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Physicochemical Properties and Consumer Acceptance of Tofu Incorporated with *Yakong*

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Abstract

Tofu has been playing an important role in people's daily diet in most of Asia and recently in North America due to several health-promoting functions, preventing and treating a number of chronic diseases such as cancer, coronary heart disease and osteoporosis. The objective of this study was to investigate the effect of different levels of *yakong* incorporation (0, 5, 10, and 15%, w/w) in preparation of firm tofu. Quality parameters such as pH, titratable, moisture content, color, and consumer preference were determined, and their correlations were analysed. There were no significant differences in pH, titratable acidity, and moisture content due to different levels of *yakong* incorporation studied (p>0.05). A significant decrease in L^* and b^*-values whereas significant increase in a^*-value was observed (p<0.05). Five percent *yakong* tofu received the most favorable mean scores with respect to color, texture, and overall acceptability. Correlation analysis revealed that *yakong* incorporation was well correlated with some of physicochemical properties as well as consumer preference.

Key words: tofu, *yakong*, physicochemical property, consumer evaluation, correlation

Introduction

Soybean (*Glycine max* (L.) Merrill), native to East Asia, is an annual plant that has been used for 5,000 years as an important component of the popular diet in these regions (Koury & Hodges, 1968). Soy contains significant amounts of all the essential amino acids for humans, and so is a good source of protein (Derbyshire et al., 1976). Moreover, soybeans and soy products are the richest sources of isoflavones in the human diet.

Soybeans have been utilized into various forms of foods, among which tofu being the most widely accepted traditional soybean food (Kim et al, 2007b). Isoflavones in tofu work together with soy protein in the prevention and treatment of a number of chronic diseases, such as cancer, coronary heart disease (CHD), and osteoporosis (Mousavi & Adlercreutz, 1993; Messina et al., 1994; Anderson et al., 1995; Mei et al., 2001; Somekawa et al., 2001; Morabito et al., 2002).

The seeds of *Rhynchosia volubilis* (*yakong*) have been used in oriental folk medicine to prevent postmenopausal osteoporosis on the basis of old classical medical books (Kim et al., 2005). *Yakong* has also been used for treatment of neuralgia, kidney disease, senile dementia (Kim et al., 2007a; Shin et al., 2008). *Yakong* contains higher amounts of isoflavones, especially genestein and daidzein than soybean does (Franke et al., 1995; Kim et al., 2000; Kang et al., 2003).

In this study, attempts were made to prepare tofu by incorporating different levels of *yakong* in the formulation of soymilk, and the effects of *yakong* incorporation on the physicochemical properties, consumer acceptance, and the correlations between them were evaluated.

Materials and Methods

Materials

Soybean and *yakong* were purchased from Orga Whole Foods (Seoul, Korea). Food grade magnesium chloride, the coagulant, was purchased from Daesan Trading Co., Ltd. (Incheon, Korea).

Preparation of tofu

Yakong was incorporated into soymilk formulation at 4 levels (0, 5, 10, and 15%, w/w) by mixing the proper amounts with soybeans. Pre-washed soybeans (500 g) and appropriate amount of *yakong* were soaked in distilled water at room temperature for 12 hr. The hydrated beans were placed in a basket to remove excess water and ground with 5000 mL distilled water using a food mixer (MX2000, Linaset AS, The

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Czech Republic) for 3 min at high speed, followed by straining through a muslin cloth and pressing to obtain soymilk. Soymilk (4000 mL) was then heated to boil and mixed with 200 mL of 5% $MgCl_2$ and held for 10 min to coagulate. The curd was gently transferred to a specially designed, perforated mould (10 × 11 ×10 cm) lined with cheese cloth and pressed for 30 min using bricks weighing 3.0 kg to produce tofus with various levels of *yakong*.

pH and titratable acidity measurement

Ten grams of sample mixed with 40 mL distilled water were prepared to measure the pH of *yakong* tofu with a pH meter (PHM210 Standard pH meter, Radiometer Analytical, Lyon, France) at room temperature. The titratable acid was determined as the titration volume in mL of 0.1 N NaOH needed to bring the pH to 5.3 after homogenization.

Moisture content determination

The moisture content was determined by drying a weighed amount of samples to a constant weight at 105°C in an oven for 24 hr (AOAC, 2000).

Color assessment

Color characteristics (CIE $L^*a^*b^*$) were measured using a Minolta Chroma Meter (Model CR-200, Minolta Co., Osaka, Japan) calibrated with a calibration plate using Y=94.2, x=0.3131, and y=0.3201. Color was measured at the same location (six sides of each cube) using 10 tofu cubes (3 × 3 × 2 cm) for each treatment.

Consumer evaluation

Yakong tofu was evaluated by 25 consumer panelists (15 males, 10 females aged between 23-28 years and 20-25 years, respectively) Four samples were presented in random order and they were asked to evaluate the consumer attributes of taste, flavor, color, mouth feel, and overall acceptability. Consumers expressed judgments about samples using a structured numeric scale of five points (5-point hedonic scale), wherein 5=like extremely, 4=like moderately, 3=neither like nor dislike, 2=dislike moderately, and 1=dislike extremely, for each attribute evaluated. Samples were steamed before being served. Each sample (1.5 × 1.5 × 2.0 cm), randomly coded using a three-digit number, was evaluated in each session. Consumers received a tray containing the samples, a glass of water, and an evaluation sheet.

Statistical analysis

The statistical analyses including Pearson correlation matrix, analysis of variance, and Duncan's multiple range test were performed using the SAS 9.1 statistical package for Windows (SAS Institute Inc., Cary, NC, USA). The means were compared with Duncan's Multiple Range test at 5% level of significance. All the experiments were done in triplicate unless specified otherwise.

Results and Discussion

pH and titratable acidity

pH and titratable acidity of *yakong* tofu with the various levels (0, 5, 10, and 15%) of *yakong* incorporation are shown in Figs. 1 and 2. There were no significant differences in pH and titratable acidity. Im et al. (2004) reported the average pH

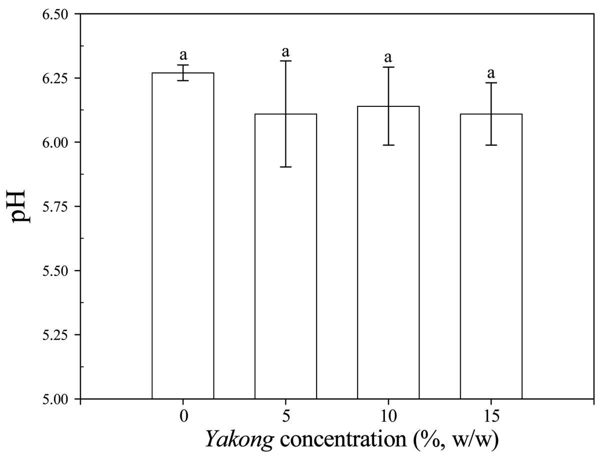

Fig. 1. Changes in pH as affected by the level of *yakong* incorporation. Means with the same letter indicate insignificant difference according to Duncan's multiple range test (p>0.05).

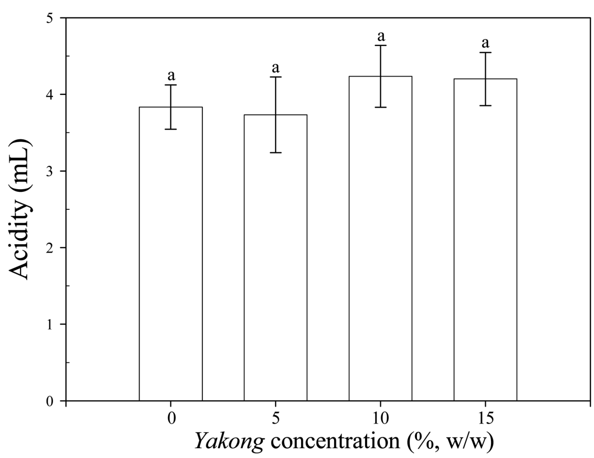

Fig. 2. Changes in titratable acidity as affected by the level of *yakong* incorporation. Means with the same letter indicate insignificant difference according to Duncan's multiple range test (p>0.05).

of typical tofu was in the range of 5.2-6.2 and pHs of *yakong* tofu in the study ranged from 6.11 to 6.27. The similar results were reported by Kim et al. (2003) for chlorella soybean curd and Seog et al. (2008) for tofu prepared with water dropwort. However, these values were higher than those of tofu prepared with carrageenan (Karim et al., 1999), with green tea powder (Jung & Cho, 2003), and basil water extracts (Im et al., 2004). Titratable acidities of *yakong* tofu varied from 3.73 to 4.23 mL/g. Titratable acidity showed that acidity of *yakong* tofu was considerably higher than those of tofu with basil water extracts (Im et al., 2004) and tofu with water dropwort (Seog et al., 2008). Those values were apparently influenced by different raw materials used especially for the one used for incorporation.

Moisture content

Changes in moisture content are shown in Fig. 3. Moisture contents of *yakong* tofu varied from 77.17 to 79.28%. Similar ranges of the moisture content were reported by Seog et al. (2008) for tofu prepared with water dropwort. Moisture contents of *yakong* tofu were not significantly affected (p<0.05) by the level of *yakong* incorporation. This is probably because of the fact that moisture and protein contents of *yakong* are not significantly different from those of soybean (Kim, 2007). *Yakong* tofu prepared with magnesium chloride as a coagulant gave clear whey, which shows the complete coagulation of soy proteins. Decreasing moisture content of *yakong* tofu may be ascribed to the denser and more compact structure with the increasing the level of *yakong*.

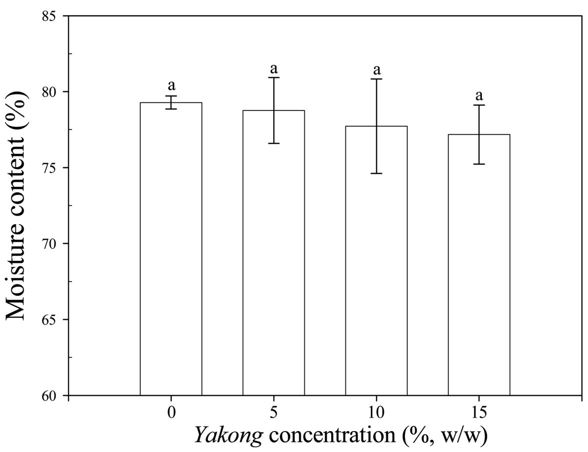

Fig. 3. Changes in moisture content as affected by the level of *yakong* incorporation. Means with the same letter indicate insignificant difference according to Duncan's multiple range test (p>0.05).

Color characteristics

Good quality tofu is white or light yellow in color. Tristimulus colorimetry of *yakong* tofu was used to access the extent of color change with different level of *yakong* incorporation (Fig. 4). L*-value (lightness) of control is comparable to that of tofu with oyster shell powder reported

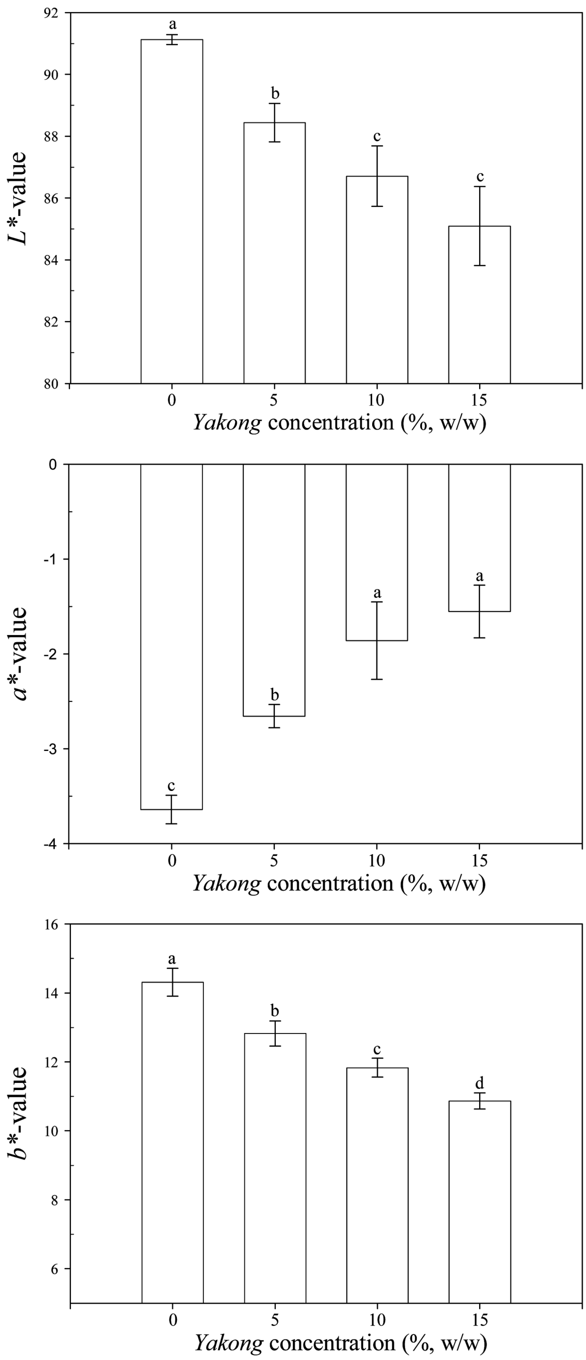

Fig. 4. Changes in color parameters (L*, a*, and b*) as affected by the level of *yakong* incorporation. Means with the different letter indicate significant difference according to Duncan's multiple range test (p<0.05).

by Kim et al. (2007b) and Lee et al. (2001), where chitosan was used as a coagulant. However, there are several findings showing lower L^*-values than ours; for example, tofu prepared with cow's milk (Kim et al., 1994), with carrageenan (Karim et al., 1999), with chlorella (Kim et al., 2003), with fruit juice of pomegranate (Kim & Park, 2006), with small black bean (Lee, 2007), and with water dropwort (Seog et al., 2008).

Incorporation of *yakong* had a significant effect ($p<0.05$) on the lightness of tofu. A significant decrease ($p<0.05$) in lightness with increasing level of *yakong* incorporation was observed and these are probably due to the dark color pigment of *yakong*. A similar decrease in the lightness was also reported for tofu prepared with ginseng from 0 to 0.5% (Kim et al., 1996), with various natural materials, in which carrot from 0 to 8%, cucumber from 0 to 12%, spinach from 0 to 1.5%, and green tea from 0 to 0.1% (Choi et al., 2000), with green tea powder from 0 to 1.0% (Jung & Cho, 2003), with chlorella from 0 to 2.0% (Kim et al., 2003), with fruit juice of pomegranate from 0 to 5% (Kim & Park, 2006), with small black bean from 0 to 60% (Lee, 2007), and with oyster shell powder from 0 to 0.2% of soy milk (Kim et al., 2007b).

a^*-Value (redness) also significantly increased with the increasing level of *yakong* incorporation. Several other researchers obtained the similar result for tofu prepared with ginseng (Kim et al., 1996), with carrot (Choi et al., 2000), with fruit juice of pomegranate (Kim & Park, 2006), and with small black bean (Lee, 2007). These are due to the colorants of each material; for instance, chrysanthemin in *yakong* and pelargonin in pomegranate, respectively. On the other hand, a decrease in a^*-value was also reported for tofu prepared with carrageenan using calcium sulfate as a coagulant (Karim et al., 1999), with cucumber, spinach and green tea (Choi et al., 2000), with green tea powder (Jung & Cho, 2003), and with chlorella (Kim et al., 2003).

b^*-Values (yellowness) of *yakong* tofu were significantly lower than that of control and as the level of *yakong* incorporation increased, b^*-values consistently correspondingly decreased ($p<0.05$). Lee (2007) also reported the similar results with the small black bean substitution. Interestingly, Kim and Park (2006) also showed b^*-values of pomegranate tofu were significantly lower than that of control, but as the fruit juice of pomegranate concentration increased, b^*-values consistently correspondingly increased ($p<0.05$). Kim et al. (2007b) also showed b^*-values of oyster shell powder tofu increased with the increasing shell powder concentration. The similar results were reported for tofu prepared with ginseng (Kim et al., 1996), with carrot (Choi et al., 2000), with green tea powder (Jung & Cho, 2003), and with chlorella (Kim et al., 2003).

Consumer evaluation

Yakong tofu samples were evaluated by a panel for color, flavor, taste, texture, and overall acceptability on a 5-point scale. Fig. 5 presents the spider charts on several attributes including color, taste, flavor, texture, and overall acceptability. In terms of color and texture, 5% *yakong* tofu received the most favorable mean score of 4.64 and 4.68, respectively, but there were no significant differences among the samples. On the other hand, 15% sample received the lowest mean scores with respect to all consumer attributes except for taste preference among all samples tested.

The overall acceptability scores ranges from 4.20 to 4.96, the highest score being given to 5% *yakong* tofu. This also indicates that all samples were considered as somewhere between "like moderately" and "like extremely"; however, higher level of *yakong* incorporation is less preferred perhaps due to strong sensory characteristics. This suggests that the incorporation of *yakong* in tofu making is successful without sacrificing the consumers' acceptance and 5% *yakong* incorporation can be recommended.

Correlation analysis

Table 1 shows the correlation between physicochemical properties and consumer attributes of tofu incorporated with different levels of *yakong.* Correlation analysis revealed that *yakong* incorporation was not correlated with color, taste, and texture score of consumer evaluation, but it was negatively

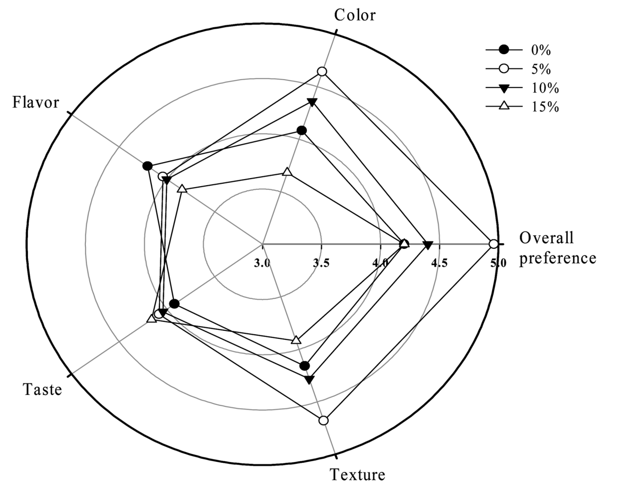

Fig. 5. Consumer evaluation profiles of tofu incorporated with *yakong*.

Table 1. Correlation between physicochemical properties and consumer attributes for tofus incorporated with different levels of *yakong* (only significant values are showing)

	Yakong concentration	Physicochemical properties				Consumer attributes	
		MC[1]	*L**	*a**	*b**	Color	Flavor
MC	-0.991**						
*L**	-0.992**	0.976*					
*a**	0.977*	-0.972*	-0.992**				
*b**	-0.994**	0.978*	0.999***	-0.991**			
Flavor	-0.978*		0.979*		0.981*		
Taste							-0.956*
Texture						0.966*	

[1] Moisture content
* Significant at $p<0.05$, ** Significant at $p<0.01$, *** Significant at $p<0.001$.

correlated with flavor preference, moisture content, L^* and b^*-values, and positively correlated with a^*-value. Correlations between moisture content and color parameters indicated that, all color parameters were highly correlated with moisture content either positively or negatively ($p<0.05$). Statistically significant positive correlation coefficients were found between L^* and b^*-values and flavor preference ($p<0.05$). Color preference was positively correlated with texture preference whilst flavor preference was negatively correlated with taste preference ($p<0.05$).

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