Characterization of meat analogue nugget: effect of textured vegetable protein

Nantawan Kitcharoenthawornchai[1] and Thepkunya Harnsilawat[1,*]

Abstract

Meat analogue nugget is the imitation product which should have texture, flavor and appearance similar to the meat nugget. Generally, the main ingredients for the meat analogue are soy protein or gluten. Textured vegetable protein (TVP) may be added to create the desirable texture. The study aimed to characterize the meat analogue nugget as the effect of TVP addition. Four formulas of meat analogue nuggets were prepared. The effect of TVP (10, 30, 50 and 70 %) was studied using texture, color and liquid separation measurements. An increase in TVP from 10 to 70 % in the formula decreased hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness ($p \leq 0.05$). Shear force and work of shearing were also decreased when increasing the TVP concentration. The addition of TVP caused the substitution of isolated soy protein, gluten and water in the formula which resulted in a fibrous structure of the product. The addition of TVP increased lightness and redness while decreased yellowness and chroma values of the uncooked meat analogue nuggets. Hue angle of all samples was in the yellowish and orange tone. This was due to the color of TVP after rehydrated which is pinkish-brown. The addition of TVP resulted in an increase in the percentage of liquid separation from the sample after centrifugation. However, the percentage of liquid separation for all samples was lower than 1.6% which meant that the liquid could be absorbed by the ingredients in the formula.

Keywords: meat analogue nugget, textured vegetable protein, textural properties, color, liquid separation

1. Introduction

Meat analogues are food products which have similar texture, color, taste and structure as meat. They can be meat substitutes or meat alternatives because they provide a good source of protein (SANA, 2010). Generally meat analogues are made from soy protein or gluten.

The main function of meat analogues is to replace meat in the diet. They may also be used as a bulking agent to extend real meat products. Textured vegetable protein (TVP) is a dry food product. It is usually made from defatted soy flour, from which soluble carbohydrate has been removed, and the residue is textured by spinning or by extrusion. Therefore, protein is the majority composition of TVP which has more than 50% (IFRPD, 2012; Sadler, 2004).

[1] Department of Product Development, Faculty of Agro-Industry, Kasetsart University, Bangkok 10900, Thailand

* Corresponding author, e-mail: thepkunya.h@ku.ac.th

It is popular to use in a vegetarian food because TVP can give a fibrous structure in the product, similar in texture of meat. There are many health benefits such as protection against heart disease, lower blood cholesterol, reduction the risk of cancer and increasing bone mass (Sadler, 2004). It can be used to reduce formulation cost because it is cheaper than meat. Other attributes such as the ability of retaining water and moisture during cooking, reheating, freezing, and thawing can also be a benefit. TVP are commonly used together to provide the desired quality, in texture, binding ability, desired amount of chewiness, or to make a product firmer or softer (Riaz, 2005). Generally consumers desire for products of meat alternative perceived as fresh, natural and high quality (Sadler, 2004).

Due to the increasing of consumer demand for healthy diets, the concern about rising meat prices, the increasing of the popularity of vegetarianism and the growing of consumer interest in related eating patterns such as the avoidance or reduced consumption of red meat (Sadler, 2004). Therefore, it is of interest to use an alternative source such as the plant protein as the ingredients in human diet. Meat nugget is one of the popular foods for all ages. It is usually produced from chicken meat, fish or others. It is one type of fried foods which is very common and generally acceptable worldwide that served at almost all fast foods restaurant chains. It is interesting to develop the meat analogue nugget which has the desirable attributes. From our previous study, it showed that consumers interested in the meat analogue nugget. The desirable attributes of the developed product should have appearance, texture and flavor similar to the nugget made from real meat. The study also revealed that texture properties were the important attributes that consumer concerns (Nantapatavee *et al*., 2010). Our preliminary test showed that the meat analogue nugget without TVP had the homogeneous appearance and texture which similar to Moo-Yor or meat ball that was not the desirable attribute of the nugget. Therefore, this study aimed to develop the formulation of the meat analogue nugget by studying the effect of TVP as the substitution of the batter in the formulation (containing isolated soy protein, gluten and water). The texture properties, color and liquid separation were also investigated.

2. Materials and Methods

2.1 Materials

Textured vegetable protein (TVP) was purchased from Institute of Food Research and Product Development (IFRPD), Kasetsart University, Thailand. Gluten was purchased from Suphisara Panich Co., Ltd., Thailand. Isolated soy protein (ISP) was donated by T&P Food Drinking Product Co. Ltd., Thailand. It was the product of Shandong Yucheng Yuwang Ecological Food Industry, Co., Ltd., China. Chicken flavor (Hydrolyzed Vegetable Protein; HVP

#B-41) was purchased from Thai Food and Chemical Co., Ltd., Thailand. Other raw materials are food grade which obtained from local supermarket in Thailand.

2.2 Preparation of textured vegetable protein (TVP)

Dried TVP was weighed and boiled in the water (the ratio of TVP to water equal to 1:3) for 7 min. After boiling, TVP was squeezed to remove the water and then chopped to reduce the size using a grinder for 1 min (Severin, SEV – 3881, Germany).

2.3 Meat analogue nugget preparation

Four formulations for producing meat analogue nugget were shown in Table 1. The TVP was varied from 10 to 70% as the substitution of batter in the formulation (part 2). To produce the meat analogue nugget, TVP (prepared from 2.2) was mixed with ISP and water using a blender for 1 min. Soybean oil, and seasonings were added and mixed together for 1 min. Gluten was then added and blended for 1 min. Meat analogue batter was formed to the rectangular shape (2.5 cm × 2.5 cm × 1.5 cm), then dipped in the flour batter. The samples were deep fried at 180°C for 5 min using palm oil. All experiments were replicated three times. The uncooked meat analogue nuggets were subjected to measure color and liquid separation while deep fried samples were measured texture properties.

Table 1 Formula of meat analogue nugget

Part	Ingredients	Formulation			
		1	2	3	4
1	Textured vegetable protein	10.0	30.0	50.0	70.0
2	Batter*	81.0	61.0	41.0	21.0
3	Soybean oil	5.4	5.4	5.4	5.4
	Seasonings	3.6	3.6	3.6	3.6
	Total	100.0	100.0	100.0	100.0

Note: * Batter consisted of 20% ISP, 20% gluten and 60% water of its weight in each formula

2.4 Texture profile analysis (TPA)

The textural properties of deep fried samples were measured using a texture analyzer (Stable Micro Systems, TA-XT plus, UK). The texture profile analysis was the modified method from Das *et al*., (2008). It was performed using central cores of ten pieces of each sample (2.5 cm × 2.5 cm × 1.5 cm), which were compressed twice to 50% of the original height by a compression probe (P 75). A crosshead speed of 2 mm/s was used. Parameters obtained from the analysis included hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness.

2.5 Shear force

Shear force and work of shearing of deep fried samples were evaluated using a texture analyzer (Stable Micro Systems, TA-XT plus, UK). Ten pieces of each sample (2.5 cm × 2.5 cm ×1.5 cm) were determined with a blade set with knife. The crosshead speed was 20 mm/s. Maximum force required to cut the sample (shear force) and the work needed to move the blade through the samples (work of shearing) were recorded.

2.6 Color

The uncooked samples (before deep frying) were used for this measurement to obtain the effect of TVP substation on the change of color. The color was measured using a spectrophotometer (Minolta, Model CM-3500d, Japan), using light source D65 and 10° viewed angle (modified from Lin and Chuang, 1999). The color parameters included L* (lightness), a* (redness), b* (yellowness), C* (chroma) and °h (hue angle) values. Prior the experiment, the equipment was standardized using the white calibration plate.

2.7 Liquid separation

The liquid separation of uncooked samples was analyzed using the modification method of Lukman *et al*., (2009). Ten grams of each sample was weighed and placed into the plastic centrifuged tube. The sample was centrifuged at 5,000×g for 10 min (25°C) by refrigerated centrifuge (Hettich, Rotina 380R, Germany). The liquid separation was determined as the percentage of liquid separation using equation (1):

$$\% \text{ liquid separation} = \frac{(W_1 - W_2)}{W_1} \times 100 \quad (1)$$

where W_1 is the weight of sample before centrifugation and W_2 is the weight of sample without liquid separation after centrifugation.

2.8 Statistic analysis

All experiments were performed in triplicate data which was expressed as means±SD. Significant differences among means were determined by the analysis of variance (ANOVA) using Duncan's multiple comparisons at $p \leq 0.05$.

3. Results and Discussion

3.1 Texture properties

Table 2 shows the texture properties of deep fried meat analogue nuggets containing different TVP concentration as the substitution of batter (part 2 in the formulation). They were determined as hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness which obtained from texture profile analysis. Shear force and work of shearing were also examined. The addition of TVP had the significant effect on those texture properties ($p \leq 0.05$). Hardness values were decreased from 63.75 N to 44.43 N which meant the lower maximum force required to compress the sample. Adhesiveness and cohesiveness values were also decreased from -1.97 to -8.71 Ns and 0.63 to 0.51, respectively. Springiness values were slightly decreased from 86.01 to 74.82% which implied the lower ability of samples to recover their original form after a deforming force was removed. Gumminess values were decreased from 3.17 to 2.48 N/cm^2 while chewiness values were decreased from 2.86 to 1.77 N/cm. The results showed that the addition of TVP lowered the required force necessary to disintegrate the sample for swallowing and therefore TVP lowered the work to masticate the sample (Das *et al*., 2008). The addition of TVP lowered shear force and work of shearing values significantly ($p \leq 0.05$) indicating their softer texture. Shear forces decreased from 63.47 to 47.07 N while work of shearing values decreased from 195.23 to 89.57 Ns. The addition of TVP reduced the maximum force required to cut the sample and also reduced the work needed to move the blade through the sample (Das *et al*., 2008). The study showed that the addition of TVP as the substitution of meat analogue batter part resulted in the soft texture of meat analogue nugget and also created the fibrous like structure. This result could be confirmed by the image of the sample. The cross section image of deep fried meat analogue nugget without TVP and meat analogue nugget with 50 % TVP are shown in Figure 1. The meat analogue nugget without TVP showed the spongy like structure with small air space (Figure 1(a)) while the meat analogue nugget with 50 % TVP showed the fibrous like structure (Figure 1(b)).

Table 2 Texture properties of deep fried meat analogue nugget containing different textured vegetable protein concentration

Parameters	Textured vegetable protein (%)			
	10	30	50	70
Hardness (N)	63.75±3.23^{a}	58.17±2.81^{b}	49.48±2.41^{c}	44.43±2.97^{d}
Adhesiveness (Ns)	-1.97±1.62^{a}	-3.58±1.52^{b}	-6.34±±2.64^{c}	-8.71±1.78^{d}
Cohesiveness (ratio)	0.63±0.05^{a}	0.61±0.03^{b}	0.54±0.03^{c}	0.51±0.06^{d}
Springiness (%)	86.01±0.46^{a}	86.02±0.31^{a}	74.99±0.42^{b}	74.82±0.43^{b}
Gumminess (N/cm^{2})	3.17±0.43^{a}	3.08±0.79^{a}	2.65±0.68^{b}	2.48±0.80^{c}
Chewiness (N/cm)	2.86±0.69^{a}	2.60±0.55^{b}	1.92±0.53^{c}	1.77±0.76^{d}
Shear force (N)	63.47±1.54^{a}	56.72±1.98^{b}	51.23±1.12^{c}	47.07±1.67^{d}
Work of shearing (Ns)	195.23±2.01^{a}	149.38±2.37^{b}	104.13±2.18^{c}	89.57±2.55^{d}

Note: $^{a–d}$ means within the same row followed by different letters were significantly difference ($p \leq 0.05$).

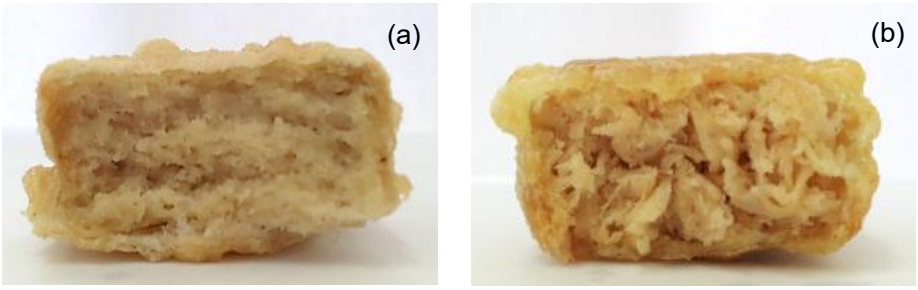

Figure 1 The cross section image of deep fried meat analogue nuggets; the sample without textured vegetable protein (a) and the sample with 50% textured vegetable protein (b)

3.2 Color

In this study, the uncooked samples were used for measuring the color. The results are presented in Table 3. The increase of TVP from 10 to 30% resulted in significantly increase in lightness of the sample. The addition of TVP increased redness (positive a* value) while yellowness (positive b* value) of the sample was decreased. It was possibly due to the color of TVP which was pinkish brown. Chroma (C*) was slightly decreased from 21.04 to 19.53 as the TVP addition increased which implied higher intensity of the product color. Hue angle (°h) of all samples (75.52–80.90) was in the yellowish and orange tone (45–90°).

Table 3 Color parameters of uncooked meat analogue nugget containing different textured vegetable protein concentration

Parameters	Textured vegetable protein (%)			
	10	30	50	70
L*	64.40 ± 0.95[b]	66.17 ± 0.90[a]	66.62 ± 0.92[a]	66.59 ± 0.93[a]
a*	3.38 ± 0.38[d]	4.10 ± 0.40[c]	4.47 ± 0.26[b]	4.95 ± 0.39[a]
b*	20.46 ± 0.58[a]	19.81 ± 0.56[b]	19.02 ± 0.56[c]	18.96 ± 0.57[c]
C*	21.04 ± 1.10[a]	20.41 ± 0.57[b]	19.83 ± 0.55[c]	19.53 ± 0.67[c]
°h	80.90 ± 1.21[a]	78.52 ± 0.97[b]	76.73 ± 0.83[c]	75.52 ± 0.85[d]

Note: [a–d] means within the same row followed by different letters were significantly difference ($p \leq 0.05$).

3.3 Liquid separation

The liquid separation of uncooked meat analogue nugget containing different TVP concentration is presented in Figure 2. In this study, liquid separation was expressed as the percentage of liquid separation from the sample after centrifugation. The liquid separation of the samples was slightly difference due to the composition in the formulation. The addition of TVP increased the percentage of liquid separation from 0 to 1.58%. The results showed that when TVP concentrations increased, liquid separation was also increased. This was probably due to the composition of meat analogue nugget in this study that contained gluten or isolated soy protein (ISP). When increased the substitution of TVP, the content of gluten or ISP was decreased. Generally gluten proteins play an important role in determining the unique quality of wheat flour by conferring water absorption capacity, cohesivity, viscosity and elasticity on dough (Wieser, 2007). Gluten can absorb approximately twice its dry weight of water to form a hydrated visco-elastic mass (Day *et al*., 2006). Soy protein also provides good moisture holding property to the product (Wolf, 1970), therefore reducing the content of gluten and isolated soy protein could increase the liquid separation of the samples. Another reason could be about the TVP added in the formula. Because it was primarily prepared by boiling in the water, therefore TVP already absorbed some water resulted in the increase in moisture content of the sample.

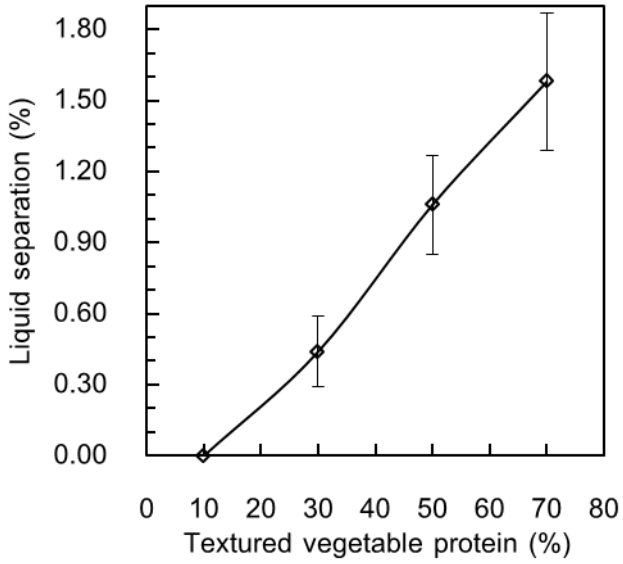

Figure 2 Liquid separation of uncooked sample before deep frying

4. Conclusion

The addition of textured vegetable protein (TVP) in the formulation of meat analogue nugget had effects on the texture properties, color and liquid separation. The addition of TVP lowered all texture properties (hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness, shear force and work of shearing). An increase in TVP tended to increase lightness and redness while decrease yellowness and chroma values of the uncooked samples (before deep frying). Hue angle of all uncooked samples was in the yellowish and orange tone. The addition of TVP increased the liquid separation of uncooked samples after centrifugation due to the change of the compositions in the formula. In summary, the addition of TVP to the formulation of meat analogue nugget could improve the texture properties by giving the softer texture and fibrous like structure of samples.

Acknowledgements

The financial support from Kasetsart University Research and Development Institute (KURDI) is gratefully acknowledged. The author would like to thanks for T&P Food Drinking Product Co., Ltd. for donating isolated soy protein used in this study.

References

Das, A. K., Anjaneyulu, A.S.R., Gadekar, Y.P., Singh, R.P. and Pragati, H. 2008. Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in frozen storage. Meat Science. 80: 607–614.

Day, L., Augustin, M.A., Batey, I.L. and Wrigley, C.W. 2006. Wheat-gluten uses and industry needs. Trends in Food Science & Technology. 17: 82–90.

IFRD (Institute of Food Research and Product Development). Textured soy protein. URL (http://ifrpd.ku.ac.th/th/products/ifrpd-protein.php) (accessed: October 19, 2013).

Lin, K.W. and Chuang C.H. 1999. Effect of dipping of raw meat materials on the physicochemical and shelf life of low fat Chinese style sausage. Journal of Food Science. 26: 583–595.

Lukman, I., Huda, N. and Ismail N. 2009. Physicochemical and sensory properties of commercial chicken nuggets. Asian Journal of Food and Agro-Industry. 2(02): 171–180.

Nantapatavee, P., Jangchud, A., Jangchud, K., Lin, J. and Harnsilawat, T. 2010. Effect of the physical properties on consumer preference of nuggets. Thai Journal of Agricultural Science. 44(5): 519–525.

Riaz, M. 2005. Soy applications in food. Textured soy protein utilization in meat and meat analogue products. New York: CRC press

Sadler, M. 2004. Meat alternatives market developments and health benefits. Trends in Food Science and Technology. 15: 250–260.

SANA (Soyfoods Association of North America). Soy meat alternative.URL(http://www.soyfoods.org/products/soy-fact-sheets/soy-meat-alternative-fact-sheet.) (accessed: October 20, 2013).

Wieser, H. 2007. Chemistry of gluten proteins. Food Microbiology. 24: 115–119.

Wolf, W. 1970. Soybean proteins. Their functional, chemical, and physical properties. Journal of Agricultural and Food Chemistry. 18: 969–976.