 0.2% sodium bicarbonate and the product is futher analyzed for ash content (6%wb), fat content (60.40%wb), dietary fiber content (4.71%wb) and calcium levels (493.85 mg/100g). The high calcium levels in tortilla chips are influenced by the addition of anchovy flour.

4 Conclusion

The optimal formulation for tortilla chips was identified as a 70:30 ratio of white corn flour to tapioca with 0.2% sodium bicarbonate. This combination yielded a product with 8.89% moisture, 6% ash, 11.02% protein, 4.64% fat, 60.40% starch, and 493.85 mg/100g calcium content. The sensory scores indicated a neutral to positive preference for color, aroma, and texture, with a particularly favorable taste score. The incorporation of anchovy flour significantly contributed to the nutritional enhancement of the tortilla.

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