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Effect of Setting Agent on Quality of Tubed-Package Sesame Tofu

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Sesame tofu is a traditional Japanese healthy food made from sesame milk. Normally, it is mixed with kudzu, a kind of starch similar to arrowroot starch. Nevertheless, there are many textural characteristics of sesame tofu in Japan market. All are packaged in square tray and eaten as snack or dessert. There have not been sesame tofu packaged in tube, which will be used for cooking in savory dish, which should be stable in shape when cooked. Therefore, this study has been focused on the effect of setting agent on quality of tubed-package sesame tofu. The setting agent used in this study were carrageenan, agar, modified starch SS, modified starch MB and arrowroot starch. Unroasted sesame seeds were studied. The results indicated that the increasing concentration of all stabilizers affected the water activity. More concentration of setting agent was applied in tubed-package sesame tofu, more water activity was obtained. The textural properties of tubed-package sesame tofu showed that all textural value increased significantly when their concentration increased especially the hardness value. The tubed-package sesame added arrowroot starch the modified starch SS gained more acceptable score than the other of setting agents added in tubed-package sesame tofu.

Keywords: sesame tofu, unroasted sesame, modified starch, arrowroot starch, carrageenan, agar

Introduction

Sesame seed (*Sesamum indicum L.*) is a flowering plant in the genus *Sesamum* which affiliated to the family Pedaliaceae. It presents more than 30 species but only *S. indicum* L. is cultivated (Makinde and Akinoso, 2014). It is cultivated in several countries such as India, Sudan, China and Burma, which provide about 60% of total world production. Sesame seed is one of the oldest oilseed crops. It an important source of oil (44–58%), protein (18–25%), carbohydrate (~13.5%) and ash (~5%) and extraordinarily rich in iron, magnesium, manganese, copper, calcium, vitamin B1 and vitamin E. Lignans are also available including sesamin, which are phytoestrogens with antioxidant and anticancer properties (Yadav *et al*, 2014).

Sesame tofu (gomatofu) is a traditional Japanese healthy food and as the representative of all the vegetarian dishes. In Chinese cuisine, this

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vegetarian dishes (*Fucha*-cuisine) called "*mafu*" normally consisting with starch and oil (Sato *et al*, 2007). Sesame tofu is made from sesame milk. Normally, it is mixed with kudzu, a kind of starch similar to arrowroot starch. The textural characteristic is so specialized which is soft, smooth, and springy. The textural properties are depending on sesame milk contents and preparing conditions such as cooking time and temperature. Moreover, the setting agent is one of the main effect on its textural characteristics, especially, the tubed package sesame tofu, which is needed the stable in shape when it is taken out of the package for cooking.

Therefore, this research aimed to study the effect of setting agent on the quality of tubed-package sesame tofu by using the setting agent such as carrageenan, agar, modified starch SS, modified starch MB and arrowroot.

Materials and methods

Materials

The unroasted of white sesame seeds was produced in Thailand. The carrageenan was supported by Wang Chemicals Co.,Ltd. (Thailand), Agar was supported by Unify chemical Co.,Ltd. (Thailand), Modified starch SS and Modified starch MB supported by Siam Modified Starch Co.,Ltd. (Thailand) and the highly pure arrowroot starch (kudzu) was purchased from the local farmer.

Preparation

The tubed-package sesame tofu was prepared from 100 g of sesame seeds and 300 g of water. They were mixed for 5 min and filtered using a sieve to obtain about 300 g of sesame milk (total solid 20%). A suspension of sesame milk was mixed with carrageenan (0.6, 0.8 and 1%), agar (0.6, 0.8 and 1%), modified starch SS (8, 10 and 12%), modified starch MB (8, 10 and 12%) or arrowroot starch (8, 10 and 12%) and then filled in tube package. Finally it was boiled at 90℃ for 50 min in water bath then cooled down for 15 min and chilled for 1 h before using for further analysis.

Water activity

The water activity of tubed-package sesame tofu samples was measured at room temperature by using the water activity meter (3TE, aqua lap). Deionized water was used as controls of known Aw values and each test was repeated 3 times.

Texture profile analysis

The textural properties of tubed-package sesame tofu was measured at room temperature by using the texture analyzer TA-X2i (Stable Micro systems, UK) The sesame tofu of each sample was cut with a diameter of 20 mm and a height of 10 mm. It was tested by using TPA which were compressed twice to 70% of their original height with a cylinder probe P/50. The pre-test, test and post-test speeds were set to 1, 2 and 2 mm/s, respectively. Each test was repeated 3 times. Hardness, adhesiveness, cohesiveness, springiness, gumminess, and chewiness were determined.

Microstructure

The microstructure of tubed-package sesame tofu was examined by the scanning electron microscope (SEM, Evo MA 10, Zeiss). The sample preparation for SEM was soaked in N_2 for quick freeze and then dried by freeze dryer. The sample was cut into small pieces and coated with gold using the gold sputter.

Sensory evaluation

The sensory evaluation of tubed-package sesame tofu was tested by forty untrained panelists. The test was determined on appearance, taste, texture and overall acceptability by using a 5-point hedonic scale. The concentration of 1.0% carrageenan, 1.0% agar 12.0%, modified starch SS, 12.0% modified starch MB and 12.0% arrowroot starch were used for testing. Tofu samples were cut in cube (10 mm) and served in steamed soup. All samples were encoded and presented in a randomized arrangement.

Experimental Design

The water activity and texture profile data were using complete randomized design (CRD) and sensory evaluation were based on randomized complete block design (RCBD). Data were analyzed using an ANOVA by the SPSS software version 16, whereas Duncan's multiple range tests was used for multiple comparisons among the means values of the tubed-package sesame tofu samples and significantly different at $P \leq 0.05$.

Results

The effect of setting agents on the water activity of sesame tofu in tubed-package.

The water activity of sesame tofu in tubed-package are shown in Table 1. The water activity of sesame tofu in tubed-package added with arrowroot starch didn't have significant difference at $P \leq 0.05$ but the water

activity of tofu added with carrageenan, agar, modified starch SS and modified starch MB increased when increasing the concentration. The sesame tofu in tubed-package added with carrageenan, agar and arrowroot starch (0.997-0.999) could hold more water than modified starch SS (0.995-0.998) and modified starch MB (0.996-0.998) at low concentration. All setting agent added in sesame tofu showed the similar water activity values.

Table 1. Water activity of sesame tofu in tubed-package added with various of setting agents.

Setting agent	Concentration (%)	Water activity (Aw)
Carrageenan	0.6	0.997 ± 0.00^{b}
	0.8	0.998 ± 0.00^{ab}
	1.0	0.998 ± 0.00^{a}
Agar	0.6	0.997 ± 0.00^{c}
	0.8	0.998 ± 0.00^{b}
	1.0	0.999 ± 0.00^{a}
Modified starch SS	8.0	0.995 ± 0.00^{b}
	10.0	0.997 ± 0.00^{a}
	12.0	0.998 ± 0.00^{a}
Modified starch MB	8.0	0.996 ± 0.00^{c}
	10.0	0.997 ± 0.00^{b}
	12.0	0.998 ± 0.00^{a}
Arrowroot starch	8.0	0.997 ± 0.00^{ns}
	10.0	0.998 ± 0.00
	12.0	0.998 ± 0.00

[1] Mean values with the different superscript of each setting agent in a column are significantly different ($P \leq 0.05$).
[2] ns means non significant difference.

The effect of setting agents on the textural properties of sesame tofu in tubed-package.

The textural properties of sesame tofu in tubed-package are shown in Table 2. All of textural values had increased when increasing the concentration for all setting agents. All textural value of sesame tofu added with both modified starches were higher than tofu added with carrageenan

and agar. This caused the tofu had a higher springiness and can resist more compression than tofu added carrageenan and agar. Tofu added with carrageenan and agar had less hardness, gumminess and chewiness values. This could be seen from the tubed-package tofu had smooth, glossy, slippery and less springy surface when compared to the tofu added with both modified starches. The sesame tofu with added arrowroot starch had lower hardness, gumminess and chewiness value than the tofu added with modified starch SS and modified starch MB but the adhesiveness and springiness value were higher. This showed that tofu added with arrowroot starch had a soft, smooth and springy texture more than tofu added with modified starch SS and modified starch MB. The results showed that tofu added with starch had the stronger gel structure than tofu added with carrageenan and agar.

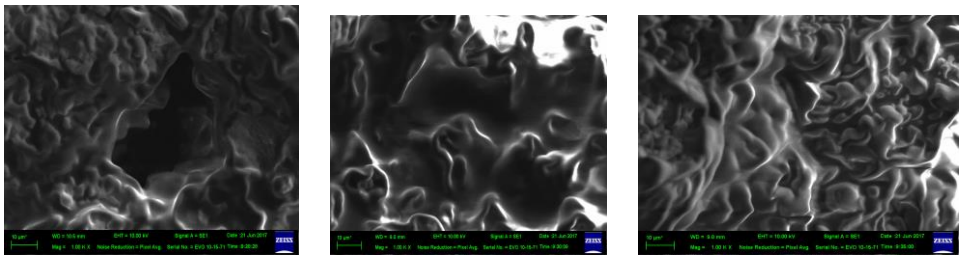
SEM observations of sesame tofu in tubed-package added with various setting agents.

The SEM observation of all setting agents revealed that gel structure were stronger and smoother surface when increasing the concentration (Figure 1-5) according with the results of the texture values shown in Table 2. Tofu added with carrageenan (Figure 1) had a gel formation and pore sizes similar to tofu added with agar (Figure 2) Regarding the tofu added with the modified starch SS and MB (Figure 3 and 4) and arrowroot starch (Figure 5) had a similar gel formation. The pore sizes of tofu added with carrageenan and agar were smaller than tofu added with the both modified starch and arrowroot starch. The tofu added with carrageenan and agar had a similar formation of gel structure which showed their hardness value (Table 2) were similar as well. From the micrograph, the tofu added with carrageenan and agar had a weaker gel structure than the tofu added with the both modified starch and arrowroot starch. This made their hardness values (Table 2) less than those added with the both modified starch and arrowroot starch.

Table 2. Textural properties of sesame tofu in tubed-package added with various of setting agents.

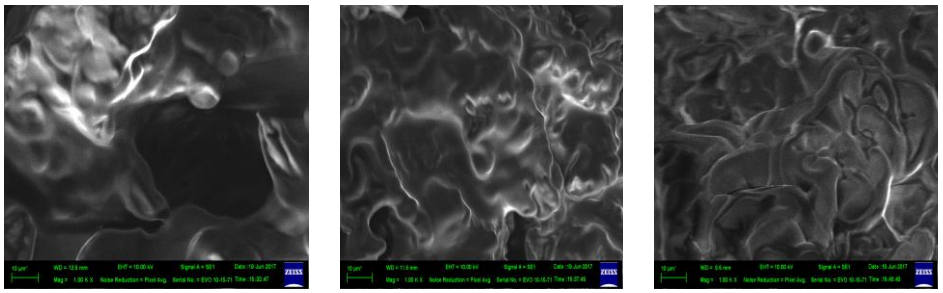
Setting agent	Concentration (%)	Hardness (g)	Adhesiveness (g.s)	Cohesiveness	Springiness	Gumminess (g)	Chewiness (g)
Carrageenan	0.6	107.4 ± 7.5 [c]	29.8 ± 1.8 [a]	0.2 ± 0.0 [a]	0.3 ± 0.0 [b]	23.4 ± 2.0 [c]	7.8 ± 1.5 [c]
	0.8	275.8 ± 13.5 [b]	20.5 ± 1.8 [b]	0.2 ± 0.0 [b]	0.4 ± 0.0 [b]	45.9 ± 3.0 [b]	16.0 ± 1.7 [b]
	1.0	446.4 ± 37.4 [a]	22.0 ± 1.8 [b]	0.2 ± 0.0 [b]	0.6 ± 0.0 [a]	71.6 ± 4.0 [a]	42.8 ± 1.8 [a]
Agar	0.6	208.2 ± 22.3 [c]	34.5 ± 3.4 [ab]	0.2 ± 0.0 [ns]	0.3 ± 0.0 [b]	41.7 ± 5.0 [c]	14.1 ± 1.6 [c]
	0.8	539.9 ± 129.7 [b]	46.5 ± 12.2 [b]	0.2 ± 0.0	0.4 ± 0.1 [b]	85.9 ± 32.0 [b]	33.1 ± 21.7 [b]
	1.0	753.3 ± 55.4 [a]	25.8 ± 1.3 [a]	0.2 ± 0.0	0.5 ± 0.1 [a]	129.4 ± 11.6 [a]	66.9 ± 12.2 [a]
Modified starch SS	8.0	491.0 ± 38.0 [b]	110.1 ± 35.1 [ns]	0.6 ± 0.1 [ns]	0.7 ± 0.0 [a]	278.0 ± 48.1 [b]	206.1 ± 42.7 [b]
	10.0	675.7 ± 77.8 [b]	197.1 ± 39.5 [ns]	0.5 ± 0.1	0.6 ± 0.1 [b]	332.4 ± 56.2 [b]	192.6 ± 25.8 [b]
	12.0	959.3 ± 139.4 [a]	146.8 ± 82.6 [ns]	0.5 ± 0.0	0.7 ± 0.0 [ab]	478.3 ± 85.6 [a]	329.9 ± 64.7 [a]
Modified starch MB	8.0	382.2 ± 65.1 [c]	103.9 ± 30.4 [ns]	0.7 ± 0.2 [ns]	0.6 ± 0.2 [ns]	269.9 ± 106.1 [ns]	148.2 ± 16.6 [ns]
	10.0	611.7 ± 17.7 [b]	140.4 ± 38.8 [ns]	0.4 ± 0.1	0.7 ± 0.2	272.3 ± 43.1	180.8 ± 19.8
	12.0	903.3 ± 105.5 [a]	185.6 ± 65.7 [ns]	0.5 ± 0.1	0.7 ± 0.1	467.7 ± 142.2	330.2 ± 151.7
Arrowroot starch	8.0	587.9 ± 51.4 [b]	197.6 ± 5.8 [c]	0.5 ± 0.0 [a]	0.8 ± 0.1 [ns]	273.1 ± 12.0 [c]	212.7 ± 33.8 [c]
	10.0	647.4 ± 43.2 [b]	290.0 ± 39.2 [b]	0.5 ± 0.0 [a]	0.8 ± 0.0	326.0 ± 10.8 [b]	264.0 ± 4.4 [b]
	12.0	876.9 ± 14.6 [a]	362.1 ± 31.6 [a]	0.4 ± 0.0 [b]	0.8 ± 0.0	378.2 ± 16.0 [a]	310.1 ± 9.6 [a]

[1] Mean values with the different superscript of each setting agent in a column are significantly different ($P \leq 0.05$).
[2] ns means non significant difference.



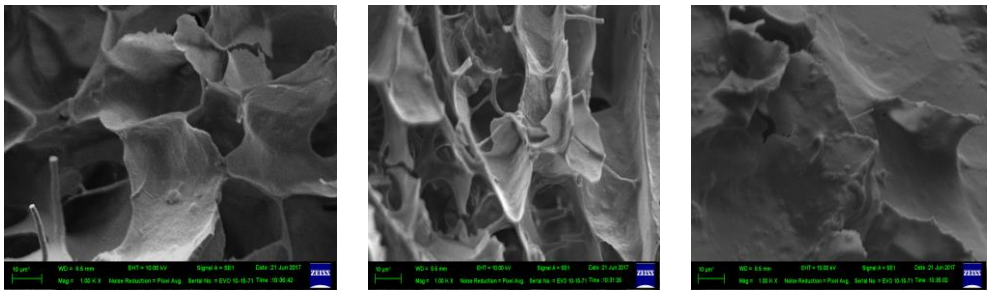
(A) (B) (C)

Figure 1 SEM micrographs of sesame tofu in tubed-package added with 0.6% carrageenan (A), 0.8% carrageenan (B) and 1.0% carrageenan (C) (x1000). Scale bars represents 10 µm.



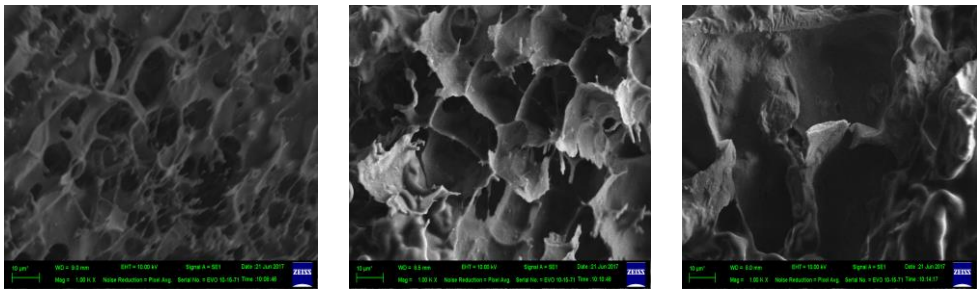
(A) (B) (C)

Figure 2 SEM micrographs of sesame tofu in tubed-package added with 0.6% agar (A), 0.8% agar (B) and 1.0% agar (C) (x1000). Scale bars represents 10 µm.



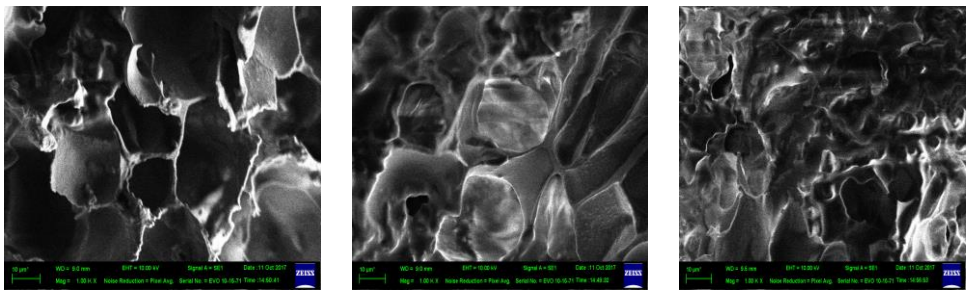
(A) (B) (C)

Figure 3 SEM micrographs of sesame tofu in tubed-package added with 8% modified starch SS (A), 10% Modified starch SS (B) and 12% Modified starch SS (C) (x1000). Scale bars represents 10 µm.



(A) (B) (C)

Figure 4 SEM micrographs of sesame in tubed-package tofu added with 8% modified starch MB (A), 10% modified starch MB (B) and 12% modified starch MB (C) (x1000). Scale bars represents 10 µm.



(A) (B) (C)

Figure 5 SEM micrographs of sesame tofu in tubed-package added with 8% arrowroot starch (A), 10% arrowroot starch (B) and 12% arrowroot starch (C) (x1000). Scale bars represents 10 µm.

The effect of setting agents on the sensory evaluation of sesame tofu in tubed-package.

The sensory evaluations of sesame tofu in tubed-package are shown in Table 3. The sesame tofu in tubed-package added with agar gained the lowest acceptable score in the appearance, taste, texture and overall acceptability. For tofu added with the modified starch SS obtained the acceptable score similar to tofu added with arrowroot starch. Both of them had a soft smooth very springy texture. Moreover, tofu added with the modified starch SS can be stable when served in steamed soup. The acceptable score in taste of tofu added with arrowroot starch and the modified starch SS. were higher than tofu added with the modified starch MB. Tofu added with carrageenan had acceptable scores in appearance, taste, texture and overall acceptability slightly lower than tofu added with

the modified starch SS because it had less springiness and less stable in steamed soup. From all the sensory results, it could be concluded that tofu added with 12% arrowroot starch and the modified starch SS were the most recognized from the test panelists.

Table 3. Sensory evaluation of unroasted sesame in tubed-package tofu (5-point Hedonic scale test).

Setting agent	Appearance	Taste	Texture	Overall acceptability
Carrageenan	3.2±1.1 [a]	2.5±1.0 [ab]	2.7±0.8 [ab]	2.7±0.9 [ab]
Agar	1.4±0.8 [c]	1.7±1.0 [c]	1.6±0.9 [c]	1.7±1.0 [c]
Modified starch SS	3.6±0.6 [a]	2.9±0.9 [ab]	3.0±0.8 [a]	3.1±1.0 [a]
Modified starch MB	2.6±1.1 [b]	2.5±1.2 [b]	2.4±1.3 [b]	2.4±1.3 [b]
Arrowroot starch	3.3±0.8 [a]	2.9±0.8 [a]	3.0±0.9 [a]	3.0±0.9 [a]

[1] Mean values with the different superscript of each setting agent in a column are significantly different ($P \leq 0.05$).

Discussion

The sesame tofu in tubed-package added with carrageenan and agar had a similar textural values and microstructure because both of them had a similar formation of gel structure. Carrageenan is polysaccharides of D-galactose, and 3, 6 anhydro-D-galactose that has sulfate groups per disaccharide units consisted of 3-linked b-D-galactopyranose and 4-linked 3,6-anhydro-a-L-galactopyranose (Necas and Bartosikova, 2013; Trius and Sebranek, 1996) and agar has disaccharide units consisted of 3-linked b-D-galactopyranose and 4-linked 3,6-anhydro-a-L-galactopyranose which is similar structure to carrageenan but the galactose are d- series in carrageenans and l- series in agars (Usov, 1997).

The sesame tofu in tubed-package added with starch as a setting agents could be stable in shape when cooked as soup more than tofu added with carrageenan and agar because carrageenan and agar is a thermo-reversible gel that it could turn back to a fluid when heating and can perform consistently when provided with the right temperatures. This caused some parts of surface of tofu with carrageenan and agar dissolved to the soup. The networks structure of sesame tofu added with starch had a tighter structure and smaller pore size than tofu added with carrageenan and agar which made more springiness and acceptable score by untrained panelists.

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