# FUNCTIONAL EFFECTS OF TOFU POWDER IN PORK EMULSION GEL

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***Abstract*—Effect of tofu powder on functionality and texture of pork emulsion gel were studied. The tofu powder (40, 60 and 80%) was replaced pork as pre-emulsion to formulate emulsion gel. The tofu powder caused increasing of emulsion stability, water holding capacity and hardness of the gels ($p<0.05$). There were significant correlation between variation of tofu powder and functionality and hardness ($p<0.01$). Water holding capacity (WHC) had significant effect on the total expressible (TEF) and fat loss of emulsion. The correlation between WHC and TEF and fat loss were significant at $p<0.01$.**

***Index Terms*—tofu powder, meat emulsion, water holding capacity and emulsion stability**

## I. INTRODUCTION

Meat emusion are comminuted meat mixture of water, proterin fat and other ingredients. In meat industry, non-meat ingredients have been evaluated as lean meat replacement of balancing the quality and quantity of functionality, nutritional value and cost. Non-meat protein ingredients especially soy protein has been used in meat emulsion product as meat replacer to improve the functional characteristics of the system; such as water binding textural properties (Lecomte et al., 1993; Ho et al., 1997; Ramezani et al., 2003). However, soy protein is been imported form oversea and manufacturing process is complicated and costly. Tofu powder is the product from ground dried tofu which can be sued as the main ingredients in processed meat product (Panyathitipong and Puechkamut, 2002). The tofu powder has high solubility and emulsion properties (Panyathitipong and Puechkamut, 2008). Moreover, Soybean has been shown to be a rich source of isoflavones, a weak form of the female hormone estrogen. Isoflavones have been shown to inhibit the growth of cancer cells, lower blood cholesterol and inhibit bone resorption. Consumption of soy food has been on the rise because the establishment of the October 1999 U.S. Food and Drug Administration (FDA) has approved soy protein claims, which links the intake of products high in soy protein with positive health benefits such as a lower risk in heart diseases. Therefore, the objective of this research was to replace pork with tofu powder in pork emulsion gel. The physicochemical properties of the gels were examined and the correlation between tofu powder and the properties were studied.

## II. MATERIALS AND METHODS

### Materials

The soybean (Chiang Mai 60) was obtained from Chiang Mai Field Crops Research Center (Thailand), cultivated during summer 2007 contained 9-10% moisture. It was stored at 15°C before tofu processing. The coagulant ($MgSO_4$) for prepare tofu powder was food grade reagent and other reagents were analytical grade.

### Pork emulsion gel preparation

Pork was ground in commercial food processor for 1 min at low speed. Salt (2.25% weight of pork, WP) and soybean oil (12% WP) were slowly added to the ground pork. Then, ice (22.5% WP) was incorporated and ground for 1 min. Sugar (5% WP) were slowly added and then ice (22.5% WP) was incorporated for 2 min at high speed. The batter was stuffed in a stainless mold and heated in a temperature controlled water bath maintained at 60°C for 20 min and 90°C for 20 min. Then, the sample was cooled immediately in cool water.

The tofu powder was prepared from the curd of the soymilk which coagulated by $MgSO_4$ and dried as described by the method of Panyathitipong and Puechkamut (2008). Tofu powder was prepared to be pre-emulsion replacing pork in the emulsion gel process. Pre-emulsion was made by mixing tofu powder with water and oil. Water was added to adjust the moisture content of tofu powder to pork and the amount of oil was equal the added oil of the formulation.

### Water holding capacity (WHC) analysis

The water holding capacity of emulsion gel samples was analyzed by the modified method of Hughes et al. (1997). 10 g batter samples were placed in centrifuge tubes and heated for 15 min in a water bath at 90°C. After heating, the samples were cooled to room temperature, and centrifuged at 9,000 rpm for 20 min. the supernatant was eliminated and the WHC of the remaining pellets were calculated as follows:

$$\text{WHC (\%)} = \left(1-\frac{\text{(weight of sample before heating- weight of sample after centrifugation)}}{\text{total water content in the sample}}\right) \text{x } 100$$

**Emulsion stability analysis**

The emulsion stability was analyzed by the modified method of Hughes et al. (1997). 25 g batter samples were placed in centrifuge tubes and centrifuged at 4,000 rpm for 1 min. The samples were heated in a water bath at 70°C for 30 min. After heating, the samples were centrifuged at 4,000 rpm for 3 min. The pellets samples were removed and weighed. The supernatants were poured into pre-weight crucibles and dried overnight at 100°C. The volumes of total expressible fluid (TEF) and the percentage fat were calculated as follows:

$$\%\text{TEF} = \frac{\text{weight of sample –weight of pellet x } 100}{\text{sample weight}}$$

$$\%\text{ fat} = \frac{\text{dried supernatant x } 100}{\text{TEF}}$$

**Texture profile analysis (TPA)**

Texture profile analysis was performed using a texture analyzer (TA-XT2i, Stable Micro Systems). A gel sample was cut and compressed twice to 30% of their original height with 75 mm diameter aluminium platen. The condition of texture analysis were as follows: pre-test speed 1 mm/s, test speed 1 mm/s and post-test speed 1 min/s. Values for hardness and springiness were recorded.

**Statistical analysis**

A completely randomize design was used and differences among group means were analyzed by Duncan's New Multiple Range Test ($p<0.05$). All the measurements were done triplicate except TPA was done 5 times.

## III. RESULTS AND DISCUSSION

**Effect of tofu powder on functionality of pork emulsion gel**

The functionality of the emulsion gel formulated with gradually tofu powder as pre-emulsion to replace pork is shown in Table 1. The variation of tofu powder caused increasing WHC. The correlation coefficient between variation of tofu powder and WHC was 0.92 (Table 2). Replacement of meat protein with tofu powder increased WHC by reducing TEF. The result agreed with Lecomte et al. (1993) and Chin et al. (1999) who reported that replacement soy protein in meat emulsion product increased WHC and decreased expressible moisture value due to soy protein absorbed water immediately to form emulsion system.

**Table 1** Effect of tofu powder on water holding capacity and emulsion stability of pork emulsion gel

| Tofu powder (%) | WHC (%) | Emulsion stability | |
|---|---|---|---|
| | | TEF (%) | Fat loss (%) |
| 0 | 73.39$^{c}$ | 3.45$^{a}$ | 2.68$^{a}$ |
| 40 | 86.95$^{b}$ | 1.86$^{b}$ | 1.69$^{b}$ |
| 60 | 88.41$^{b}$ | 1.67$^{b}$ | 1.52$^{c}$ |
| 80 | 90.91$^{a}$ | 1.38$^{c}$ | 1.42$^{c}$ |

$^{a-c}$Different letters within same column are significantly different at $p<0.05$

The emulsion stability of the emulsion formulated with tofu powder were significant ($p<0.05$). The variation of tofu powder caused decreasing TEF and fat loss thus increasing emulsion stability. The correlation coefficients between tofu powder and TEF and fat loss were -0.95 and -0.94 respectively (Table 2). The TEF and fat loss of emulsion gel depended on WHC. The correlation coefficients between WHC and TEF and fat loss were -0.99 and -0.93 respectively (Table 2). The TEF of emulsion decreased when increase tofu powder due to moisture absorption of tofu powder that is similar result with Vural et al. (2004) and Choi et al. (2009) who reported that non-meat ingredients were added in meat emulsion caused decreasing TEF. Fat loss of emulsion were decreased might be caused protein in tofu powder participate in some emulsification that influence their adsorption capacity at the oil and water interface (Ayadi et al., 2009)

**Table 2** Correlation coefficients among tofu powder, water holding capacity, fat loss and hardness of pork emulsion gel

| Relationship | Correlation coefficients |
|---|---|
| Tofu powder/WHC | 0.95** |
| Tofu powder/TEF | -0.95** |
| Tofu powder/fat loss | -0.94** |
| Tofu powder/hardness | 0.96** |
| WHC/TEF | -0.99** |
| WHC/fat loss | -0.93** |

** is significant correlation at $p<0.01$

**Effect of tofu powder on texture of pork emulsion gel**

The effect of tofu powder on hardness of the gel is show in Table 3. When the tofu powder was incorporated in meat emulsion system exhibited higher hardness of the gels. The correlation coefficient between tofu powder and hardness was 0.96 (Table 2) The results indicated that tofu powder increased structural stability of the gel matrix that is similar result with Hung and Zayas (1992) and Barbut (2006) who reported that addition non meat protein in meat emulsion products were significantly increased hardness. The mixture of meat protein and soy protein are heated making up a multiple gel complex (Chin et al., 1998) allowing the proteins to interact and produce a second gel structure that acts as a filler for the primary meat protein gel network to stabilize meat emulsion system (Drakos et al., 2007) and might lead to the strengthening of structure.

**Table 3** Effect of tofu powder on hardness of pork emulsion gel

| Tofu powder (%) | Hardness (g·force) |
|---|---|
| 0 | $2311.49^{d}$ |
| 40 | $3476.46^{c}$ |
| 60 | $4662.71^{b}$ |
| 80 | $6028.08^{a}$ |

$^{a-c}$Different letters within same column are significantly different at $p<0.05$

## IV. CONCLUSION

The influence of tofu powder affects on functionality and texture of the pork emulsion gel. The correlation between variation of tofu powder, functionality and texture of emulsion gel were significant ($p<0.01$). The WHC, emulsion stability and hardness of the emulsion gels were increased with increasing tofu powder.

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