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Effect of Chilling and Freezing Storage of Cookie Dough on Dry Roasted Pork Cookie Quality

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Abstract

Low temperature is an easy technique which preserves and retains product quality. The objectives of this research were to develop the Trang local roasted pork pieces into cookies and to study the effect of chilling and freezing of cookie dough on cookie quality. The methodology of research was conducted by studying 3 different levels (25%, 50% and 75%) of dry roasted pork suitable to be cookie and study the cookie properties: microbiological and physical quality. The results of this research indicated that addition of dry roasted pork into cookie dough at 50% level received the highest sensory score for all aspects. The 50% dry roast pork cookie dough was studied regarding chilling and freezing storage condition, and determined color, spread ratio and textural quality. The color parameters were determined through lightness (L*), redness (a*) and yellowness (b*) values of both cookie dough models stored under chilling and freezing and the results showed that these values increased with increasing retention time. In terms of cookie color from chilling and freezing cookie dough, it was found that L* and a* decreased but b* was unchanged. The spread ratio for both cookies from chilling and freezing dough decreased, the spread ratio of freezing dough was lower than chilling dough. When cookie's textural quality was investigated, hardness value from both chilling and freezing cookie dough increased after week 2 and increase rate continued until week 6. In addition, the chewiness value increased for both cookies from chilling and freezing dough. The fracturability of cookies from chilling and freezing dough slightly increased after 6-week storage. Crispiness value of both cookies from chilling and freezing dough were stable as early as 2 weeks and continually increased until last storage time at week 6.

Introduction

Trang roasted pork originated in Trang Province in Thailand's southern region. The majority of Trang residents start their day consuming roasted pork and coffee. Trang roasted pork is now a GI product, which refers to a product that is associated with a specific geographic place. As a result, it is a souvenir item for

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tourists. The cutting process causes some red meat to fall off into little pieces, which the customers do not want because it's small and hard.

A cookie is a popular snack that may be enjoyed by people of all ages and genders. It is easy to eat, usually served with a soft drink or other beverage, and it's a cheap product with a long shelf life (Olaoye et al., 2007). The major ingredients in cookie dough are wheat flour, oil, and sugar. It can be adapted in a variety of flavors, and minor additives such as nuts, dry fruit, color, and flavor can be mixed in as desired., The final step in preparing cookies is to heat the cookie dough in an oven.

Chilling and freezing are common conditions in the food sector, and they have an impact on product quality. Both ways can keep a product fresh and easily available in every home. Several studies have been performed on the effect of chilling and freezing of batter. Gupta et al. (2011) studied frozen method storage of cookie dough and it was found that cookies prepared after freezing of dough were crisper than the normal. Ávalos et al. (2016) studied the effect of refrigeration and freezing of batter in gluten free baking product and the results showed that the properties did not change when the batter was frozen.

This research was initiated to develop roasted pork pieces left over from trimming process to make cookies because roast pork tends to be compatible, easy to cook and has a long shelf life. The main objectives of this research were to develop cookie products from dry roasted pork and to study the effect of the storage condition of cookie dough comparing chilling and freezing on cookie quality. The findings offer alternatives to produce freshness of cookies from ready to bake dough, the storage of dough and contributes to the knowledge of the effects of refrigeration and freezing of dough in cookie products.

Materials and methods

1. Raw materials preparation

All the raw materials were procured from local supermarket. All purpose flour (Kite, United flour mill Ltd., Thailand), tapioca flour (Baiyok, Bangkok Inter Food co.Ltd., Thailand), sugar (Lind, Thai Roong Ruang sugar group., Thailand), butter (Orchid. Ampol Food Processing Ltd. Thailand), salt (Prung thip, Krua Pimay, Thailand) and soybean oil (Augun, Thai Vegetable Oil Public Co. Ltd., Thailand) were used in the formulation.

2. Cookie dough preparation

The dough was prepared using a kitchen aid mixer (5K5SS Model, USA.) with paddle attachment. Initially, all dry ingredients were mixed in a mixing bowl (all purpose flour, tapioca flour and salt) and the dry ingredients were sifted to aerate them and remove any possible lumps. Butter was beaten for 3 mins until well distributed and then sugar was added gradually. When the butter was mixed well with sugar, dry ingredients were added into the mixing bowl and beaten into smooth dough. The next step was to gradually add soybean oil and again mix well. The cookie dough was shaped with a cookie press with a thickness of 0.5 cm and 4.0 cm diameter. The cookie dough was transferred to baking sheet that was placed on the baking tray. Cookie dough temperature was controlled at 25°C before baking in the Zanolli oven (Teorema polis, Itali). The cookie dough was heated for 16 mins at 170°C.

Ground roast pork preparation started from selecting fresh legs pork that was cleaned with water and rinsed then set aside on sieve to drain. Pork was cut to size 2x3x1 cm pieces. The pork was then mixed with spice and herb and placed at room temperature for 2 hours to absorb the meat with the seasoning. Then Convotherm combination oven (OES 6.10 Model, Germany) was used to roast the pork at 140°C for 20 mins and then cooled at room temperature. The researcher grinded the pork mixture and spead on tray using Bos mall hot air oven (FF-68, Thailand) at 60°C for 12 hrs. Water activity (a_w) was 0.8. The result is shown in Fig.1.

Fig. 1 Dry roasted pork

The cookie formulation and cookie method were as follows according to Kun Mae Manee (2018), basic formulation of cookie was standardized after conducting

preliminary trials. There were 3 formulas used for cookie and sensory test conducted with 50 untrained panelist and scored by a 9 hedonic scale (1 = dislike very much and 9 = like very much). The formula that received the highest score was selected for further study of development of dry roasted pork cookie.

Table 1 Cookie dough formula

Ingredients	Percent (%)
All purpose flour	38
Tapioca flour	13
Sugar	18
Butter	28
salt	1
Soybean oil	2

Remark: Modified from Kun Mae Manee (2018)

2. Cookie formula selection

The researcher studied the maximum dry roasted pork quantity to cookies dough with three different levels at 25%, 50% and 75%, respectively. Dry roasted pork cookie formulas were selected by sensory evaluation. The sensory evaluation was conducted with 100 sensory panelists using a 9-point hedonic scale (1 = dislike very much and 9 = like very much) (Rawendra & Dwi, 2020). The sensory test was conducted to evaluate 5 aspects comprising of color, odor, flavor, texture and overall acceptability. All samples were contained in transparent plastic bag served at room temperature in the same time. The participants were assessed individually, drinking water at room temperature used to clean the palate during sensory test action. The data were analyzed statistically for determining the cookie formula with the highest acceptability score.

3. Cookie dough storage condition

The cookie formula with the highest score was then used to study the effects of the chilled and frozen dough storage process. Cookie dough were shaped and kept individually into plastic bags, stored in plastic containers and chilled at 8°C (System form : STF-40C, Thailand) and frozen at -18°C (System form : STF-20F, Thailand) for 6 weeks. Every week, stored cookies dough was removed from the plastic container and thawed until it reached 25°C. Fresh cookie dough from refrigeration and freezer were baked in oven at 170°C for 16 mins.

4. Quality of cookie

4.1 Microbiological quality

All storage time, microbiological analysis of chilled and frozen cookie dough were *Salmonella* spp. and *Staphylococcus aureus* by FDA, BAM (Maturin & Peeler, 2001)

4.2 Physical quality

4.2.1 Color quality was measured using Hunter Lab Color Flex (Model A60-1012-312, Hunter Associates Laboratory Inc., USA). The measurement parameters were shown as L(lightness), a*(redness) and b* (yellowness). Every week, cookie dough and baked cookie were color measurement. It was tested with 3 replicates and each replicate used 5 samples.

4.2.2 Spread ratio The spread ratio was calculated from the ratio of spread to thickness (W/T). To determine the diameter, five cookies were measured with a diameter of 0.01 mm precision vernier caliper after cooling and to determine the thickness according to Agu et al. (2007). The average of the two measurements was divided by fives and taken as diameter and thickness then calculated to spread factor. For each test, five cookies were used and tested with 2 replicates.

4.2.3 The texture was determined by texture analyzer (Model: TA-XTPlus), using blade knife probe (HDP/BS). The device setting followed Hwang et al. (2016) under the conditions of pre-test speed at 1 mm/s, test speed at 3 mm/s, post-test speed at 10 mm/s, and distance of 15 mm. The tests were conducted to determine the hardness, chewiness, fracturability and crispiness. Tests were performed with 3 replicates, each replicate used 5 samples.

5. Statical analysis

The statical analysis was conducted using SPSS software (SPSS Version 17; SPSS Inc., Chicago, USA). Data were analyzed by ANOVA and Duncan's New Multiple Range Test for identifying the different properties of cookie dough and cookie at the 95% confidence level ($P<0.05$).

Results and discussion

1. Cookie formula selection

The result of the selection of dry roasted pork cookie by testing the preference of all levels of dry roasted pork is shown on Table 2. Sensory attributes including color, odor, flavor, texture and overall acceptance of dry roasted pork cookie were determined. A 9-point hedonic scale was used as standard procedure to assess product preference. The scoring from 100 untrained individuals were shown in Table 2 above. In this study, there were no significant ($p > 0.05$) differences in the perception of the samples in terms of flavor and overall acceptance in all formulas. The appearance of roasted pork cookie at 25% and 75% had no significant differences but found

Table 2 Sensory test of dry roasted pork cookie in difference level of dry roasted pork

Characteristics	Dry roasted pork (%)		
	25%	50%	75%
Appearance	7.52 ± 0.95[b]	7.94 ± 0.88[a]	7.57 ± 1.23[b]
Color	7.61 ± 0.87[b]	7.95 ± 0.97[a]	7.71 ± 0.92[ab]
Odour	7.56 ± 1.24[b]	8.00 ± 1.19[a]	7.67 ± 1.61[ab]
Flavor[ns]	7.76 ± 1.19	7.99 ± 1.27	7.59 ± 1.67
Texture	7.90 ± 1.25[a]	7.71 ± 1.31[ab]	7.48 ± 1.38[b]
Overall acceptance[ns]	7.92 ± 0.87	7.99 ± 1.15	7.78 ± 1.32

Remark: a, b, c superscripts with different letters in the same row are different ($p < 0.05$), all values are shown as mean ± S.D.
ns refers to no statistically significant differences ($p \geq 0.05$)

significant difference in case of 50% level. The color values for 25% 50% and 75% levels were 7.61, 7.95 and 7.71, respectively. For the dry roasted pork cookie at 25% and 50%, there were significant differences ($p < 0.05$) but for 75% formula, there were no significant difference with 25% and 75%. The ground roasted pork in cookie dough was natural dark brown, so the 75% cookie sample was darker than other formula. The result of color sensory was agreement with Kumar et al. (2016), they studied the quality attributes and storage stability of chicken meat biscuit and reported that the very dark color may not be liked by the panelist. The similar results were found for odor and color and the sensory scores were 7.56,8.00 and 7.67. respectively. The roasted pork cookie at 25% and 50% had significant differences ($p < 0.05$) but the 75% formula had no significant difference with 25% and 75%. The texture score had 7.90, 7.71 and 7.48, respectively. The roasted pork cookie at 25% and 75% had significant differences ($p < 0.05$) but 50% formula had no significant difference with 25% and 75%. All aspects of roasted pork cookie at 50% had the highest scoring except for texture. The texture of roasted pork cookie at 25% which contained the less grounded roasted pork had the highest score because it was crispier. The dry roasted pork cookie at 50% needed continued study

Fig. 2 Dry roasted pork chilling cookie dough (left) and dry roasted pork freezing cookie dough (right)

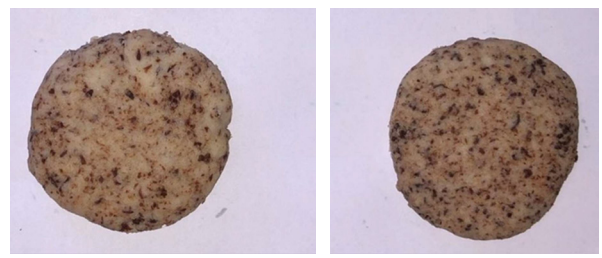

Fig. 3 Dry roasted pork cookie from chilling cookie dough (left) and dry roasted pork cookie from freezing cookie dough (right)

regarding the effect of the storage condition of cookie dough.

The dry roasted pork cookie dough at 50% formula was selected to chilling and freezing storage for 6 weeks of study. The cookie dough under chilling condition at 8°C and freezing condition at -18°C are shown in Fig. 2 and Fig. 3.

2. Microbiological quality

All storage time, the chilled and frozen cookie dough were determined for microbiological test, it found that microbiological value was in accordance with the Notification of the Ministry of Public Health No.364 B.E.2556 (Thailand Public Health, 2013) regarding food standards for pathogenic microorganisms (ready to cook food). It was determined that no *Salmonella* spp. per 25 g was found and no *Staphylococcus aureus* per 100 g of dough was found.

Table 3 Effect of chilling and freezing storage condition on cookie dough's color

Week	Chilling			Freezing		
	L	a*[ns]	b*	L	a*	b*
0	33.11 ± 0.31[a]	6.49 ± 0.21	9.82 ± 0.31[a]	33.11± 0.22[a]	6.49 ± 0.18[a]	9.82 ± 0.15[a]
1	32.90 ± 0.43[a]	6.55 ± 0.39	12.52 ± 0.19[b]	36.48 ± 0.37[b]	7.49 ± 0.24[b]	8.88 ± 0.10[b]
2	31.77 ± 0.20[b]	6.62 ± 0.24	13.03 ± 0.42[c]	34.68± 0.20[c]	7.69 ± 0.14[abc]	10.74 ± 0.26[b]
3	30.96 ± 0.11[c]	6.51 ± 0.34	14.16 ± 0.35[d]	33.37 ± 0.21[a]	7.90 ± 0.11[c]	10.97 ± 0.17[b]
4	29.86 ± 0.50[d]	6.56 ± 0.32	15.49 ± 0.32[e]	31.54 ± 0.33[d]	8.77 ± 0.17[d]	12.50 ± 0.27[c]
5	28.75 ± 0.29[e]	6.83 ± 0.29	16.39 ± 0.26[f]	30.48± 0.24[e]	8.96 ± 0.19[d]	14.59 ± 0.25[d]
6	27.76 ± 0.33[f]	6.88 ± 0.61	16.42 ± 0.29[f]	28.59 ± 0.21[f]	9.20 ± 0.19[e]	18.60 ± 0.39[e]

Remark: a, b, c, d, e, f superscripts with different letters in the same column are different ($p < 0.05$), all values are shown as mean ± S.D. for three samples. ns refers to no statistically significant differences ($p \geq 0.05$)

3. Physical quality

Physical qualities were determined important to the cookie property, namely the color of cookie dough, cookie color, spread ratio and texture.

When the color of cookie dough with different condition chilling and freezing was investigated, the color of the cookie dough was yellow due to the nature of the butter which was present in recipe. The color values are presented in Table 3, lightness (L*) redness (a*) and yellowness (b*) of chilling cookie dough increased. The same result was found for cookie dough color of freezing storage as lightness (L*) redness (a*) and yellowness (b*) increased with increasing retention time. This result was similar to the result of Ávalos et al. (2016) who reported the refrigeration or freezing of batter turned darker mainly the baked products containing dairy product, probably due to the Maillard reactions between proteins and reducing sugar. According to Patrignani et al. (2014) suggestion that lipids can suffer oxidation during storage, and the products of lipid oxidation, as ketones, can react with proteins and produce Maillard compounds. This effect was observed previously in biscuits. Moreover, Zamora & Hidalgo (2005) reported that free radicals produced during lipid oxidation could react with biscuit proteins modifying the product color. On the other hand, Dogan (2006) reported that when cookie batter (sugar snap, chocolate chip and hazelnut cookie) was stored at 4°C for 6 weeks and at −18°C for 6 months, no significant changes were observed in the physical characteristics of batter.

In Table 4 above, the results of cookie color from differences in storage condition are shown. The cookie color from cookie dough storage under chilling, lightness (L*) was constant for the first 2 weeks and gradually changed to darker until the last week of storage, redness (a*) value for the first 5 weeks were significantly different at ($P<0.05$) with week 6, and while yellowness (b*) value were not significantly different ($P\geq0.05$). The color of the cookie from freezing dough found that lightness (L*) redness (a*) decrease trend and yellowness (b*) were not significantly different ($P \geq 0.05$).

These results were consistent with Chevallier et al. (2000) that reported the color effect of cookie had many factors, in this study the appearance of main cookie was brown. Cookie's color may be influenced from Millard reactions, it occurs between reducing sugar with amino acids and caramelization of sugar. Purlis (2011) reported that browning of cookie was important quality parameter. Most bakery product's color depends both on the physicochemical characteristics of the raw dough, such as water content, pH, reducing sugars, and amino acid content. In addition, the operating conditions during processing, mainly the final baking have an effect on cookie's color.

Table 4 Effect of chilling and freezing storage condition on cookie color

Week	Chilling			Freezing		
	L	a*	b* ns	L	a*	b* ns
0	65.00a ± 0.49^{a}	9.39a± 0.80^{a}	13.23 ± 0.65	65.00^{a} ± 0.49^{a}	9.39^{a}± 0.80^{ab}	13.23 ± 0.65
1	64.98 ± 0.28^{ab}	9.24 ± 0.59^{a}	14.16 ± 0.81	64.24 ± 0.41^{b}	9.38 ± 0.69^{ab}	13.80 ± 0.48
2	64.24 ± 0.29^{b}	9.28 ± 0.69^{a}	14.00 ± 0.76	62.36 ± 0.37^{c}	9.42 ± 0.72^{ab}	14.23 ± 0.82
3	63.36± 0.61^{bc}	9.22 ± 0.60^{a}	14.23 ± 0.46	60.04 ± 0.64^{d}	9.44 ± 0.50^{b}	14.22 ± 0.51
4	62.30 ± 0.71^{c}	9.27 ± 0.65^{a}	14.41 ± 0.59	59.79 ± 0.97^{d}	8.58 ± 0.57^{a}	14.10 ± 0.46
5	60.28 ± 0.44^{d}	9.35 ± 0.72^{a}	14.71 ± 0.67	58.82 ± 0.74^{d}	8.56 ± 0.86^{a}	14.09 ± 0.58
6	59.34 ± 0.74^{d}	8.85 ± 0.62^{b}	14.30 ± 0.67	57.06 ± 0.89^{e}	8.61 ± 0.49^{a}	14.11 ± 0.86

Remark: a, b, c, d superscripts with different letters in the same column are different ($p < 0.05$), all values are shown as mean ± S.D. for three samples. ns refers to no statistically significant differences ($p \geq 0.05$)

Table 5 Effect of chilling and freezing storage condition on spread ratio

Week	Chilling			Freezing		
	Width (cm.)	Thickness (cm.)	Spread ratio (W/T)	Width (cm.)	Thickness (cm.)	Spread ratio (W/T)
0	4.29 ± 0.03^{c}	0.46 ± 0.02^{a}	9.34 ± 0.11^{e}	4.29 ± 0.03^{b}	0.46 ± 0.02^{a}	9.34 ± 0.11^{f}
1	4.40 ± 0.06^{d}	0.50 ± 0.01^{bc}	8.74 ± 0.15^{d}	4.01±0.10^{a}	0.50 ± 0.01^{b}	8.26 ± 0.27^{d}
2	4.28 ± 0.08^{bc}	0.50 ± 0.01^{b}	8.57 ± 0.13^{cd}	4.13 ± 0.10^{ab}	0.53 ± 0.02^{c}	7.75 ± 0.49^{d}
3	4.42 ± 0.02^{d}	0.53 ± 0.01^{c}	8.38 ± 0.22^{bc}	4.27 ± 0.11^{b}	0.61 ± 0.01^{d}	7.02 ± 0.10^{c}
4	4.21 ± 0.04^{abc}	0.52 ± 0.02^{bc}	8.08 ± 0.39^{b}	4.15 ± 0.08^{ab}	0.61 ± 0.01^{d}	6.84 ± 0.12^{bc}
5	4.13 ± 0.08^{a}	0.62 ± 0.02^{d}	6.71 ± 0.14^{a}	4.08 ± 0.08^{a}	0.61 ± 0.01^{d}	6.65 ± 0.22^{b}
6	4.17 ± 0.10^{ab}	0.65 ± 0.03^{e}	6.45 ± 0.29^{a}	4.19 ± 0.07^{ab}	0.65 ± 0.02^{e}	6.16 ± 0.14^{a}

Remark: a, b, c, d superscripts with different letters in the same column are different ($p < 0.05$), all values are shown as mean ± S.D. for five samples

Spread ratio has the measure of the quality index of cookies using the cookie width to cookie thickness ratio. The results of chilling and freezing storage condition had an effect on cookie quality. In Table 5 it is shown that cookies from cookie dough that were treated under chilling found that the spread ratio value in first week was highest and decreased until week 6. Cookies from freezing cookie dough decreased, spread ratio value of first 2 weeks were not significantly different at ($P \geq 0.05$) and slightly decreased from week 1 to the end of storage time in week 6.

A comparative study was conducted for the spread ratio of cookies, between chilling dough and freezing dough and it was found that the spread ratio value for all weeks of cookies from cookie dough freezing higher than cookies from cookie dough chilling. The results were consistent with Hamed et al. (2015) indicating that cookie had a significant decrease in spread factor after the first week of frozen storage followed by an insignificant reduction until the end of frozen storage time (4 weeks). Gupta et al. (2011) also reported that the thickness of the freeze-thaw cookies was higher than normal; one and diameter was almost same as that of normal ultimately spread ratio became decreased. In addition, other researchers reported that the incorporation of air was highly important in cookie development and therefore cookie spread ratio may be affected by the type of fat used in the formulation (Rogers, 2004). Sikorski (2004) gave the reason that it was probably due to the ability to retain more water during baking that increased gluten development. The enhanced gluten development leads to the decrease of the cookie spread ratio. In addition, Manaf et al. (2019) suggested that the influence of plant and animal-based fats on cookie properties was an important factor for an increase in length and decrease in weight and thickness of cookies.

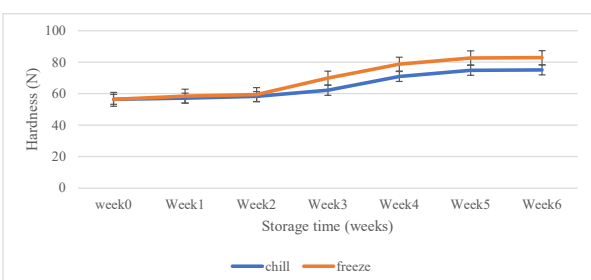

Fig. 4 Influence of chilling and freezing cooking dough storage on cookie hardness

The texture quality was important parameter of cookies, Fig. 4. shows the hardness that is summarized and values are plotted to a graph. The result obtained showed that different condition of cooking dough storage changed the hardness properties of cookies. It is evident from Fig.4 that the cookie dough from refrigerator and freezer after baking tend to have an increase hardness. The highest hardness value was obtained from freezing cookie dough. Among all weeks, cookies from cookie dough both chilling and freezing yielded the highest value in the end of storage at week 6.This was in agreement with Leray et al. (2010) who reported that a progressive increase of the hardness was observed during the aging, the changes occurred during frozen storage leads to an increase hardness of bread. Hamed et al. (2015) suggested that the type of flour, batter recipe and baking condition influenced cookie texture quality. The results were in accordance with O'Brien et al. (2003) who reported that fat was the ingredient responsible for tenderness of biscuits and it keeps the quality. Moreover, Hoseney & Rogers (1994) reported that hardness of the cookies is caused by the interaction of proteins and starch by hydrogen bonding.

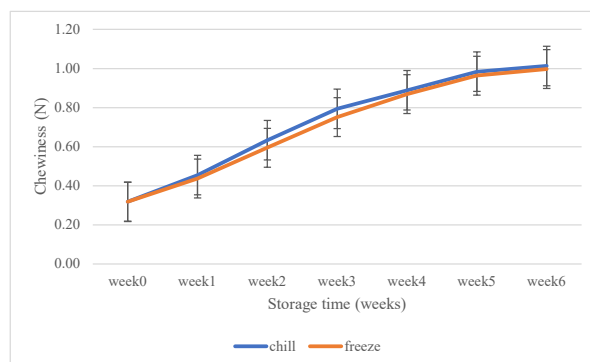

Fig. 5 Influence of chilling and freezing cooking dough storage on cookie chewiness

The chewiness was one property of cookie characteristic, commonly the chewiness is measured from resistance of chewing in the mouth. The results shows that chewiness of cookies from chilling dough and freezing dough were similar value in week 1 until week 6. It slightly increased in value range 0.45-1.01 N in cookies from chilling dough and range 0.44 – 1.00 N from freezing dough. Olewnik & Kulp (1984) reported that fat and water in the system were effective of cookie dough physical properties, If the fat distribution in the cookie system was poor, flour particles will

remain accessible to water. The result effects in the development of gluten proteins. So, the cookie chewiness was present.

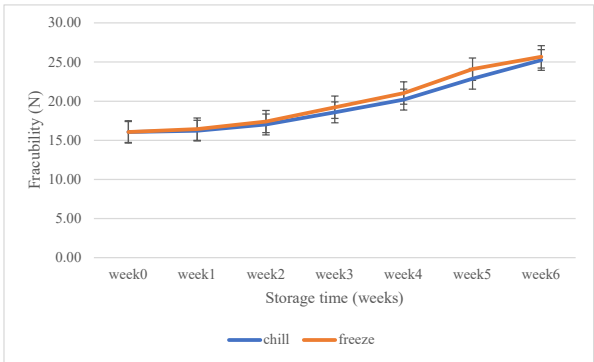

Fig. 6 Influence of chilling and freezing cooking dough storage on cookie fracturability

Fig. 6 shows the values obtained from cookies from cookie dough storage for 6 weeks. Each week and each condition contained a total of 15 samples. The results showed that fracturability of cookies from chilling and freezing dough increased, indicating that these products were more brittle when batter was treated by chilling and freezing before baking. This study provided the same results with Gupta et al. (2011) who reported that cracking was another critical factor, especially in cookies. The cracking pattern became another important physical property and did not significantly change with storage time.

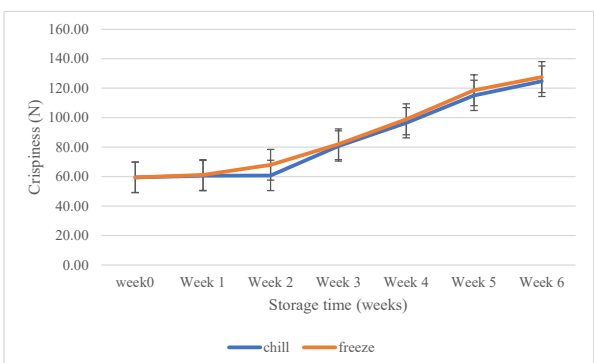

Fig. 7 Influence of chilling and freezing cooking dough storage on cookie crispiness

The results showed that crispiness of cookies from chilling and freezing dough increased. After week 2, the crispiness value of both cookies from chilling and freezing dough were high more than crispiness value at week 0 which were cookies from fresh cookie dough. These results were consistent with the findings of Gupta et al. (2011) who reported that cookies produced from batter containing barley flour and underwent freeze–thaw cycles every 4 h for 24 h were crisper than the freshly baked ones. Wheat flour (control) dough undergo increase cohesiveness and decrease adhesiveness. That also gives more crispiness to the baked cookies This indicates that frozen storage of batter produces cookies with lower breaking force, which was confirmed in the current study. It was also observed that the longer the frozen storage period of batter, the lower the breaking force of the produced cookie became. This could be attributed to the ice crystals formed during frozen storage, which weakens the hydrophobic bonds and redistributes water in the batter resulting in a physical damage to its structure (Rasanen et al., 1997).

Conclusion

The findings of this study showed that both chilling and freezing storage conditions influenced the cookie quality. In terms of cookie dough color and cookie color, L* and a* decreased and b* increased for both chilling and freezing conditions. Chilling and freezing therefore influenced cookie spread ratio. The spread ratio of cookies from freezing dough was lower than cookies from chilling dough. In sum, increasing storage time of cookie dough was related to increases in hardness, chewiness, fracturability and crispiness value.

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