Effect of Different Carbohydrate Sources on Sweetened Pasteurised Milk

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ABSTRACT

In this study, four types of carbohydrate, i.e., lactose, glucose, sucrose and honey were added to raw milk and then processed at 72°C for 15 seconds. After the pasteurisation process, all the pasteurised milk were found to have the number of viable microorganisms below 2.90 log cfu ml^{-1}. The addition of different types of carbohydrate did not significantly affect the pH, total acidity and viscosity values of the pasteurised milk. The glucose-added pasteurised milk had the highest amount of reducing sugars, while the sucrose-added pasteurised milk contained the lowest amount of the similar sugars. However, the sucrose-added pasteurised milk had the highest score for its sweetness properties in a sensory analysis whereas the lactose-added pasteurised milk received the lowest score for the same parameter. The honey-added pasteurised milk significantly changed its color to become darker with red and more yellow colour directions.

Key words: Pasteurised milk, Sucrose, Glucose, Lactose, Honey

INTRODUCTION

Milk products in the market are available in a wide range of choices, i.e., from liquid products, including pasteurised, sterilised and Ultra-High-Temperature (UHT) milk to more-viscous products such as yoghurt and sweet condensed milk and to low-moisture-content products, for example, butter and dried milk. Interestingly, in each type of product, there is a more specific variation. In pasteurised and UHT milk, manufacturers have included different flavours such as strawberry, chocolate, coffee, banana and pandan. Despite of these extra values, milk producers in Thailand also produce sweetened liquid milk. The sweetened liquid milk will normally be added with 4% (w/w) sucrose. In fact, from a consumer survey on the satisfaction for ready-to-drink milk in Bangkok in 1996 (the survey was done for 265 consumers and 49 shops), it was found that the most favourite milk product was sweetened liquid milk, followed by ready-to-drink yoghurt, plain milk (no added sugar), chocolate-flavoured milk, coffee-flavoured milk and strawberry-flavoured milk (Kasikorn Research Center, 2001).

The familiarity of Thai consumer with sweetened liquid milk has risen a question for the extent of Maillard (browning) reactions in the products, especially for UHT milk that can be kept for up to 6 months. The reaction itself occurs between reducing sugars, mainly lactose and amino acids, typically lysine, and is affected by pH, time, temperature, water activity, moisture content and amount of the precursors (Walstra and Jenness, 1984; Lewis and Heppell, 2000). In milk products, the Maillard reaction is generally undesirable because of a production of brown colour, a development of off-flavours, reduction in nutritive values, polymerization of milk proteins and changing on the heat stability of the milk (Fox and McSweeney, 1998; van Boekel, 1998; Muir and Banks, 2000).

The purpose of this project was to study the effect of different sources of carbohydrate on pasteurised milk immediately after a heat treatment at 72°C for 15 seconds. The microbial, chemical, physical and sensory properties of the milk were examined and the possibility of the Maillard reaction in the milk would be discussed.

MATERIALS AND METHODS

Milk Processing

An amount of 2 l raw milk from Dairy Farming Promotion Organization of Thailand, Huaykaew Road, Chiang Mai was divided into 5 batches. Into 4 batches, 4 different carbohydrates at a concentration of 4% (w/v) were added. The 4 carbohydrates were lactose (DIFGO, CM Chemical Company, Thailand), glucose (DIFGO, CM Chemical Company, Thailand), sucrose (DIFGO, CM Chemical Company, Thailand) and honey ('Erawan' brand, Chiang Mai, Thailand). The last batch of raw milk, used as a control, did not have any carbohydrate addition. All the carbohydrates were stirred in the milk until they were dissolved properly. The raw milk was then put inside a water-bath (Gallenkamp, Germany) that had been preheated to a temperature slightly above 72°C. The temperature inside the milk samples was monitored throughout the heating process, using another flask of raw milk that contained a thermometer. When the temperature of the milk reached 72°C, the milk was hold for another 15 seconds before it was cooled down immediately in cold water until the temperature dropped to below 10°C.

Microbiological analysis

The raw and pasteurised milk samples were analyzed microbiologically for their total viable microorganisms and spores. The total viable microorganisms were determined by making serial 1 in 10 dilutions of milk samples, using a solution that was prepared from 8.5 g NaCl (Merck, OV Chemical and Supply, Thailand) and 1.0 g lactone (DIFGO, OV Chemical and Supply, Thailand) for 1 l solution. An amount of 1 ml sample from the appropriate dilution was transferred into a plate and added with Plate Count Agar (Scharlau microbiology ref. 01-161). The agar was mixed properly with the milk samples and left to solidify. After the agar had solidified, the plates were incubated aerobically at 37°C for 48 h. The procedure was done for two plates for each milk sample dilution.

For the number of spores, the milk samples were initially heated at 80°C for 10 min (Rosenquist and Hansen, 1998; Mansour et al., 1999) before the similar procedure for measuring the total viable microorganisms was repeated.

pH analysis

This was a quick and simple method to monitor the quality changes in the heat-treated samples. The temperature of milk samples was initially allowed to increase to room temperature before measurement by a pH-meter (Microprocessor pH meter model pH 537, West Germany).

Total acidity

For this measurement, 20 ml of milk samples were firstly added with 20 ml distilled water and 1 ml of phenolphthalein indicator. The mixture solution was titrated against 0.1 N NaOH solution (DIFGO, CM Chemical company, Thailand) until a faint pink colour appeared. The total acidity was then calculated according to the following equation:

$$= 0.0090 \text{ x amount of NaOH solution (ml) x } \frac{100}{20}$$

Reducing sugar

The amount of reducing sugars was measured following the Lane and Eynon titration method, described by Ruchanakraikan and Ratanapanon (2001). In brief, 10 ml of milk samples (or 7 ml for the milk samples added with glucose) were transferred into a 200 ml volumetric flask. An amount of 5 ml Carrez I solution prepared from 21.9 g of zinc acetate dihydrate (Merck) and 3 ml of acetic acid glacial (Merck) in 100 ml distilled water, and another 5 ml of Carrez II solution made from 10.6 g of potassium ferrocyanide (Merck, CM Chemical Company, Thailand) in 100 ml distilled water were added into the milk sample. The milk sample was then topped up with distilled water until the total volume was 200 ml. All the solution in the flask was mixed properly and left for 20 minutes to precipitate. After the precipitation time had finished, the solution was filtered with a Whatman filter paper no. 4. The filtrate of the solution was poured into a burette, ready to be used for a titration against a Fehling solution. The Fehling solution was prepared by mixing 5 ml of Fehling reagent no.1 that was prepared from 62.278 g of $CuS0_4.5H_2O$ (Merck) in 1 l distilled water; 5 ml of Fehling reagent no. 2 which was made from 100 g of NaOH and 346 g of $NaKC_4O_6.4H_2O$ (Merck) in 1 l distilled water and 1 drop of Methylene blue indicator. In addition, 2-3 glass beads were also added to this solution. The Fehling solution was then titrated against the filtrate of the solution until the colour of the solution changed from blue-purple to brick-red. The Fehling solution was boiled all the time during the titration. The amount of the filtrate solution needed to titrate the Fehling solution determined the amount of invert sugars in the sample, which was read from the Invert Sugar Table for 10 ml Fehling's solution (Ruchanakraikan and Ratanapanon, 2001).

Viscosity analysis

The viscosity of milk samples was measured by a Brookfield DV-II+ Programmable Viscometer (USA), using a spindle no. 506 at 160 rpm.

Colour analysis

The colour of carbohydrate sources and milk samples, expressed in L*, a* and b* values was determined, using a colorimeter (Minolta Chroma meter CR-300 series, Japan).

Sensory analysis

The sensory analysis was carried out by two different methods. The first method was a ranking method for the sweetness and colour of the milk samples (Lawless and Heymann, 1998). Untrained panelists were served with 5 different milk samples (pasteurised milk added with lactose, glucose, sucrose and honey and the control pasteurised milk) in plastic cups labeled with 3-randomly-digit codes and a cup of drinking water. After a brief explanation, panelists were asked to put in order the sweetness and colour of the milk samples from the least sweet (no. 1) to the sweetest (no.5) samples and from the lightest (no.1) to the darkest (no.5) samples, respectively. The results of the ranking method were calculated based on their normal scores (Attabhanyo, 1999) and then analyzed statistically.

For the second method, a preference method, panelists were only given the 4 sweetened pasteurised milk samples in plastic cups labeled with 3-randomly-digit codes and a cup of drinking water. In this test, panelists were asked to write down the most preferable milk from the presented samples and the reason(s) for their choices.

Statistical analysis

Calculations using a Randomized Complete Block Design (RCBD) of the Analysis of Variance (ANOVA) with three replications were carried out for the analysis results (Montgomery, 2001).

RESULTS AND DISCUSSION

The microbiological quality of raw milk used in this project varied between 3.41-4.46 log cfu ml^{-1} for the aerobic viable microorganisms and below 1.00 log cfu ml^{-1} for the spore counts. This quality of raw milk, especially for the aerobic viable microorganisms, was considered to be acceptable according to the recommendation from the Dairy Farming Promotion Organisation of Thailand, which was below 200,000 cfu ml^{-1} or 5.30 log cfu ml^{-1}. Furthermore, the raw milk quality was still satisfactory for the higher standard of European raw milk which is at 50,000 cfu ml^{-1} or 4.70 log cfu ml^{-1} (Pettipher, 1993; Muir, 1996a).

Immediately after pasteurisation treatments, the numbers of viable microorganisms were reduced to below 2.90 log cfu ml^{-1} (Table 1). These results were accepted to be within the microbial standard of pasteurised milk both in Thailand, approved by the Dairy Farming Promotion Organisation and the Food Control State (2002) and in Europe (Muir, 1996b), which were below 30,000 cfu ml^{-1} or 4.48 log cfu ml^{-1}. For the spore counts in the pasteurised milk samples, the pasteurisation treatment did not show any significant effect on the microorganisms. This was because the results of spore count in the pasteurised milk samples were similar to that of the raw milk samples (the full results are not presented).

Table 1. Total viable microorganisms (cfu ml^{-1}) of pasteurised milk samples.

Pasteurised milk	Experiments		
	1	2	3
Control	8.50×10^1	7.50×10^1	3.33×10^2
Lactose-added pasteurised milk	2.10×10^2	$\leq 1.00 \times 10^1$	$\leq 1.00 \times 10^1$
Glucose-added pasteurised milk	1.35×10^2	1.80×10^2	7.93×10^2
Sucrose-added pasteurised milk	7.00×10^1	5.55×10^2	$\leq 1.00 \times 10^1$
Honey-added pasteurised milk	$\leq 1.00 \times 10^1$	$\leq 1.00 \times 10^1$	$\leq 1.00 \times 10^1$

One of the interesting things that should be noted from the microbiological results was the number of total viable microorganisms in the honey-added pasteurised milk (Table 1). All of the experiment results for the honey-added pasteurised milk showed that the number of viable microorganisms constantly dropped to below 10 cfu ml^{-1} directly after the pasteurisation process. This finding should be correlated with the chemical compositions of honey which are composed of many compounds including fructose, glucose, other carbohydrates, enzymes, amino and organic acids, minerals, aroma substances, pigments, waxes and pollen grains (Belitz and Grosch, 1987). In fact, a research by Taormina et al., (2001) found that an enzyme called glucose oxidase and phenolic compounds, which are naturally present in honey had an antimicrobial activity against foodborne pathogen. It suggested that these compounds and/or some other unknown compounds in honey could work synergistically with the heat treatment to continuously reduce more microorganisms in the pasteurised milk compared to the other carbohydrates. A further investigation in this area would be a challenge to unveil what these components are and how these components can be used maximally during food processing.

The chemical analysis results for raw and pasteurised milk samples are presented in Table 2. From the results of pH measurement, it is clearly shown that different sources of carbohydrates did not have any significant effect on the pH values of the pasteurised milk, although honey caused the pH value of the pasteurised milk to be slightly lower than the other carbohydrates. The pH values of the pasteurised milk samples, which were between 6.65-6.72, were not significantly different from that of the raw milk which showed that the pasteurisation treatment as a mild heat processing did not significantly alter the equilibrium of hydrogen ion in the milk. The pH value of the raw milk used in this experiment was in the normal range of the pH value for milk either in Thailand or abroad, which was between 6.5-6.7 (Celestino et al., 1996; Nanasombat, 1996; Early, 1998).

Table 2. Chemical analyses of raw and pasteurised milk samples.

Milk samples	pH values	Total acidity (% lactic acid)	Reducing sugars ($\%^{w}/_{v}$)
Raw milk	$6.70 \pm 0.09^{a*}$	0.14 ± 0.00^{a}	3.31 ± 0.08^{a}
Control	6.72 ± 0.01^{a}	0.14 ± 0.00^{a}	3.29 ± 0.05^{a}
Lactose-added pasteurised milk	6.70 ± 0.02^{a}	0.14 ± 0.00^{a}	5.75 ± 0.46^{b}
Glucose-added pasteurised milk	6.69 ± 0.04^{a}	0.14 ± 0.01^{a}	7.29 ± 0.71^{c}
Sucrose-added pasteurised milk	6.71 ± 0.02^{a}	0.14 ± 0.01^{a}	3.28 ± 0.09^{a}
Honey-added pasteurised milk	6.65 ± 0.01^{a}	0.15 ± 0.00^{a}	5.58 ± 0.18^{b}

* Different letters within one column indicate significant differences at 95% confidential level

Table 2 also presents the total acidity values for the raw and pasteurised milk samples. The total acidity results confirm the pH results that different sources of carbohydrates and the pasteurisation treatment did not significantly affect the acidity of the milk samples. All the results from the total acidity measurement were in the range of the standard acidity of raw milk, fresh and sweetened pasteurised milk in Thailand as recommended by the Dairy Farming Promotion Organization, Tungjaranchai and Kavilla (1988) and abroad (Fox and McSweeney, 1998).

The measurement of available reducing sugars in milk samples revealed that the highest amount of reducing sugars was present in the glucose-added pasteurised milk (Table 2). It was followed by the lactose- and honey-added pasteurised milk samples. The sucrose-added pasteurised milk had a similar quantity of reducing sugars, compared with the raw and control pasteurised milk samples. The reducing sugar results were strongly affected by different carbohydrates that were added to raw milk. Since glucose is a monosaccharide that has a free aldehyde group which can reduce Fehling solutions (BeMiller and Whistler, 1996), the 4% addition of this sugar to raw milk produced a pasteurised milk that had 4% reducing sugars higher than the control pasteurised milk (Table 2). Similar to glucose, lactose also has a free aldehyde group (BeMiller and Whistler, 1996). However, one lactose molecule contains 2 molecules of monosaccharide (glucose and galactose). Therefore, the potential of the sugar as a reducing sugar would be 50% lower than glucose at a similar weight (Table 2). For the honey-added pasteurised milk, the result showed that different types of carbohydrates in honey had a potential to act as reducing sugars similar to the lactose-added pasteurised milk. The last sugar that did not show any significant effect on the amount of reducing sugars in pasteurised milk was sucrose. This sugar showed different characteristics than the other types of carbohydrates because sucrose is a disaccharide that does not have any free aldehyde group in its structure (BeMiller and Whistler, 1996). Although sucrose did not directly affect the amount of reducing sugars in pasteurised milk, the pasteurised milk itself had already contained some reducing sugars from the presence of natural lactose in raw milk. Therefore, Maillard reactions which are the reactions caused by reducing sugars and amino acids could still take place both in the control and sucrose-added pasteurised milk samples.

For the physical measurements of pasteurised milk samples, the first measurement was the viscosity determination. The results from this measurement showed that the addition of various sources of carbohydrates did not significantly affect the viscosity of the pasteurised milk samples at 95% confidential level (Table 3). This result could be useful when processing raw milk using continuous plate heat exchangers. Since different types of sugars did not significantly affect the viscosity of the milk, the processors could use several types of sugars in various types of pasteurised milk without a need to change the setting of their processing plants.

Table 3. Viscosity measurements at 160 rpm of raw and pasteurised milk samples.

Milk samples	Viscosity (cp)	Torque (%)
Raw milk	5.59 ± 5.17[a*]	10.2 – 68.7
Control	1.89 ± 0.07[a]	9.7 – 10.2
Lactose-added pasteurised milk	2.04 ± 0.06[a]	10.5 – 11.3
Glucose-added pasteurised milk	5.23 ± 4.58[a]	10.5 – 62.6
Sucrose-added pasteurised milk	7.61 ± 7.37[a]	9.0 – 96.1
Honey-added pasteurised milk	9.14 ± 7.09[a]	9.4 – 99.0

* Different letters indicate significant differences at 95% confidential level

Another physical parameter that was measured was the color of pasteurised milk samples. When comparing the overall color values between raw and pasteurised milk samples (Table 4), it showed clearly that the honey-added pasteurised milk had a significantly different color from the raw milk or the remainder of the pasteurised milk samples. The honey-added pasteurised milk had a darker color with red and more yellow color directions compared to the color of other milk samples (Table 4). The different color of the honey-added pasteurised milk was more related to the natural color of honey itself rather than a color due to Maillard reactions. This conclusion could be made since the lactose- and glucose-added pasteurised milk samples that had equal or more reducing sugars than the honey-added pasteurised milk did not show any significant difference in terms of color from the raw and control pasteurised milk samples. When measuring the natural color of honey used in this research (Table 5), it was found that the honey had a dark color with red and blue color directions. Comparing with the color of lactose, glucose and sucrose that had colors in a same direction with the raw milk, i.e., white with green and yellow color directions (Table 5), it showed that the natural color of honey had a significant effect on the color of pasteurised milk.

Table 4. Color measurement of raw and pasteurised milk samples.

Milk samples	L* value	a* value	b* value
Raw milk	88.19 ± 0.21[a*]	-2.00 ± 0.77[a]	13.19 ± 0.69[a]
Control	88.75 ± 0.18[a]	-2.23 ± 0.61[a]	13.19 ± 0.47[a]
Lactose-added pasteurised milk	88.24 ± 0.74[a]	-2.12 ± 0.65[a]	13.26 ± 0.67[a]
Glucose-added pasteurised milk	88.41 ± 0.84[a]	-2.03 ± 0.79[a]	13.37 ± 0.81[a]
Sucrose-added pasteurised milk	88.55 ± 1.18[a]	-2.22 ± 0.76[a]	13.27 ± 0.84[a]
Honey-added pasteurised milk	82.20 ± 0.39[a]	0.45 ± 0.56[b]	14.02 ± 0.50[b]

* Different letters within one column indicate significant differences at 95% confidential level

Table 5. Color measurement of different carbohydrate sources.

Carbohydrate types	L* value	a* value	b* value
Lactose	98.33 ± 0.03	-4.57 ± 0.02	7.83 ± 0.02
Glucose	100.01 ± 0.05	-4.94 ± 0.01	5.43 ± 0.02
Sucrose	87.95 ± 0.67	-4.94 ± 0.03	6.71 ± 0.07
Honey	20.17 ± 1.85	5.46 ± 0.79	-3.03 ± 0.89

From Table 4, it can also be seen that a pasteurisation process did not significantly affect the color of pasteurised milk samples. Even with a higher amount of reducing sugars in the lactose- and glucose-added pasteurised milk samples, the milk color did not differ significantly from the raw milk. Although the color measurement could not show the extent of Maillard reactions in the pasteurised milk samples, the finding could not be interpreted that the Maillard reactions did not occur in pasteurised milk. One explanation for the result, which could not detect the changing of milk color immediately after pasteurisation processes, was because the development of brown pigments as one of the results of condensation of amino compounds and sugar fragments occurred in the final stage of Maillard reactions (van Boekel, 1998). The early stage of Maillard reactions can be observed from the loss of lysine availability as was done by Naranjo et al., (1998). In their experiment, the workers observed the loss of lysine in mixture solutions of casein and various sources of carbohydrates during storage at 37, 50 and 60°C. The research revealed that the loss of lysine could be observed even at 37°C. When the storage temperature was higher, the loss of lysine was also accelerated. Another study by Morales et al., (1996) also unveiled that samples of pasteurised milk showed fluorescence-intermediary compounds, which were recognized as components that were formed before brown pigments in the pathway of Maillard reactions. All of these publications showed that the Maillard reactions still occurred in pasteurised milk. However, the extent of the reactions would depend on the chosen time and temperature of pasteurisation processes and the storage temperature in which the milk would be stored. Since the shelf life of pasteurised milk could be extended (Wirjantoro and Lewis, 1996), the presence of Maillard

reactions in pasteurised milk should be considered carefully, especially at elevated storage temperatures.

The color measurement of pasteurised milk samples by a colorimeter was strongly correlated with the results of sensory analysis for the same parameter. Table 6 shows that panelists could differentiate the honey-added pasteurised milk samples from the other pasteurised milk samples. The honey-added pasteurised milk samples were perceived to have a darker color compared with the other pasteurised milk samples, which was similar to the results using the colorimeter. Whereas for the other pasteurised milk samples, the panelists had a problem to clearly distinguish their colors.

Table 6. Sensory evaluation for the sweetness and color of pasteurised milk samples.

Milk samples	Sweetness	Color
Control	$-1.08 \pm 0.13^{a*}$	-0.44 ± 0.24^{ab}
Lactose-added pasteurised milk	-0.46 ± 0.14^{b}	-0.10 ± 0.26^{bc}
Glucose-added pasteurised milk	-0.01 ± 0.12^{c}	0.04 ± 0.11^{c}
Sucrose-added pasteurised milk	1.13 ± 0.05^{d}	-0.65 ± 0.26^{a}
Honey-added pasteurised milk	0.42 ± 0.17^{e}	1.16 ± 0.00^{d}

* Different letters within one column indicate significant differences at 95% confidential level

Another parameter that was measured by the sensory analysis was the sweetness of pasteurised milk samples. This parameter is not correlated with the amount of reducing sugars in pasteurised milk, instead the sweetness of a specific carbohydrate is more associated with the sugar-ring conformation of that particular carbohydrate that will match with the receptor molecules in the human tongue (Coultate, 1989). From the sensory analysis results (Table 6), it can be seen that panelists could significantly rank the pasteurised milk samples in an order of control, lactose-, glucose-, honey- and sucrose-added pasteurised milk for the least sweet milk to the sweetest milk. These results were in conformity with the relative sweetness of different carbohydrates that were added to the pasteurised milk, which were ranked from the lowest sweetness to the highest sweetness as lactose < glucose < sucrose (Coultate, 1989). For the honey-added pasteurised milk samples, the panelists positioned the milk to be between the sucrose- and glucose-added pasteurised milk samples. This result was a reflection of the main carbohydrate compositions of honey, which are fructose and glucose. Since fructose had sweetness below sucrose and above glucose (Coultate, 1989), the presence of fructose in the honey-added pasteurised milk significantly increased the sweetness of the pasteurised milk itself.

Beside the color and sweetness parameters, a sensory panel was also conducted for the panelist's preference towards the sweetened pasteurised milk samples (Table 7). It was interesting to find out that not even half of the panelists preferred the sucrose-added pasteurised milk which is the main sweetened pasteurised milk in the Thai markets. One-third of the panelists preferred the glucose-added pasteurised milk samples. The addition of glucose in

pasteurised milk will actually give a benefit for people that need a quick energy, since the carbohydrate is a simple sugar that will be easily digested. However, the addition of this sugar would increase the presence of reducing sugars in pasteurised milk. Therefore, another option that can be chosen by the dairy industries is to reduce the amount of added sucrose in their pasteurised products. Besides, the reduction of 4% sucrose addition will reduce the cost of production and the presence of less carbohydrate in pasteurised milk will also be good for children that have problems with obesity.

Table 7. Sensory evaluation for panelist's preference towards the sweetened pasteurised milk samples.

Milk samples	Preference (%)*	Reason
Lactose-added asteurised milk	15	Like a very faint sweet taste/not sweet
Glucose-added pasteurised milk	30	Like a taste that was not too sweet
Sucrose-added pasteurised milk	30	Have the highest satisfaction for sweetness
Honey-added pasteurised milk	25	Like the flavor of honey and the taste and color of the pasteurised milk

* The preference percentage is based on 20 panelists

Another result that should also be considered from the panelist's preference was their preference for the honey-added pasteurised milk samples (Table 7). A quarter of the panelists liked the specific characteristics of this pasteurised milk due to honey addition. This high percentage of result would indicate that honey might be another source of carbohydrates that could increase the value of pasteurised milk. Beside the specific flavor of honey which might be preferable for some groups of people and its popularity for health benefit, the addition of honey would also have an extra advantage by constantly reducing more microorganisms in the pasteurised milk, compared to the other sources of carbohydrate.

CONCLUSION

Pasteurisation process would reduce the number of viable microorganisms in raw milk. The reduction of viable microorganisms was between 1.08 to 3.46 log cfu ml^{-1}, depending on the type of carbohydrates that was added to the raw milk. For the spore count, the pasteurisation process did not show any significant effect. The honey-added pasteurised milk had constantly the lowest number of microorganisms, compared to the other sources of carbohydrate.

Processing raw milk with different types of sugar in the range of pasteurisation condition would not affect the pH, total acidity and viscosity parameters of the pasteurised milk. However, different sources of carbohydrate would significantly influence the amount of reducing sugars and sweetness of the pasteurised milk. Since almost half of panelists preferred pasteurised milk samples that were not too sweet, the Thai dairy industries could reduce the amount of added sucrose in their pasteurised products or use honey as an alterna-

tive source of carbohydrate. Using honey as a carbohydrate source would produce a pasteurised milk with a special color, flavor and taste characteristic.

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