

The compositions and properties of spray dried tuna flavor powder produced from tuna precooking juice

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Abstract: This study was to utilize the waste from canned tuna processing (tuna precooking juice) for producing dried tuna flavor powder. Tuna precooking juice was centrifuged and concentrated to 15% total soluble solid (TSS). Maltodextrin (DE 9) was added to increase the TSS of tuna precooking concentrate to 20, 22, 24 and 26%, then dried by spray dryer at 180°C inlet air temperature. The compositions and properties of spray dried tuna flavor powder were determined. Color of spray dried tuna flavor powders was pale brown. The composition of tuna flavor powders consisted of 4.63±0.2 to 7.46±0.3% moisture, 28.49±0.5 to 42.06±0.1 % protein and 3.44±0.3 to 4.25±0.3% ash. TBARS value of the powders was 0.51±0.08 to 0.62±0.05 mg MDA/kg sample. Bulk density of the powders was increased with increasing maltodextrin levels. All spray dried tuna flavor powders showed high in solubility. Based on compositions and properties, tuna flavor powders should produce from tuna precooking concentrate with 22% TSS.

Keywords: Tuna flavor powder, spray drying, composition, physical properties

Introduction

Thailand has become the world largest exporter of canned tuna and largest importer of fresh and frozen tuna. By year 2009, tuna products with total amount of 483,894 tons and value of 61,036 million baht were exported (Department of Foreign Trade, 2009). Tuna processing produced 30–35% product yield, 20–35% of solid waste and 20–35% of liquid waste (Prasertsan *et al.*, 1988). Normally, utilization of tuna solid waste or by-product is in the form of low value applications such as fishmeal or pet foods (Barlow, 2000). Tuna precooking juice was liquid by-product incurred in the process of ripening in the early stages (pre-cooking) process of canned tuna. After evisceration, tunas were heated by steam at 100–105°C for a period of time depending on the size of fish. Tuna precooking juice contained soluble protein, gelatin and fat (Uttamangkabovorn *et al.*, 2005). Several researchers have utilized the tuna precooking juice as flavor sauce by enzyme hydrolysis and concentrated to increase protein content. The flavor sauce contained amino acids especially, glutamic acid, which provides umami flavor (Samocha *et al.*, 2004). One possible way to use the tuna liquid wastes is to produce tuna flavor powder for human consumption.

Spray drying is the most widely use industrial process for removal of solvent involving particle

formation and drying. One problem in spray drying is the stickiness. To minimize the stickiness problem, both process-based and material science-based approaches are in place. Process-based approaches include the mechanical scraping of the chamber wall, the introduction of cold air at the bottom, and the use of low temperature/low humidity air. An example of the material science-based approach involves the addition of drying agents to reduce the stickiness of the powders (Adhikari *et al.*, 2003). Several researchers have added drying aids which are high molecular weight carbohydrates such as maltodextrin to reduce the stickiness of the material and reduce wall deposition problems. Generally, drying aids have high molecular weights and high glass transition temperatures. Maltodextrins are oligosaccharides, made from starch, that have dextrose equivalents (DE) of less than 20. The use of maltodextrin as a drying aid has given good results in terms of minimizing wall deposition (Langrish *et al.*, 2007). Maltodextrin was applied to drying process of soup, coffee, tea (Sharpless *et al.*, 1997) and lemon juice powder (Roustapour *et al.*, 2006). It is also applied to protein quantification in milk (Akazawa *et al.*, 1999) or to an analysis of trace elements in orange juice (Simpkins *et al.*, 2000). In addition, spray dry technique also used in fish flavor products such as fish protein hydrolysate powder (Nilsang *et al.*, 2005). Kurozawa *et al.* (2009) who produced chicken protein hydrolysate powder

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by hydrolysis with alkalase® and added maltodextrin for spray dry (inlet air temperature was 180°C and outlet air temperature was 91-102°C). The products were pale brown in color and contained the chicken flavor.

The objective of this present study was to produce tuna flavor powder by spray drying and determined chemical composition and physical properties of tuna precooking powder before formulation into ready mix seasoning powder.

Materials and Methods

Preparation of tuna precooking juice concentrate and tuna flavor powder

Tuna precooking juice was kindly provided by Tropical Canning Co., Ltd., Hat Yai, Thailand. The juice was collected from precooking process, where tunas were steamed for a certain time at 100–105°C. The juice was stored overnight at 4°C. After chilling, the floating fat was removed from surface of tuna precooking juice. The juice was heated up to 40°C and centrifuged at 8,000 rpm to remove the suspended solid. Tuna precooking juice was concentrated in an evaporator to obtain the concentrated juice with 15% total soluble solid (TSS), then stored at –20°C until use. After that, the concentrated tuna precooking juice was heated to 70°C and maltodextrin with a DE value of 9 (Shandong Xiwang Imp. & Exp Trade Co.,Ltd, China) was added to increase the TSS of tuna precooking concentrate to 20, 22, 24 and 26%. The tuna precooking concentrate was spray dried by spray dryer (NIRO, U.S.A.), with an inlet air temperature at 180°C and outlet air temperature of 75°C. The powder was collected and packed in aluminum foil laminated bags and sealed as vacuum packaging. The packed tuna flavor powder was stored at room temperature, which was around 30±2°C for further analysis.

Chemical properties

Proximate analysis

The tuna cooking juice concentrate and tuna flavor powder was used for moisture, protein, lipid, ash and salt contents analysis. The moisture content was measured using an oven method according to Association of Official Analytical Chemists (AOAC International) standard. Salt content was determined using the Vorhard method. The Kjeldahl method was used for protein determination and the Soxhlet method was used for the lipid content. For ash content, the sample was weigh and transfer to a muffle furnace at 550°C until a white or light grey ash is obtained. Three replications of all of these measurements were

carried out.

Water activity

The water activity of the powder was determined using a water activity meter (Novasina, Switzerland). The temperature was maintained at 24.5±0.5°C.

Thiobarbituric acid

Thiobarbituric acid (TBA) content of the tuna flavor powder was determined by the method described by Egan *et al.* (1981).

Total soluble solid (TSS)

The total soluble solid (TSS) of tuna cooking juice (15 %TSS) was determined using a hand refractometer (ATAGO, Tokyo, Japan) at 25 °C. All experiments were conducted at room temperature and average values of three replications were reported.

Physical properties

Color of tuna flavor powder

The color of tuna flavor powder was measured using a colorimeter (Miniscan, Hunterlab, Va, USA) in CIE L*, a*, b* color space. The powder was placed on the light port of Color Reader. Each value represents a mean of triplicate determination of three different positions for each sample. The values were reported as the average of individual value as L (lightness), a (+a is red, -a is green) and b (+b is yellow, -b is blue). Before measuring the color, the Color Reader was standardized with black and white calibration tiles supplied with the instrument.

Bulk density of tuna flavor powder

Tuna flavor powder, 5.0±0.1 g, was gently filled into a dried 10 ml cylinder, rapped gently the cylinder for 3 times. The volume of the powder was recorded as according to the method of Chitomarar (2002). The bulk density was calculated as following relationship.

$$\text{Bulk density} = \frac{\text{Weight of tuna flavor powder}}{\text{Volume of tuna flavor powder}}$$

Solubility of tuna flavor powder

An amount of 0.5 g of tuna flavor powder (W_1) was placed in a 100 ml glass beaker and added with 5 ml distilled water at 25°C. The powder was gently mixed by a spatula for 1 min or until no more fine particles was seen. The solution was then filtered

through a Whatman filter paper No.4 that was known for its weight (W_2). The filter paper was dried at 100°C for 4 h in a hot air oven, cooled in a desiccator and weighed again (W_3). The powder solubility was calculated by the procedure of Kahtani and Hassan (1990) as:

$$\% \text{ Solubility} = 100 - \frac{\{[W_3 - W_2] \times 100\}}{W_1}$$

Particle size distribution

Particle size of tuna flavor powder was tested by Laser particle size analyzer (LS 230, COULTER:LPSA)

Morphology of tuna flavor powder

The appearance, size and shape of the powder samples were examined with scanning electron microscope (SEM) (JEOL, JSM-5800 LV, JOEL Ltd., Tokyo, Japan). The samples were mounted on an aluminum stub using a double sided adhesive tape and thereafter making it electrically conductive by coating with a thin layer of gold in vacuum condition. The scanning electron microscope was operated at 10 kV an acceleration voltage.

Statistical analysis

All measurements were made in triplicate for each sample. Data were subjected to analysis of variance (ANOVA) and mean comparisons were performed using the Duncan's new multiple range test.

Results and Discussion

Chemical composition and quality of 15% TSS tuna precooking juice concentrated and tuna flavor powder

Prepared tuna precooking juice was centrifuged and concentrated in a rotary evaporator to obtained 15% TSS. The composition of the concentrate consisted of 86.58% moisture, 4.34% ash, 3.09% salt, 1.02% lipid, 7.10% protein and 0.98 a_w . Several researchers reported that tuna precooking juice are good sources of high quality proteins and there is an opportunity to use more fish processing by-products as protein ingredients for food and feed in industrial applications. This result was agreed with the report of Oh *et al.* (2007) that the component of 5 folds concentrated seafood cooking drip from skipjack tuna, octopus and oyster cooking drip consisted of 30, 15 and 23 °Brix, 71.8, 86.2 and 80.2 %moisture,

18.2, 7.4 and 6.8 %crude protein, 0.6, 0.7 and 0.6 %crude lipid, 10.5, 6.3 and 11.8%salt, 8.7, 4.9 and 10.4 %crude ash, respectively. The variation in composition of seafood cooking concentrate depending on species, age, source of seafood, season and prepared raw material (hydrolysis or concentrate) (Prasertsan *et al.*, 1988)

The composition of tuna flavor powders consisted of 4.63 to 7.46% moisture, 28.49 to 42.06% protein, 0.87% to 1.00% lipid, 3.44 to 4.25% ash and 10.88% to 16.76% salt, respectively. Moisture, protein salt and lipid contents tended to decrease with increasing the TSS with maltodextrin, while ash content and %yield of the powder tended to increase (Table 1). From preliminary experiments, an analysis of ash content in maltodextrin was 4.17% and adding maltodextrin to tuna precooking concentrate not only increased the TSS but also ash content of the powder. However, protein, lipid and salt contents of powder was decreased because the ratio of tuna concentrated to maltodextrin was varied, this may due to the percentages of maltodextrin added (Abadio *et al.*, 2004; Kurozawa *et al.*, 2009). This result was similar to spray-dried tomato paste and ginger juice that moisture content also decreased with increasing maltodextrin concentration due to its hygroscopic property (Goula *et al.*, 2005; Phoungchandang and Sertwasana, 2010). In spray drying system, the water content of feeding sample affected the final moisture content of the powder. Addition of maltodextrin to the feed prior to spray drying increased the total solid content and reduced the amount of water for evaporation resulting to decrease the moisture contents of the powder produced. This meant that powders with lower moisture content could obtained by increasing the percentages of maltodextrin added (Abadio *et al.*, 2004).

Water activity (a_w) is an important index for spray-dried powder because it can greatly affect the shelf life of the powder produced. Generally, food with $a_w < 0.6$ is considered as microbiologically stable and if there is any spoilage occurred, it is induced by chemical reactions rather than by micro-organism (Goula *et al.*, 2005). From this experiment, the water activity of tuna flavor powder decreased with increasing the level of maltodextrin (Table 1). Phoungchandang and Sertwasana (2010) reported that a_w in spray dried ginger powder decreased with increasing maltodextrin concentration as a drying aid.

TBARS value is indicative of oxidative changes resulted from formation of the unpleasant off flavor in the product (Sharma *et al.*, 1995). Since tuna flavor powder consisted of oil from tuna, which

was containing the unsaturated fatty acid, it was susceptible to oxidative deterioration. It was found that TBARS values in the products was very low (0.51-0.62 mg malonaldehyde/kg sample) reflecting to the low formation of off flavor. Several researchers reported that the spray dried fish protein hydrolysate powder was light brown in color with fish-like and dry squid-like odor, and diluted fish sauce-like taste (Nilsang *et al.*, 2005). This result was also in accordance with Teerasuntonwat and Raksakulthai (1995) who reported that the shrimp head powder that extract with 1%NaCl was light brown in color and strongest shrimp flavor. Haard (1992) reported that seafood products cooking juice consisted of water soluble flavor compounds including low molecular weight (MW) components, i.e., free amino acids (glutamic acid, glycine, taurine), peptides, organic acid (lactic acid), sugar (glucose, ribose) and inorganic salts (Na^+ , K^+ , Cl^-). Tuna cooking juice consisted of amino acid, especially, glutamic acid that enhancing the umami taste (Jao and Ko, 2002).

Table 1. Chemical composition, yield, a_w and TBA of tuna flavor powder produced from 20-26%TSS tuna precooking concentrate.

Parameters	20% TSS	22% TSS	24 % TSS	26 % TSS
Moisture (%)	7.46 ± 0.3 ^a	7.20 ± 0.1 ^a	6.01 ± 0.1 ^b	4.63 ± 0.2 ^c
Protein (%)	42.06 ± 0.1 ^a	34.69 ± 0.2 ^b	30.25 ± 0.1 ^c	28.49 ± 0.5 ^d
Lipid (%)	1.00 ± 0.02 ^a	0.97 ± 0.02 ^a	0.95 ± 0.01 ^a	0.87 ± 0.1 ^b
Ash (%)	3.44 ± 0.3 ^b	3.86 ± 0.2 ^{ab}	4.25 ± 0.3 ^a	4.25 ± 0.3 ^a
Salt(%)	16.76 ± 0.08 ^a	13.40 ± 0.08 ^b	11.70 ± 0.08 ^c	10.88 ± 0.09 ^d
a_w	0.48 ± 0.02 ^a	0.49 ± 0.01 ^a	0.42 ± 0.01 ^b	0.33 ± 0.01 ^c
Yield (%)	11.2 ± 1.70 ^c	17.1 ± 1.5 ^b	17.8 ± 1.4 ^b	23.3 ± 1.0 ^a
TBA (mg MDA/kg sample)	0.62 ± 0.05 ^a	0.61 ± 0.02 ^a	0.58 ± 0.07 ^{ab}	0.51 ± 0.08 ^b

^{a-d} Mean within a row with different letters are significantly difference (p<0.05)

Physical properties of tuna flavor powder

Color

Color of 15%TSS tuna precooking concentrated was 33.92±0.06 in L*value, 12.07±0.10 in a* value and 27.23±0.3 in b* value. Maltodextrin (DE 9) was added to increase the TSS of tuna cooking to 20, 22, 24 and 26% TSS. The spray dried powder was pale brown in color with L*value was 80-84.38, a* value was 3.23–4.50 and b* value was 18.53–22.52 (Fig 1). L* value of the powder increased significantly with added maltodextrin in tuna concentrate up to 26% TSS. The a* value was slightly decreased with increasing the TSS, while the yellowness (b* value) was decreased significantly, especially, at 26%TSS.

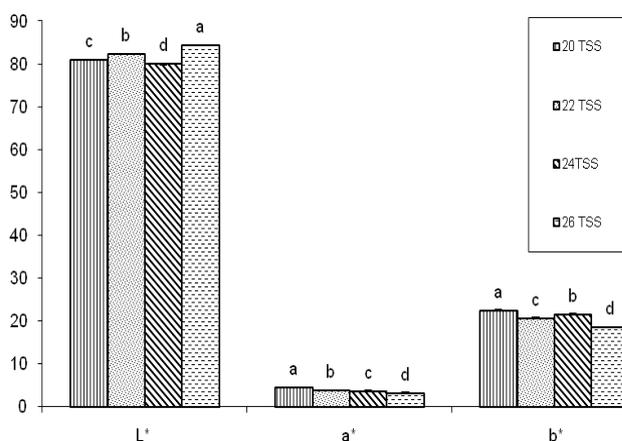


Figure 1. The color of spray dried tuna flavor powder produced from 20-26%TSS tuna precooking concentrate

An increasing of L* value in spray dried powder resulted from maltodextrin. Because maltodextrin was white in color, increasing the level of maltodextrin increased L* of the powder. The color of spray dried powders from this experiment was agreed with Nilsang *et al.* (2005) who reported that the color of spray dried hydrolyze fish soluble concentrate was light brown. This result was also in accordance with Kurozawa *et al.* (2009) reported that the pale brown color of chicken flavor powder from chicken cooking drip increased when increasing the level of maltodextrin.

Bulk density

Bulk densities of the tuna flavor powder produced from tuna concentrate with 20, 22, 24 and 26%TSS were 0.39±0.01, 0.41±0.01, 0.41±0.01, and 0.44±0.02 g/ml, respectively. Bulk densities of the powder from tuna concentrate with 20, 22 and 24 %TSS were significantly lower (p<0.05) than from 26%TSS. This result was in accordance with Sarochawitkasit *et al.* (2007) who reported that bulk density of spray

dried pineapple juice was increased with increasing maltodextrin. The high bulk density in sample implied that the particles tend to stick together (Goula and Adamopoulos, 2008).

Solubility

Solubility is one of the most important physicochemical and functional properties of protein concentrates. Solubility of tuna flavor powder was 60.87-70.12%. The solubility tended to increase with increasing maltodextrin level up to 24 %TSS. This result was agreed with Sarochawitkasit *et al.* (2007) who reported that solubility of spray dried pineapple juice was 93–96% when adding 37-43% maltodextrin. There seems to exist a tendency for water solubility increased when increasing replacement of maltodextrin (Cano-Chauca *et al.*, 2005) The high solubility of powder indicated potential applications in formulated food systems by providing an attractive appearance and a smooth mouth feel to the product (Sathivel *et al.*, 2004).

Based on the composition and physical properties, the spray dried tuna flavor powder produced from 22%TSS tuna precooking concentrate was providing desirable finished product. This sample was selected for morphological study.

Particle size distributions and Scanning electron microscope (SEM) of tuna flavor powder

Particle sizes of tuna flavor powder were in range of $7.23 \pm 3.85 - 7.4 \pm 3.97 \mu\text{m}$. The average particle sizes of tuna flavor powder produced from 22%TSS tuna precooking concentrate was $7.4 \pm 3.97 \mu\text{m}$. Typically, particle size had impacted on bulk density (Grabowski *et al.*, 2006) when particle size decreased, the bulk densities increased. In addition, particle in spherical shape also had the highest bulk density value (Buffo and Reineccius, 2000). This implied that average particle size of tuna flavor powder produced from 20 %TSS tuna precooking concentrate was the smallest. Grabowski *et al.* (2006) revealed that particle size may aid in the slightly increased solubility of the powders. The shape of spray dried tuna flavor particle illustrated in Fig 2. Porrarud and Pranee (2010) reported that the shape of spray dried maltodextrin was spherical particles with dented surface. However, in this study found that shape of spray dried tuna precooking juice concentrate with 22% TSS was various in sizes and shapes (spherical, irregular and shrunk). This result was agreed with Norziah *et al.* (2009) and Kurozawa *et al.* (2009) who reported that scanning electron microscopy in fish oil encapsulated powders and meat protein hydrolysate powder showed some spherical, smooth and many

particles presented a spherical shape with a shriveled surface when increasing maltidextrin.

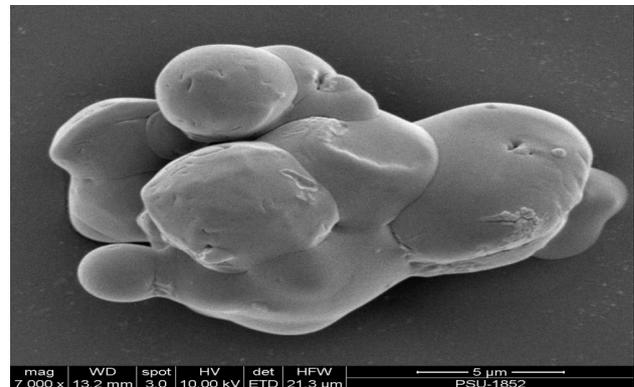
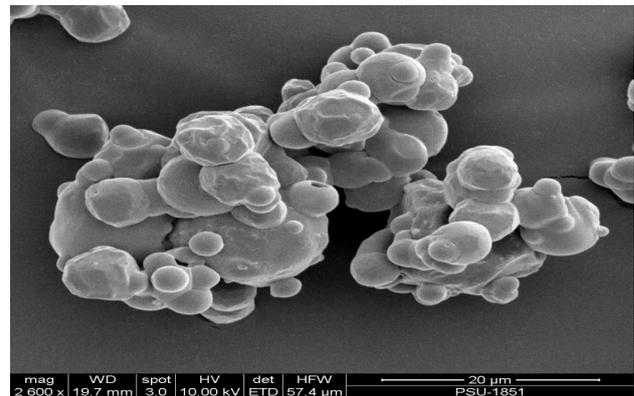
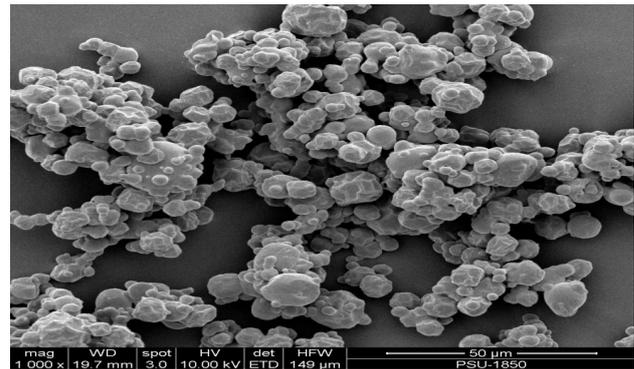


Figure 2. Scanning electron microscope (SEM) of spray dried tuna favor powder formulated with maltodextrin 22% TSS; (a) 1,000x, (b) 2,600x and (c) 7,000x.

This may be due to rapid particle shrinkage during the early stage of the drying process (Rosenberg *et al.*, 1985).

Conclusion

Tuna flavor powder producing from tuna precooking juice concentrate was pale brown in color, high protein, high solubility and low in oxidative off-flavor. From the composition, physical properties and morphology revealed that spray dried tuna flavor powder producing from 22% TSS tuna precooking juice concentrate was desirable. This result suggested

that tuna flavor powder could be used as a ready mix tuna flavoring powder or a flavor supplement in various fishery products.

Acknowledgments

The authors would like to thank the Agro-Industry Practice School (APS) Program and also the Graduated School, Prince of Songkla University for their financial support to conduct this research.

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