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Research Article

Antioxidant activity and sensory evaluation of mixed vegetables (*Piper sarmentosum* Roxb. and *Brassica rapa* subsp. *pekinensis*) crispy snack

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Abstract - This research aimed to examine the antioxidant activity, chemical, physical properties and sensory evaluation of mixed vegetables (Cha-Plu, *Piper sarmentosum* Roxb. and Chinese cabbage, *Brassica rapa* subsp. *pekinensis*) crispy snack (MVCS). Three treatments of MVCS with varying ratio of vegetables (*P. sarmentosum* : *Brassica rapa* subsp. *pekinensis*) comprising MVCS (2:1), MVCS (1:1), and MVCS (1:2) were examined. The increasing of *P. sarmentosum* showed a significant on ash (20.21±0.19^a) and crude fiber (13.85±0.13^a). However, other proximate composition such as crude lipid, crude protein and carbohydrate were not a significant difference (P ≥0.05). Meanwhile, MVCS (1:2) that with high ratio of Chinese cabbage had the highest lightness (65.03±0.98^a). Regarding texture profile analysis, MVCS (1:2) showed the highest force on hardness (N) (172.40±3.03^a) but the minimum crispness (N) of 6.73±3.03^c was noted for MVCS (2:1). Besides, the highest total phenolic content (650.20 mg/100 g DW) and DPPH radical-scavenging activity (898 mg Trolox equivalent mg/100 g DW) were observed in MVCS (2:1). Regarding sensory evaluation, the majority of panelists scored 7.63±1.16^a out of 9 for MVCS (1:1) on the overall acceptability and other dimensions also received the highest score among three samples. Therefore, the nutrition value and sensory evaluation results from this study indicated that mixed Cha-Plu and Chinese cabbage could produce a snack with significant higher antioxidant activity and a variety of healthy snacks in order to capture the opportunity in a healthy food market.

Keywords: Antioxidant activity, ready-to-eat snacks, crispy vegetable, sensory evaluation, chemical properties

1. Introduction

A large natural fiber source is vegetable and it is recognized to a healthy diet food by World Health Organization (World Health Organization, 2019). Nonetheless, not only fiber but also it is a crucial source of multiple components such as vitamin mineral and antioxidant compounds namely phenolic compound (López-Hernández *et al.*, 2022). González-Jiménez *et al.* (2015) stated that vegetable consumption on a daily day could provide more benefits on health in terms of a protective effect against some diseases as an example of diabetes, obesity and coronary heart. The variety of vegetables would contain a different nutrition therefore people have to choose the various colors and types of vegetables to consume in order to digest those benefits. However, most vegetable needs to cook before intake by using the traditional heat treatment comprising boiling, blanching or steaming. The process of cooking could reduce the nutrition value and change in the chemical composition of vegetable. Similarly, previous studies reported that broccoli (*Brassica oleracea* var. *italica*) cooked by microwaving at 5 minutes increasing total polyphenol content up to 12% but reducing 60% in boiling at 10 minutes (López-Hernández *et al.*, 2022). Thus, a fresh vegetable may be suitable for consumption but some vegetables have some compounds such as oxalic acid that still need to cook before eating. Besides, Nicklett and Kadell (2013) suggested that older and adult people should consume vegetables and vegetable products as a daily routine because they can prevent the exacerbation of geriatric conditions namely falls and walking disability. In addition, vegetable-based foods are a novelty product and it provides a metabolic health and positive effect on the inflammatory (Torres *et al.*, 2022).

The exciting market would be healthy snacks because consumers tend to increase expenditure on this market by around 2% a year-over-year and it is expected to expand the annual growth rate to 5.1% from 2018 to 2025 (Grant view research Inc., 2017; Nielsen ICC., 2014; Chen *et al.*, 2018). High awareness on health leads to raise the demand for healthy snack products. Nonetheless, this kind of product still presents as dried-vegetable or vacuum fried products and the main materials would be banana, tomato, sweet potato, carrot and mushroom. Thus, other nutritional vegetables could become alternative sources in order to respond to a consumer requirement in the near future of a healthy snack market. However, Stokkom *et al.* (2019) suggested that consumers accepted the combinations of vegetable more than single vegetable. The result showed that the combination of green bell pepper with carrot (1:2) increased sweetness and the different ratio (2:1) reduced bitterness. Therefore, mixed-vegetable snack would attract more chance on a consumer satisfaction.

The leaves of Piper sarmentosum Roxb. (Piperaceae), (*P. sarmentosum*) are widely used in cuisines of South Asian and distributed in Malaysia, India, Thailand and other countries in the southeastern region (Raman *et al.*, 2012; Sun *et al.*, 2020). Thai people call Cha-Plu as a local name and it is a crucial ingredient of Miang kham. This kind of food is a roll snack with several ingredients including roasted-coconut, dried-shrimp, chili, roasted-peanut, shallots, small cube ginger, cube lime, wrapped with a leaf of *P. sarmentosum* and topping with special sauce in a single bite. The leaf is green leaf, unique taste, specific aroma and it is categized to Chinese herbal medicine in China. The leaves and stems extraction exhibits antimicrobial activity, rich of antioxidant activity and anti-inflammatory (Masuda *et al.*, 1991; Hussain *et al.*, 2009; Hafizah *et al.*, 2010; Chanprapai & Chavasiri, 2017). Regarding the rich of nutrition value, consumers usually consume this vegetable as a fresh leave. However, there are not many food products made or mixed with P. *sarmentosum*'s leaf, particularly a healthy snack product found in the market.

Chinese cabbage (*Brassica rapa* subsp. *Pekinensis*) is one of the most commonly consumed vegetable in Asian kitchens and it is rich of vitamins, minerals and fiber (Yang *et al.*, 2022). Likewise, Jung *et al.* (2016) stated that Chinese cabbage comprised high dietary fibers and a major number of functional phytochemicals (benzyl isothiocyanate, indoles, sitosterols). Furthermore, some Polishes also prefer fresh-cut Chinese cabbage and usually used as an ingredient in several vegetable mixes for chicken salad or other salad (Grzegorzewska *et al.*, 2022) and there are very significant as a raw material of kimchi which is a popular traditional fermented vegetable in Korea (Chun *et al.*, 2022). Apart from that, because of its natural sweetness, Chinese cabbage is usually used to enhance flavor of broth. Moreover, Kim *et al.* (2014) presented that organically grown Chinese cabbage had three sugar contents including fructose (18.92%), glucose (34.58%) and sucrose (4.27%). Hence, the combination of both vegetables, the leaves of *P. sarmentosum* and Chinese cabbage, would be possible to produce a healthy snack because *P. sarmentosum* is rich in nutrition values but it is a little bit spicy and foul-smelling and the natural sweetness of Chinese cabbage could improve this concerned point.

The purpose of the study was to examine the antioxidant activity, chemical properties, physical properties and sensory evaluation of mixed vegetable (*Piper sarmentosum* Roxb. and *Brassica rapa* subsp. *pekinensis*) crispy snack (MVCS). The results from this study would be alternative for making healthy snack and potential to further commercial production.

2. Materials and methods

2.1. Sample preparation

The leaves of *Piper sarmentosum* Roxb. (Piperaceae) and Chinese cabbage (*Brassica rapa* subsp. *Pekinensis*) were bought from the local market in Udon Thani, Thailand. The key ingredients were illustrated in Figure 1. Snack ingredients are presented in Table 1. The ratio of two vegetables (*P. sarmentosum* : Chinese cabbage) added into the snack were varied including MVCS (2:1), MVCS (1:1), and MVCS (1:2), respectively. The other ingredients used for mixed vegetable crispy snack preparation including green okra, wheat flour, soy sauce, sugar, salt, white pepper, cayenne, and wate).

After washing vegetablest *P. sarmentosum*, Chinese cabbage and green okra were cut into a small size, around 1 inch. Then, three vegetables were blanched for 3 min, cooling down in ice slush. After that, the vegetables were blended (Philips, Series 5000, HR2221/00) with water and cooked them until vegetables became homogenized texture. Other ingredients were added and stirred for 15 min. The study poured the mixture into a baking tray (60 cm x 30 cm) and baked it in a hot air oven for 6 hours at 60°C.

(A) (B)

Figure 1. The leaves of (A) *Piper sarmentosum* Roxb. (Piperaceae) and (B) Chinese cabbage (*Brassica rapa* subsp. *Pekinensis*)

Table 1. The mixed vegetable crispy snack ingredients and the ratio of vegetables used

Ingredient (%)	Treatment (Cha-Plu : Chinese cabbage)		
	2:1	1:1	1:2
Cha-Plu	34.20	25.91	17.62
Chinese cabbage	17.62	25.91	34.20
Green okra	20.73	20.73	20.73
Wheat flour	1.04	1.04	1.04
Soy sauce	2.07	2.07	2.07
Sugar	3.11	3.11	3.11
Salt	1.04	1.04	1.04
White pepper	1.04	1.04	1.04
Cayenne	1.04	1.04	1.04
Water	18.13	18.13	18.13

2.2. Proximate composition

The study determined six components of proximate composition including crude lipid, crude protein, ash, crude fiber, moisture and carbohydrate. The analysis procedures were performed following the Association of Official Analytical Chemist, (AOAC, 2005) standard methods. Soxhlet extraction (FatExtractor, E500, BUCHI) was used to analysis lipid content and Kjeldahl method (K-355, BUCHI) was examined the crude protein. Each sample was analyzed in triplicate and a dry weight basis was calculated for the results.

2.3. Color measurement

Color of sample were determined by using CIE color score. A colorimeter (CR 400, Minota, Japan) was used to measure the color value of each sample. Three dimensions of this scale were L*, a*, and b*.

The color value would explain following;

L* indicates darkness to lightness (0-100),

a* indicates greenness to redness (-a*, +a*)

b* indicates blueness to yellowness to (-b*, +b*)

The sample was measured the surface position and performed with five replications.

2.4. Texture profile analysis

The texture profile properties were measured following Chen *et al.* (2018) and Lisiecka *et al.* (2021). The instrument was TA-XT2i Texture Analyzer (Stable Micro Systems Ltd., Surrey, UK). The study determined the cutting force (CF) of samples by using cutting test speed of 500 mm/min. Accordingly the compression test, the results were carried out on single mixed vegetable crispy snack by using 100 mm/min as the working head test speed. The study evaluated the texture properties comprising hardness (H); the highest force in the texture profile analysis and crispness (CR); difference of force between the first significant peak force and the first minimum of the force following the first significant force in the test cycle (Lisiecka *et al.*, 2021). The maximum force and the slope of the force curve from the starting of the compression to the fracturability point or the first peak of force were conducted to report the data collection. Furthermore, the study determined texture analysis of ten replications per sample.

2.5. Antioxidant activity

The study considered the antioxidant capacity by analyzing total phenolic content and DPPH-radical scavenging assay. The procedures were carried out according to Fang *et al.* (2022), Burgos *et al.* (2013), and Romanet *et al.* (2021).

Regarding total phenolic extraction, 1.00 g of sample was mixed with 7 mL 80% methanol and ultrasonic extracted for 10 min. After that, each sample was centrifuged (8,000 g, 4, 10 min). The extraction was extracted the same procedures and the same condition in triplicate. The supernatants were separated by using 0.42 m filter (Whatman Qualitative) and 80% methanol was used to adjust the final volume (25 mL). Then, the extraction (500 microliters) was mixed with distilled water (500 L) and Folin Ciocalteu reagent (1 mL). After maintaining for 5 min, the study added 5% sodium carbonate (5 mL) and increased the reaction solution to 10 mL with distilled water. The adjusted solution was incubated at room temperature for 1 hour. The absorbance was determined at 765 nm by using a spectrophotometer (UV-2550, Shimadzu, Japan) and gallic acid was used as a standard. Last of all, the result was presented in mg/100 g DW.

In addition, the method of DPPH radical-scavenging assay began with mixing 4.9 mL DPPH (0.1 mmol/L dissolved in methanol) with total phenolic extraction solution (0.1 mL), then the mixed solution were stored in dark place for 30 minutes. After that, the absorbance was measured at 517 nm and the results were presented in milligrams of Trolox equivalent antioxidant capacity (TEAC) per gram DW (mg Trolox equivalent mg/100 g DW.

2.6. Sensory evaluation

Fifty untrained-panelists (n=50) were students and staffs of Udon Thani Rajabhat University, Thailand. The study conducted the data collection in triplicate. The panelists were requested to score five sensory properties of samples including color, texture, taste, aroma and overall acceptability. 9-point Hedonic scale used to evaluate the samples and scale ranging from 1 to 9 numerical values, 1 indicated dislike extremely and 9 indicated like extremely (Santosh *et al.*, 2021). On the test day, the pieces of mixed vegetables crispy snack (5 cm x 10 cm) containing in a plastic bag with a random number and mineral water were served.

2.7. Statistical analysis

The data was conducted in triplicate for proximate composition and antioxidant activity (n=3), five replications for color measurement (n=5) and ten replications for texture profile properties (n=10). The study applied statistical analysis that was SPSS for Mac (SPSS Institute Inc., Chi- cago, IL, USA). The results were reported as mean standard deviation (SD). Two-way analysis of variance (ANOVA) and Duncan's new multiple-range test used to explain a level of significant difference as P 0.05.

3. Results and discussion

3.1. Proximate composition

The results of proximate composition are presented in Table 2. Six components including crude lipid, crude protein, ash, crude fiber, moisture and carbohydrate were determined. Three samples of mixed vegetables crispy snack (MVCS) were not a significant difference (P 0.05) on crude lipid and crude protein. The results ranged from $0.88{\pm}0.73^{a}$ to $0.91{\pm}0.03^{a}$ and $5.21{\pm}0.20^{a}$ to $5.87{\pm}0.18^{a}$, respectively. Nonetheless, MVCS (2:1) had the highest amount of ash content ($20.21{\pm}0.19^{a}$) among three samples, followed by MVCS (1:1) ($17.91{\pm}0.33^{b}$) and MVCS (1:2) ($14.84{\pm}0.10^{c}$). Also, MVCS (2:1) had the highest percentage of crude fiber ($13.85{\pm}0.13^{a}$) but MVCS (1:1) not differed from MVCS (1:2) at 95% confidential level. Similarly, Calubaquib and Suyu (2020) mentioned that fortified Filipino snacks by using vegetables as an ingredient increased ash and crude fiber because they were rich in mineral and fiber sources. Meanwhile, fish flour and shrimp head enriched protein value on a snack nutrition quality (Baskar *et al.*, 2022). Regarding moisture, MVCS (1:1) and MVCS (1:2) had the highest moisture value ($17.89{\pm}0.11^{a}$ and $17.21{\pm}0.11^{a}$), respectively. Nevertheless, among three MVCS samples did not different on carbohydrate value and the quantity ranged from $48.82{\pm}0.11^{a}$ to $53.96{\pm}0.11^{a}$. Folorunso *et al.*, (2016) studied the nutrition quality of snacks produced from broken rice flour. The result showed that snacks had a higher carbohydrate content and would give the human body high energy. Based on proximate composition results, the study would state that high amount of ingredients' nutrition could affect mixed vegetables snacks' nutrition value as well.

Table 2. Proximate composition of mixed vegetable crispy snack

Sample	Proximate composition (%)					
	Crude lipid	Crude Protein	Ash	Crude Fiber	Moisture	Carbohydrate
P. sarmentosum : *Brassica rapa* subsp. *Pekinensis*						
2:1	0.900.13[a]	5.210.20[a]	20.210.19[a]	13.850.13[a]	11.010.11[b]	48.820.11[a]
1:1	0.880.73[a]	5.350.01[a]	17.910.33[b]	8.760.23[b]	17.890.11[a]	49.210.91[a]
1:2	0.91.03[a]	5.870.18[a]	14.840.10[c]	7.210.11[b]	17.210.11[a]	53.960.11[a]

The results are presented as means (n=3) standard deviation (SD) and the means with the different letters ([a,b,c,…])
within a column are significantly different (p 0.05)

3.2. Color measurement and texture profile analysis

Color measurement and texture profiles of mixed vegetable crispy snack were displayed in Table 3. CIE, L*, a*, and b*, color scale used to determine the color value of samples. The lightest score observed in MVCS (1:2) (65.03±0.98[a]) followed by MVCS (1:1) (53.45±1.12[b]) and (2:1) (45.17±1.03[c]), respectively. The study found that color of *P. sarmentosum* affected the sample color because it is a dark green leaf, which would also decrease the L* value. In contrast, the sample which contained a higher ratio of Chinese cabbage was lighter. Furthermore, the a* value that indicates greenness to redness, all sample show greenness value and the highest a* value was -10.19±1.03[a], MVCS (2:1). Meanwhile, three samples were not a significant difference (P 0.05) on b* value and the ranged from 15.07±1.03[a] to 19.11±0.93[a]. In addition, ready-to-eat dried vegetable snacks (*Cucurbita maxima*) had high b* value (65.60±2.71) because of high carotenoid content and this pigment is oranges/yellow. Therefore, it would affect the snack's color and show a higher on +b* valua (Konopacka *et al.*, 2010). Whereas, snack supplemented with fresh vegetables show significantly influenced sample color because of an ingredient addition. The results were lower on b* value (23.33) and a* value (1.65) than control. Therefore, the ingredient color is the main key that contribute to color appearance of the product.

Regarding texture profile analysis, the study presented three results including cutting force, hardness, and crispness (Table 3). Accordingly, MVCS (1:2) had a maximum of cutting force value (120.34.303[a]), while MVCS (2:1) and MVCS (1:1) were not a significant difference (P 0.05). Besides that, MVCS (1:2) showed the highest force on hardness (N) (172.40±3.03[a]). On the other hand, MVCS (2:1) needed the minutest force to determine the hardness property. Shah *et al.* (2017) mentioned that the sample was more crispy texture and it would be less elastic property because it needs a lower force to cut a sample. Accordingly, the study assumed that MVCS (2:1) was less elastic because this sample was the least force needed to cut the structure. The minimum crispness (N) of 6.73±3.03[c] was noted for MVCS (2:1). At the same time, much upper force was found to indicate a lower crispy texture of MVCS (1:2), 12.483.03[a]. From this study, the vegetable combination of mixed vegetable crispy snack not only affect the nutrition value but also color value and texture property.

Table 3. Color value and texture profile analysis of mixed vegetable crispy snack

Sample	Color value			Texture profile		
	L*	a*	b*	Cutting force; CF (N)	Hardness (N)	Crispness (N)
P. sarmentosum : *Brassica rapa* subsp. *Pekinensis*						
2:1	45.171.03^{c}	-10.191.03^{a}	15.071.03^{a}	84.132.35^{b}	107.172.89^{c}	6.733.03^{c}
1:1	53.451.12^{b}	-8.071.03^{b}	19.110.93^{a}	90.561.93^{b}	164.604.11^{b}	10.213.03^{b}
1:2	65.030.98^{a}	-5.261.03^{c}	18.171.14^{a}	120.343.03^{a}	172.403.03^{a}	12.483.03^{a}

L*- lightness, a* - green (-), red (+), b* - blue (-), yellow (+)
The results are presented as means (color measurement (n=5) and texture profile analysis (n=10)) standard deviation (SD). The means with the different letters ($^{a,b,c,...}$) within a column are significantly different (*p* 0.05)

3.3. Antioxidant activity

The study separated antioxidant activity results into two categories and they were demonstrated in Figure 2, (a) total phenolic content and (b) DPPH radical-scavenging activity. Besides that, the study presented the results in mg/100 g DW for total phenolic content and mg Trolox equivalent mg/100 g DW for the second. The highest total phenolic content (650.20 mg/100 g DW) and DPPH radical-scavenging activity (898 mg Trolox equivalent mg/100 g DW) were found in MVCS (2:1). The results were observed that both samples consisted of the highest *P. sarmentosum* ratio, this could assume that the mentioned ingredient affects the amount of antioxidant activity. Meanwhile, MVCS (1:1) and MVCS (1:2) were not a significant difference (P 0.05). The total phenolic content result of both samples showed 525.89 mg/100 g DW and 489.07 mg/100 g DW, respectively. Nonetheless, a significant difference (P 0.05) between MVCS (1:1) and MVCS (1:2) were observed in the number of DPPH radical-scavenging activity. MVCS (1:1) (500.18 mg Trolox equivalent mg/100 g DW) showed a slightly higher amount than MVCS (1:2) (350 mg Trolox equivalent mg/100 g DW) on DPPH radical-scavenging activity. Likewise, snacks fortified with bamboo shoot also found significant results of antioxidant activity among treatments and the study compared three different preparations including soaked, boiled, and unprocessed-bamboo shoot (Santosh *et al.*, 2021). They found that phenolic compounds soluble in water decreased after soaking and boiling. In addition, the study would state that the cooking process could reduce soluble phenolic compounds and this study suggests that future research would compare the amount of total phenolic compound between before and after cooking process. The outcome research would contribute to more understanding. Besides, the study prepared mixed vegetable crispy snacks by baking them in a hot air oven, these would help to keep antioxidant compounds. Although the main ingredient of snacks would have a high number of antioxidant compounds, the food processing process would be another crucial factor to maintain these compounds.

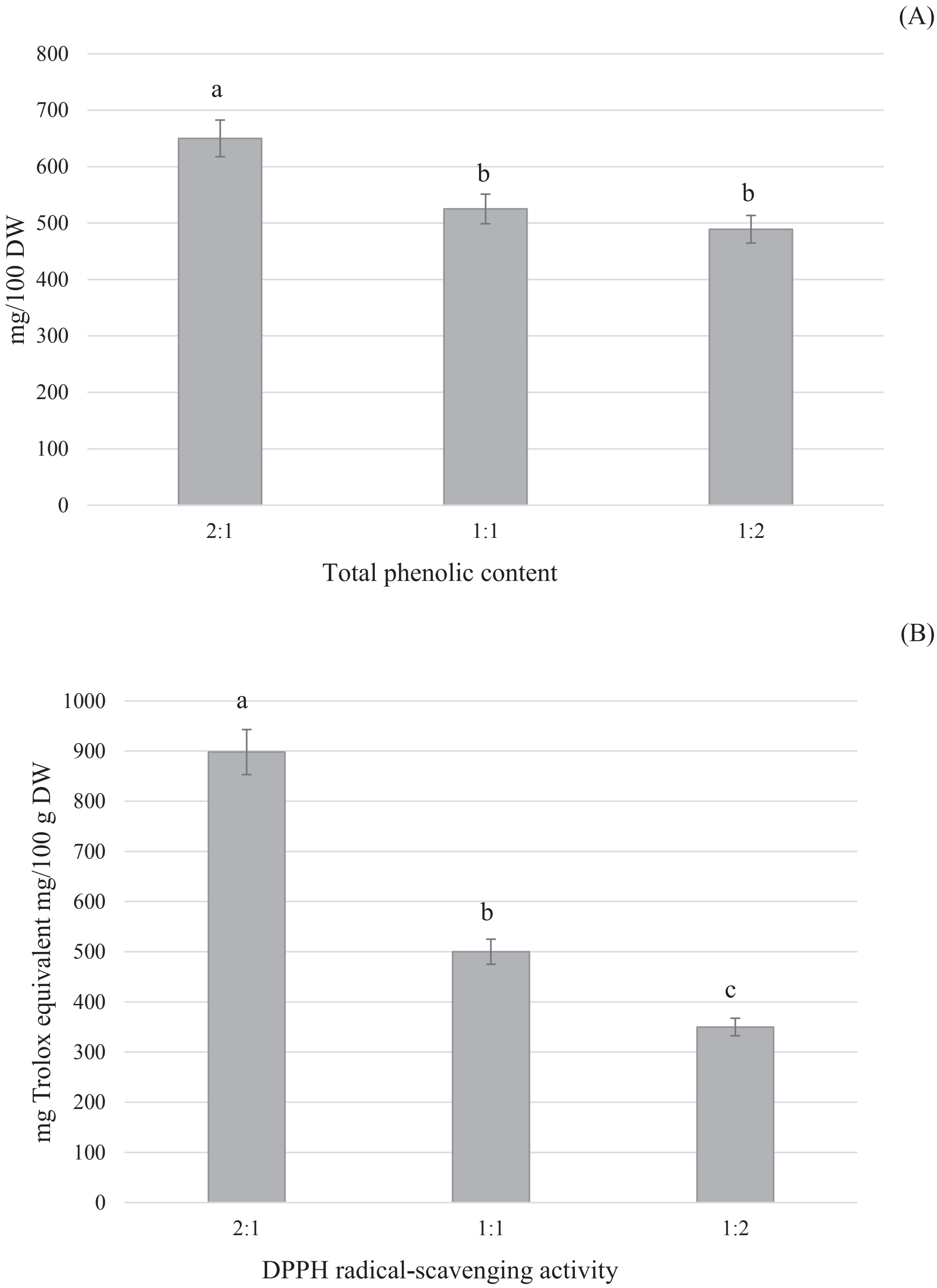

Figure 2. Antioxidant activity including (A) total phenolic content and (B) DPPH radical-scavenging activity. 2:1, 1:1, and 1:2 were three ratios of mixed vegetables crispy (*P. sarmentosum* : *Brassica rapa* subsp. *Pekinensis*) snack. The results are presented as means (n=3) standard deviation (SD). The means with the different letters ([a,b,c,…]) within a column are significantly different

3.4. Sensory evaluation

Fifty untrained-panelists determined sensory attribution of mixed vegetable crispy snack (MVCS) illustrated in Figure 3. The panelists had to evaluated five attributions including color, texture, taste, aroma, and overall acceptability. According to color, the majority of panelists agreed that MVCS (1:1) and (1:2) were not a significant difference (P 0.05). The color scores were 7.89±0.91[a] and 7.60±0.11[a] out of 9, respectively. Nevertheless, the panelists considered that MVCS (1:1) differed from MVCS (1:2) on texture characteristic. Meanwhile, MVCS (2:1) was the lowest score on the color (5.12±0.81[b]) and texture attribution (5.60±1.19[c]). Besides that, MVCS (1:1) was the highest ranked on taste (7.13±1.03[a]) and aroma (8.20±0.98[a]) followed by MVCS (1:2) and (2:1), respectively. At the same time, most people accepted MVCS (1:1) on the overall acceptability results (7.63±1.16[a]). The panelists mentioned that this sample with *P. sarmentosum* : *Brassica rapa* subsp. *Pekinensis* (1:1) would be suitable ratio because of good taste and not too stinky smelling. Previously studies, Stokkom *et al.* (2019) confirmed that food produced from combination vegetables was more accepted than single vegetable because the sweet taste of one vegetable could reduce a bitter taste and this would contribute to raising vegetable consumption. Nonetheless, vegetable snacks' shape and cooking method were also crucial factors due to most customers appropriating consume this type of snack in a finger shape and deep-fried was the most popular cooking method (Forsberg *et al.*, 2022). Furthermore, the healthy snack market is a high potential to expand because of a large customer group and more acceptance of sensory assessments such as ready-to-eat dried vegetables (*Cucurbita maxima*) got 6.80 out of 10 (Konopacka *et al.*, 2010), crispy salted snacks fortified with bamboo shoot received 7.25 out of 9 (Santosh *et al.*, 2021) and potato-based snack-pellets added with fresh vegetables achieved 7.28 out of 9 (Lisiecka *et al.*, 2021). Thus, vegetable snacks could help in managing hunger between meal and also benefit to health.

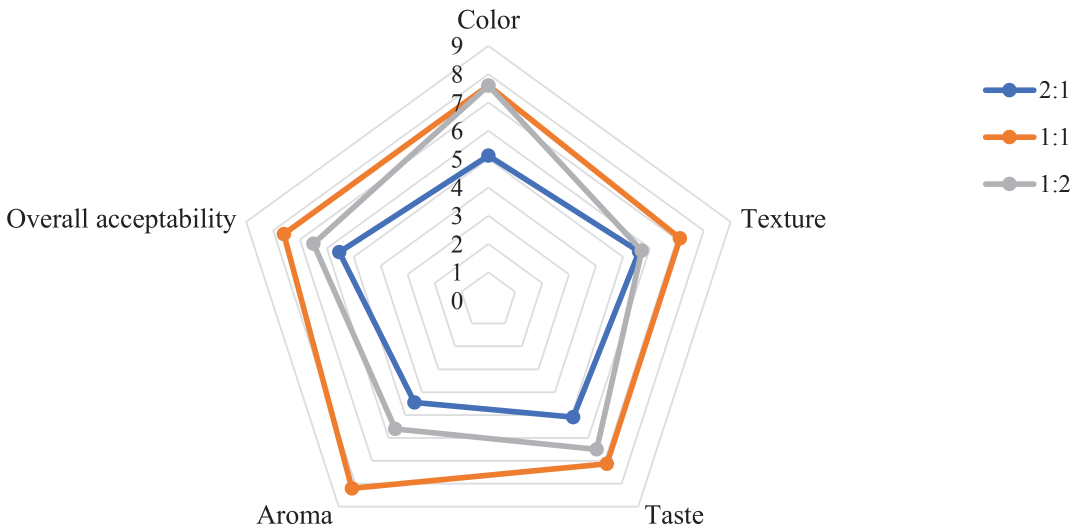

Figure 3. Sensory attributes of three ratios of mixed vegetables crispy (*P. sarmentosum* : *Brassica rapa* subsp. *Pekinensis*) snack. The study conducted the data collection in triplicate and fifty untrained-panelists each time. The results are presented as means standard deviation (SD).

4. Conclusion

Food is an energy source of a human body and it comprises the nutrition and other bioactive compounds. Human have to consume a main meal three time per day and a light meal such as snack would decrease a hunger between breakfast and lunch or lunch and dinner. The study developed a nutrition snack by using mixed vegetables to be easy for a consumer who would not prefer to eat vegetable. However, vegetable combination is a crucial process because the majority of green leaf consist of high nutrition value but it has a stinky smelling. At the same time, Chinese cabbage has a natural sweet taste and it could reduce the off flavor of the crispy snack. Therefore, combination with other vegetables would provide more advantages in taste and color of the snack. Based on the study, increasing *P. sarmentosum* showed a significant on crude fiber, ash and antioxidant activities but it affected the texture elasticity of the product. When the study considered sensory evaluation result, most of the panelists accepted mixed vegetable crispy snack (1:1). Thus, the study would suggest that 1:1 was a suitable ratio between Cha-Plu and Chinese cabbage in snack developed in this study.

5. Acknowledgement

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6. References

AOAC. (2005). *Official methods ofsanalysis* (18^{th} ed.). Association of Official Analytical Chemists, USA.

Burgos, G., Amoros, W., Munoa, L., Sosa, P., Cayhualla, E., Sanchez, C., *et al.* (2013). Total phenolic, total anthocyanin and phenolic acid concentrations and antioxidant activity of purple-fleshed potatoes as affected by boiling. *Journal of Food Composition and Analysis*, *30*, 6-12.

Calubaquib, B. J., & Suyu, C. M. (2020). Proximate composition of fortified Filipino snacks for picky eaters. *Indian Journal of Science and Technology*, *13*(1), 61-69.

Chanprapai, P., & Chavasiri, W. (2017). Antimicrobial activity from *Piper sarmentosum* Roxb. against rice pathogenic bacteria and fungi. *Journal of Integrative Agriculture*, *16*(11), 2513-2524.

Chen, J., Venkitasamy, C., Shen, Q., McHugh, H. T., Zhang, R., & Pan, Z. (2018). Development of healthy crispy carrot snacks using sequential infrared blanching and hot air-drying method. *LWT - Food Science and Technology*, *97*, 469-475.

Chun, J., Kang, Y., Lee, J., Yun, Y., Oh, T., & Yoon, M. (2022). The combined effect of nitrogen and biochar amendments on the yield and glucosinolate contents of the Chinese cabbage. *Journal of King Saud Universit- Science*, *34*, 101799. https://doi.org/10.1016/j.jksus. 2021.101799.

Fang, H., Yin, X., He, J., Xin, S., Zhang, H., Ye, X., Yang, Y., & Tian, J. (2022). Cooking methods affected the phytochemicals and antioxidant activities of potato from different varieties. *Food Chemistry: X*, *14*, 100339. https://doi.org/10.1016/j.fochx.2022.100339.

Folorunso, A. A., Omoniyi, S. A., & Habeeb, A. S. (2016). Proximate composition and sensory acceptability of snacks produced from broken rice (*Oryza sativa*) flour. *American Journal of Food and Nutrition*, *6*(2), 39-43.

Forsberg, S., Olsson, V., Bredie, P. L. W., & Wendin, K. (2022). Vegetable finger foods-Preferences among older adults with motoric eating difficulties. *International Journal of Gastronomy and Food Science*, *28*, 100528. https://doi.org/10.1016/j.ijgfs. 2022.100528.

Grzegorzewska, M., Badełek, E., Szczech, M., Kosson, R., Wrzodak, A., Kowalska, B., Colelli, G., Szwejda-Grzybowska, J., & Maciorowski, R. (2022). The effect of hot water treatment on the storage ability improvement of fresh-cut Chinese cabbage. *Scientia Horticulturae*, *291*, 110551.https://doi.org/10.1016/j.scienta. 2021.110551.

González-Jiménez, F. E. Cooper-Bribiesca, B. L., Hernandez-Espiosa, N., Nunez-Breton, L. C., & Reyes-Reyes, M. (2015), Empleo de antioxidants en el tratamiento de diversas enfermedades cronico-degenerativas. *Vertientes Rev. Espec. En Ciencias la Salud*, *18*, 16-21.

Hafizah, A., Zaiton, Z., Zulkhairi, A., Mohd, I. A., Anita, N. M., & Zaleha, A. (2010). *Piper sarmentosumas* an antioxidant on oxidative stress in human umbilical vein endothelial cells induced by hydrogen peroxide. *Journal of Zhejiang University Science* (B), *11*, 357-365.

Jung, J. S., Kim, J. M., and Chae, W. S. (2016). Quality and functional characteristics of kimchi made with organically cultivated young Chinese cabbage (*olgari-baechu*). *Journal of Ethnic Foods*, *3*, 150-158.

Kim, J., John, M. M. K., Hae-Kyung, M., Jin, K., Enkhtaivan, G., & Kim, H. D. (2014). Morphological and biochemical variation of Chinese cabbage (*Brassica rapa* spp. Pekinensis) cultivated using different agricultural practices. *Journal of Food Composition and Analysis*, *36*, 12-23.

Konopacka, D., Seroczynska, A., Korzeniewska, A., Jesionkowska, K., Niemirowicz-Szcztt, K., & Plocharski, W. (2010). Studied on the usefulness of Cucurbita maxima for the production of ready-to-eat dried vegetable snacks with a high carotenoid content. *LWT-Food Science and Technology*, *43*, 302-309.

Lisiecka, K., Wojtowicz, A., Mitrus, M., Oniszczuk, T., & Combrzynski, M. (2021). New type of potato-based snack-pellets supplemented with fresh vegetables from the Allium genus and its selected properties. *LWT, Food Science and Technology*, *145*, 111233. https://doi.org/10.1016/j.lwt. 2021.111233.

López-Hernández, A. A., Ortega-Villarreal, S. A., Rodriguea, V. A., Lomeli, L. M., & González-Martínez, E. B. (2022). Application of different cooking methods to improve nutritional quality of broccoli (*Brassica oleracea* var. *italica*) regarding its compounds content with antioxidant activity. *International Journal of Gastronomy and Food Science*, *28*, 100510. https://doi.org/10.1016/j.ijgfs. 2022.100510.

Masuda, T., Inazumi, A., Yamada, Y., Padolina, W.G., Kikuzaki, H. & Nakatani, N. (1991). Antimicrobial phenylpropanoids from *Piper sarmentosum*. *Phytochemistry*, *30*, 3227-3228.

Nicklett, E.J. & Kadell, A.R. (2013). Fruit and vegetable intake among older adults: a scoping review. *Maturitas, 75* (4), 305-312. https://doi.org/10.1016/j.maturitas. 2013.05.0005.

Nielsen ILC. (2022, June 13). *Global snack food sales reach $374 billion annually*.wGrand view researcht.

Raman, V., Galal, A. M., & Khan, I. A. (2012). An investigation of the vegetative anatomy of *Piper sarmentosum*, and a comparison with the anatomy of *Piper betle* (Piperaceae). *American Journal of Plant Sciences*, *3*, 1135-1144.

Romanet, R., Sarhane, Z., Bahut, F., Uhl, J., Schmittkopplin, P., Nikolantonaki, M., *et al.* (2021). Exploring the chemical space of white wine antioxidant capacity: A combined DPPH, EPR and FT-ICR-MS study. *Food Chemistry*, *355*, 129566.

Santosh, O., Bajwa, K. H., Bisht, S. M., & Chongtham, N. (2021). Antioxidant activity and sensory evaluation of crispy salted snacks fortified with bamboo shoot rich in bioactive compounds. *Applied Food Research*, *1*, 100018.

Shah, F. U. H., Sharif, M. K., Butt, M. S., & Shahid, M. (2017). Development of protein, dietary fiber, and micronutrient enriched extruded corn snacks. *Journal of Texture Studies*, *48*, 221-230. https://doi.org/10.1111/jtxs.1223.

Stokkom, V. L. V., Graaf, D. C., Wang, S. Kooten, V. O., & Stieger, M. (2019). Combinations of vegetables can be more accepted than individual vegetables. *Food Quality and Preference*, *72*, 147-158.

Sun, X., Chen, W., Dai, W., Xin, H., Rahmand, K., Wang, Y., Zhang, J., Zhang, S., Xu, L., & Han, T. (2020). *Piper sarmentosum* Roxb.: A review on its botany, traditional uses, phytochemistry, and pharmacological activities. *Journal of Ethnopharmacology*, *265*(5), 112897. https://doi.org/10.1016 /j.jep.2020.112897.

Torres, S., Contreras, L., Veron, H., & Isla, I., M. (2022). Chapter 10 - Prospects of dairy and vegetables-based food products in human health: Current status and future directions. *Research and Technological Advances in Food Science*, 243-267.

World Health Organizatio). (2020). *Increasing fruit and vegetable consumption to reduce the risk of noncommunicable diseases*. World Health Organization.

Yang, B., Ma, W., Wang, S., Shi, L., Li, X., Ma, Z., Zhang, Q., & Li, H. (2022). Determination of eight neonicotinoid insecticides in Chinese cabbage using a modified QuEChERS method combined with ultra performance liquid chromatography-tandem mass spectrometry. *Food Chemistry*, *387*, 132935. https://doi.org/10.1016/j.foodchem.2022.132935