Chapter 4
Results and Discussion

4.1 Production of soft candy

This section was used to produce a soft candy by following the formula and processing conditions of Chaiseri (2543). This formula was also used as a prototype in the next section to produce soft yogurt candy by replacing water with ferment milk. The soft candy prototype was semi-solid, yellow-white color with milky flavor.

4.2 Production of soft yogurt candy prototype

Three types of soft yogurt candy prototype (using stirred yogurt, a combination of fermented milk:stirred yogurt (1:1) and fermented milk) were produced under the same processing condition. The proximate analysis, physical characteristics, chemical characteristics, microbiological characteristics and sensory evaluation of the three soft yogurt candies were shown in Tables 4.1, 4.2, 4.3, 4.4 and 4.5, respectively.

Table 4.1 Proximate analysis of soft yogurt candy prototypes affected by different ferment milk types

Chemical compositions	Types of ferment milk		
	Stirred yogurt	Stirred and fermented milk (1:1)	Fermented milk
Moisture content (%)	9.23±0.03^{b}	9.13±0.01^{b}	9.38±0.03^{a}
Protein (%)	0.92±0.03	0.92±0.01	0.97±0.01
Fat (%)	5.21±0.02	5.05±0.08	4.99±0.07
Ash (%)	0.55±0.05	0.52±0.02	0.57±0.02
Carbohydrate (%)	84.09±0.06	84.38±0.03	84.09±0.09

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

It was shown that the moisture content of three soft yogurt candy prototypes were significantly different (P≤0.05) (Table 4.1). The highest moisture content (9.38±0.03%) was found in the soft yogurt candy added with fermented milk. The difference in the moisture content could be affected by different types of ferment milk and manual stirring during the production process of the candy. However, different types of ferment milk did not affect protein, fat, ash and total carbohydrate contents of the soft yogurt candy (P>0.05). The soft yogurt candy had a higher moisture content, ash and carbohydrate when compared to honey flavor soft candy (8.66, 0.51 and 64.82%, respectively). Lower protein and fat were found in soft yogurt candy compared to the honey flavor soft candy (2.23 and 23.78%, respectively). This could be due to different ingredient compositions (Chaisukanyasan, 2546).

Table 4.2 Physical characteristics of soft yogurt candy prototypes affected by different fermented milk types

Physical characteristics	Types of fermented milk		
	Stirred yogurt	Stirred and fermented milk (1:1)	Fermented milk
a_w	0.60 ± 0.01^a	0.53 ± 0.01^b	0.64 ± 0.01^a
L*	80.16 ± 0.23^a	76.45 ± 0.43^b	79.47 ± 0.13^a
a*	0.08 ± 0.05^b	0.47 ± 0.13^a	-0.38 ± 0.05^c
b*	16.39 ± 0.21^b	17.72 ± 0.54^a	17.24 ± 0.34^{ab}

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

From Table 4.2, it could be seen that type of fermented milk significantly affected the physical properties of soft yogurt candies. The a_w and L* values, which represented sample's lightness, of the stirred yogurt and fermented milk candies were significantly higher than those of the mixture stirred yogurt and fermented milk candy (P≤0.05). The highest a* value (redness/greenness) was observed in the mixture stirred and fermented milk candy formula, whereas the lowest b* value (yellowness/blueness) was found in the stirred yogurt candy formula.

For the texture analysis, it was done using a P/5N probe, which was suggested by the texture analyzer company (Stable Micro Systems, 2010). Unfortunately, due to lack of a confectionery holder and the high stickiness of soft yogurt candy, the probe could not be withdrawn from the candy sample after being inserted. Therefore, the texture of the candy could not be determined. A work by Nowakowski and Hartel (2002) on mixturs of sugar and commercial corn syrupnproducts disployed that the mixtures could be measured fot their hardness using a 5 mm diameter stainless steel probe that penetrate (0.1 mm/s) the mixture surface to a depth of 0.2 mm. The mixture were placed between a disk-shape sample (10 mm diameter by 5 mm high). Another work by Baiano and Del nobile (2005) on almond paste pastries that was composed was 500 g almonds, 400 g sugar, 100 g whole eggs and aromas in 1000 g pastries, used a 3 diameter standard plunger at a crosshead speed 100mm/min

Table 4.3 Chemical characteristics of soft yogurt candy prototypes affected by different fermented milk types

Chemical characteristics	Types of fermented milk		
	Stirred yogurt	Stirred and fermented milk (1:1)	Fermented milk
Total acidity (as % lactic acid)	0.25±0.01	0.24±0.01	0.24±0.01
Total solids (%)	90.77±0.02[a]	90.87±0.01[a]	90.62±0.02[b]
Moisture (%)	9.23±0.03[b]	9.13±0.01[b]	9.38±0.03[a]
Total soluble solids (% Brix)	88.96±0.25[a]	86.70±0.33[b]	88.71±0.24[a]
Reducing sugar before inversion (g/100 g)	15.58±0.13[a]	15.47±0.03[b]	15.34±0.02[b]
Reducing sugar after inversion (g/100 g)	57.08±0.13	56.93±0.11	57.45±0.42
Sucrose (g/100 g)	19.94±0.26	20.04±0.12	20.51±0.40
Total sugars (g/100 g)	27.60±0.11	27.77±0.11	28.16±0.40

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

From Table 4.3, it was revealed that total solids, moisture content, total soluble solids and reducing sugar before inversion were significantly different (P≤0.05). These differences could be due to the different types of fermented milk added in each formula. The moisture content of the fermented milk candy was significantly higher than the other combinations, whereas the soft yogurt candy added with a mixture of stirred yogurt and fermented milk had the highest total solid content when compared with the other formulas. The total acidity, reducing sugar after inversion, sucrose and total sugars in different candy samples were not significantly different (P>0.05).

Table 4.4 Microbiological characteristics of soft yogurt candy prototypes affected by different fermented milk types

Microbiological properties	Types of fermented milk		
	Stirred yogurt	Stirred and fermented milk (1:1)	Fermented milk
Total plate count (CFU/g)	<10	<10	<10
Yeast and Mold (CFU/g)	<10	<10	<10
Osmophillic yeast (CFU/g)	<10	<10	<10

From Table 4.4, it was found that Total plate count, yeast and mold and osmophillic yeast of different candy samples were < 10 CFU/g. The result showed that the thermal treatment at 110-115°C for 2 min could kill most of the microorganisms in the candy raw materials.

For the sensory quality of soft yogurt candy, at the beginning the panelists (15 students) determined the score for ideal soft candy using the basic formula of soft candy (Chaiseri, 2543). The results of this assessment were

- Color 4.20 ± 1.76
- Flavor 5.80 ± 2.05
- Sweetness 5.10 ± 1.97
- Saltiness 2.70 ± 1.09
- Hardness (in the mouth) 4.10 ± 2.53
- Stickiness 3.40 ± 2.43
- Chewiness 4.00 ± 2.66
- Overall acceptance 10.00 ± 0.00

Table 4.5 Sensory evaluation of of soft yogurt candy prototypes affected by different fermented milk types (the value was the ratio between the soft yogurt candy and the ideal soft yogurt values)

Sensory attributes	Types of fermented milk		
	Stirred yogurt	Stirred and fermented milk (1:1)	Fermented milk
Color	0.95±0.09^{c}	1.04±0.08^{b}	1.13±0.01^{a}
Flavor (milk)	0.83±0.01	0.76±0.01	0.79±0.02
Sweetness	1.01±0.07	1.00±0.02	1.01±0.02
Saltiness	0.94±0.03	0.93±0.01	0.93±0.06
Hardness (in the mouth)	1.15±0.06^{c}	1.36±0.03^{b}	1.49±0.10^{a}
Stickiness	1.47±0.15	1.56±0.07	1.42±0.04
Chewiness	1.16±0.08^{b}	1.29±0.03^{a}	1.39±0.09^{a}
Overall acceptance	0.61±0.03^{a}	0.55±0.03^{b}	0.50±0.02^{b}

Remarks: different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

Based on the first sensory result, 15 students that comprised of the postgraduate students of the Division of Food Science and Technology, Faculty of Agro-Industry, ChiangMai University evaluated soft yogurt candy samples using the ideal score for soft candy (Appendix C, the 2nd sensory form).

The sensory evaluation of three soft candy prototypes added with fermented milk, a mixture of stirred yogurt and fermented milk and stirred yogurt was performed to find out the best formula based on sensory panelists. From Table 4.5, it was shown that types of fermented milk significantly affected the mean ratios of color, hardness, chewiness and overall acceptance (P≤0.05), whereas no significant different was found for flavor, sweetness, saltiness and stickiness. The highest values of color and hardness, which were higher than the ideal score, were found in the candy added with fermented milk. The candy added with stirred yogurt had the highest mean ratio in overall acceptance and the closest to the ideal candy when compared with other formulas. Therefore, the soft candy added with stirred yogurt was chosen to be the prototype for further study. The next experiment was to determine the effect of sugar alcohols (maltitol and sorbitol) on the soft yogurt candy quality.

4.3 Effect of sugar alcohols on the soft yogurt candy quality

Soft yogurt candies in this section were added with sugar alcohols instead of sucrose. The other ingredients of soft candy were similar to the prototype candy added with stirred yogurt. Four sugar sources, including 100% sucrose (prototype product), maltitol:sorbitol (50:50), 100% maltiltol and 100% sorbitol, were utilized to make soft yogurt candy under the same processing conditions. It was revealed that soft candies containing 100 and 50% sorbitol could not be solidified to form candy under this process condition. The candies maintained to be liquid and burnt with a prolong heating condition, which could be due to the high solubility of sorbitol (Nabors, 2001). Due to this problem, soft yogurt candies with sorbitol could not be studied. However, it could be used in hard candy (Jackson, 1990).

The physical and chemical characteristics of three soft yogurt candies with different sugar sources were shown in Tables 4.6 and 4.7, respectively.

Table 4.6 Physical characteristics of soft yogurt candy with different sugar sources

Physical characteristics	Type of sugar sources		
	100% Maltitol	Maltitol:Sucrose (50:50)	100% Sucrose
a_w	0.53 ± 0.01^{b}	0.50 ± 0.01^{b}	0.61 ± 0.01^{a}
L*	73.11 ± 0.31^{b}	65.73 ± 0.15^{c}	77.31 ± 0.27^{a}
a*	-0.47 ± 1.12^{b}	3.18 ± 0.25^{a}	0.48 ± 0.18^{b}
b*	15.73 ± 0.04^{c}	21.56 ± 0.19^{a}	18.26 ± 0.32^{b}

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently ($P\leq0.05$) between treatments.

Physical properties of soft yogurt candy with different sugar sources were shown in Table 4.6. It was observed that the types of sugar sources significantly affected a_w, L*, a* and b* values of the candies ($P\leq0.05$). The a_w and L* values of candy with 100% sucrose were significantly higher than those of the other candies, whereas the soft candy with a mixture maltitol and sucrose had the highest a* and b* values.

Table 4.7 Chemical characteristics of soft yogurt candy with different sugar sources

Chemical characteristics	Type of sugar sources		
	100% Maltitol	Maltitol:Sucrose (50:50)	100% Sucrose
Total acidity (as % lactic acid)	0.23±0.01	0.24±0.01	0.23±0.01
Total solids (%)	90.97±0.03	91.04±0.02	91.05±0.02
Moisture (%)	9.03±0.03	8.96±0.02	8.95±0.02
Total soluble solids (% Brix)	84.27±2.62	86.41±1.10	88.73±1.87
Reducing sugar before inversion (g/100 g)	14.11 ± 0.19^{c}	14.49 ± 0.02^{b}	15.39 ± 0.03^{a}
Reducing sugar after inversion (g/100 g)	29.40 ± 0.04^{c}	40.26 ± 0.12^{b}	56.35 ± 0.07^{a}
Sucrose (g/100 g)	14.53 ± 0.02^{c}	24.47 ± 0.03^{b}	38.92 ± 0.07^{a}
Total sugars (g/100 g)	28.64 ± 0.03^{c}	38.97 ± 0.12^{b}	54.31 ± 0.07^{a}

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently ($P\leq0.05$) between treatments.

From Table 4.7, it was shown that the reducing sugar before and after inversion, sucrose and total sugars in the soft candy with 100% sucrose were significantly the highest when compared with other candies. Since sucrose would be hydrolyzed to invert sugars when heated under acidic condition (Jackson, 1990), the amount of invert sugar after inversion increased more than 3.5 times in the candy with 100% sucrose. The total soluble solids in the soft yogurt candy with 100% sucrose was also the highest, but was not significantly different from other candies.

From the results of physical and chemical characteristics of soft yogurt candy with different sugar sources, it could be identified that maltitol was suitable for soft yogurt candy production, due to lower amounts of reducing sugar before and after inversion, sucrose and total sugars in the candy when compared to the 100% sucrose candy. Besides, it would not participate in Maillard reaction, thus the color change in maltitol candy would be lower than sucrose candy. The 100% sucrose candy, which had the highest reducing sugars, could readily have Maillard reaction, especially during heating at high temperature (Belitz and Grosch, 1999). The soft yogurt candy with maltitol also reduced the caloric value and dental caries (Nabors, 2001 and Maguire *et al.* , 1999).

A study to replace sucrose with honey in soft yogurt candy was performed in the next experiment to determine the possibility of using honey in the candy production.

4.4 Effect of honey on the soft yogurt candy quality

The effect of honey on soft yogurt candy quality was investigated in this section. Candies with different ratio of honey were made using the prototype method of processing. The physical and chemical characteristics of the candies were analyzed and showed in Tables 4.8 and 4.9, respectively.

Table 4.8 Physical characteristics of soft yogurt candy with different honey contents

Physical characteristics	Ratio of honey		
	100% Honey	Honey: Sucrose (50:50)	0% Honey (100% Sucrose)
a_w	0.48±0.01	0.50±0.01	0.54±0.01
L*	72.15±0.67^c	76.76±0.78^b	80.48±0.36^a
a*	3.32±0.05^a	0.97±0.10^b	0.07±0.03^c
b*	24.08±0.30^a	18.88±0.15^b	16.95±0.16^c

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

The result showed that the amount of honey significantly affected the L*, a* and b* color values (P≤0.05). The candy with no honey (100% sucrose) had the highest L* value, whereas the 100% honey candy had the highest a* and b* values. As the results, the 100% honey candy was darker and more saturated with red and yellow colors than the other candies. Increasing the honey content in the candy formula tended to reduce the a_w. However, it was not significantly different in the term of a_w among the three soft yogurt candies.

The chemical characteristics of soft yogurt candy with different honey contents were presented in Table 4.9. The total soluble solids, reducing sugar before and after inversion, sucrose and total sugars were significantly different between different candy samples. The soft yogurt candy without honey (100% sucrose) had the highest total soluble solids, reducing sugar after inversion, sucrose and total sugars, whereas the soft yogurt candy with 100% honey had the highest value of reducing sugar before inversion due to the high glucose and fructose content in the honey (Belitz and Grosch, 1999).

Table 4.9 Chemical characteristics of soft yogurt candy with different honey contents

Chemical characteristics	Ratio of honey		
	100% Honey	Honey: Sucrose (50:50)	0% Honey (100%Sucrose)
Total acidity (as % lactic acid)	0.25±0.01	0.25±0.01	0.23±0.01
Total solids (%)	90.85±0.03	90.94±0.03	91.05±0.02
Moisture (%)	9.15±0.03	9.05±0.03	8.95±0.02
Total soluble solids (% Brix)	87.89±0.43^{ab}	87.24±0.24^{b}	88.87±0.00^{a}
Reducing sugar before inversion (g/100 g)	35.15±0.13^{a}	26.22±0.14^{b}	15.44±0.05^{c}
Reducing sugar after inversion (g/100 g)	51.30±0.54^{b}	55.28±0.19^{a}	56.52±0.03^{a}
Sucrose (g/100 g)	15.34±0.46^{c}	27.61±0.32^{b}	39.02±0.07^{a}
Total sugars (g/100 g)	50.50±0.52^{b}	53.82±0.17^{a}	54.46±0.02^{a}

Remarks: values were mean of 3 replication ± s.d.
Different letters that followed numbers within the same row indicated significant differently (P≤0.05) between treatments.

From the results, it could be seen that fully replacing sucrose with honey was not suitable for soft yogurt candy because of the high content of glucose and fructose in honey. High honey content in the soft candy formula affected the candy's color because it increased Maillard reaction, which made the candy darker from the reaction between reducing sugars in honey and amino acids in yogurt and sweetened condensed milk. Thus, partial substitution of sucrose with honey was considerable better to reduce the undesirable properties of the 100% honey candy.

4.5 Effect of packaging materials and storage temperatures on the soft yogurt candy quality

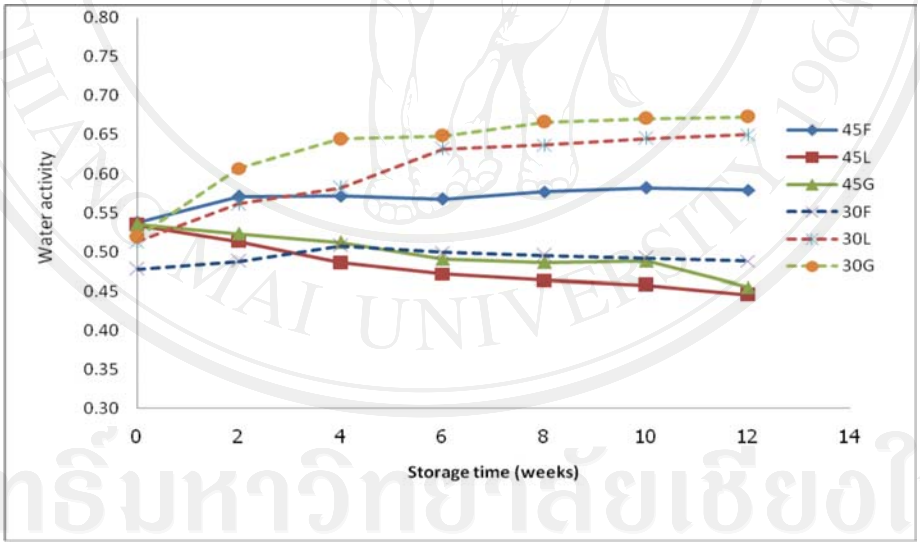
In this section, different types of packaging materials and storage temperatures on the keeping quality of soft yogurt candy during 3 months storage period were investigated. The soft yogurt candies made from stirred yogurt (section 4.2) were packed in aluminium foil bag, laminated plastic bag and Oriented Polypropylene (OPP) bag and stored at 30 and 45°C for 3 months. The representative samples were analyzed every 2 weeks during storage time and the results were as followed;

4.5.1 Physical quality of soft yogurt candy during storage

The physical characteristics of soft yogurt candy during storage period were reported in Figures 4.1-4.4 and Appendix D, Table 1. The effects of packaging materials and storage temperatures analyzed using analysis of variance (ANOVA) on the physical quality of soft yogurt candy were described as followed;

a_w of yogurt candy

Changing of the soft yogurt candy's a_w during storage period was shown in Figure 4.1. According to statistical analysis, types of packaging materials, storage temperatures, interaction of both factors and storage time were significantly affected the product's a_w ($P \leq 0.05$). Increasing the storage temperatures reduced the candy's a_w, except for the candy in aluminium foil. At longer storage time, the a_w of soft yogurt candy in laminated plastic and OPP bags stored at 45°C tended to decrease. This could be due to higher losses of water at higher storage temperature. Soft yogurt candies wrapped in OPP bag and stored at 30°C had the highest a_w compared to those of other treatments after 2 weeks of storage. This indicated that the candies absorbed more water, which might be affected by the water vapor permeability of OPP (0.2-0.5 g.mil per 100 in^2. day at 38°C, 90% RH) (Sun Lee and Piergiovanni, 2008). This was higher than aluminium foil which had the excellent barrier properties to water, gas and aroma (Sun Lee and Piergiovanni, 2008).

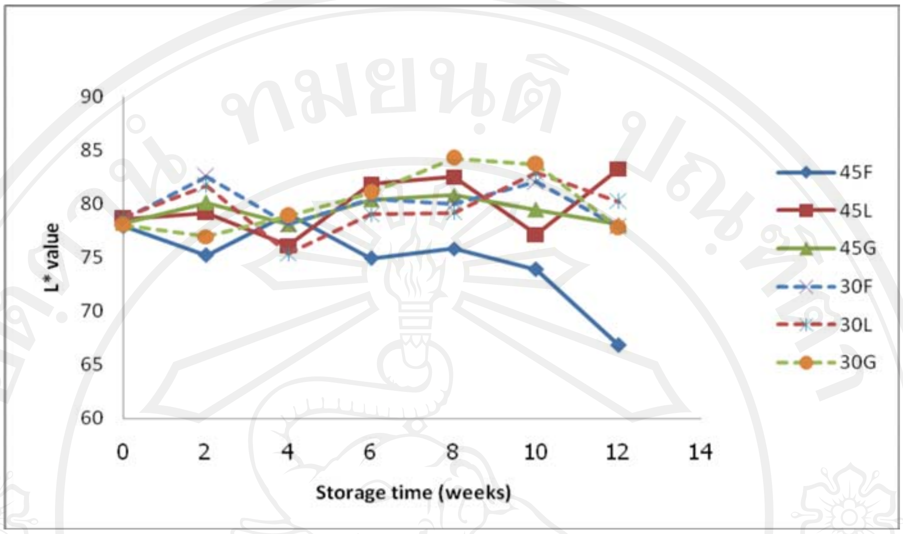


F = Aluminium foil   L = Laminated plastic   G = Oriented polypopylene

Figure 4.1 a_w of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

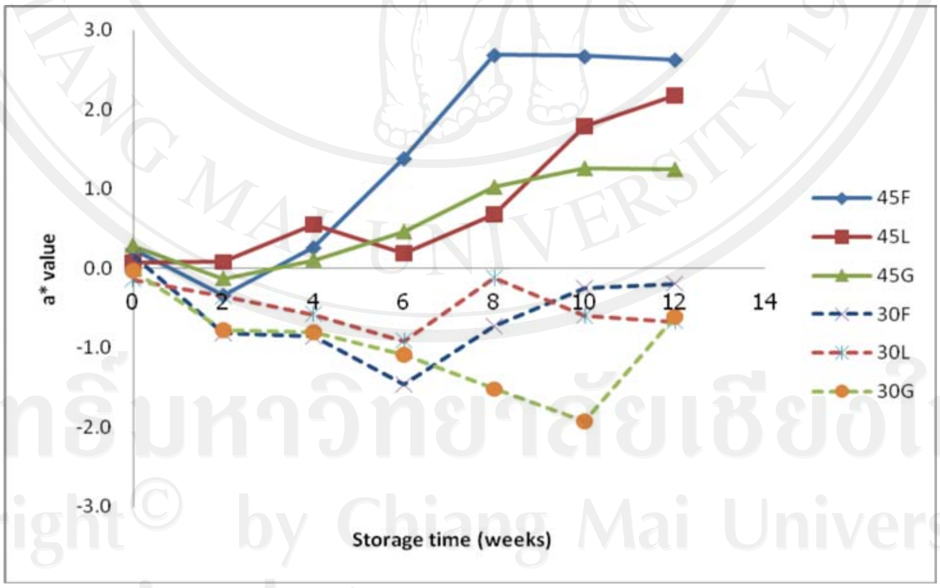
Color values of yogurt candy

Changing in the L*, a* and b* values of soft yogurt candy was shown in Figures 4.2, 4.3 and 4.4, respectively. The statistical analysis showed that packaging materials, storage temperatures, interaction of both factors and storage time significantly affected L*, a* and b* values ($P \leq 0.05$). However, interaction of packaging materials and storage temperatures did not significantly affect a* values ($P > 0.05$). Higher L* value, lower b* values and negative a* values were observed in the soft yogurt candies kept at 30°C. Higher storage temperature tended to increase a* and b* values and decrease L* values, which could be due to Maillard reaction (Belitz and Grosch, 1999).



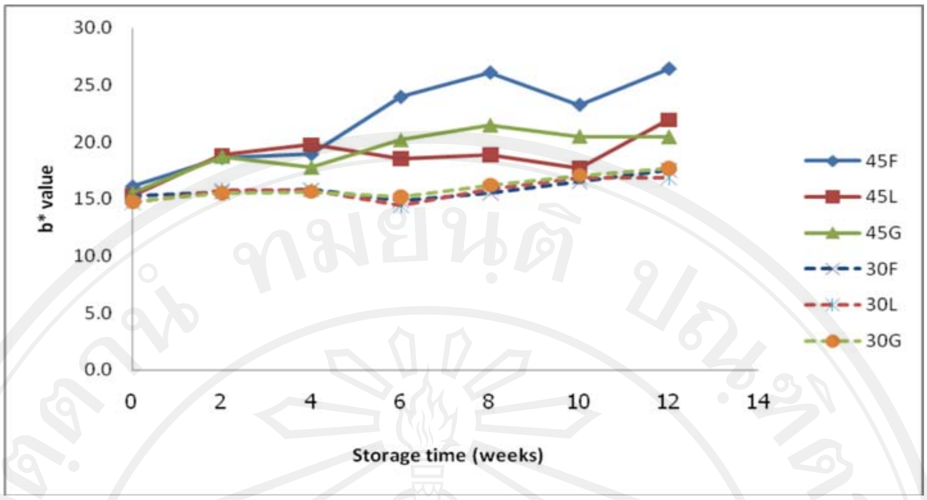
F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.2 L* values of soft candy affected by packaging materials and storage temperatures during 3 months storage period



F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.3 a* values of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period



F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

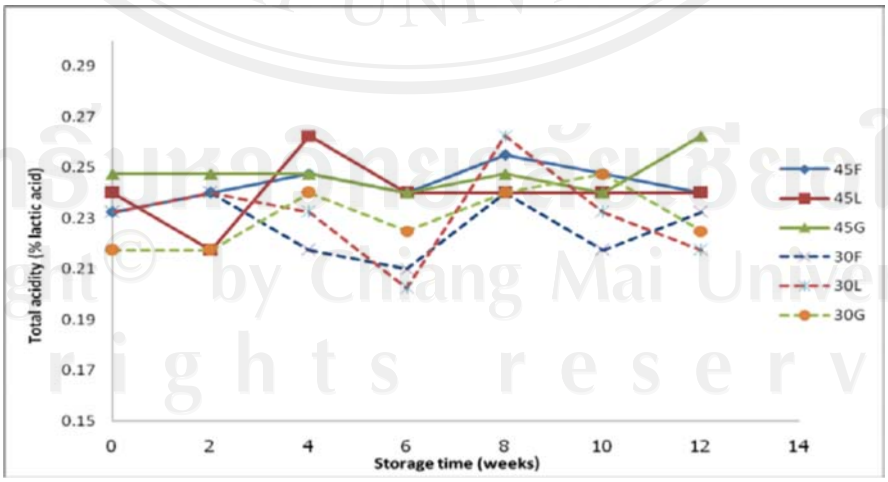
Figure 4.4 b* values of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

4.5.2 Chemical quality of soft yogurt candy during storage

The chemical characteristics of soft yogurt candy during storage period were reported in Figures 4.5-4.12 and Appendix D, Tables 2 and 3. The effects of packaging materials and storage temperatures using an analysis of variance (ANOVA) on the chemical quality of soft yogurt candy were explained as followed:

Total acidity of soft yogurt candy

Data analysis indicated that storage temperature significantly affected the soft yogurt candy's acidity ($P \leq 0.05$) (Figure 4.5). Higher storage temperature tended to increase the candy's acidity. Different packaging materials and storage period did not significantly affect the candy's acidity.

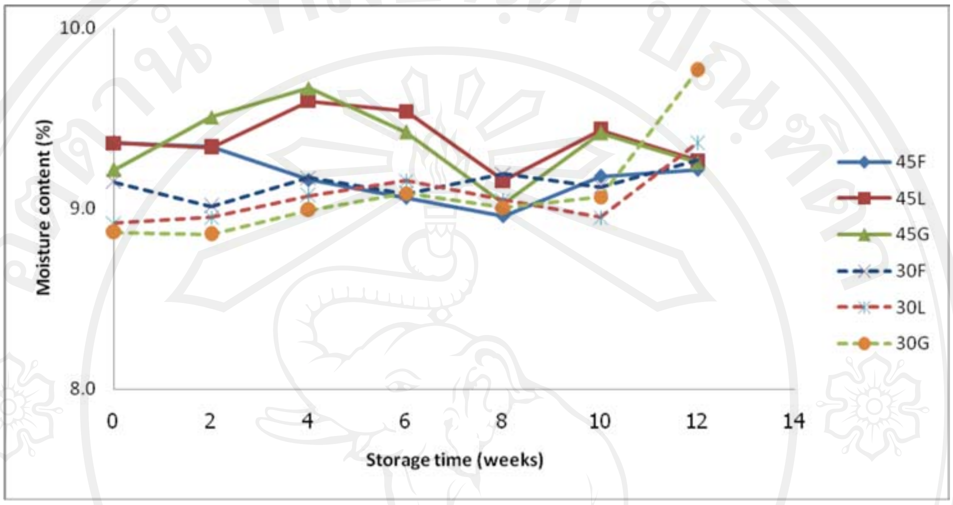


F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.5 Total acidity (% lactic acid) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

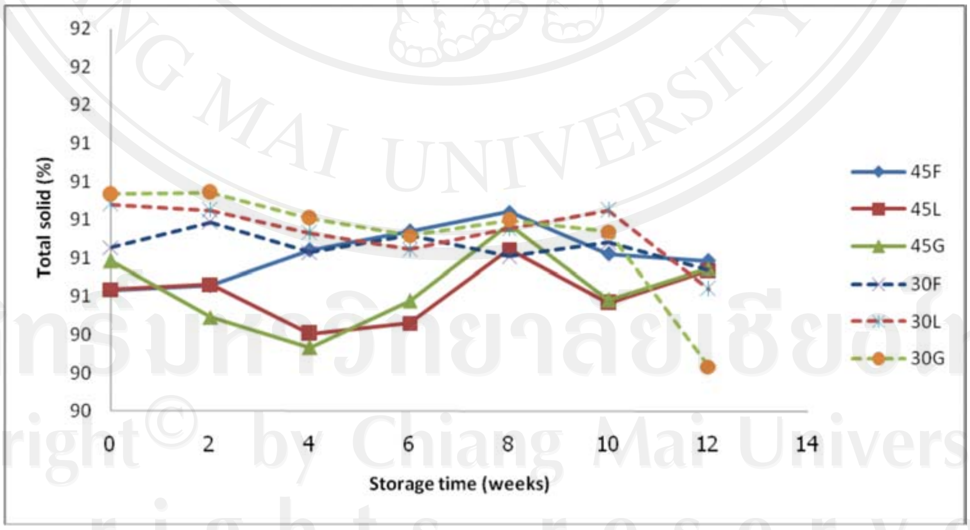
Moisture content and total solids of soft yogurt candy

Moisture content and total solids of soft yogurt candy stored in different packaging materials and storage temperatures were significantly different between different treatments (P≤0.05) (Figures 4.6 and 4.7). The candy in the OPP bag at 30°C had a significance increase in the moisture content during 3 months storage. This was parallel with the results of the a_w (Figure 4.1).



F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.6 Moisture content (%) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

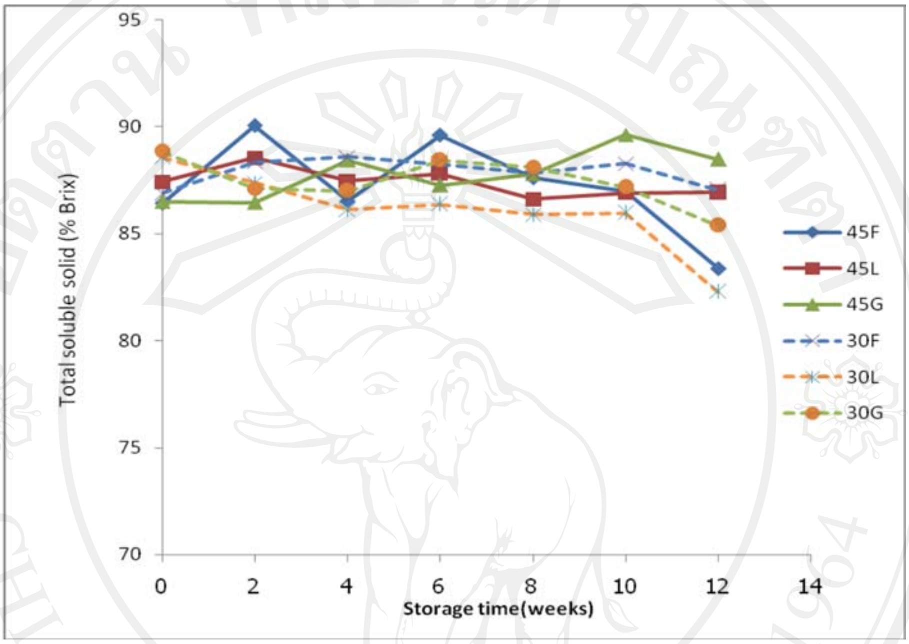


F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.7 Total solids (%) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

Total soluble solids of soft yogurt candy

In the term of total soluble solids, no significant difference was found between different soft yogurt candy samples kept in different packaging materials and storage temperatures (Figure 4.8). However, storage time was significantly affected the candy's total soluble solids. Higher total soluble solids were found at longer storage period.



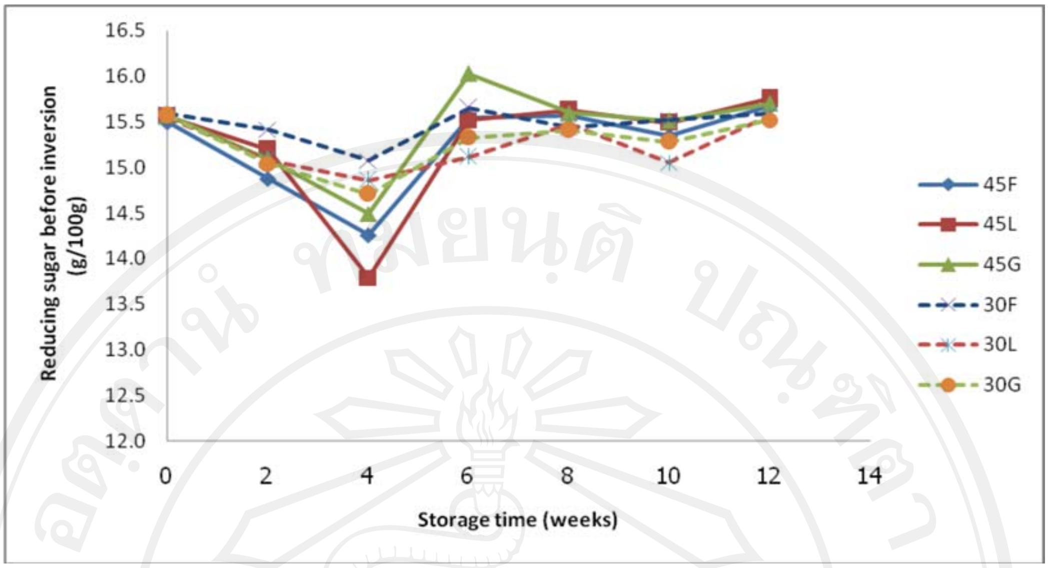
F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.8 Total soluble solids (% Brix) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

Sugar contents of soft yogurt candy

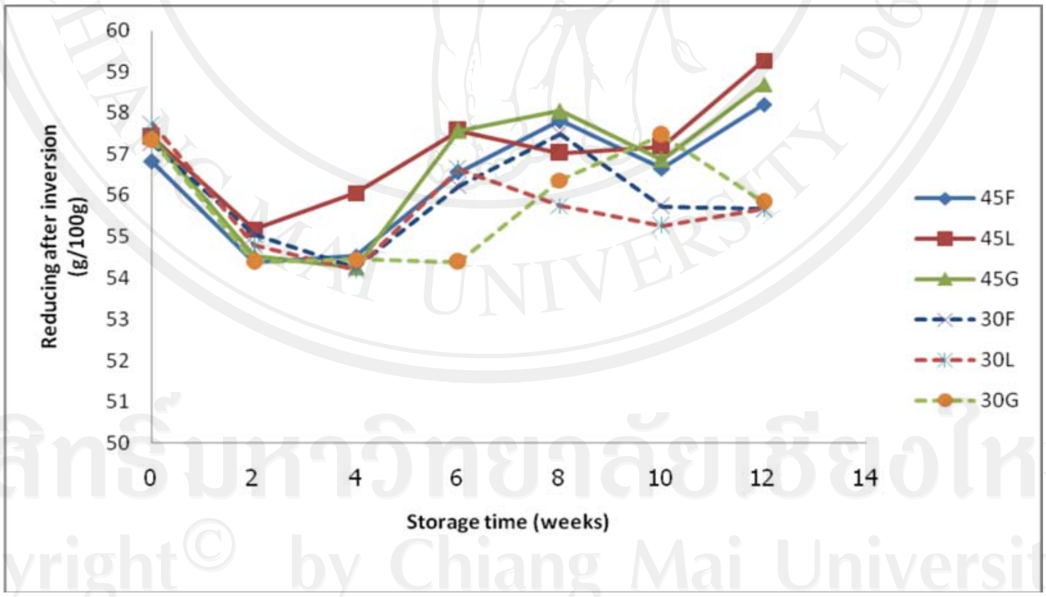
Figures 4.9-4.12 and Appendix D, Table 3 showed the fluctuation of sugar contents in soft yogurt candy during storage. It was found that reducing sugars after inversion, sucrose and total sugar in the candies were significantly affected by storage temperatures and time. Higher storage temperature tended to increase the reducing sugars after inversion, sucrose and total sugars. Although fluctuation of these 3 sugar contents was not uniform, similar trend of changes could be observed.

There was not any significant effect of packaging materials and storage temperatures on reducing sugars before inversion. This sugar type was significantly affected by the interaction of packaging materials and storage temperatures with storage time.



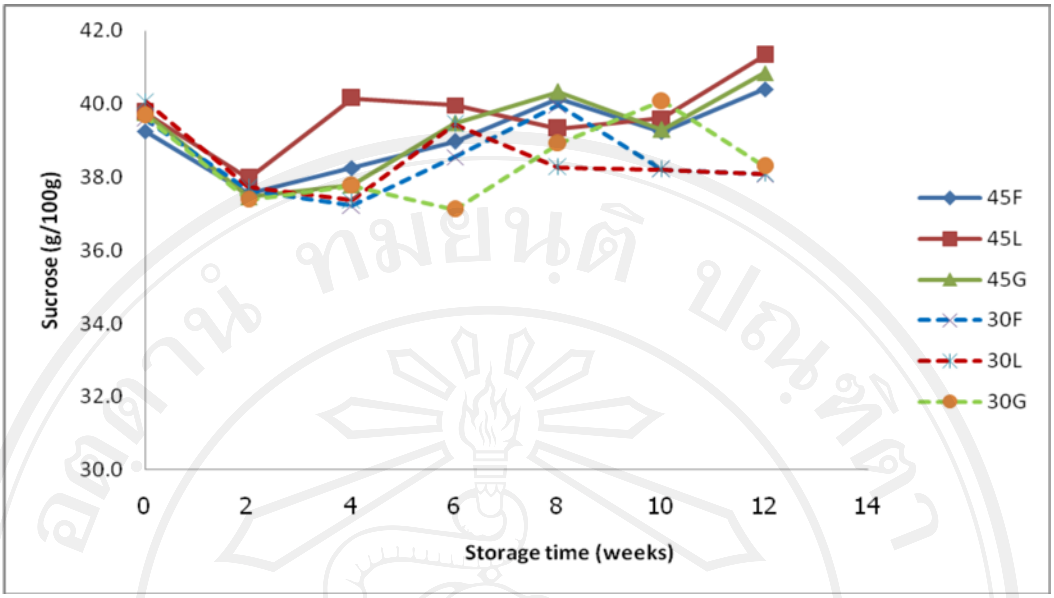
F = Aluminium foil   L = Laminated plastic   G = Oriented polypopylene

Figure 4.9 Reducing sugars before inversion (g/100g) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period



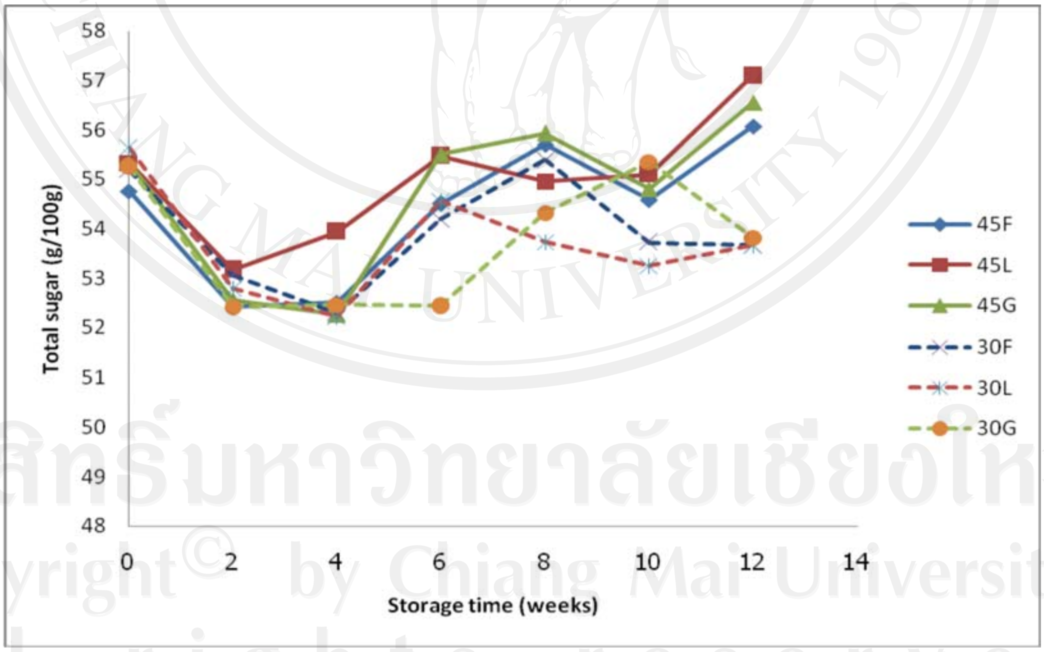
F = Aluminium foil   L = Laminated plastic   G = Oriented polypopylene

Figure 4.10 Reducing sugars after inversion (g/100g) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period



F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.11 Sucrose (g/100g) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period



F = Aluminium foil L = Laminated plastic G = Oriented polypopylene

Figure 4.12 Total sugars (g/100g) of soft yogurt candy affected by packaging materials and storage temperatures during 3 months storage period

4.5.3 Sensory evaluation of soft yogurt candy during storage

Sensory evaluation of soft yogurt candy using 9-point hedonic scale evaluated by 50 panelists of under graduate and post graduate students of the Division of Food Science and Technology was carried out to determine the changes of soft yogurt candy's sensory properties during storage. The sensory data at 0, 6 and 12 weeks were shown in Tables 4.10, 4.11 and 4.12, respectively.

Table 4.10 Sensory evaluation of soft yogurt candy affected by packaging materials and storage temperatures at the beginning of storage period (0 week)

Sensory attributes	Storage condition					
	45°C F	45°C L	45°C OPP	30°C F	30°C L	30°C OPP
Color	7.76 ± 0.85^{a}	7.46 ± 0.89^{bc}	7.50 ± 0.97^{b}	$7.62 \pm 0.^{92ab}$	7.22 ± 1.13^{c}	7.68 ± 0.77^{ab}
Flavor	5.72 ± 1.59^{c}	6.28 ± 1.14^{ab}	6.34 ± 1.00^{a}	5.94 ± 1.49^{bc}	6.06 ± 1.04^{abc}	6.30 ± 1.15^{a}
Sweetness	6.80±1.12	6.78±1.11	6.86±0.86	6.74±1.05	6.62±1.01	6.76±0.89
Saltiness	6.61±1.13	6.49±1.10	6.45±1.06	6.41±1.26	6.29±1.27	6.53±1.16
Hardness (in month)	5.92 ± 1.64^{bcd}	5.84 ± 1.56^{cd}	6.24 ± 1.35^{abc}	6.31 ± 1.37^{ab}	5.76 ± 1.44^{d}	6.43 ± 1.19^{a}
Stickiness	$5.301.49^{c}$	5.76 ± 1.32^{ab}	6.13 ± 1.07^{a}	5.67 ± 1.48^{bc}	5.54 ± 1.35^{bc}	5.72 ± 1.44^{abc}
Chewiness	5.20±6.02	$5.64 \pm 1.^{59bc}$	6.22 ± 1.45^{a}	6.08 ± 1.61^{ab}	5.42 ± 1.49^{c}	6.00±1.39
Overall acceptance	6.02 ± 1.46^{b}	6.08 ± 1.21^{b}	6.66 ± 1.15^{a}	6.76 ± 1.15^{a}	6.20 ± 1.16^{b}	6.72 ± 1.11^{a}

Remarks: values were mean of 3 replication ± s.d.
F = Aluminium foil bag, L = laminated plastic bag, OPP= OPP bag
Different letters that followed numbers within the same row indicated significant differently ($P \leq 0.05$) between treatments.

At the beginning of the storage, it was found that color, flavor, hardness, stickiness, chewiness and overall acceptance of soft yogurt candy samples were significantly different between different treatments (Table 4.10). Although all the candy samples were produced using a same processing condition, different batch productions still had an effect on the sensory properties of the final product, which could be detected by sensory panelists. The moderate acceptance of soft yogurt candy (between 6.02 and 6.76) was contributed by the high stickiness and hardness (toughness) of the candy.

At 6 weeks of storage, all of the sensory attributes were significantly affected by storage conditions (Table 4.11). Generally, higher scores of sensory properties were achieved in the candy samples stored at 30°C, particularly for the color characteristics. This could be affected by less chemical reaction occurred at lower storage temperature compared to those kept at 45°C.

Table 4.11 Sensory evaluation of soft yogurt candy affected by packaging materials and storage temperatures after 6 weeks of storage

Sensory attributes	Storage condition					
	45°C F	45°C L	45°C OPP	30°C F	30°C L	30°C OPP
Color	5.36±1.75^{c}	6.19±1.17^{b}	5.26±1.58^{c}	7.72±1.28^{a}	7.40±1.01^{a}	7.28±1.10^{a}
Flavor	5.64±1.33^{b}	5.53±1.14^{b}	5.45±1.08^{b}	5.74±1.41^{ab}	5.74±1.24^{ab}	6.09±1.27^{a}
Sweetness	6.64±1.24^{ab}	6.30±1.35^{bc}	6.00±1.56^{c}	6.96±1.10^{a}	6.62±1.45^{ab}	6.81±1.31^{a}
Saltiness	6.53±1.35^{a}	6.02±1.26^{bc}	5.79±1.57^{c}	6.55±1.36^{a}	6.32±1.51^{ab}	6.60±1.44^{a}
Hardness (in month)	6.09±1.59^{ab}	5.06±1.64^{c}	5.20±1.63^{c}	5.57±1.73^{bc}	6.19±1.83^{ab}	6.47±1.50^{a}
Stickiness	6.46±1.37^{a}	5.81±1.76^{bc}	5.46±1.82^{c}	6.08±1.78^{ab}	6.00±1.72^{abc}	5.81±1.73^{bc}
Chewiness	6.15±1.60^{a}	4.58±1.65^{b}	4.31±1.89^{b}	5.99±1.80^{a}	6.02±1.78^{a}	6.13±1.62^{a}
Overall acceptance	6.38±1.31^{a}	5.71±1.45^{b}	5.26±1.71^{b}	6.52±1.59^{a}	6.47±1.44^{a}	6.68±1.40^{a}

Remarks: values were mean of 3 replication ± s.d.
F = Aluminium foil bag, L = laminated plastic bag, OPP= OPP bag
Different letters that followed numbers within the same row indicated significant differently ($P \leq 0.05$) between treatments.

Table 4.12 Sensory evaluation of soft yogurt candy affected by packaging materials and storage temperatures after 12 weeks of storage

Sensory attributes	Storage condition					
	45°C F	45°C L	45°C OPP	30°C F	30°C L	30°C OPP
Color	4.23±1.43^{c}	6.4±1.16^{b}	6.24±1.20^{b}	7.42±1.25^{a}	7.16±0.93^{a}	7.42±0.84^{a}
Flavor	5.08±1.55^{c}	5.22±1.59^{bc}	5.36±1.45^{abc}	5.83±1.67^{a}	5.84±1.54^{a}	5.74±1.44^{ab}
Sweetness	6.40±1.53^{c}	6.38±1.60^{c}	6.54±1.49^{bc}	6.90±1.23^{ab}	7.00±1.25^{a}	7.00±1.09^{a}
Saltiness	6.27±1.20^{bc}	6.12±1.29^{c}	6.35±1.06^{bc}	6.43±1.32^{abc}	6.72±1.09^{a}	6.58±1.25^{ab}
Hardness (in month)	5.72±1.39^{c}	6.10±1.73^{bc}	5.65±1.72^{c}	6.31±1.58^{ab}	6.76±1.28^{a}	6.54±1.47^{ab}
Stickiness	6.28±1.46	6.20±1.79	5.71±1.64	6.00±1.57	6.44±1.23	6.55±1.35
Chewiness	6.13±1.29^{a}	4.77±1.38^{b}	4.78±1.32^{b}	6.22±1.05^{a}	6.48±1.42^{a}	6.42±1.42^{a}
Overall acceptance	5.38±1.53^{b}	5.31±1.47^{b}	5.10±1.41^{b}	6.86±1.39^{a}	6.80±0.93^{a}	6.74±1.07^{a}

Remarks: values were mean of 3 replication ± s.d.
F = Aluminium foil bag, L = laminated plastic bag, OPP= OPP bag
Different letters that followed numbers within the same row indicated significant differently ($P \leq 0.05$) between treatments.

At the end of the storage period, different storage conditions still produced a significant effect on the soft yogurt candy sensory characteristics, except for stickiness (Table 4.12). The candy samples stored at 30°C had higher values for all of the sensory attributes compared to those that kept at 45°C. The candy packed in aluminium foil and stored at 45°C significantly had the lowest color values ($P \leq 0.05$). The panelists significantly gave higher overall acceptance for the candy kept at 30°C compared to those that stored at higher storage temperature.

From the sensory data, it could be concluded that the storage temperature at 45^{O}C was not recomended for soft yogurt candy because the sensory values of the product decreased rapidly, especially for the color property. The optimum conditions to store soft yogurt candy were packed in aluminium foil bag and kept at 30^{O}C. The reasons for these were because aluminium foil had excellent air and water barrier properties (Sun Lee and Piergiovanni, 2008) and at 30^{O}C storage temperature, the sensory properties of the candy had less changes.

4.5.4 Microbiological quality of soft yogurt candy during storage

The microbiological quality of soft yogurt candy during storage was presented in Table 4.13.

Table 4.13 Microbiological quality of soft yogurt candy affect by packaing materials and storage temperatures during 3 months storage period

Packaging materials	Storage temperatures (°C)	Storage times (weeks)	Total plate count (CFU/g)	Yeast and mold (CFU/g)	Osmophillic yeast (CFU/g)
Aluminium foil	30	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10
Aluminium foil	45	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10
Laminated plastic bag	30	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10
Laminated plastic bag	45	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10
OPP	30	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10
OPP	45	0	<10	<10	<10
		2	<10	<10	<10
		4	<10	<10	<10
		6	<10	<10	<10
		8	<10	<10	<10
		10	<10	<10	<10
		12	<10	<10	<10

No microbial growth was found in the candy samples throughout the storage period. The number of Total plate count, yeast and mold and osmophillic yeast were < 10 CFU/g. It was shown that the packaging materials and storage temperatures did not affect the microbial growth. The low number of microorganisms in the candy samples was contributed from the heating step during the candy production and the hygienic condition during the production and storage of the product.