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Quality properties of northern Thai beef sausage (sai-ua-nuea) with different additional levels of selected herbs

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Abstract Different levels of selected herbs (0–20% w/w) were affected northern Thai beef sausage (sai-ua-nuea) quality in terms of color, water activity (a_w), cooking loss, texture, proximate composition, and sensory attributes. The L^* and a^* values were diminished for sai-ua-nuea with higher herb content, while the b^* value unaffected. The a_w value of sai-ua-nuea without selected herbs was 0.93; it raised to 0.96 when adding selected herbs at a ratio of 10–20% of the a_w value. The cooking loss of the samples decreased gradually with the addition of selected herbs. In cooked sai-ua-nuea, selected samples with incorporated herbs showed significantly lower results in all textural parameters (firmness, hardness, springiness, cohesiveness, gumminess, and chewiness) than the control. Proximate analysis results showed that the addition of selected herbs on sai-ua-nuea samples improved their nutritional values. It was found that an increase of selected herbs leads to a higher fiber content and lower fat content in sai-ua-nuea. Regarding sensory characteristics, the addition of selected herbs did not significantly affect any of the sensory scores tested in terms of odor, texture, taste, and juiciness attributes. However, the increased levels of selected herbs decreased the good appearance level more than 10% in terms of color and overall linking scores. Therefore, these results suggested that a suitable addition of selected herbs would be 10% for the development of a healthier sai-ua-nuea product.

Keywords: Northern Thai beef sausage, Herb, Fiber, Texture

Introduction

One of the predominant economically viable forms of livestock raised in Thailand are beef cattle (FAO, 2002). The utilization of beef cattle is typically for meat production. In recent years, the consumption of marbling meat has increased. Marbling is a term used to define the content of fat inside beef muscle, known as intramuscular fat tissue (Boonsaen *et al.*, 2017). Since this product is growing in demand, premium meat qualities, i.e., tenderness and juiciness characteristics, are becoming more of a concern. Consequently, portions of minced meat produced in the trimming, shredding, and cutting

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process are often deemed undesirable for utilization and thus are seen as having a lower value. These portions are known as comminuted meat (Bolger *et al.*, 2017). It is important to properly present minced beef with a comminuted meat value as having an extended shelf life and added value.

Sai-ua is a traditional form of northern Thai sausage, and it is one type of comminuted meat product. It is important to note that sai-ua is not the only famous authentic local food in the northern of Thailand, but that it contributes as a healthy product due to its nourishing ingredients. Sai-ua can be produced from minced meat, mainly pork, mixed with herbs and spices, namely: dried chili, kaffir lime leaf, lemongrass, garlic, shallot, turmeric, as well as seasoning. All ingredients are generally stuffed into porcine intestines or artificial casings and then baked or grilled (Luangvaree *et al.*, 2017).

It is well known that beef and meat products are an important source of protein, fat, vitamins, trace minerals, and other nutrients with significant health benefits (Pereira and Vicente, 2013). However, some beef product characteristics might not be attractive, like the dark color and strong flavour, resulting in unacceptability for the consumers. To avoid these problems, the addition of selected fragrant herbs is employed. Besides this, the development of meat products is increasingly focused on the consumption of healthier products with the reduction or elimination of saturated fat (Ospina *et al.*, 2012), as well as enrichment with nutritious ingredients such as fiber (Sánchez-Zapata *et al.*, 2013), and herbs (Półtorak *et al.*, 2018). The addition of herbs to meat products increases the nutrition values and exhibited antimicrobial properties. Jayawardana *et al.* (2015) reported that the addition of 0.50% drumstick (*Moringa oleifera*) leaves in chicken sausages could decelerate lipid oxidation and decreased microbial load without affecting their colors and sensory qualities. Bae *et al.* (2019) revealed that an increase of 0.5% turmeric power improved water retention capacity and inhibited lipid oxidation as well as the total microbial count of sliced meat in Korean dishes as called Pyeonyuk.

The aim of this work was to test the development of northern Thai beef sausage (sai-ua-nuea) with different additional levels of selected herbs and to evaluate their physicochemical and sensory characteristics.

Materials and methods

Raw material

Beef meat samples, including lean finely-textured beef is derived from the trimmings of beef cuts (top round, bottom round, and chuck) and beef back fat, were obtained from Phayao beef, Phayao province, Thailand. Other

ingredients include porcine intestine, herbs, spices, and seasoning, these were purchased from a local market in Phayao, Thailand.

Preparation of northern Thai beef sausage (sai-ua-nuea)

To properly produce northern Thai beef sausage (sai-ua-nuea), the ingredients were prepared. Briefly, the comminuted meat and fat were stored at 4℃ in the refrigerator before sai-ua-nuea processing. All the curry paste ingredients were ground with a coarse component for 1 min using a blender to prepare the sai-ua-nuea mixture. The sai-ua-nuea formula was 60.4% minced lean beef, 15.1% minced fat, 17.4% curry paste, 1.5% fish sauce, 1.3% shrimp paste, 1.3% salt, 1.0% soy sauce, 1.0% sugar, and 1% gourmet powder. The main ingredient (minced lean beef and minced fat), curry paste, and seasoning were manually blended thoroughly in a mixing bowl. Other selected herbs, sliced spring onion (*Allium fistulosum*) and culantro (*Eryngium foetidum*), were added to the manufactured sample. Each selected herb was prepared in a ratio of 0, 10, 15, and 20 %, compared to the main ingredients, with the first ratio, 0, named as control, and the following above ratios T1, T2, and T3, respectively, and then mixed again until they were sticky. The mixture was then stuffed into porcine intestines, and then the casings were closed and chipped. Samples were cooked in an air convection oven (CO-709, OTTO, Thailand) until their internal temperature reached 70±2 ℃, which was assessed using a thermocouple probe.

Color measurement

The Hunter color values CIE system (lightness, L^*; redness (+)/greenness (-), a^*; yellowness (+)/blueness (-), b^*) of the cooked samples were determined with a colorimeter (Hunter Lab, Color Quest XE, USA). Color determination was performed in 5 repetitions.

Water activity

The water activity (a_w) of the cooked samples was assessed using an electronic dew-point water activity meter (AquaLab 4TE, Decagon Devices Inc., Pullman, WA, USA). Each measurement was done in three replications.

Texture analysis

Warner-bratzler shear test

Firmness was determined using the method of de Huidobro *et al.* (2005) with a Texture Analyser (TA–XT Plus, Stable Micro Systems Ltd., Surrey,

UK). The samples were cut into chunks of 3 cm thickness and then pressed down with a blade set of the Warner Bratzler at a constant pre-test speed of 3.0 mm/sec, a test speed of 2.0 mm/sec, and a post-test speed of 5.0 mm/sec. The texture analyzer was calibrated with 50 kg maximum load cell. Firmness value was expressed in kg.

Texture profile analysis *(*TPA*)*

The texture profile analysis was done according to de Huidobro *et al.* (2005). Cooked samples were uniformly cut into 1 cm thick slices and were tested with Texture Analyser (TA–XT Plus, Stable Micro Systems Ltd., Surrey, UK). Samples were compressed to 60% of their original height with a cylindrical probe of 50 mm in diameter (P/50) at the following settings: Load cell, 50 kg, pre-test speed, test speed, and post-test speed were 1, 2, and 5 mm/sec, respectively, and time before the second compression was set at 5 sec. The texture profile parameters were determined and then each measurement was done with 5 replicates and the average value was reported.

Cooking loss

Briefly, cooking loss was determined following the procedure of Ángel-Rendón *et al.* (2019). The weight of the sample was recorded before (W_{bc}) and after cooking (W_{ac}), and cooking loss was calculated based on the following equations:

$$Cooking\ loss\ (\%) = \frac{W_{bc} - W_{ac}}{W_{bc}} \times 100$$

Proximate analysis

The approximate composition (moisture, protein, ash, and fat content) of cooked sai-ua-nuea was determined using the official standard method (AOAC, 2012). Unless otherwise stated, all reagents used in this study were of analytical grade.

Sensory evaluation

Sensory analysis of the sai-ua-nuea was executed immediately after cooking. Thirty untrained panellists evaluated the sensory attributes of cooked sai-ua-nuea using a 9-point hedonic scale. All samples were randomly assigned labels with three-digit numbers and served to the assessors. Sensory attributes in terms of appearance, color, odor, taste, texture, juiciness, and overall linking of the sai-ua-nuea were estimated on a scale of 1–9 (1 = extremely disliked, 9 = extremely liked).

Statistical analysis

Data is presented as mean ± standard derivations. The experiment was replicated 3 times, and IBM SPSS Statistic 22.0 software was used for the statistical analysis. A one-way ANOVA was performed for the significant test between each sample. Significant differences (p<0.05) among the means were compared using Duncan's new multiple range test.

Results

The effect of different levels of selected herbs on the physicochemical characteristics of sai-ua-nuea

The effect of different levels of selected herbs on the color parameters in sai-ua-nuea is summarized in Table 1. Lightness (L*), redness (a*), and yellowness (b*) values were estimated for the sai-ua-nuea with different selected herb content. The L* values of the samples ranged from 46.17 to 47.63 and tended to decrease with the increasing addition of selected herbs. The sai-ua-nuea control samples (selected herbs 0 %) had a higher lightness (L*) value than that of T2 and T3 but were not significantly different compared with T1. The redness (a*) value of the sai-ua-nuea with the addition of various selected herbs was in the range of 3.90 to 6.38. The highest a* value was found for sai-ua-nuea without selected herbs (control) (p<0.05). The results showed that the yellowness (b*) value ranged from 21.61 to 25.02. No statistically significant difference in the yellowness (b*) value was observed among treatments (p>0.05).

As a result, the a_w value of sai-ua-nuea increased as selected herb content was increased (Table 1). The a_w value of sai-ua-nuea without and with selected herbs showed a statistical difference (p<0.05). The highest a_w value was observed in the T1, T2, and T3 treatments and was equal to 0.96, while the a_w value of the control batch was 0.93 with the significantly lowest value (p<0.05).

Table 1. Color parameter and a_w of sai-ua-nuea with different levels of selected herbs

Parameter	Control[1/]	T1	T2	T3
L*	47.63 ± 0.03 [a2/]	46.95 ± 0.40 [ab]	46.32 ± 0.38 [bc]	46.17 ± 0.10 [c]
a*	6.38 ± 0.22 [a]	4.60 ± 0.57 [b]	3.90 ± 1.16 [b]	4.19 ± 0.59 [b]
b*	21.61 ± 0.55 [a]	25.02 ± 2.01 [a]	23.84 ± 0.68 [a]	24.59 ± 2.33 [a]
a_w	0.93 ± 0.01 [b]	0.96 ± 0.00 [a]	0.96 ± 0.00 [a]	0.96 ± 0.00 [a]

1/: Control, selected herbs 0 %; T1, selected herbs 10 %; T2, selected herbs 15 %; T3, selected herbs 20 %

2/: Mean ± SD with different superscript letters indicate significant differences (p<0.05)

Table 2. Textural parameters of sai-ua-nuea with different levels of selected herbs

Textural parameters	Control[1/]	T1	T2	T3
Firmness (kg)	7.36 ± 0.71 [a2/]	6.82 ± 0.28 [a]	5.75 ± 0.40 [b]	4.49 ± 0.71 [c]
Hardness (N)	352.73 ± 41.48 [a]	172.63 ± 6.80 [b]	170.07 ± 8.76 [b]	157.84 ± 4.97 [b]
Springiness (mm)	0.80 ± 0.06 [a]	0.73 ± 0.02 [ab]	0.72 ± 0.04 [ab]	0.71 ± 0.06 [b]
Cohesiveness	0.42 ± 0.03 [a]	0.41 ± 0.04 [a]	0.31 ± 0.05 [b]	0.28 ± 0.04 [b]
Gumminess (N)	15,179.75 ± 1519.73 [a]	7,196.61 ± 682.56 [b]	5,478.43 ± 1061.36 [bc]	4,477.82 ± 4422.32 [c]
Chewiness (N x mm)	12,163.29 ± 1747.21 [a]	5,262.92 ± 485.51 [b]	3,954.39 ± 721.10 [bc]	3,144.66 ± 371.97 [c]

1/: Control, selected herbs 0 %; T1, selected herbs 10 %; T2, selected herbs 15 %; T3, selected herbs 20 %

2/: Mean ± SD with different superscript letters indicate significant differences (p<0.05)

The textural parameters of sai-ua-nuea prepared with different levels of selected herbs are shown in Table 2. The addition of selected herbs led to a decrease in the sai-ua-nuea texture profile (firmness, hardness, springiness, cohesiveness, gumminess, and chewiness). The control and T1 samples had a higher value of firmness compared to other samples with added selected herbs, ranging from 4.49–7.36 kg. The hardness values of sai-ua-nuea were in the range of 157.84–352.73 N. The control sample had the highest value in terms of hardness, compared to the sample with added selected herbs (p<0.05). There was no significant difference in the hardness value of the sai-ua-nuea among treatments formulated with selected herbs (p>0.05). The control group presented a higher springiness value than that of the T3 treatment while the T1 and T2 sample results were insignificant, being in the range of 0.71 to 0.80 mm. In addition, no significant difference in cohesiveness was observed between the T1 treatment and the control, but there was a statistical difference in the T2 and T3 treatments. Gumminess and chewiness were influenced by the addition of selected herbs. Both parameters, containing selected herb samples, had a more minimal value than the control one (p<0.05).

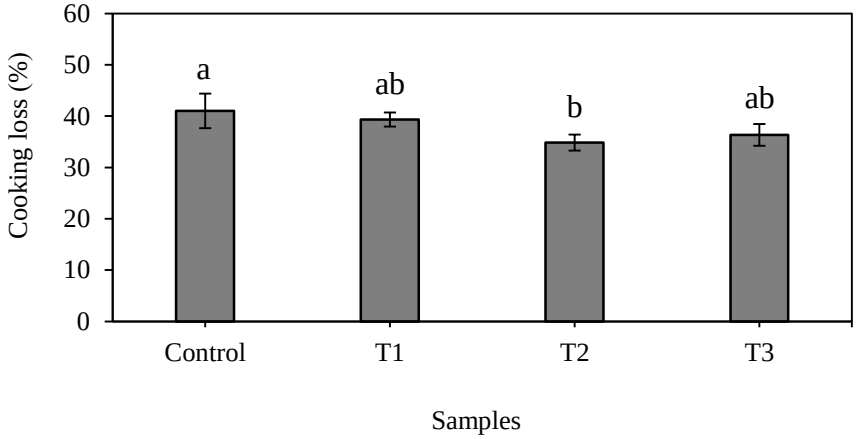

Figure 1. Cooking loss (%) of sai-ua-nuea with different levels of selected herbs, Control, selected herbs 0 %; T1, selected herbs 10 %; T2, selected herbs 15 %; T3, selected herbs 20 %

The effects of different levels of selected herbs on cooking loss are presented in Figure 1. The cooking loss level of sai-ua-nuea with selected herbs was in the range of 34.87–41.01%. The result showed that the cooking loss of samples with selected herbs slightly decreased when herbal levels increased. The control group displayed the highest level of cooking loss at 41.01% and was significantly different (p<0.5) when compared with the T2 sample (34.87%). However, cooking loss for the control, T1, and T3 samples was not significantly different (p>0.5).

Table 3. Proximate composition of sai-ua-nuea with different levels of selected herb

Proximate composition (%)	Control[1/]	T1	T2	T3
Moisture	42.23 ± 3.30 [b2/]	46.32 ± 3.24 [ab]	51.97 ± 2.65 [a]	52.16 ± 2.69 [a]
Fat	19.60 ± 0.10 [a]	15.98 ± 0.10 [b]	12.88 ± 0.07 [c]	11.82 ± 0.38 [d]
Protein	23.39 ± 0.52 [a]	22.87 ± 0.91 [ab]	21.06 ± 0.93 [bc]	20.33 ± 0.40 [c]
Fiber	3.34 ± 0.28 [b]	5.05 ± 0.49 [a]	5.37 ± 0.93 [a]	6.04 ± 1.09 [a]
Ash	4.35 ± 0.12 [a]	3.95 ± 0.23 [ab]	3.93 ± 0.30 [ab]	3.70 ± 0.20 [b]
Carbohydrate [ns]	7.09 ± 3.47	5.82 ± 3.62	4.79 ± 4.56	5.94 ± 2.98

1/: Control, selected herbs 0 %; T1, selected herbs 10 %; T2, selected herbs 15 %; T3, selected herbs 20 %

2/: Mean ± SD with different superscript letters indicate significant differences (p<0.05)

ns = not significant different

The results of the proximate analysis of sai-ua-nuea with different levels of selected herbs are listed in Table 3. There existed significant differences in moisture, fat, protein, fiber, and ash content among the different treatments. As expected, moisture and fiber content were shown to increase with the increasing addition of selected herb content. The moisture content of sai-ua-nuea with mixed selected herbs was 42.23–52.16%. It has been found that sai-ua-nuea with added herbs in the T3 group had the higher moisture content, equal to 52.16% more than that of the control batch; however, this result showed no significant variance from the T1 and T2 treatments ($p>0.5$). Interestingly, the fiber content was dramatically affected by the addition of selected herbs. In the T3 sample the fiber content was shown to be at 6.04%, which was not significantly different ($p>0.5$) from the T1 and T2 samples, equal to 5.05% and 5.37%, respectively, but was significantly different ($p<0.05$) from the control group. The fat content of the sai-ua-nuea ranged between 11.82 and 19.60%. The results revealed that the highest fat content was to be found in the control sample, with a value of 19.60% ($p<0.05$). All samples with added selected herbs, especially the T3 treatment, had a lower fat content than the sample with 0% selected herbs ($p<0.05$). The protein content of the T2 and T3 samples was significantly lower than that of the control treatment. The value was between 20.33–23.39%. The ash content of the sai-ua-nuea treatments ranged from 3.70 to 4.35%. Moreover, the ash content tended to decline with the addition of selected herbs. The control sample appeared to exhibit a significantly ($p<0.05$) higher ash content than the T3 samples, however, this result did not vary significantly from those of the T1 and T2 treatments. In contrast, there was an insignificant difference ($p>0.5$) between treatments in terms of carbohydrate content, ranging from 4.79 to 7.09%.

The effect of different levels of selected herbs on sensory evaluation of sai-ua-nuea

The results obtained the sensorial analysis of the different treatments of sai-ua-nuea used in the study is shown in Figure 2. The results illustrated that appearance and color scores were affected by the incorporation of selected herbs. The control and T1 treatments received the highest scores, while a gradual decrease in score was observed as a function of further increases in selected herb content. With regards to the overall scores, they ranged from 6.77–7.60, with the maximum level obtained from the T1 sample (7.60). The T1 sample presented a greater score than the T3 sample ($p<0.05$), but it was a nonsignificant difference when compared with the control and T2 treatments ($p>0.05$). Additionally, the lowest scores for color and overall linking were for the T3 treatment, which was found to be 6.40 and 6.77, respectively. No

significant differences were observed for odor, texture, taste, and juiciness among all treatments (p>0.5). Based on all the attributes, the T1 treatment scored 7.00, 7.07, 7.03, 7.37, 7.00, and 7.60 for color, odor, texture, taste, juiciness, and overall linking, respectively, whereas its score was second highest in term of appearance at 7.03. The control treatment scored the highest for appearance with scores of 7.23. In this study, it was shown that 10 % of the selected herbs should be added to sai-ua-nuea for a better sensorial result.

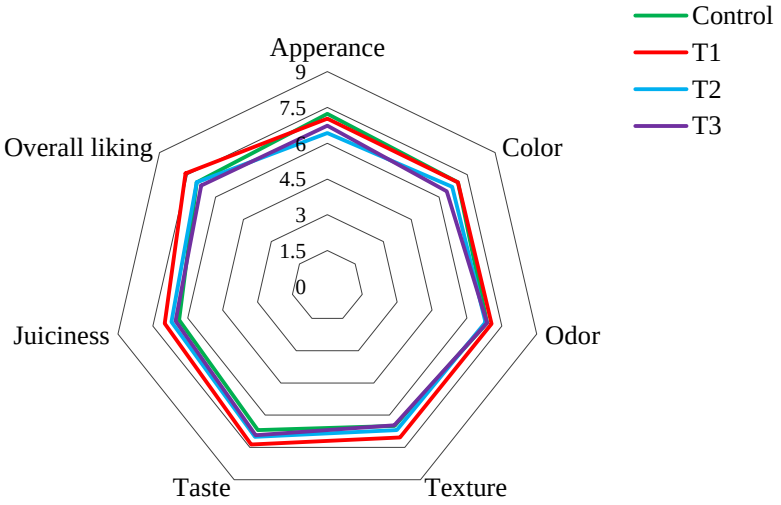

Figure 2. Sensory evaluation of sai-ua-nuea with different levels of selected herb, Control, selected herbs 0 %; T1, selected herbs 10 %; T2, selected herbs 15 %; T3, selected herbs 20 %

Discussion

Regarding the color characteristics of cooked sai-ua-nuea, the levels of selected herbs affected the lightness (L*) and redness (a*) parameters of sai-ua-nuea. The lightness (L*) and redness (a*) had a declining trend as the selected herb levels were increased. These results are in concordance with Hawashin *et al.* (2016) who demonstrated that the addition of destoned olive cake powder resulted in the darkening of beef burgers. Essid *et al.* (2018) reported similar results, having observed a lightness (L*) and redness (a*) value reduction in dry ewe sausages formulated with rosemary powder. For this research, the darker color of the sai-ua-nuea could have been due to the greenish color of the spring onions and culantro that were added. Additionally, Serdaroglu *et al.*

(2018) stated that the highest redness value in their experiment with beef patties was obtained without the addition of dried pumpkin pulp and seeds, this was attributed to the control patties only having contained minced beef, which has a high myoglobin level.

It should be noted that a higher difference was observed in the a_w value of cooked sai-ua-nuea with added selected herbs, when compared to the control sai-ua-nuea. However, Salejda *et al.* (2016) did not observe any alteration in the a_w value when they added walnut green husk to cooked sausages. Noticeably, in the current study the addition of fresh spring onion and culantro, which both have very high a_w content, resulted in a higher a_w value in sai-ua-nuea formulated with selected herbs. Sai-ua-nuea is a sausage with a high a_w (a_w = 0.93–0.96) which was the optimal point for microbial growth. Thus, it allowed a susceptible spoilage evolution when microorganism contamination occured, and inappropriately employed preservation methods. To control the growth of microorganisms and avoided the shortened shelf life, it should be vacuumed seal and stored at low temperature chilling or freezing, which would positively affect.

In terms of the texture properties, the addition of selected herbs had a significant effect on the textural parameters of sai-ua-nuea. All parameters decreased when the selected herbs were incorporated. These results indicated that a softening effect had been observed when the selected herbs were added to samples. The softness of sai-ua-nuea by adding fresh herbs was possibly increased due to the ingredients that helped to absorb and retained moisture. Furthermore, the presence of fresh herbs might reduce the binding ability among proteins rather than the water-binding property of the meat products. This result related to the effect of dietary fiber presented in fresh herbs. Our study revealed that adding fresh herbs with high dietary fiber to sai-ua-nuea increased softness because dietary fiber may disturb the protein-protein or protein–water gel network (Choi *et al.*, 2019, Salejda *et al.*, 2016). The obtained results are in agreement with Savadkoohi *et al.* (2014) who studied the effects of tomato pomace on the textural attributes of beef ham. Moreover, similar results were reported by Syuhairah *et al.* (2016) who found that chicken sausage containing vegetables had a lower hardness, springiness, adhesiveness, cohesiveness, and chewiness than that of the control group.

During the processing of meat, its ability to bind water and fat after heat denaturation of the protein can be measured by cooking loss, which, in meat products, is considered an indicator that determines the yield of the cooking method and affected meat characteristics (Pathare and Roskilly, 2016). Within our study, cooking loss showed a slightly decreasing trend in the samples with selected herbs added, compared to those in the control group. It may be due to

the high dietary fiber content in the spring onion and culantro herbs, which functioned in a water binding capacity (Jeong and Han, 2019). Similar results were reported that beef sausage was incorporated with different levels of pomegranate peel powder (El-Nashi *et al.*, 2015). Choi *et al.* (2019) , and showed that the reduction of cooking loss in pork sausages was affected by the addition of an appropriated amount of cacao bean husk as dietary fiber.

Based on the results of a proximate analysis, it was found that progressive increased in the level of selected herbs concurrently increased the moisture and fiber content of cooked sai-ua-nuea products. It was due to the presence of fresh selected herbs, which contained a higher moisture content. It should be noted that the addition of selected herbs was an important factor with regards to fiber content, but fat and protein content showed decreasing trends. Some studies concerning meat products resulted to the moisture retention and water-binding capacity were affected by dietary fiber content. It would increase the amount of dietary fiber (Choi *et al.*, 2019, Ham *et al.*, 2017). Comparable outcomes were reported by Jeong and Han (2019), who found that the addition of Wanggasi-Chunnyuncho (*Opuntia humifusa* f. *jeollaensis*) fruit powders at increased concentrations leded to increase moisture and total dietary fiber content, diminished protein and fat content. Furthermore, Zargar *et al.* (2014) reported that the moisture and fiber content of chicken sausages increased significantly with increasing levels of pumpkin pulp.

According to the data obtained for sensory evaluation, the addition of selected herbs was not significantly changed in the odor, texture, taste, and juiciness attributes of the sai-ua-nuea. Concerning appearance, color, and overall liking, the scores for the samples enriched with selected herbs showed a gradual decline at higher content levels. The score afforded to these attributes decreased as the level of selected herbs which increased over 10%. The progressive decreased in appearance, and color scores that could be correlated with the panelists' expectations of a lower greenish color for sai-ua-nuea. Besides, a gradual decline of overall liking might be related to the lower scores for appearance and color attributes. Hence, the T1 sample was more acceptable than any of the other treatments, the panellists were higher score of 7 for all attributes. Typically, when developing a new product using a 9-point hedonic scale which score of 7 that indicated to be moderately liked (Hobbs *et al.*, 2014). Similar to our results, a study presented by Hawashin *et al.* (2016) found no significantly changed in the sensory attributes of beef patties due to the incorporation of destoned olive cake powder to 4%, but beef patties with high concentration at 6% showed significantly decreased sensory values. Likewise, Lopez-Vargas *et al.* (2014) reported that the utilized additions of passion fruit albedo in pork burgers found that the samples added with 2.5% of passion fruit

albedo showed higher scores in overall acceptability than those with 5% of the passion fruit albedo.

In conclusion, the different levels of selected herbs in the sai-ua-nuea products were recorded for their physicochemical, textural, and sensorial characteristics. Spring onion and culantro were used as the selected herbs in the sai-ua-nuea samples. With increased in the selected herbs, it was less adversedly affected on cooking loss. Additionally, the incorporation of selected herbs in sai-ua-nuea improved the texture and functional qualities. According to the sensory scores, there was not over 10% addition of the selected herbs which can be recommended to produce a quality sai-ua-nuea product as a dietary fiber source. This finding indicated that the addition of selected herbs seems to be an alternative gastronomic for developing comminuted meat products, which would be beneficial for consumers' health.

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