WALAILAK JOURNAL
http://wjst.wu.ac.th Agricultural Technology and Biological Sciences

Color Characteristics and Maillard Reactions of Chicken Meat Jerky with Different Sweeteners during Storage

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Received: 3 October 2014, Revised: 10 February 2015, Accepted: 7 March 2015

Abstract

The color characteristics of chicken meat jerky, prepared with sucrose and mixed sugar (sucrose: fructose: sorbitol 70: 15: 15), were investigated during storage at room temperature under different conditions (vacuum, 33, and 75 % relative humidity (RH) conditions). Changes in color values (L*, a*, b*) and the degree of Maillard reaction of the product were determined. The samples prepared with mixed sugar had more browning (brown color) than the samples prepared with sucrose (dark-yellow color) in all storage conditions ($p < 0.05$). The samples prepared with mixed sugar had a decrease in L* value and an increase in a* and b* value during storage, which corresponded to Maillard reaction development. The values of L*, a*, and b*, as well as the degree of Maillard reaction of samples prepared with the same sugar types, were not significantly different during storage in various storage conditions ($p \geq 0.05$). Sensory scores of the color of chicken meat jerky kept in vacuum and 75 %RH conditions indicated preference within 30 days of storage, while samples stored in 33 %RH condition were acceptable within 15 days of storage.

Keywords: Color, Maillard reaction, chicken meat jerky, sweetener, storage condition

Introduction

Chicken meat jerky is a kind of traditional jerky that is processed similar to Chinese-style jerky meat, by adding a high sugar level for a palatable sweet taste [1]. Sucrose is generally used as marinate sugar in meat products. Currently, sorbitol is added, partially to substitute sucrose in intermediate-moisture meat, for controlling the appropriate water activity (a_w) and texture [2]. Sorbitol is a sugar alcohol that has about 60 % less sweetness than sucrose. It acts as an excellent humectant and plasticizer, to tenderize the jerky meat product [2-4].

Chicken meat was used as the raw material in chicken meat jerky, because of the advantage of a high protein source (about 18 - 22 % wet basis) [5] and having less religious restrictions. However, chicken breast muscle has a low myoglobin content [5], which might result in less brown color development of the product after heat processing. Kranen *et al*. (1999) mentioned that myoglobin content could not be detected in the *Pectoralis* of six-week-old broiler chickens [6]. Color is a quality attribute of chicken meat jerky that affects consumer preference. Wongwiwat and Wattanachant studied the effect of sugar types on quality of sweet-dried chicken meat product. They found different color shades of the product [7]. Product made from sucrose or sorbitol displayed a dark-yellow color, while product made from fructose or lactose displayed a dark-brown color [7]. This was due to sucrose and sorbitol being a nonreducing sugar that has no reducing ends to participate in a Maillard reaction [8-11]. Moreover, fructose is a reactive reducing sugar that can originate browning in jerky product by nonenzymatic browning reactions, mainly in Maillard reactions [12]. Nevertheless, the desirable color of chicken meat jerky is golden-brown. The usage of different sugar types as marinate sugars in chicken meat jerky should be an approach to improve the preferred color appearance. The study of Wattanachant and Adulyatham (2014) found that the application of mixed sugar ingredients in sweet chicken meat jerky had the best acceptable color characteristic through sensory evaluation. The ratio of mixed sugar included sucrose, fructose, and sorbitol, at a ratio of 70: 15: 15, respectively [13].

The chicken meat jerky classified in intermediate-moisture meat products has a_w ranged from 0.6 to 0.9, and moisture content in the range of 10 - 50 % [14,15]. Food stability and other properties can be better predicted from a_w than from water content [16]. Relative vapor pressure (RVP) is the scientific soundness of a_w for estimating food stability ($a_w = p/p_0 = RVP$). There are two aspects related between RVP and equilibrium relative humidity (ERH) (RVP = %ERH / 100). RVP is an intrinsic property of a sample, while ERH is a property of the atmosphere in equilibrium with the sample [16]. Maillard reaction is an important deterioration that takes place in food product during storage. Mathlouthi (2001) concluded that Maillard reaction exhibits an optimum at a_w 0.65 [17]. The extent of Maillard reaction has been monitored by the increase in colorless intermediate product formation (*A*280) and brown color development (*A*420), as well as the decrease in free amino groups, total sugar content, and pH [12,18,19]. The increasing brown color in jerky meat was induced by Maillard reaction [1], leading to change in color [20]. The essential features of color in term L*, a*, and b* indicates lightness or darkness, redness or greenness, and yellowness or blueness, respectively. Furthermore, Chroma (C*) represents the saturation, purity, or intensity of visual color. Hue (h*) angle describes hue or color [21]. The Maillard reaction development was followed by L* value decrease and a* and b* value increase [21,22].

The humidity in the environment particularly changes RVP in food product during storage. In this study, the relative humidity (RH) of storage conditions varied at 33 % and 75 %RH, as well as vacuum condition, which followed the packing and storage condition of the product during sale in the market. In chicken meat jerky prepared for retail without protected packaging, moisture and oxygen permeated into the product. The normal RH environment in Thailand was found to be 75 %RH. Moreover, the 33 %RH was imitated by the RH condition when the product contained moisture absorber in an oxygen/moisture barrier package. Furthermore, the vacuum condition is an alternative packaging to improve the shelf-life quality of food products [23,24]. The objective of this study was to investigate color and Maillard reaction extent of chicken meat jerky prepared with different sugar types (sucrose and mixed sugar), stored under various conditions at room temperatures. The acceptableness of the product was ascertained by color attribute sensory evaluation.

Materials and methods

Chicken meat

The frozen breast chicken meat was purchased from Saha Farms Company Limited (Songkhla, Thailand). The breast chicken meat was obtained from 38 - 42 day-old broiler chickens. The weight of breast meat ranged from 160 to 190 g. Before sample preparation, the meat was thawed at 4 °C for 24 h and the skin removed. The obvious fat and connective tissue were trimmed off. The breast chicken meat was ground using a blender (MK-5086M, Panasonic Co., Ltd., Malaysia) before being prepared as chicken meat jerky. Sugar ingredients, consisting of sucrose, sorbitol, and fructose, as well as salt (NaCl), were of Food grade.

Chicken meat jerky preparations

The ground meat was marinated directly with 2 % salt and 35 % sugar (w/w of meat). The marinate sugars used in this study were divided into 2 treatments, sucrose and mixed sugar (sucrose: fructose: sorbitol = 70: 15: 15). The mixture was held at 4 °C for 15 min before forming a sheet paste with a plastic block into size $4 \times 6 \times 0.3$ cm^3. Moisture content of the samples before drying was approximately 60 - 65 % (wet basis). The sheet paste was preheated in a hot-air dryer at a controlled temperature of 45 °C until 30 ± 3 % of moisture content was obtained by gradually removing water and protein stabilization. The dryer was completed with a rotating-aluminum tray of 3 rpm, an air inlet 3 m/s, and an air outlet 2 m/s (Faculty of Agro-Industry, PSU, Songkhla, Thailand). After that, the dried sheet paste was deep-fried in palm oil at 120 °C for 8 min. Samples were cooled at room temperature for 10 min, and the excess surface oil was blotted with towel paper. The chicken meat jerky were stored at room temperature under different conditions; vacuum packaging (Nylon/LLDPE film), 33, and 75 %RH, for 1 month. The vacuum packing was done with a vacuum device (Audion Elektro, Audionvac VM203, Holland). The storage conditions of 33 % and 75 %RH were set in hermetically plastic boxes (17×30×9 cm^3) which were saturated with $MgCl_2$ and NaCl, respectively. All samples were analyzed for physical and chemical characteristics, as well as sensory evaluated for color attributes on day 0, 3, 7, 15, 22 and 31.

Analysis

Color measurement

The color of chicken meat jerky was measured at the surface of the sample in eight replications, using a HunterLab colorimeter (ColorFlex, USA). Color profiles of lightness (L*), redness (a*), and yellowness (b*) were reported as per the complete International Commission on Illumination (CIE) system. The hue (° h*) and Chroma (C*) values were determined by calculation from equation arctan (b*/a*) and $(a^{*2} + b^{*2})^{1/2}$, respectively.

pH measurement

The pH of samples was determined by homogenizing samples with distilled water at a ratio of 1: 5 (w/v), as described by Han *et al*. [25]. The pH values of homogenate were measured by using a pH meter (Mettler Toledo, Schwerzenbach, Switzerland).

Measurement of UV-absorbance

Absorbance at 280 nm (*A*280) was used to determine the intermediate products of Maillard reaction, as described by Carabasa-Giribet and Ibarz-Ribas [26]. This determination was carried out using a spectrophotometer (UV-1601, Shimadzu, Japan). The method for sample extraction was appropriately modified and prepared by weighing the samples (5 g) and then homogenizing with distilled water at 50 ml. The macromolecules were precipitated with Carrez I and Carrez II solution. The samples were adjusted by volume to 100 ml and filtrated through filter paper No. 1. The supernatant was appropriately diluted with water, in order to have an absorbance signal of less than 0.9.

Browning intensity

Brown color was extracted to indicate the nonenzymatic browning reaction development, as described by Ramírez and Cava [27], with some modification. Samples were homogenized with 40 ml methanol for 1 min, and then the volume of the sample adjusted to 50 ml with methanol. The homogenate was stirred using a magnetic stirrer at room temperature. After 2 h, the homogenate was centrifuged at 8,000×g for 15 min. The absorbance of the supernatant was recorded with a spectrophotometer at wavelength 420 nm (*A*420).

Free amino group content

Free amino group content was determined by the OPA method as described by Nielsen *et al*. (2001) [28]. Samples were dissolved in 5 % sodium dodecyl sulfate (SDS), and subjected to heat at 85 °C for complete protein solubility. The homogenate were centrifuged at 8,000×g for 15 min. The supernatant (400 µl) were added to test tubes containing 3 ml OPA reagents. The mixture stood for exactly 2 min before recording at 340 nm in the spectrophotometer. Serine was used as a standard for measuring.

Total sugar content

Total sugar content in the sample was determined according to the phenol-sulfuric acid reaction [29] with some modification [12]. The sample was homogenized with distilled water and heated in a water bath at 60 °C for 25 min. After cooling, the protein and non-sugar fractions were precipitated with Carrez I and Carrez II solution [30]. The supernatant were appropriate diluted to exact volumes. Briefly, 500 µl of each sample, 500 µl of a phenol solution (5 % w/v), and 2.5 ml of a concentrated sulfuric acid solution were added. Mixtures were vortexed and incubated in boiling water for 5 min and then cooled on ice for 10 min. Absorbance was read at a wavelength of 490 nm. The standard curve was measured with glucose.

Sensory evaluations

A piece of chicken meat jerky collected from each time of storage was served to panelists. Thirty panelists were used, aged within a range of 25 to 30 years, all post-graduate students in the Faculty of Agro-Industry, Prince of Songkhla University, Thailand. The 9-point hedonic scales were used to evaluate the color attribute of the chicken meat jerky. The scores ranged from 1 = dislike extremely to 9 = like extremely.

Statistical analysis

The Completely Randomized Design (CRD) was used to study physical and chemical analysis. The sensory evaluation was conducted using Randomized Complete Block Design (RCBD). All experimental data were analysed by analysis of variance (ANOVA). The statistical analyses were performed at a significant difference level of 95 % ($p < 0.05$), applied by Duncan's Multiple Range Tests (DMRT).

Results and discussion

Color appearance of chicken meat jerky during storage

Figure 1 shows the appearance of chicken meat jerky prepared with different sugar types, stored under different conditions. The results showed that samples prepared with mixed sugar had more browning than those prepared with sucrose at all storage conditions, since day 0 until day 31 of storage. The sample prepared with sucrose on day 0 of storage displayed a dark-yellow color. The sample prepared with mixed sugar displayed a brown color. During storage, the color of samples prepared with sucrose stored at vacuum and 75 %RH condition rarely changed, while the samples stored at 33 %RH condition seemed of a lighter color (pale-yellow) with prolonged storage time. This result was in concomitance with moisture loss from the surface of the sample stored at 33 %RH, as shown by the significant decrease in a_w (**Figure 2**). The samples prepared with mixed sugar were a darker brown along the extended storage time at all storage conditions. It was clearly elucidated by the darker brown in samples stored in day 31 compared to the initial storage. The surface color of samples prepared with mixed sugar kept at vacuum conditions was less changed, compared to the samples kept at 75 and 33 %RH conditions. This might be due to the effect of relative vapor pressure (RVP) or a_w of samples influenced by browning development by Maillard reaction [31,32]. Moisture equilibration between sample and environment during storage at different conditions affected RVP or a_w of the sample (**Figure 2**). The samples kept in vacuum conditions could block the moisture change. The storage condition of 75 %RH resembled the a_w of the samples, resulting in a slight moisture change. The 33 %RH condition could strongly alter the a_w of the samples during storage, leading to higher color changes compared to other treatments.

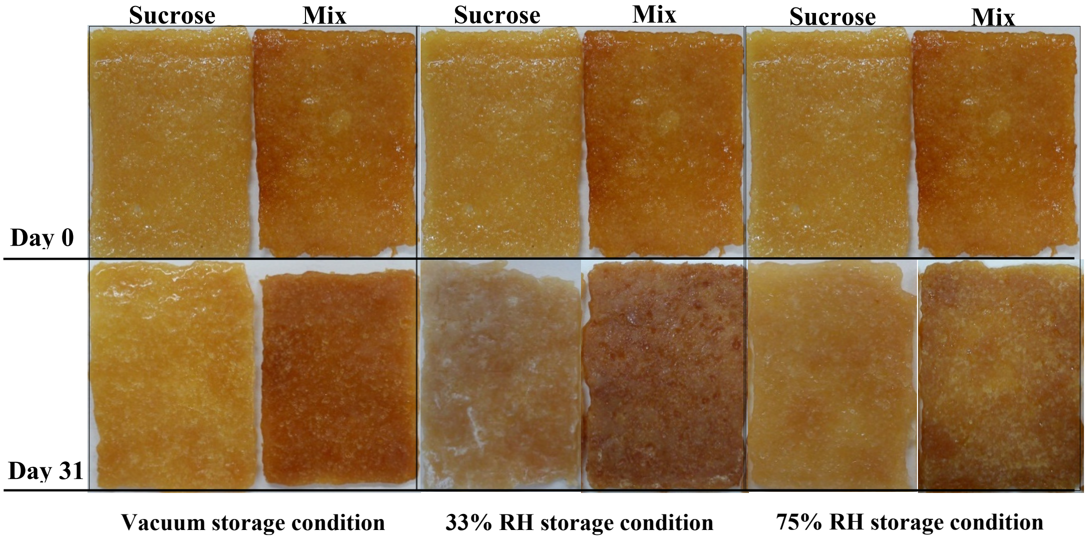

Figure 1 Appearance of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

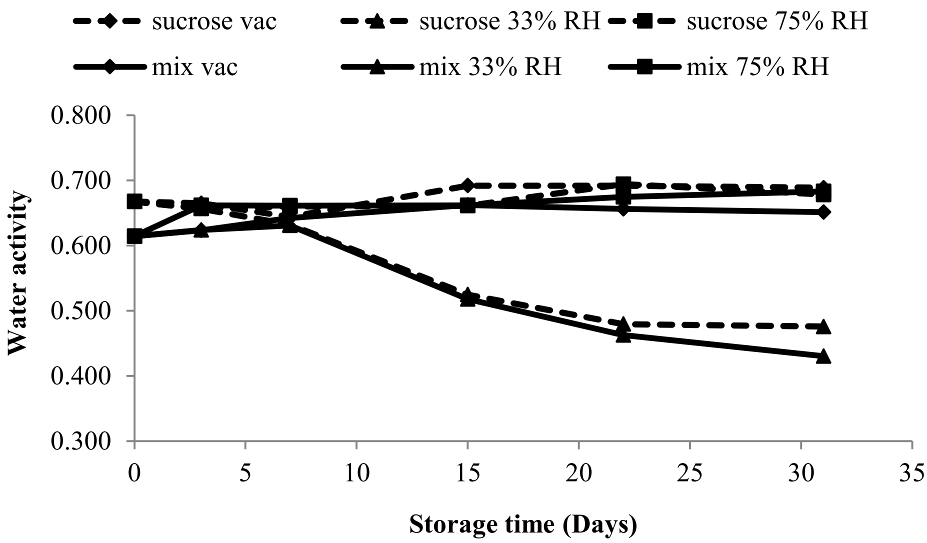

Figure 2 a_w of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

The sensory scores for the color attributes of chicken meat jerky during storage are displayed in **Figure 3**. The color scores of samples prepared with mixed sugar stored at different conditions were markedly higher than the samples prepared with sucrose on day 0 to 15 of storage ($p < 0.05$). The preference for color attributes of chicken meat jerky prepared with mixed sugar on day 0 to 7 of storage ranged from like moderately to like extremely (sensory score ranged from 7 to 8). After day 15 of storage, the samples prepared with sucrose and mixed sugar stored at vacuum and 75 %RH condition had the highest color scores. However, the sensory scores of those treatments were not significantly different ($p \geq 0.05$), which was in the range of neither like nor dislike to like slightly (sensory score ranged from 5 to 6). The lowest scores were observed at samples stored in 33 %RH condition, which were deemed unacceptable by sensory evaluation (sensory score less than 5). This was probably because the sample kept at 33 %RH condition resulted in water loss, and displayed an unacceptable color attribute.

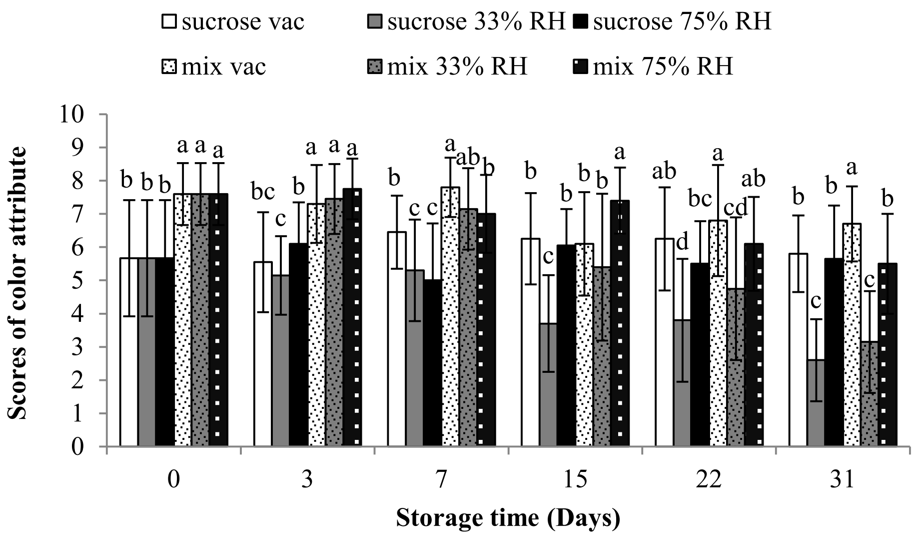

Figure 3 Sensory scores for color of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.
Note a-d means within the same storage time with different letters are significantly different at $p < 0.05$.

Human vision could only qualitatively define product color, but HunterLab instruments could quantitatively separate the scales of color, intensity or vividness. The color appearance of chicken meat jerky prepared with sucrose or mixed sugar and kept under various storage conditions corresponded to the L*, a*, b*, h*, and C* value of the product.

The value of L*, a*, and b* of chicken meat jerky during storage are shown in **Figure 4**. L* values of all samples at different storage conditions after day 15 of storage were significantly different ($p < 0.05$). The samples prepared with sucrose and mixed sugar stored at 33 %RH condition had higher L* value than those stored in conditions of 75 %RH and vacuum conditions, respectively ($p < 0.05$) at approximately 8 - 22 %. The a* value of chicken meat jerky prepared with mixed sugar (8.38) was markedly higher than the samples prepared with sucrose (0.65) ($p < 0.05$). Samples prepared with sucrose and mixed sugar stored at 33 %RH condition had greater a* value than those stored at vacuum and 75 %RH condition, respectively ($p < 0.05$). The b* value of samples prepared with sucrose in all storage conditions was not changed during storage ($p \geq 0.05$). The samples prepared with mixed sugar kept in vacuum and 33 %RH had b* value higher than those kept at 75 %RH conditions ($p < 0.05$) (**Figure 4**).

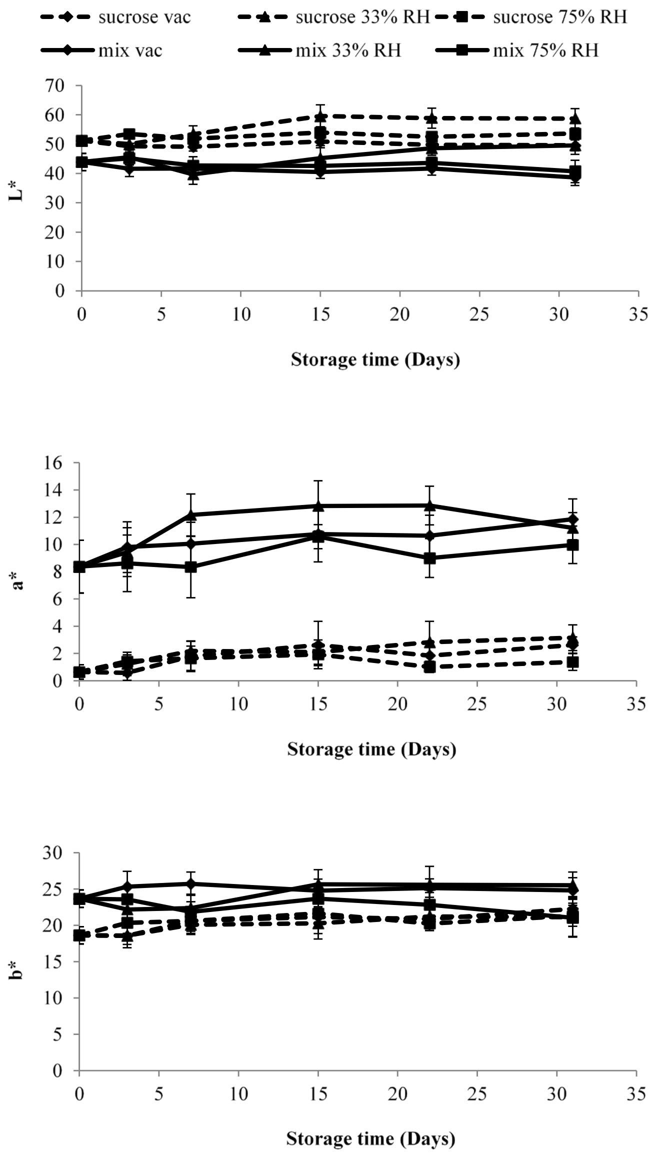

Figure 4 L*, a*, and b* value of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

The values of a* and b* of chicken meat jerky prepared with mixed sugar at all storage conditions tended to increase when the storage time increased, while L* of the samples tended to decrease at extended storage times. Fructose in mixed sugar could generate brown color in the product, resulting in lower lightness (L*) value, as well as higher redness (a*) and yellowness (b*) value [7]. Sorbitol used in chicken meat jerky could not take part in Maillard reaction [8]. The amount of sorbitol probably diluted the extent of browning development in this product. The L*, a*, and b* of samples prepared with sucrose showed little change during storage. Sucrose is a nonreducing sugar that could not participate in Maillard reaction [12]. However, a dark-yellow color was obtained in samples prepared with sucrose, because of some degradation of sucrose with heat processing [33]. The samples kept at 33 %RH condition had the highest L*, a*, and b* values compared to other storage conditions, which corresponded to the appearance of the product (**Figure 1**). Ngadi *et al*. pointed that the decrease in L* value and the increase in a* and b* values of fried chicken nuggets at 190 °C might be attributed to Maillard browning and caramelization at high frying temperatures [22].

Figure 5 displayed h* angle values of chicken meat jerky during storage. It was found that the samples prepared with sucrose had h* values of about 81 to 89, which were higher than the samples prepared with mixed sugar (61 to 71) at all storage conditions ($p < 0.05$). The h* value of all samples decreased as the storage time increased ($p < 0.05$). A Hue angle of 0 ° is red, and 90 ° is yellow [34]. The h* value could identify the color of chicken meat jerky, which was in a range of red and yellow, that is, brown color. The C* value of chicken meat jerky at different storage conditions are shown in **Figure 6**. The results showed that the samples prepared with mixed sugar had more C* value than the samples prepared with sucrose at all storage conditions ($p < 0.05$). The C* value or color intensity of all samples increased when the storage time increased ($p < 0.05$).

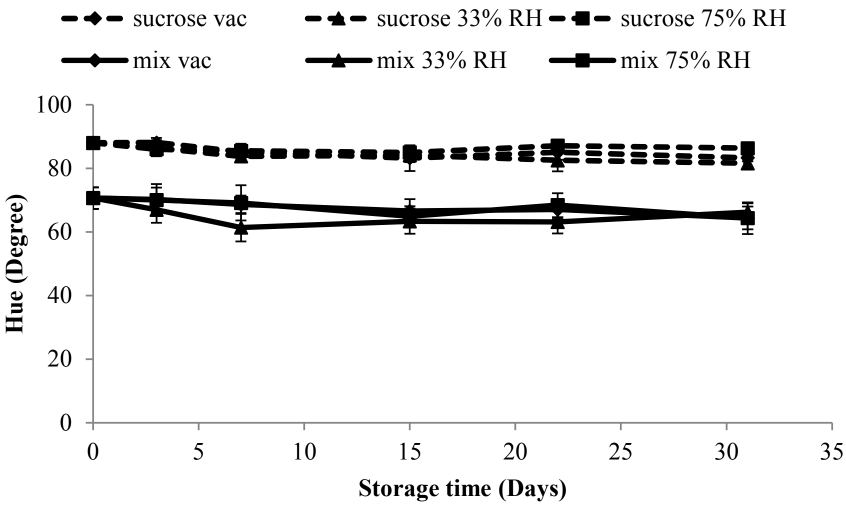

Figure 5 Hue (h*) angle of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

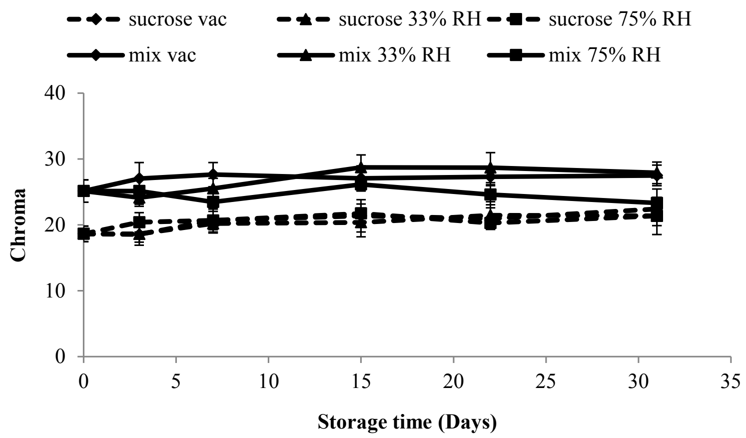

Figure 6 Chroma (C*) of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

Maillard reaction development of chicken meat jerky during storage

The chicken meat jerky prepared with sucrose or mixed sugar showed different color appearances because of Maillard reaction. The extent of browning reaction could be evaluated with the decrease of reactants and pH, as well as the increase in absorbance intensity of the extract at 280 nm (*A*280) and 420 nm (*A*420) [12,35]. **Figure 7** displays free amino group content of chicken meat jerky during storage at various conditions at room temperature. The results showed that free amino groups of all samples decreased when the storage time increased ($p < 0.05$). The samples prepared with mixed sugar consumed higher free amino groups than the sample prepared with sucrose during storage ($p < 0.05$). The availability of free amino groups of samples during storage was calculated and compared with those treatments on day 0 of storage. On day 31 of storage, the lowest availability of free amino groups was found in samples kept at 75 %RH (62.72 %), whereas the samples stored at 33 %RH showed the highest available free amino group contents (90.60 %).

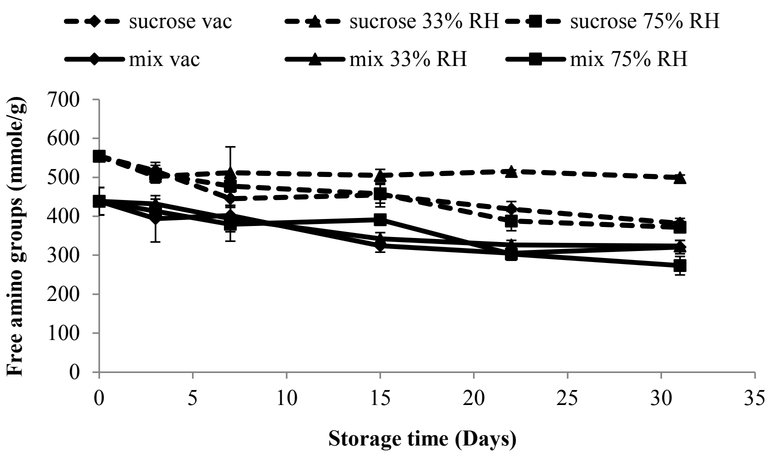

Figure 7 Free amino groups content (mmole/g) of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

The remaining sugar of the samples during storage was also evaluated by comparing with those treated on day 0 of storage. The remaining sugar of the samples prepared with sucrose at all storage conditions had a slight change during storage of approximately 91 - 96 % (**Figure 8**). Samples prepared with mixed sugar had the remaining sugar content less than that prepared with sucrose on day 31 of storage ($p < 0.05$). The percentage of available amino groups and remaining sugar (**Figures 7** and **8**) could indicate the extent of Maillard reaction in the early stage [12]. It was demonstrated that the chicken meat jerky prepared with mixed sugar containing reducing sugar, that is, fructose, originated the high degree of Maillard reaction, resulting in reactants being consumed. The total sugar contents of samples prepared with the same sugar types stored in different conditions were not significantly different ($p \geq 0.05$).

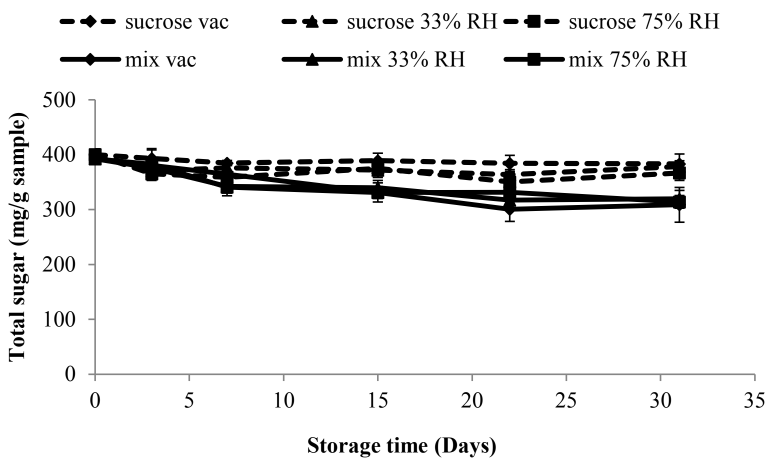

Figure 8 Total sugar content (mg/g) of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

The measurement of sample extracts at absorbance 280 nm (*A*280) and pH pointed to the extent of Maillard reaction development in the advanced stage [36]. The substances absorbed in UV wavelength are the colorless intermediate products which are precursors in Maillard reaction (**Figure 9**) [37]. The *A*280 value of all samples increased at prolonged storage times ($p < 0.05$). The chicken meat jerky prepared with mixed sugar had an intensity of *A*280 more than samples prepared with sucrose at all storage conditions ($p < 0.05$). The samples prepared with sucrose and mixed sugar had the highest *A*280 intensity when stored at vacuum conditions, followed by those stored at 33 %RH and 75 %RH conditions, respectively ($p < 0.05$).

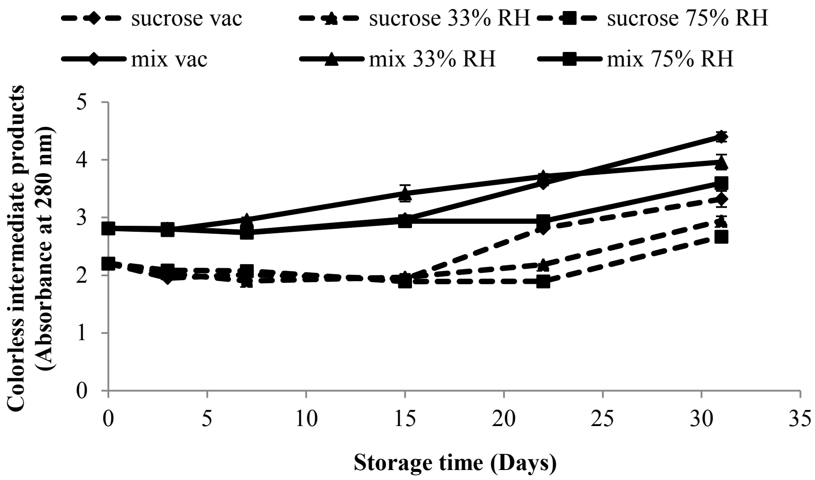

Figure 9 Colorless intermediate products (*A*280) of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

The pH of all samples decreased when the storage time increased ($p < 0.05$) because the formation of organic acids, such as formic acid and acetic acid, are the important end products of Maillard reaction [38]. The samples prepared with mixed sugar had a lower pH than the samples prepared with sucrose ($p < 0.05$), as shown in **Figure 10**. This was probably because Maillard reaction could initiate, since the drying process was at 45 °C, and was further increased in the frying process (120 °C). The effect of fructose acting as a reducing sugar reactant could fasten the formation of intermediate product in the advance stage by decreasing pH. The samples prepared with sucrose and mixed sugar kept at 75 %RH condition had the highest pH decrease compared to the sample on day 0 of storage, approximately 3.10 to 3.20 %. The samples stored at 75 %RH had a_w in a range of 0.6 to 0.7, which accelerated the Maillard reaction to the maximum rate, resulting in a higher pH decrease [39].

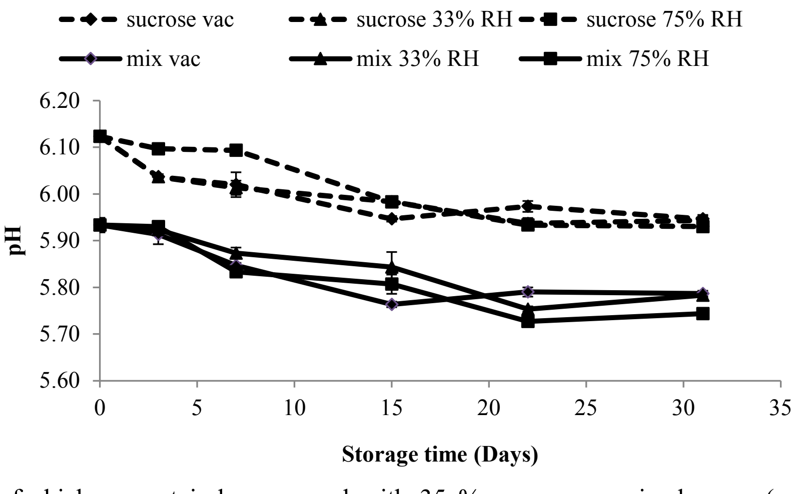

Figure 10 pH of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

Additionally, browning intensity was monitored for *A*420 value to evaluate the extent of Maillard reaction in the final stage [18] (**Figure 11**). It was found that all samples at all storage conditions had an increase of *A*420 at prolonged storage times ($p < 0.05$). Browning intensity of samples prepared with sucrose in all storage conditions was not significantly different ($p \geq 0.05$) during storage. The browning intensity of samples prepared with mixed sugar was markedly greater than those prepared with sucrose ($p < 0.05$). The highest browning intensity as an effect of storage condition was found in samples stored at 33 %RH, followed by storage at 75 %RH and vacuum conditions, respectively ($p < 0.05$). Browning intensity (**Figure 11**) of chicken meat jerky positively related to the surface color (**Figure 1**). The study of Ramírez *et al.* confirmed that the absorbance at 420 of methanol-extraction of color compounds in meat product positively correlated with a*, b*, and C* value; however, L* negatively correlated with extracted color compounds [27].

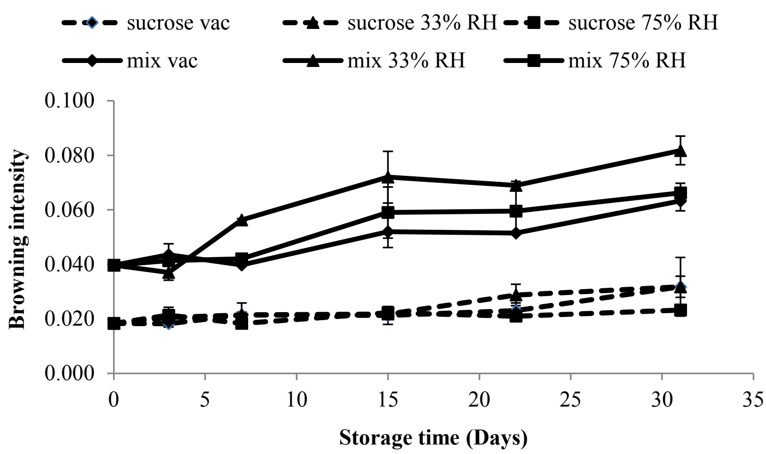

Figure 11 Browning intensity (*A*420) of chicken meat jerky prepared with 35 % sucrose or mixed sugar (sucrose: sorbitol: fructose 70: 15: 15; Mix) (w/w of meat) during storage at room temperature in different storage conditions.

Chicken meat product prepared with mixed sugar had a higher degree of Maillard reaction compared to samples prepared with sucrose. The results were accompanied by a large decrease in total sugar content, amino reactant, and pH, as well as a high increase in colorless intermediate product (*A*280) and browning intensity (*A*420) of samples prepared with mixed sugar. This was because sucrose is a nonreducing sugar and has no reducing ends to interact with amino acids in contribution to Maillard reaction [11]. The effect of storage condition, vacuum, or humidity of environment was not directly influenced by the extent of Maillard reaction in chicken meat jerky.

Nevertheless, the effect of a_w of samples had extreme impact on the degree of Maillard reaction. The samples stored at vacuum and 75 %RH had a_w values in a range of 0.6 to 0.7 during prolonged storage time (**Figure 2**). The samples kept at 33 %RH showed a substantial a_w decrease, in a range of 0.6 to 0.4, when the storage time increased ($p < 0.05$) which corresponded to the highest browning intensity. The maximum rate of Maillard reaction development was in a range of a_w of 0.6 - 0.8, which covered the a_w range of chicken meat jerky kept in all storage conditions [31,32,39,40]. Pan and Melton [39] concluded that the fastest rates of Maillard reaction in lactose and caseinate mixture heated at 60 °C occurred at intermediate RHs (67 to 80 %RH), with a maximum rate close to 75 %RH. Moreover, some investigators observed the maximum rate of Maillard reaction in equilibrated systems of about 0.5 a_w [40,41], probably due to the difference in the nature of samples, heating temperature, heating time, or conditions of reaction, etc. The most alteration in color of chicken meat jerky was found to depend on sugar types and a_w of samples that accelerated Maillard reaction development.

Conclusions

Chicken meat jerky prepared with mixed sugar (sucrose: fructose: sorbitol 70: 15: 15) markedly displayed brown color, while samples prepared with sucrose were of dark-yellow color, because of Maillard reaction development. The usage of mixed sugar could improve sensory color attributes. Storage condition could affect the color and shelf-life of the product. The sensory evaluation of color attribute of chicken meat jerky kept at vacuum and 75 %RH conditions was preferable at 30 days of storage. The samples stored in 33 %RH condition were acceptable within 15 days of storage. The extent of Maillard reaction was indicated by intermediate product formation (*A*280), brown color development (*A*420), decrease in free amino groups, total sugar content, and pH, which corresponding to the L* value decrease and a* and b* value increase during storage.

Acknowledgements

This work was funded by a grant from Prince of Songkla University and the Office of the Higher Education Commission, which supported a CHE Ph.D. Scholarship (CHE 510615).

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