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Evaluation of drying time on thickness variations on the physical and sensory test of tortilla chips

Widya Puspantari [1*], Dayu Dian Perwata Sari[1], Kokom Komariyah[1], Budiyanto Budiyanto[1], Donowati Tjokrokusumo[2]

[1]*Research Center for Agroindustry, National Research and Innovation Agency, South Tangerang, Indonesia*
[2]*Research Center for Food Technology and Processing, National Research and Innovation Agency, Yogyakarta, Indonesia*

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ABSTRACT

Tortilla chips have differences of thickness, some consumers like thick tortillas and others like thin tortillas. The thickness of the tortilla affects the drying process. This research aimed to study the optimum drying time using cabinet drier on tortilla chips, consisting of two thickness levels (2mm and 4mm), to produce crispy tortillas that consumers accepted. The drying was carried out using a cabinet dryer at a temperature of 50 ^{0}C with variations in drying time of 60, 90, and 120 minutes then fried using deep frying. Moisture and oil content, swelling power, color parameters, fracturability, calories, and sensory quality were analyzed. The results showed that the moisture content of drying ranged from 7,61 - 9,04% and 9,51 - 15,33% and, after frying, ranged from 1,38 - 2,04% and 1,02 - 1,71%, for 2 mm and 4 mm thickness, respectively. Oil content ranged from 9,06 – 12,11%. The brightness and fracturability of tortillas were significantly different, while the swelling power was not significantly different. A crispier tortilla was obtained at a drying time of 90 minutes, 651,30 g and 767,00 g for 2 mm and 4 mm, respectively. Tortilla calories ranged from 4635,54 – 4696,48 cal/g, while a commercial product was 5200 cal/g. The results of the sensory quality evaluation showed that consumers liked tortillas that were dried for 90 minutes with scores of color, texture, and overall acceptability were 3,97; 3,60; 3,76, and 3,72; 3,04; 3,10, for 2mm and 4mm thickness, respectively. The results showed that the optimal drying time for tortilla chips with a thickness of 2 mm and 4 mm using a cabinet dryer at 50^{0}C was 90 minutes.

* Corresponding author
Email: widy010@brin.go.id
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INTRODUCTION

Processing fresh food products into crackers and chips is an alternative to maintaining product quality, increasing shelf life, preventing damage, and diversifying agricultural products. The drying process is one of the handlings of food ingredients to maintain food preservation longer. Tortillas are snacks such as triangular-shaped chips made from corn and other ingredients such as flour, tapioca, and salt. These snacks are favored by consumers from all walks of life and ages. Currently, tortillas are formulated with the addition of various flours such as grasshopper flour (Contreras Jiménez et al. 2020), seaweed (Panjaitan et al. 2020), vegetable flour (Syarifah and Amrih 2021), soybean flour and kidney beans (Syaiful et al. 2022). Other flours to increase the nutritional content of tortillas into snacks that meet daily nutritional value.

Tortillas in each country have differences in shape, thickness, color, taste, and raw materials. Various kinds of tortilla shapes include roller, round, scoops, triangle, strips, and shaped with thin and thick thicknesses. As many as 46% of consumers prefer thick tortillas over thin (de la Peña 2018). The desired average thickness of the tortilla is about 2.3 mm to 3.2 mm, with a maximum thickness of less than 5.5 mm (Zimmerman et al. 2001). In addition to tortillas with a thickness of 2 mm, there are tortillas made from a mixture of corn flour and peanut flour with a thickness of 3 mm (Ochoa-Martínez et al. 2016). The thickness of the tortilla affects the drying and crunchiness.

The drying of tortillas is one factor determining the quality of tortilla crispiness. Tortilla making was previously done by burning the dough at 302-316 ^{0}C for 15 to 30 seconds and then frying until the tortilla moisture content was 3% (Zimmerman et al. 2001). However, several studies have used an oven for drying tortilla dough, such as drying tortillas with a thickness of 1 mm made by baking at 240 ^{0}C for 2 minutes and then frying at 190 ^{0}C for 1 minute (Kaur and Aggarwal 2017), drying tortillas with a thickness of 2 mm using an oven with the low temperature at 55 ^{0}C for 90 minutes then fried at 150 ^{0}C for 5 seconds (Syaiful et al. 2022), and 100 ^{0}C for 1 hour (Syarifah and Amrih 2021). Small industries require efficient and affordable drying methods for their production processes. A cabinet drier is one of the large-capacity drying machines widely used by the small snack industry. For example, making tortillas by drying using a cabinet dryer, including making tortillas with a thickness of 2 mm from a mixture of corn flour and tempeh flour using a cabinet dryer at 55 ^{0}C for 2 hours 30 minutes, then fried at 100 ^{0}C for 7 seconds (Suryani 2022). Drying on thick tortillas has never been done before using a cabinet dryer.

Two levels of chip thickness were studied to show how the drying conditions affected the quality of tortilla chips. This study aims to determine the optimal drying time for tortillas at 2 mm (thin) and 4 mm (thick) using a cabinet dryer at 50 ^{0}C. Parameters tested to evaluate tortillas include water and oil content, expansion volume, texture, color, and hedonic test. Knowing the optimal drying time for tortillas using a cabinet dryer is hoped that small snack food processing industries can use a cabinet dryer with a larger capacity than an oven to produce tortillas to increase their income.

METHODS

Materials

Corn seed Bisi 2 was obtained from corn farmers (Tangerang Selatan, Banten). Corn was nixtamalized with KOH 2% and then dried at 60 ^{0}C using a cabinet drier. The nixtamalized corn was ground and sieved on 60 mesh. Corn flour was kept in vacuum plastics until it was used. Flour and other ingredients such as corn starch, salt, and baking powder were obtained from local markets. The fat content was measured using petroleum ether and analytical grade from Merck (Germany) with the soxhlet apparatus.

Research Method

Preparation of Tortilla Chips

Nixtamalized corn was mixed with corn starch, salt, and baking powder. The mixtures were combined with water to make the dough in a food processor. The dough was passed through a sheeter machine to obtain tortillas with a thickness of 2 mm and 4 mm and then cut into pieces to form a rectangular-shaped tortilla. Tortillas were dried in a cabinet drier (AHC-050, China) at 50^{0}C at various time drying (60, 90, and 120 minutes) into A, B, C, D, E, and F formulas (Table 1). Dried tortillas were fried in a deep fryer (EF-82, China). The fried samples were drained on paper towels to prevent the product from being crushed, cooled to room temperature, and packaged in the metalized plastic pouch until used.

Table 1 Variation of drying time tortillas

Tortillas	Thickness (mm)	Time of drying (min)
A	2	60
B	2	90
C	2	120
D	4	60
E	4	90
F	4	120

Chemical Analysis of Tortilla Chips

The moisture content of tortillas after drying and frying was analyzed using the oven by AOAC method 925.10, and fat content using Soxhlet with petroleum ether by AOAC method 945.16 (AOAC 2005). All tests were carried out in triplicate. The calorific value of the product was measured using a bomb calorimeter (IKA C 6000, China).

Physical Analysis of Tortilla Chips

The color profiles (L*, a*, and b*) of chips at room temperature were measured using a Konica Minolta Chroma Meter (CR-410, Japan). The measurement was a triplet. The degree of thickness expansion of tortillas was measured by the percentage difference between the thickness of the tortillas before and after being fried (Olivares 2010). Thickness was measured using a micrometer, and ten chips were performed.

The degree of thickness expansion, L, was calculated by:

$$L = \frac{l(t) - lo}{lo} \times 100$$

Where lo is the initial thickness of the raw sample and l(t) is the thickness of the sample at drying time t.

The fracturability of tortilla chips was measured using a Texture Analyser (Stable Micro Systems TA.XT PlusC, United Kingdom) with a ball probe of,25 cm (P/0.25S), a circular support insert, and a Heavy-Duty Platform (HDP). A ball probe passed centrally through the sample at a distance of 3 mm using a rate of 1 mm/s until the sample broke. Twelve chips were performed.

Acceptability Test

Samples were no salt and flavorings. Samples are coded with arbitrarily selected 3-digit numbers. Semi-trained panelists of 25 people from 20 to 40 years old, men and women, evaluated tortillas (A, B, C, D, E, and F) in three parameters: color, texture, and overall acceptance. Consumer acceptability scores on a 5-point hedonic scale (Scale: 1-dislike extremely; 2-dislike slightly; 3-neutral; 4-like; 5-like extremely).

Statistical Analysis

The results were evaluated using ANOVA and Tukey test ($\alpha = 0,05$). The software used was Minitab 19.0.

RESULTS AND DISCUSSION

Drying times related to energy consumption are very important in the food industry, with scale-up applications and energy savings. Product drying in small industries that use cabinet dryers needs to be optimized for each product for efficiency of energy and production costs. For example, tortilla chips are one of the most popular snacks. Tortilla chips can be one of the typical snacks of corn-producing regions in Indonesia with the addition of local protein or mineral sources.

The drying of the tortilla affects the crispiness. The crispiness of the tortilla is affected by the water content. Drying efficiency using a cabinet drier at a temperature of 50^0C at various times to determine the optimum drying time to produce crispy tortillas at a thickness of 2 mm and 4 mm. During the drying runs of tortillas were recorded the moisture content of tortillas thickness of 2mm and 4mm, ranging from 7,610% - 15,33% (Table 2).

The result showed that increasing thickness significantly increased the drying time. The moisture content after frying ranged from 1,02 – 2,04 %. Similar to other results, the water content of tortillas after drying ranged from 7,61% to 15,33%, and after frying, 1,02% – 2,14% (Velez-Ruiz et al. 2006). Drying time which obtained a tortilla moisture content of less than 10%, was 60, 90, 120 minutes, and 120 minutes for a thickness of 2 mm and 4 mm, respectively. The water content of tortilla chips was significantly affected by the drying times on a thickness of 4 mm ($p < 0.05$), but for a thickness of 2 mm, the drying times of 90 and 120 minutes were not affected.

The fat content of tortillas ranged from 9,06 - 11,23 % and 11,38 – 12,11 % for thickness at 2 mm and 4 mm, respectively (Table). Drying time has not significantly affected fat content for a thickness of 2 mm ($p > 0.05$) but significantly affected a thickness of 4 mm ($p < 0,05$). The results are similar to other research in

that a product with higher initial moisture content has a higher fat content and higher porosity, indicating that only a fraction of the evaporated water is replaced by the oil in tortilla chips. The fat content to water removed ratio was not significantly affected by frying oil temperature in the 130 - 190°C range. During cooling, the chips absorbed about 64% of the total fat content, and 36% remained on the chip's surface (Moreira et al. 1997).

Table 3 shows the color values of the tortillas at different drying times. The lightness value (L) of the 2 mm sample was significantly different ($p < 0,05$) at 90 minutes of drying, and the yellowness (b) was significantly different ($p < 0,05$) at 120 minutes of drying. The tortillas of 4 mm darker than 2 mm were caused by higher water content (Picture 1). The change of color is mainly affected by drying time and thickness for the same material. The lightness of the sample was similar to the commercial (Happy Tos), whereas the redness (a) was higher, and the yellowness (b) was smaller. The formula of the raw material and the process influences the color of the corn chips tortilla.

Table 2 The moisture content of tortillas after drying and frying

Tortillas	Thickness (mm)	Time of drying (min)	Moisture of drying (%)	Moisture of frying (%)	Fat content (%)
A	2	60	$9,035 \pm 0,219^{C}$	$1,785 \pm 0,078^{ab}$	$12,11 \pm 0,67^{a}$
B	2	90	$7,990 \pm 0,028^{d}$	$2,040 \pm 0,127^{a}$	$11,89 \pm 0,03^{a}$
C	2	120	$7,610 \pm 0,071^{d}$	$1,385 \pm 0,177^{bc}$	$11,38 \pm 0,11^{a}$
D	4	60	$15,330^{a} \pm 0,000^{a}$	$1,705 \pm 0,163^{ab}$	$11,23 \pm 0,14^{a}$
E	4	90	$10,860^{b} \pm 0,311^{b}$	$1,120 \pm 0,057^{c}$	$9,59 \pm 0,03^{b}$
F	4	120	$9,195^{c} \pm 0.120^{c}$	$1,020 \pm 0,071^{c}$	$9,06 \pm 0,05^{b}$

Note: Means with a different letter in the same column for tortillas are significantly different ($p < 0,05$)

Table 3 Color profiles of tortillas

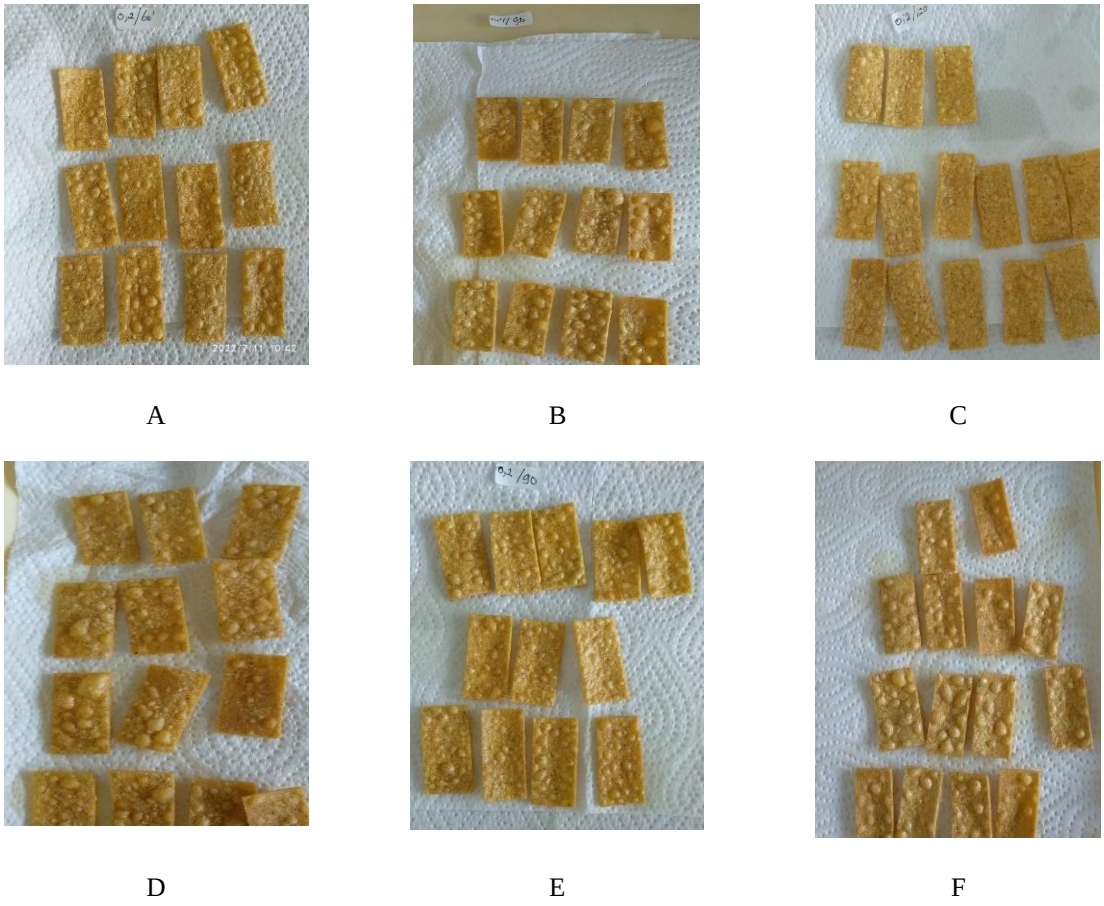
Tortillas	L (lightness)	a (redness)	b (yellowness)
A	$70,450 \pm 0,078^{a}$	$7,933 \pm 0,085^{b}$	$28,033 \pm 0,073^{b}$
B	$69,513 \pm 0,237^{b}$	$8,120 \pm 0,066^{b}$	$28,467 \pm 0.140^{b}$
C	$70,213 \pm 0,127^{a}$	$8,060 \pm 0,060^{b}$	$29,033 \pm 0,076^{a}$
D	$68,047 \pm 0,121^{c}$	$8,127 \pm 0,110^{b}$	$28,940 \pm 0,210^{a}$
E	$67,873 \pm 0,102^{c}$	$8,147 \pm 0,134^{b}$	$28,030 \pm 0,047^{b}$
F	$69,047 \pm 0.300^{b}$	$8,578 \pm 0,286^{a}$	$28,477 \pm 0,300^{b}$
Commercial	$69,400 \pm 0,201$	$5,820 \pm 0,243$	$31,357 \pm 0,657$

Note: Means with a different letter in the same column for tortillas are significantly different ($p < 0.05$)
A= 2 mm, 60 ^{0}C; B= 2 mm, 90 ^{0}C; C= 2 mm, 120 ^{0}C; D= 4mm, 60 ^{0}C; E= 4 mm, 90 ^{0}C; F= 4 mm, 120 ^{0}C

Table 4 Thickness expansion and fractuability of tortillas

Tortillas	Thickness expansion (%)	Fracturability (g)	Calories (Cal/g)
A	$233,90 \pm 0,146$	$724,910 \pm 20,870^{bcd}$	4696,48
B	$281,40 \pm 0,609$	$651,300 \pm 53,400^{d}$	4681,26
C	$237,90 \pm 0,361$	$683,400 \pm 38,700^{cd}$	4669,98
D	$256,10 \pm 0,044$	$812,700 \pm 72,800^{b}$	4658,69
E	$224,90 \pm 0,089$	$767,000 \pm 69,700^{bc}$	4635,54
F	$193,70 \pm 0,142$	$932,600 \pm 66,200^{a}$	4623,65
Commercial	N/A	333,466	5200

Note: Means with different letters in the same column for tortillas are significantly different ($p < 0,05$).
A= 2 mm, 60 ^{0}C; B= 2 mm, 90 ^{0}C; C= 2 mm, 120 ^{0}C; D= 4mm, 60 ^{0}C; E= 4 mm, 90 ^{0}C; F= 4 mm, 120 ^{0}C. N/A=not analyzed



A B C

D E F

Note:A= 2 mm, 60 ^{0}C; B= 2 mm, 90 ^{0}C; C= 2 mm, 120 ^{0}C; D= 4mm, 60 ^{0}C; E= 4 mm, 90 ^{0}C; F= 4 mm, 120 ^{0}C

Figure 1 Tortilla chips after being dried at different times and deep fried

Table 5 Acceptability of Tortillas

Tortillas	Color	Texture	Overall of acceptances
A	4,040 ± 0,455	3,520 ± 0,872	3,760 ± 0,636^a
B	3,976 ± 0,717	3,600 ± 1,041	3,760 ± 0,926^a
C	3,960 ± 0,841	3,440 ± 1,003	3,480 ± 1,046^{ab}
D	3,640 ± 0,810	3,600 ± 1,225	3,560 ± 1,044^{ab}
E	3,720 ± 0,843	3,040 ± 1,207	3,140 ± 0,995^{ab}
F	3,600 ± 0,866	2,840 ± 1,143	2,920 ± 0,954^b

Note: Means with a different letter in the same column for tortillas are significantly different ($p < 0,05$).
A= 2 mm, 60 ^{0}C; B= 2 mm, 90 ^{0}C; C= 2 mm, 120 ^{0}C; D= 4mm, 60 ^{0}C; E= 4 mm, 90 ^{0}C; F= 4 mm, 120 ^{0}C

Changes in thickness during the frying of foodstuff are usually referred to as thickness expansion. They are defined as the ratio of the dimension difference of the sample before and after frying. Thickness expansion at different drying times was determined using Equation 1, and the results are presented in Table 4. The thickness expansion of tortilla chips was not significantly different ($p > 0,05$). The time of drying is not significantly affected by thickness expansion. The chips' thickness did not change for the first 30 s, then increased by only 10% and remained the same until the end of frying at 190 ^{0}C for tortillas from fresh soybean (Kawas and Moreira 2001). The expansion of tortillas ranged from 193,70 - 281,40%. The chips' thickness increased and bubbles at the surface due to the barrier created by the tight surface, resulting in vapor expansion inside the chips' pores (Kawas and Moreira 2001). After 10 seconds of frying, the chips have bubbles at the surface (Figure 1).

Crispiness is one of the essential variables in assessing the quality of tortilla chips. In this study,

tortillas were made from corn that has been nixtamalized. In making tortilla chips, soaking in a lime solution or nixtamalization is known to increase the crispness of the resulting product (Adinda 2017). The value of its fracturability measures the crispness of the tortilla. The fracturability of tortillas with different drying times was significantly different in each treatment ($p < 0,05$). The fracturability of tortillas had lower fracture strength at 90 minutes of drying, while 120 minutes were higher. The starch structure is more solid after 90 minutes of heating (Table 4).

The higher the fracturability value, the harder the tortilla was because the force required to break was higher. The value of breaking strength was proportional to the water content of the tortilla after drying. The texture analysis of the different drying treatments showed a positive relationship between air temperature (Lujan-Acosta et al. 1997). The fracturability of sample B was the smallest of all but twice of commercial but was still accepted. The calories were not significantly different at different drying times ($p > 0,05$).

Color is a factor that humans first consider in choosing food. Foods with unattractive or deviant colors tend not to be chosen by consumers, even though they have high nutritional value and good texture (Febrianto et al. 2014). The panelists accepted the color of the tortilla from the time difference with a minimum score of 3,6 which means the whole product has a score that belongs to the preferred rating. The Panelist's acceptance of tortilla color and texture with different drying times was not significantly different ($p > 0,05$). Overall acceptance of tortillas was significantly different ($p < 0,05$) at 120 minutes. Texture and overall acceptability decreased on 4 mm tortillas drying for 90 and 120 minutes. More panelists chose tortillas of 2 mm than of 4 mm, but tortillas of 4 mm were still liked (**Error! Reference s ource not found.**). The implications of the results were the drying of tortillas of 2 different thicknesses (2 and 4 mm) can be done using a cabinet oven drying at 50° for 90 minutes. Small industries can use cabinet ovens to produce tortillas of different thicknesses according to consumer preferences.

CONCLUSIONS

As a result, the tortillas were crispy and accepted. Drying time for 90 minutes at 50 ^{0}C using a cabinet dryer at a thickness of 2 mm and 4 mm tortillas was suitable to produce a crispy tortilla. Based on the hedonic test, the Panellist chose tortillas with a drying time of 90 minutes with texture scores of 3,6 for 2 mm and 3,14 for 4 mm, with fracturability values were smaller (crispier) 651,300 g and 767,000 g, respectively.

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