Vitamin E-Enriched Vegetable Nuggets Using Palm Fat

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INTRODUCTION

Deep-fried or baked batter food products receive very high demand nowadays. They are made of meat, vegetables and other materials such as cheese. One well-known product that falls under this category is chicken nuggets. The product was invented in the 1950s by Robert C. Baker who was a professor in Food Science at Cornell University. Chicken nuggets started to be commercially sold in the early 1980s by a fast-food restaurant (Hopkins, 2012). Nowadays, chicken nuggets are one of the common items in menus of school canteens. They are categorised under processed meat products by the Food and Agricultural Organisation of the United Nations (FAO). In processed meat formulations, which include chicken nuggets, animal fat has become one of the crucial ingredients. However, animal fats have been identified as one of the causes of dietary diseases due to their saturated fatty acids and *trans*-fatty acids content (Abd Hamid *et al.*, 2015).

Intake of animal fats can be reduced by substituting these fats with vegetable fats in processed meat products. According to Jime´nez-Colmenero (2007), liquid oil as well as vegetable fats provide good lipid profile in meat-based functional foods formulations. Value-added processed meat products can be produced from vegetable fats which are functional ingredients too (Toldra and Reig, 2011). For example, chicken fat in frankfurters has been partially replaced by a palm oil and palm stearin blend. The study found that the sensory properties of the frankfurters were as good as the commercial sample (Tan *et al*., 2006). In addition, palm oil and its fraction are used widely in solid fat formulations as they are free from *trans*-fatty acids (Miskandar and Noor Lida, 2011).

Notwithstanding this, practitioners of vegetarian diets are growing in number, especially in developed countries. Vegan or vegetarian nuggets can be produced by not only substituting the fats in nuggets with vegetable fats but also replacing the meat (animal protein) with plant-based protein. Plant-based proteins in vegetarian food provide a texture that is comparable to meat products due to the binding capability of the protein. Soya-based protein (*tofu* and *tempeh*) and wheat-based protein (*seitan*) are such examples of plant-based protein. *Figure 2* shows pictures of *tofu*, *tempeh* and *seitan*. These plant-based proteins are widely used in vegetarian food nowadays. The nutritional values of soya-based protein and vital wheat gluten are shown in *Table 1*. *Seitan*, for example, has been vastly exploited in products such as extruded products, bakery products, ready-to-eat snacks and soups. Other binding agents such as xanthan gum, Arabic gum and gelatin can be incorporated in the formulations to enhance the texture of the imitation meat products, and processed meat products as well (Feng *et al*., 2013; Totosaus and Pérez-Chabela, 2009; Somboonpanyakul *et al*., 2007).

PRELIMINARY STUDY

A preliminary study was conducted to formulate palm-based vegetarian nuggets using three different types of protein, namely *tofu*, *tempeh* and *seitan*, together with other ingredients such as palm fat, binding agent, oats, and flavouring. Physical analyses of the three types of palm-based fried vegetarian nuggets were conducted to select the best protein for further optimisation of the vegetarian nugget formulation. Sensory evaluation based on 180 students revealed that acceptance level for the *tofu*-, *tempeh*-, and *seitan*-based nuggets was 73%, 82% and 92%, respectively. Subsequently, *seitan* was used in this study to determine the optimum amounts of vitamin E-enriched palm fat, oats and xanthan gum in the vegetarian nugget formulation. In addition, *seitan* possessed the lowest fat content and the highest protein content compared with the other two types of plant-based protein.

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Figure 1. Example of nuggets.

Figure 2. Examples of plant protein sources: tofu, tempeh *and* seitan.

TABLE 1. NUTRITIONAL VALUES OF *TOFU*, *TEMPEH* AND *SEITAN*

Typical Value	**Firm** *Tofu*	*Tempeh*	*Seitan*
Calories (cal)	70.0	173.0	90.0
Fat (g)	3.5	6.0	1.0
Carbohydrate (g)	2.0	12.0	3.0
Protein (g)	8.0	16.6	18.0
Fibre (g)	0.0	9.0	1.0
Sodium (mg)	20.0	8.0	380.0

Note: All values reported are based on 3 oz (85.05 g) of sample.
Source: Jenny Sugar (2011).

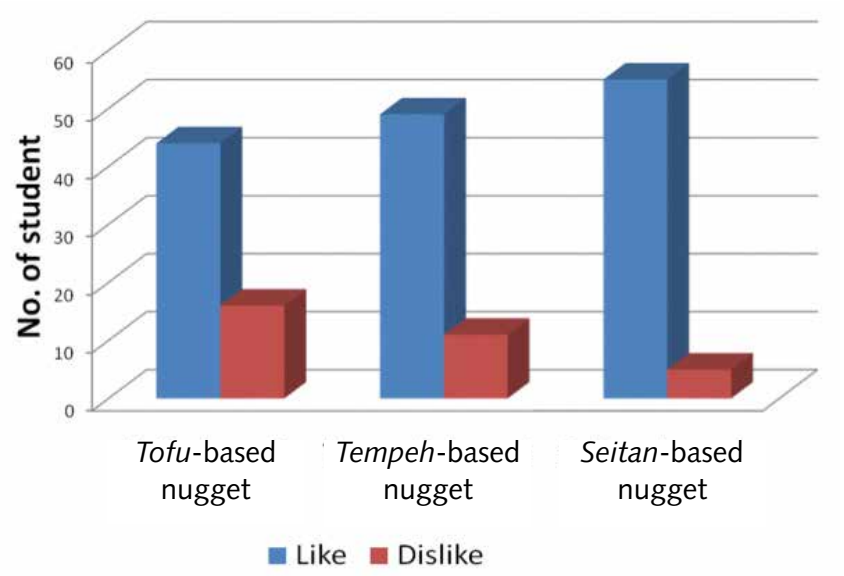

Figure 3. Preference by students for vegetarian nuggets formulated using three different types of plant-based protein.

PROPERTIES OF VITAMIN E-ENRICHED PALM FAT VEGETABLE NUGGETS

Oil and Vitamin E Content

The vitamin E-enriched vegetable nuggets absorbed approximately 8%-12% oil during frying. Most of the oil absorption took place towards the end of the frying process. The absorption also occurred during the cooling phase of the fried products when the food microstructures were penetrated by the oil from the food surface (Durán *et al.*, 2007). It has also been reported that the key factors for oil absorption were roughness of the surface as well as the microstructure (Moreno *et al.*, 2010). Dueik *et al.* (2012) reported that food microstructure plays a major role in oil absorption by fried products in both atmospheric and vacuum frying. Oil content and porosity were reported to be linearly correlated in these frying processes. The centrifugation process may massively reduce oil absorption during these frying processes, and it has been suggested to be conducted at the end of the frying process.

Vitamin E content in the fried vitamin E-enriched vegetable nuggets was greatly correlated to their oil content. A higher content of oil resulted in a higher content of vitamin E. Vitamin E content in the range of 38 to 101 ppm was recorded in the fried nuggets. Less oil absorption in these vegetable nuggets may be due to the use of *seitan* in the formulation. Gluten (in this case, *seitan* protein) has a great influence on the structure, resulting in a more elastic dough which is less absorptive of oil (Gazmuri and Bouchon, 2008). Gazmuri and Boucon also reported that products having high gluten content absorb less oil and have low moisture content. In addition, xanthan gum limited oil absorption by the nuggets apart from its function as a binding agent.

Firmness and Toughness of Product

Firmness of the vitamin E-enriched vegetable nuggets refers to its hardness while toughness of the nuggets refers to its biteability. The amount of fat in food products has a compelling effect on juiciness and texture (Cengiz and Gokoglu, 2007). Reducing the amount of fat in processed meat product formulations, for instance, resulted in a firmer, more rubbery and darker coloured product with less juiciness and tolerable mouth-feel. Other than fat content, the level of oats and xanthan gum incorporated in the formulation strongly affected the firmness and toughness of the vitamin E-enriched vegetable nuggets. Nonetheless, the interaction between these two ingredients (oats and xanthan gum) was insignificant in affecting firmness and toughness. The firmness of the fried vitamin E-enriched vegetable nuggets was in the range of 2666-4086 g, while toughness of the nuggets was in the range of 6200-9085 g.

Nuggets that had 15%-25% oats with 5%-6% palm fat were most firm. Notwithstanding this, nuggets that had oats content of more than 20% with 9%-10% palm fat content showed great firmness. In addition, nuggets with a xanthan gum content of 9%-10% and oats content of 15%-20% resulted in high firmness. On the other hand, less tough nuggets were achieved with the addition of 10%-15% oats and more than 7% palm fat in the formulations. However, an oats content of more than 15% with 5%-7% palm fat and more than 8% xanthan gum produced relatively tougher nuggets.

OPTIMUM FORMULATION OF VITAMIN E-ENRICHED PALM FAT VEGETABLE NUGGETS

Table 2 shows the optimum formulation for the vegetarian nuggets containing vitamin E-enriched palm fat after optimising four ingredients, namely, vitamin E-enriched palm fat, *seitan*, oats and xanthan gum. The oil content of the fried vegetable nuggets was 15.0±1.0% while their firmness and toughness were 5373.8±0.8 g and 2088.0±1.0 g, respectively. Nuggets using this formulation were well-accepted by the sensory panel. Good scores were received for aroma, hardness, crispiness on the outside and taste as shown in *Figure 4*.

TABLE 2. OPTIMUM FORMULATION FOR VITAMIN E-ENRICHED PALM FAT VEGETABLE NUGGETS

Ingredient	Percentage (%)
Vitamin E-enriched palm fat	6.4
Seitan	54.8
Oats	10
Xanthan gum	6.8
Cold water	10
Sago flour	10
Salt	0.3
Sugar	0.2
White pepper powder	0.2
Chicken flavour	1.3

Figure 4. Sensory scores for vitamin E-enriched palm fat vegetable nuggets based on the optimum formulation.

Figure 5. Vitamin E-enriched palm fat vegetable nuggets.

CONCLUSION

Combining 54.8% *seitan*, 6.4% vitamin E-enriched palm fat, 6.8% xanthan gum and 10% oats created the optimum formulation for gluten-based vegetarian nuggets with vitamin E. The product was well-accepted by the sensory panel. The nuggets can become a nutritious alternative to chicken nuggets, and has a lot of market potential. The product is suitable for people from all walks of life, especially children.

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