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Effect of Thickness on Qualities of Dried Sweet Bamboo Shoots (*Dendrocalamus asper* Backer) Products

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Abstract

The objective of this research was to investigate the effect of thickness on the quality of dried sweet bamboo shoots (SBS). The SBS were prepared with various thicknesses. The quality of dried SBS was investigated, including weight loss, lightness, hardness, and sodium chloride content. The results indicated that the weight loss and the amount of sodium chloride tended to decrease when the thickness of SBS increased. Conversely, the brightness and hardness varied directly as the thickness of SBS. The effect of thickness on drying time and rehydration time using different methods of SBS were studied. The results showed that the SBS with a thickness of 2 mm had the shortest drying time and rehydration time. The dried SBS was soaked in water at room temperature for 30 min before boiling in hot water. This method had the shortest rehydration time when compared with other methods. The sensory evaluation of dried SBS after rehydration by untrained panelists were investigated. It was found that SBS with a thickness of 2 mm had the highest scores on sensory acceptability in appearance, color, texture, flavor, and overall liking score. The analysis of the chemical composition of dried SBS was high carbohydrate (48.18%), protein (22.52%), and low-fat content (4.18%). The shelf life of dried SBS product was at least 6 months. Accordingly, the knowledge gained from this study can be applied to the production of dried SBS, which can extend the shelf life of SBS and added value of agricultural products.

Introduction

The scientific name of rough giant bamboo is a *Dendrocalamus asper* Backer. It is a kind of rhizome bamboo with large clumps, and straight body pressed together into a rather tight clump. The tip of the body is curved to hang down. There are four species of this bamboo in the group, which are small bamboo, green bamboo, big bamboo and sweet bamboo. The sweet bamboo is a valuable economic crop and popular with consumers because the shoots of this species are large, without burr, sweet in taste, crispy in texture and fine

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white (Chiang Mai Rajabhat University, 2020). Currently, there is an increase in the area of sweet bamboo growing in Thailand. To the fresh shoots, the plant can also be processed into bamboo shoots in a sealed container or dried in sun, which can be sold to foreign countries almost all over the world. The highest improting countries are Japan, followed by the United States, Hong Kong and Saudi Arabia (Bhattarakosol & Seejan, 2020). The bamboo shoots are a source of high-quality protein, low fat and high fiber. The chemical composition of fresh SBS and long sheath bamboo shoots were reported. The moisture, protein, fat and dietary fiber were 91-92%, 1-3.44%, 0.06-0.13% and 2.23-2.60%, respectively. Moreover, there are 18 free amino acids, including all 8 essential amino acids (Kusalaruk & Limsangouan, 2016). The problem for bamboo shoots growers is that in high season, the sale price of fresh bamboo shoots is lower. If it is improperly kept, fresh bamboo shoots will rapidly reduce in quality post-harvest. Therefore, bamboo shoot processing is an option that will help extend the shelf life of bamboo shoots and help add value to agricultural products and provide a variety of options for consumers.

The dried bamboo shoots are obtained by boiling fresh bamboo shoots. They are peeled, then grated into strips or sliced or cut into sheets. It is mixed with salt, and dried using solar heat or other energy. They are rehydrated in boiling water before use (Thai industrial standards institute, 2020). The purpose of making dried bamboo shoots is to extend the shelf life. The water activity is reduced, which influences inhibiting the growth of microorganisms and the activity of enzymes. The drying process helps reduce the weight and volume of bamboo shoots. They are more convenient to store and transport, including, the convenience for off-season consumption.

There are many factors of drying rate, including the characteristic of bamboo, pressure, temperature, relative humidity, wind speed, specific humidity, and the amount of bamboo shoots for drying. The physical properties of bamboo shoots such as size, shape, volume, and surface area are important for drying rate (Fellows, 2017). The effect of different drying temperatures on phytochemistry and antioxidant activity of bamboo shoots was studied. It was found that the use of high temperatures in drying resulted in the reduced phytochemicals and antioxidant activity in bamboo shoots. The optimum drying temperature was 60 °C (Seewaeng & Siriamornpun, 2019). The thickness of sliced bamboo shoot affected the cyanide content in fresh bamboo shoot (Rana et al., 2012). Generally, the thickness influenced on the conductive heat transfer and water droplet evaporation of raw material during drying. Therefore, it is one of the important factors for drying rate and quality of dried bamboo shoots.

The objective of this research was to study the effect of thickness on the quality of dried SBS. Phytochemicals and sensory evaluation were investigated to select the optimum thickness to produce dried SBS.

Materials and methods

1. Preparation of SBS

The SBS were obtained from the agriculture group in Sa Kaeo province. The fresh SBS were cut. The SBS with similar growth stages of equal size and length approximately 30 cm were selected. The shell was peeled off and washed with water.

2. Study on the effect of thickness on quality of dried SBS

The prepared SBS were cut by slicing machine (HH-society, China). The SBS with a thickness of 2, 4, 6, 8 and 10 mm, 5 mm in width, and 100 mm in length were prepared. The SBS were boiled in hot water for 30 min, and were fermented with 10% of salt for 3 hr. It has been washed with water 5 times. It was boiled in hot water for 30 min and was washed with water. It was drained and dried in a hot air dryer at 60°C, dried until the final moisture content of SBS was not more than 10%.

3. Quality analysis of SBS

3.1 Weight loss

The weight loss before drying was measured. The fresh SBS and processed SBS before drying were weighed by balance (Zepper EPS-3001, China). The weight loss before drying values was defined as follows: Weight loss before drying (%) = [(weight of fresh SBS – weight of SBS before drying)/ weight of fresh SBS] x 100 (Kotoki & Deka, 2010).

The weight loss after drying was measured. The SBS before drying and after drying were weighed by balance (Zepper EPS-3001, China). The weight loss after drying values was defined as follows: Weight loss after drying (%) = [(weight of SBS before drying – weight of SBS after drying)/ weight of SBS before drying] x 100 (Kotoki & Deka, 2010).

3.2 Color

The color of SBS was measured by color meter

(Colorimeter, WR10QC, China). The CIE system was evaluated by L * or brightness (0 = black, 100 = white), a * (+ a = red, -a = green) and b * (+ b = yellow, -b = Blue). Browning value was calculated as follows: Browning value = (ΔL * / L0 *) / 100, where ΔL* was the difference of brightness between two measuring points. and L0 * was the reference brightness (Lertwiram & Sawatming, 2020).

3.3 Hardness

The hardness of SBS was measured by texture analyzer (Daiichi FG 520K, Japan). The cylinder probe with 8 mm of diameter was used and the unit of force measured was newtons (N).

3.4 Salt content analysis

The rehydration SBS was measured using a digital salinity meter (HANNA, HI96821, USA).

3.5 Rehydration

Rehydration of SBS after drying by different methods as follows: 1) soak in room temperature 2) boil in hot water 3) soak at room temperature for 30 min before boiling in hot water were investigated. The complete rehydration was obtained by observing the appearance, size, hardness and weight of SBS by comparison with SBSs before drying. The optimum rehydration time of SBS with different thicknesses was investigated.

3.6 Sensory evaluation

Sensory evaluation of rehydration SBS by 30 untrained panelists was investigated. The importance of liking of appearance, color, texture, flavor and overall liking were expressed by 9-point hedonic scale (9 = most liked, 1 = most disliked).

3.7 Chemical composition analysis

The chemical composition of dried SBS including moisture, protein, fat, carbohydrates, ash and energy was analyzed (Association of Official Analytical Chemists, 2012).

3.8 Shelf life of dried SBS

The dried SBS were packed in sealed plastic bags and stored at 30°C for 6 months. They were evaluated every 3 months. The moisture content, yeast and mold were investigated.

4. Statistical analysis

The statistical technique one-way ANOVA was used for calculating. Duncan's new multiple-range Test (DMRT) was used to compare the difference in the average values at the 95% confidence level (Duncan, 1995).

Results and discussion

1. Effect of thickness on physicochemical properties of dried SBS

The effect of thickness on weight loss of SBS before drying and after drying was shown in Fig. 1. The weight loss of SBS was decreased when the thickness of SBS increased. The weight loss of SBS before drying and after drying was compared. It was found that the SBS after drying had higher weight loss values than before drying. In general, the moisture of bamboo shoots evaporates during drying, which involves both mass transfer and heat transfer. The heat is transferred to the surface of bamboo shoots and the water in bamboo shoots evaporates by the latent heat of vapor formed. The steam will spread through the air film and be blown away by the movement of the hot air. This condition will cause the vapor pressure on the surface of bamboo shoots to be lower than the steam pressure inside of bamboo shoots, resulting in differences in vapor pressure. The inner of bamboo shoots have high vapor pressure and gradually reduced when bamboo layer approached the dry air. This causes pressure to expel water from bamboo shoots cells (Damondaran & Parkin 2017). Obviously, bamboo shoots of 2 mm thickness have more surface contact with air than other sizes which leads to it having the highest weight loss. The thickness of bamboo shoots affected on the drying rate. The bamboo shoots with a high ratio of surface area to volume will have a lot of water evaporation and have a faster drying rate. Therefore, the drying rate of thick bamboo shoots be slower than thinner ones. The drying rate was decreased when the thickness of bamboo shoots increased (Fellows, 2017). A similar observation had found with dried apples which were reported by Paradkar & Sahu (2018).

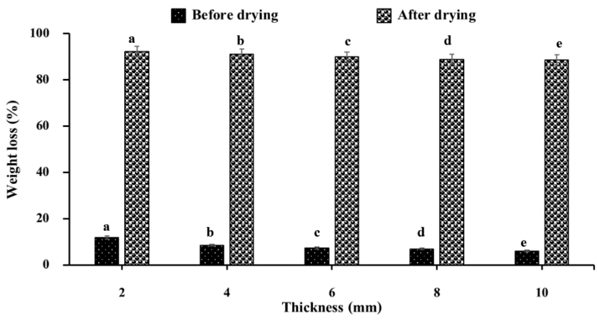

Fig. 1 The effect of different thickness on weight loss of SBS

The unit operation before drying, including size reduction, boiling, salt fermentation affects the weight loss of bamboo shoots. The size reduction of bamboo shoots causes to cells damage that affecting the ratio between the surface area exposed to the environment. If there is a lot of surface area, water will be more likely to spread out than having a small area of contact that can cause high weight loss (Suphamityotin, 2013). The weaken cell membranes of bamboo shoots was found when the bamboo shoots were boiled in hot water. The diffusion of water from the bamboo shoots allowed the sodium chloride to spread more easily into the cell. Moreover, the salt concentration increases osmotic pressure and reduces the water activity of bamboo shoots (Yuenyongputtakal, 2013).As the suitable concentration of NaCl solution, the osmotic pressure of the solution decreases. This simplifies the increased removal of water from bamboo shoots and thereby decreases the cyanide content (Rana et al., 2012).

The effects of the thickness on the color value of SBS before drying, after drying and rehydration is shown in Table 1. The results show that the color values of SBS before drying, after drying and rehydration had significant difference of the 95% confidence interval when $p \leq 0.05$. The brightness (L *) tends to decrease when the thickness of the SBS increases. The a* value indicates the red to green color value. If the a* value is negative in the green range and the a* value is positive in the red range. The a* value tends to increase when the thickness of the SBS before drying, after drying and rehydration increases. Furthermore, the b* value indicates the yellow to blue range. If the b* value is negative in the blue range and the b* value is positive in the yellow range. The b* value tends to increase when the thickness of the SBS before drying, after drying and rehydration increases. The browning value is shown in Fig. 2. It was found that the browning value varied directly as the thickness of SBS before drying, after drying and rehydration. There are many factors for changing of color in SBS before drying, after drying and rehydration. The enzymatic browning reaction occurs at the surface of SBS when exposed to oxygen in the air. In general, bamboo shoots contain polyphenol oxidase (PPO) that is a browning catalyst (Huang et al., 2002). The enzymatic browning reaction is an oxidation reaction. It occurs when the cells of bamboo shoots are bruised, torn, bumped, crushed, sliced or chopped. The enzyme, substrate and oxygen react together. Colorless monophenol is oxidized to colorless diphenol. It is oxidized to o-quinone, which reacts with amino acids or proteins to be brown substances and will form a polymer with large molecules that has a brown color such as melanin (Damondaran & Parkin, 2017). In addition, heating by boiling and drying may result in the Maillard reaction between reducing sugar and amino acids, proteins or other nitrogen compounds with the heat catalyzed (Zhang et al., 2011).

Table 1 The effect of different thickness on color changing of SBS

Color	Thickness (mm)				
	2	4	6	8	10
Before drying: L*	88.60±0.14[a]	87.23±0.05[b]	86.46±0.12[c]	85.27±0.02[d]	84.49±0.29[e]
Before drying: a*	-0.67±0.03[c]	1.76±0.03[b]	1.81±0.05[b]	2.45±0.30[a]	2.32±0.08[a]
Before drying: b*	6.85±0.08[e]	7.32±0.47[d]	10.07±0.02[c]	11.11±0.07[b]	12.46±0.18[a]
After drying: L*	79.66±0.10[e]	73.56±0.22[d]	70.30±0.15[c]	68.78±0.02[b]	63.11±0.18[a]
After drying: a*	5.03±0.02[e]	5.44±0.16[d]	6.49±0.10[c]	9.03±0.22[b]	10.24±0.13[a]
After drying: b*	18.58±0.11[d]	18.65±0.38[d]	23.84±0.05[c]	24.38±0.12[b]	30.47±0.36[a]
Rehydration: L*	85.25±0.03[a]	81.42±0.15[b]	78.92±0.60[c]	75.87±0.39[d]	74.54±0.36[e]
Rehydration: a*	0.65±0.02[e]	2.75±0.03[d]	5.45±0.31[c]	6.36±0.39[b]	8.24±0.32[a]
Rehydration: b*	11.16±0.05[e]	19.22±0.24[d]	22.52±0.26[c]	23.32±0.17[b]	25.47±0.13[a]

Remark: mean±SD, a-e means within each row indicate significant differences ($p \leq 0.05$) using Duncan's multiple range test

The effect of heat also affects the color change of pigment compositions in SBS, such as carotenoids, flavonoids, phenol, chlorophyll and betalains, etc (Bal et al., 2011). Chlorophyll is a green pigment that is in the chloroplast of plants. It is important in the photosynthesis process of plants that turns into glucose. It is a nutrient that provides energy in the cells of plants. Chlorophyll is unstable when exposed to heat. It turns into pheophytin which turns from green to brown color (Erge et al., 2008). The different thickness of SBS affects the processing and chemical composition. The thin SBS has a large surface area. Therefore, the heat transfer from the unit operation occurs faster. Polyphenol oxidase, which is the main cause of the browning reaction, and it is easily destroyed under high temperature. The low-thickness will take shorter time to dry than high-thickness. Resulting in low-thickness having a higher brightness than high-thickness. The color characteristics of SBS before drying, after drying and rehydration was compared. It was found that SBS after drying had a darker brown color than SBS before drying and rehydration due to the change of water which is the main component in SBS. The SBS before drying and rehydration have high water content in the cells. The firm cells, resulting in a high brightness of SBS were observed. As for after drying SBS, the water in the cells is eliminated, causing the cells to shrink or become wrinkled resulting in a darker brown color that the brightness of the SBS decreases.

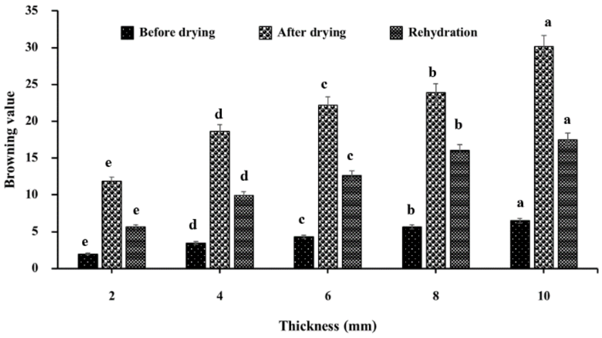

Fig. 2 The effect of different thickness on browning value of SBS

The effect of different thickness on the hardness of SBS is shown in Fig. 3. It was found that the hardness of SBS had significant difference of the 95% confidence interval when $p \leq 0.05$. The hardness was increased when the thickness of fresh, before drying, after drying and rehydration of SBS increased. Apparently, the SBS after drying had the highest hardness, followed by before drying, and rehydration, respectively. The hardness of fresh SBS has the strong structure. In general, the SBS is the main chemical constituents of carbohydrates that is found both digestible and indigestible. Most digestible carbohydrates are starch and sugar. Indigestible carbohydrates are the strong structure in plants tissues, including cellulose (73.83%), hemicellulose (12.49%), lignin 10.15 (%), pectin (0.37%) and other substances (3.16%) (Azeez & Orege, 2020). It gives strength of SBS structure, which directly effect on the SBS texture. The high-thickness has a high hardness, and the structure is stronger than SBS with low-thickness. The texture of SBS that through boiling in hot water and fermented with salt were very soft. The SBS boiling in hot water causes some structural changes and the cell membrane weakens. Moreover, fermentation with sodium chloride salt increases the propulsion of osmosis causing the spread of water and solvent (Yuenyongputtakal, 2013). Therefore, the hardness of SBS decreased compared to fresh SBS.

The effect of drying on the hardness of SBS was investigated. It was found that SBS after drying had higher hardness values compared to other procedures. It may be caused by the water in the cells of SBS is eliminated during drying, which causing the structure of SBS to shrink, dry, crispy. The high-thickness has a higher hardness than the low-thickness. Furthermore, the dried SBS is soaked in water that it absorbs water. The structure of the SBS absorbs water, causing the cells to develop better and with more firmness. It is not sticky or hardened, soft, flexible, and similar to SBS before drying. The water molecules penetrate the cells of SBS. The hardness of SBS rehydration decreased compared to SBS after drying.

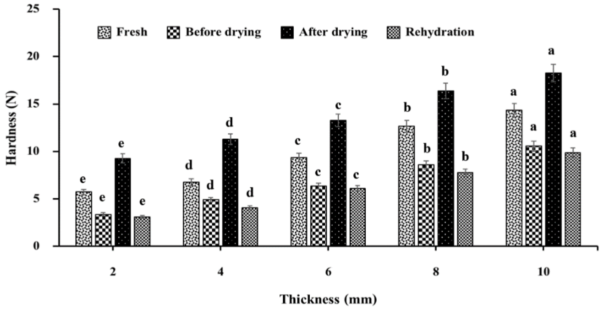

Fig. 3 The effect of different thickness on the hardness of SBS

The effect of different thickness on the sodium chloride content of SBS after rehydration is shown in Fig. 4. It was found that the sodium chloride salt content of SBS after rehydration at various thickness had significant difference of the 95% confidence interval when $p \leq 0.05$. The amount of sodium chloride salt in SBS after rehydration was decreased when the thickness of SBS increased. The sodium chloride salt content in SBS is safe for consumption. According to the Recommended Daily Intakes (Thai RDI) of sodium in the nutrient list, recommended daily for Thais aged 6 and over is 2000 mg (Ministry of public health, 2020). The use of sodium chloride mixed bamboo shoots resulted in the removal of water by the osmosis method that can reduce the amount of water in bamboo shoots. The osmosis factor is related to mass transfer and product quality. Some water is removed from bamboo shoot tissues. The difference in osmotic pressure between bamboo shoots cells and osmotic solutions occurs. It is a driving force that causes the mass transfer between SBS cells and osmotic solutions. In the opposite direction through the cell membrane, which acts as a semi-permeable membrane. The cell wall of bamboo shoots can expand. When the pressure occurs within the cell, the membrane cell acts as a semi-permeable membrane. The water is more permeable than osmotic solutions. The mass transfer is occurring between osmotic system. The water inside the cells of bamboo shoots will spread from the cells to osmotic solutions.

Sodium chloride will spread into the cells of bamboo shoots. Some substances contained within the bamboo shoots cell will spread from the cell to osmotic solution (Yuenyongputtakal, 2013). The thickness of bamboo shoots affects the mass transfer of osmotic material. It is the result of the movement of water from bamboo shoots and the movement of the solvent from the osmotic solution. The ratio between the contact area and the osmotic solution has an effect. The bamboo shoots with a low thickness will have a lot of surface area. Water is more likely to propagate than high thickness bamboo shoots with little contact area. It results in low-thickness bamboo shoots having higher sodium chloride content than high-thickness bamboo shoots.

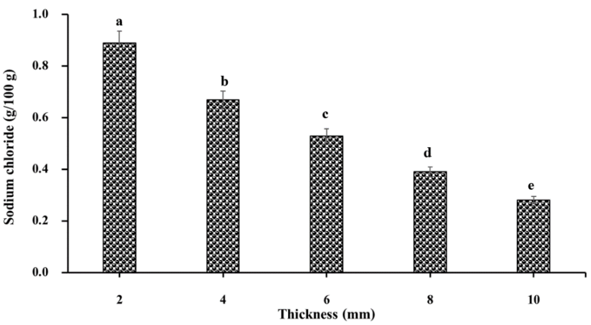

Fig. 4 The effect of different thickness on the sodium chloride content of SBS after rehydration

2. Effect of thickness on drying time and rehydration time using different methods of SBS

The effect of thickness on drying time and rehydration time using different methods of SBS is shown in Fig. 5. It was found that the drying time and rehydration time varied directly as with the thickness of SBS. The thickness, size, shape, volume, surface area of SBS is a physical property that affects the drying time. The low thickness SBS have a high ratio of surface area to volume, it will have more area for water evaporation and faster drying rate. Therefore, the drying rate of high-thickness will be slower than the low-thickness. The drying rate varied directly as with the thickness of SBS.

Rehydration quality is important for dried bamboo shoots. It involves changes in the physicochemical of unit operations of bamboo shoots preparation before drying and during drying (Sirijariyawat et al., 2017). The thickness of bamboo shoots influences rehydration time. The high-thickness is longer to recover water than the low-thickness. Rehydration of bamboo shoots after drying by different methods as follows: soak in room temperature, boil in hot water and soak at room temperature for 30 min before boiling in hot water were studied. The result shows that the combination method between soaking the water at room temperature 30 min before boiling in hot water had the least amount of rehydration time, followed by boiling in boiling water, and soaking the water at room temperature, respectively. Soaking dried SBS at room temperature, it absorbs water into the cells, causing the SBS structure to weaken. When the temperature increases, resulting in the water absorbed during the initial phase. The heat transfer within the cells improves, resulting in the water returning faster than other methods. The rehydration of dried bamboo shoots involves the process of bamboo shoots preparing before drying and during drying, which affects the changes structural of bamboo shoots. There are many factors affecting on rehydration rate such as temperature and drying time. The thick bamboo shoots had a long drying time. It is dry and hard on the surface area, causing fluctuations in air flow rate and difficult to control the moisture transfer from bamboo shoots. Prolonged heating of the bamboo shoots cell walls has been damaged, resulting in decreased water absorption of bamboo shoots (Madan & Pare, 2017).

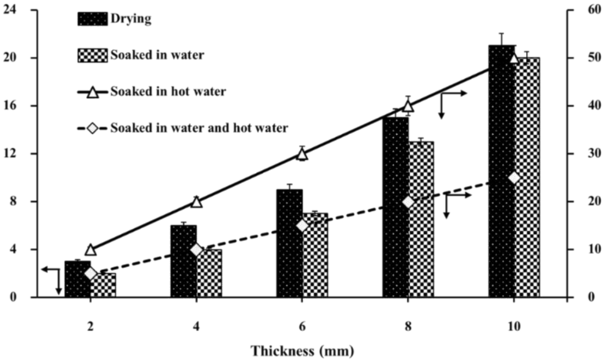

Fig. 5 The effect of different thickness on time for drying and soaking of SBS

3. Effect of thickness and rehydration using different methods on the sensory acceptance of SBS

The effect of thickness and rehydration using different methods on the sensory acceptance of SBS shown in Table 2. It was found that the mean scores of sensory acceptability of SBS with a thickness of 2 mm which rehydration using 3 different methods, had the highest scores on appearance, color, texture, flavor and overall liking. The SBS with a thickness of 10 mm had the lowest average score on appearance, color, texture, flavor and overall liking. In general, the average liking score trends to decrease when the thickness of SBS increases. The sensory evaluation results were consistent with the obtained values from the physicochemical analysis of SBS. Obviously, the appearance and natural color of the SBS were not dark. The SBS with a thickness of 2 mm had the least brown color. The texture after rehydration was soft, not sticky or hardened. It was like boiled SBS before drying and the flavor was natural of bamboo shoots. Therefore, the SBS with a thickness of 2mm was the appropriate size for further development in the production of dried SBS for commercial production. In addition, the advantages of producing dried SBS with a low thickness, which does not take long to dry compared to using high thickness. It saves energy in drying and results in shorter rehydration times at a high thickness. The quality of the final product with low-thickness had better physicochemical and sensory properties than that of high-thickness.

Table 2 The effect of different thickness and soaked methods on sensory evaluation of SBS

Attribute	Thickness (mm)				
	2	**4**	**6**	**8**	**10**
Soaked in water (hr)	2	4	7	13	20
Appearance	$7.77{\pm}0.86^{a}$	$7.37{\pm}0.89^{ab}$	$6.87{\pm}1.20^{bc}$	$6.40{\pm}1.13^{cd}$	$6.10{\pm}1.32^{d}$
Color	$8.00{\pm}0.79^{a}$	$7.50{\pm}0.94^{a}$	$6.73{\pm}1.26^{b}$	$6.53{\pm}1.28^{bc}$	$6.03{\pm}1.61^{c}$
Texture	$7.67{\pm}0.88^{a}$	$7.37{\pm}0.89^{ab}$	$6.77{\pm}1.14^{b}$	$6.13{\pm}1.46^{c}$	$5.90{\pm}1.65^{c}$
Flavor	$7.83{\pm}0.79^{a}$	$7.43{\pm}0.86^{a}$	$7.40{\pm}0.93^{a}$	$6.63{\pm}1.40^{b}$	$6.30{\pm}1.62^{b}$
Overall liking	$7.90{\pm}0.88^{a}$	$7.33{\pm}1.03^{a}$	$6.63{\pm}1.35^{b}$	$6.17{\pm}1.72^{bc}$	$5.53{\pm}1.48^{c}$
Soaked in hot water (min)	10	20	30	40	50
Appearance	$7.10{\pm}1.24^{a}$	$6.40{\pm}1.77^{a}$	$4.83{\pm}2.45^{b}$	$4.07{\pm}2.74^{bc}$	$3.00{\pm}2.02^{c}$
Color	$7.20{\pm}1.27^{a}$	$6.07{\pm}2.02^{b}$	$4.97{\pm}2.30^{c}$	$3.83{\pm}1.95^{d}$	$2.70{\pm}1.84^{e}$
Texture	$6.83{\pm}1.44^{a}$	$5.73{\pm}2.18^{b}$	$4.47{\pm}2.45^{c}$	$3.37{\pm}2.13^{d}$	$2.13{\pm}1.57^{e}$
Flavor	$7.07{\pm}1.41^{a}$	$6.03{\pm}2.08^{ab}$	$4.90{\pm}3.00^{bc}$	$4.87{\pm}2.52^{bc}$	$4.33{\pm}2.64^{c}$
Overall liking	$7.00{\pm}1.39^{a}$	$5.57{\pm}1.92^{b}$	$4.87{\pm}2.56^{b}$	$3.60{\pm}2.46^{c}$	$2.77{\pm}2.03^{c}$
Soaked in water and hot water (min)	5	10	15	20	25
Appearance	$7.57{\pm}0.90^{a}$	$7.10{\pm}0.66^{a}$	$6.53{\pm}1.01^{b}$	$5.97{\pm}0.93^{c}$	$5.43{\pm}1.33^{d}$
Color	$7.67{\pm}0.84^{a}$	$7.20{\pm}0.71^{a}$	$6.50{\pm}1.22^{b}$	$5.80{\pm}1.10^{c}$	$5.37{\pm}1.47^{c}$
Texture	$7.43{\pm}0.73^{a}$	$7.13{\pm}0.73^{ab}$	$6.57{\pm}1.07^{b}$	$5.73{\pm}1.28^{c}$	$5.03{\pm}1.61^{d}$
Flavor	$7.60{\pm}0.62^{a}$	$7.20{\pm}0.66^{ab}$	$6.97{\pm}0.85^{b}$	$5.83{\pm}1.39^{c}$	$5.20{\pm}1.79^{d}$
Overall liking	$7.63{\pm}0.76^{a}$	$7.07{\pm}0.78^{a}$	$6.33{\pm}1.09^{b}$	$5.77{\pm}1.63^{bc}$	$5.30{\pm}1.39^{c}$

Remark: Mean±SD, $^{a-d}$ means within each row indicate significant differences ($p \le 0.05$) using Duncan's multiple range test

4. Chemical compositions and shelf life of dried SBS

The chemical composition of dried SBS with 2 mm was analyzed. It was found that moisture content, protein, fat, total carbohydrate and ash were 11.86 ± 0.92%, 22.52 ± 0.18%, 4.18 ± 0.16%, 48.18 ± 0.86% and 13.26 ± 0.26%, respectively. The energy was 320.24 ± 1.04 kcal. The dried SBS was kept in sealed plastic packaging for 6 months at 30°C. The results show that dried SBS had moisture content not more than 14% by weight. Yeast and mold were not more than 500 colonies per 1 gram samples, which are safe for consumption, according to the standard of dried bamboo shoots products. The standard range, the number of acceptance level from the yeast and mold of dried bamboo shoot products were not more than 500 colonies per 1 gram sample (Thai industrial standards institute, 2006).

Conclusion

The thickness of SBS is important for the drying rate and the quality of dried SBS. Physicochemical properties and sensory evaluation were investigated for selecting the suitable thickness to produce dried SBS. It was found that the weight loss was increased when the thickness of SBS decreased. The unit operations during processing affects weight loss. The SBS during the drying process had higher weight loss values than before drying. The browning value and the hardness of the SBS varied directly as the thickness. The low-thickness had a higher salt content than the high-thickness. The high thickness had longer drying time and longer rehydration time. The SBS with 2 mm received the highest overall liking scores of sensory acceptability. Apparently, the optimum thickness for producing dried SBS was 2 mm. The dried SBS was high fiber, low fat, and protein content. It has a shelf life in sealed packaging for at least 6 months. Therefore, the knowledge gained from this research can be used as a guideline for the development of dried SBS which can be further extended for commercial production. Further development should be studied about the other choice for drying and techniques for reducing the water recovery time of SBS, etc.

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