

Potential application of overripe tempe dried powder as plant-based instant stock

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Abstract:

Recent studies along with the local wisdom support the usage overripe tempe (OT) as plant-based umami source ingredients (USI). A market survey was done in this study in order to select target commercial USI product. Subsequently, OT was processed and formulated to compete the selected target product. The selected survey area was defined as modern market located in Tangerang City, Indonesia. Thirty validated respondents were taken into this survey. The selection of target USI commercial product was done based on the criteria as follow: (1) sold in selected survey area; (2) used by validated respondents; and (3) used in Indonesian savory dishes. Among five selected USI, instant chicken stock was defined as target commercial product in OT powder application. Subsequent market survey showed that in case of instant stock, taste property is the most important selection factor. Dried powders of OT were prepared by using oven- and freeze-drying method. Intensity scaling of attribute was conducted by employing 30 validated panelists to evaluate the umami intensity of the OT powder. Oven dried OT had highest umami intensity and thus was selected for further formulation of OT stock. OT stock was developed from chicken stock formula, using Design Expert software, to meet national standard requirement of stock and consommé. Taste acceptance and umami intensity of selected OT stock formula (6.71 ± 1.27 , 5.65 ± 1.64) was significantly below the commercial target products (7.24 ± 1.24 , 7.68 ± 1.78). Further

development of OT powder as plant-based instant stock must to take into account improvement in the umami intensity and reduction of insoluble solid residue.

Keywords: overripe tempe, instant stock, formulation, umami

Introduction

Plant-based protein have been an increasing lifestyle in food consumption [1] due to published benefits in health, and well-being, include among others economical, ecological and social concern [2-4]. However calcium and vitamin B12 intake in vegetarian diet remained concern [5-6] that required diet diversification in health promotion. Tempe had been know as potential source of protein in Indonesia as well as in other countries [7] as it was reported to promote the calcium absorption [8-9] and to provide vitamin B-12 that was not exist in it original beans [10-11].

Further solid-state fermentation as in overripe tempe increased the total soluble amino acid [12-13], increasing its value as protein source. Further sensory evaluation also indicating the potency of overripe tempe to provide umami-flavor and enhance other taste [13], which make it a potential to be developed as plant-based umami source ingredients (USI). Attempt has been made to create standard of physical and chemical characteristic of overripe tempe based on its potential use as USI [14]. However, the direction of product development is required for the formulation of overripe tempe ingredient. In this study, the most potential utilization of overripe tempe powder as plant-based USI was defined using structurized market survey and formulation in consumer-led product development.

Materials and methods

Market survey

Survey area and respondents were first defined as tools in the market survey. Selected survey area is modern market meeting these criteria: (1) located inside the shopping mall; (2) place at least five variance of USI from different brands. Respondents of defined survey area were validated using below criteria: (1) visited at least one of the supermarket in target market area with minimum shopping frequency 4 times a month; (2) prepared their food themselves at home minimum 5 times a week; (3) have ever used USI in their cooking. Candidates of

target commercial USI from the defined market area matched following criteria: (1) sold in selected survey area; (2) used by validated respondents; and (3) used in Indonesian savory dishes. The respondents were subsequently requested to select important attributes of the selected umami source ingredients that affect their decision of purchase on consumption. Furthermore the respondents were also requested to select the Indonesian savory dishes that match the application of selected umami source ingredients.

Overripe tempe powder formulation

Overripe tempe was grinded and exposed to oven drying (60 °C, 6 h), and freeze drying (-80 °C, 24 h) to form powder with moisture content below 10% as described in previous study [12]. In the market survey target commercial umami source ingredient was defined along with its important attributes that affect consumer preference. The most important attribute in combination with Indonesian national standard (SNI) of the product were then used as guidelines for the umami source ingredient formulation development using overripe tempe. The formulation used Design Expert® software version 6.0.8 using limitation derived from SNI. And the selected formula was then compared to the commercial target using hedonic and umami intensity rating sensory evaluation. And further improvement was acquired from physical chemical characteristic and naive consumer response to the umami source ingredients formulated from overripe tempe powder.

Sensory evaluation

Two types of sensory evaluation were performed to the selected formula of umami source ingredients from overripe tempe powder, which were hedonic evaluation and umami intensity rating test. In hedonic sensory evaluation, 30 naive respondents with no aversion to soy and soy derivative products were employed to evaluate the acceptance of the product. Responses were measured using nine ordinal responses from extremely dislike to extremely like and were analyzed statistically using Wilcoxon test. The umami intensity-rating test was conducted using 30 panelists that have followed screening on basic tastes and 42 h training on sensory attributes, sensory evaluation protocol, basic tastes introduction and recognition, and also basic tastes ranking and rating for pure solution and products. Responses for the umami intensity-rating test were measured using nine numerical responses with 1 defined as not detected and 9 defined as very strong intensity and were analyzed statistically using Friedman test.

Results and discussion

Epidemiological study showed that socioeconomic status (SES) is highly related with diet preference and quality. Higher nutrition knowledge and awareness on well-being might contribute to the higher diet quality in people of higher SES [15]. The higher SES group tends to have more consumption of lean-protein, whole grains, and plant-based products [16]. Therefore in this study, survey area was defined as commercial market in Tangerang City, Indonesia, where higher SES group tend to shop for their groceries and those that provide higher alternative protein or umami-source ingredients. Six modern supermarkets were then validated as the survey area, which were then used as criteria in the selection of respondents and target commercial umami-source ingredient. Respondents taken were those having habit to shop in the survey area with minimum frequency 4 times a month, and have been using umami-source ingredients in their daily cooking. Thirty validated respondents were then chosen to conduct the survey.

Overripe tempe (OT) higher glutamic acid contents shown to contribute to the umami-taste of OT and was able to enhance the intensity of basic tastes [13]. Processing of OT into powder was made as an attempt to increase the shelf life, availability, and practicality in the overripe tempe further development as umami-source ingredients [12-13], and thus powder form was taken into account in the selection of target commercial umami source ingredients. Long history of OT usage in Indonesian savory dishes [17] was also taken into account as one criterion in the selection. Based on the criteria, five varieties of USI were chosen as target commercial product. Trends of usage and applications of the selected USI, showed instant chicken stock as the most preferred USI and soup or soup like dishes as the most preferred application (Table 1).

Subsequent survey to select attributes of instant stock that contribute to consumer preference showed that taste was the most important attributes, followed by aroma, and natural source of ingredients (Table 2). National standard of Indonesia for stock and consommé [18] requires commercial chicken stock to meet following requirements: (1) total nitrogen minimum 100 mg/l; (2) total fat minimum 3 g/l; (3) maximum salt 12.5 g/l; and (4) negative microorganism and limited metal contamination. And therefore the OT stock formula was developed to meet total criteria (1) and (2) using commercial chicken stock formula as starting formula.

Table 1 Trend of usage and application of umami source ingredients selected in the market survey

Umami Source Ingredients (USI) Varieties	Usage trend (%) ¹	Application trend of each USI in Indonesian savory dishes (%) ²							
		Curry (-like) dishes	Grilled dishes	Mari- nated dishes	Noodle -based dishes	Porridge -based dishes	Rice- based dishes	Soup (-like) dishes	Vegetable- based dishes
Instant chicken stock	96.67	46.67	20.00	40.00	30.00	40.00	10.00	93.33	10.00
Monosodium glutamate (MSG)	66.67	36.67	10.00	20.00	43.33	16.67	3.33	53.33	3.33
Chicken-flavored flavor enhancer	93.33	63.33	53.33	50.00	43.33	36.67	20.00	86.67	16.67
Mushroom- and plant-based stock	73.33	30.00	33.33	23.33	20.00	13.33	10.00	46.67	23.33
Mixed spices and herbs seasoning	76.67	66.67	43.33	16.67	26.67	3.33	10.00	16.67	6.67

¹Values were expressed as percentage of respondents that used the USI in comparison to total response

²Values were expressed as percentage of respondents that chose a certain application of the USI in comparison to total response

Table 2 Attributes that affect instant stock preference

Attributes of instant stock	Impact on preference (%) ¹
Aroma	60.61
Natural ingredients	51.52
Price	18.18
Taste	87.88
Other	27.27

¹Values were expressed as percentage of respondents that considered the attributes are important factor in affecting their decision to consume or purchase instant stock in comparison to total response

Freeze and oven-dried OT powder was prepared as 2.0 % w/v solution and compared for its sensory attributes intensity, except umami intensity that was compared in four different concentration (0.5, 1.0, 1.5, 2.0%). Statistically, significant difference was only found in the color attributes where oven-dried OT powder in solution has darker color compare to the freeze-dried (Figure 1). Heating may induce non-enzymatic browning reaction such as Maillard [19], especially due to presence of free amino acid and simple carbohydrates as product of mould and bacteria activities during OT fermentation [20]. Maillard reaction was also known to contribute in the production of chemical components correlated with savory flavors [19]. The umami intensity between oven-dried and freeze-dried OT powder in solution

has no significant different statistically, however in all four concentration tested, umami intensity of oven-dried OT in solutions were constantly higher in value (Table 3). In agreement with previous study aroma of freeze-dried OT powder was significantly stronger than the oven-dried OT powder [12], however, upon the dilution in water, difference in the intensity was not detected. As taste was considered as the most important attribute in stock, further OT formulation was done using oven-dried OT powder.

Table 3 Sensory attributes intensity of oven-dried and freeze-dried overripe tempe powder in solution

Attribute intensity evaluated	Overripe tempe (OT)		
	dissolution concentration (% w/v)	Oven-dried OT	Freeze-dried OT
Aroma	4.0	6.15 ± 1.58 ^a	5.94 ± 1.58 ^a
Color	4.0	5.45 ± 1.52 ^a	1.94 ± 1.39 ^b
Taste:			
Bitterness	2.0	2.75 ± 1.55 ^a	2.35 ± 1.57 ^a
Saltiness	2.0	3.54 ± 2.57 ^a	3.66 ± 2.82 ^a
Sourness	2.0	2.63 ± 1.31 ^a	2.70 ± 1.34 ^a
Sweetness	2.0	1.25 ± 0.98 ^a	1.80 ± 1.42 ^a
Umami	0.5	4.36 ± 2.03 ^a	3.55 ± 1.99 ^a
Umami	1.0	4.70 ± 1.91 ^a	4.30 ± 1.93 ^a
Umami	1.5	5.48 ± 2.25 ^a	4.58 ± 1.93 ^a
Umami	2.0	7.15 ± 1.16 ^a	6.85 ± 1.91 ^a

¹Values were expressed as mean (n=30) ± standard deviation. Numbers with similar alphabet indicated no significant differences (p > 0.05) along the same row.

Commercial chicken stock formula was defined as starting formula in the development of OT stock. Major ingredients used were oven-dried OT powder in replacement of chicken extract and flavor enhancer, and other ingredients added were salt, oil, caramel syrup, garlic powder, and pepper (Table 4). Formulation was made in correlation to Indonesian standard (SNI) minimum requirement of nitrogen and fat (100 mg/l; 3 g/l) and maximum limit of salt (12.5 g/l) [18]. Formula optimization was conducted using maximum total nitrogen, minimum dissolution time, and minimum cost as decision factor. The selected formula (26.5% of OT powder, 20.7% salt, 20.0% oil, 20.0% of caramel syrup, 6.5% garlic powder, and 6.3% of

pepper) was subsequently tested for its conformity to SNI (Table 5) and compared to the commercial products in term of sensory intensity and acceptance solubility properties, color, and protein content (Table 6).

Table 4 Ingredients of commercial chicken stock and overripe tempe stock formula

Ingredients	Composition (%) in		
	Referred commercial chicken stock formula	Various OT Stock Formula	Selected OT Stock formula
Chicken flavor, chicken extract, yeast extract, MSG, sugar, other additives	32.71	-	-
OT Powder	-	24.62-43.20	26.5
Salt	38.98	20.70-25.00	20.7
Liquid chicken fat	1.69	-	
Vegetable oil	15.25	10.00-20.00	20.0
Sugar	10.17	-	
Caramel syrup	0.17	10.00-20.00	20.0
Garlic powder	-	6.48 - 10.48	6.5
White pepper	-	2.00-6.30	6.3
Xanthan gum	0.17	0.00-2.34	0.0

Table 5 Comparison of overripe tempe stock conformity with requirement in Indonesian National Standard (SNI)

Evaluation Criteria	Value in Overripe Tempe Stock	Requirement in National Standard
Total nitrogen (mg/L)	228	min. 100
Total fat (g/L)	5.44	min. 3
Sodium chloride (g/L)	3.31	max. 12.5

The selected formula was shown to meet the Indonesian national standard (SNI) requirement [18]. However OT stock had significantly lower umami and saltiness intensity (5.64 ± 1.64 ; 5.35 ± 1.64) that might contribute to its lower taste and overall acceptance (4.84 ± 1.75 ; 5.48 ± 1.55) compared to the commercial products. Analysis of solubility properties and protein content showed that OT stock had significantly higher insoluble solid and solubility time ($1.71 \pm 0.17\%$; 74.75 ± 0.71 s) and significantly lower total protein content (8.99 ± 0.56 mg BSA eq/ml). The higher fiber content of OT stock as plant-based USI might contribute to above situation. Color analysis showed that OT stock already has the same range of color with the commercial stocks (Table 6).

Further market survey of OT stock as guideline for further improvement showed that 70% of the respondent dislike or neither like nor dislike the product. Most of the respondents (83%) suggested "taste improvement and a small group of the respondents (10%) also suggested consistency improvement. More specific consistency improvement might refer to reduce the insoluble solid as indicated in 70% response stating "dislike" or "dislike very much" the high amount of residue in the OT stock (Table 7). It is at best, that further development of OT stock will work to improve the taste acceptance by increasing the umami intensity and apply such processing to reduce the amount of insoluble solid residue after dissolution and also the dissolution time.

Conclusions

Preliminary market study define chicken stock in soup or soup like-dishes as target commercial product in the development of overripe tempe (OT) powder as plant-based umami source ingredients. Oven-dried OT powder, were chosen as basic ingredients of OT stock, as it constantly showed higher umami intensity value in various concentration compared to the freeze-dried. The formula of OT stock were developed using emphasize to meet requirement of the Indonesian national standard (SNI) and taste acceptance. The selected formula (26.5% of OT powder, 20.7% salt, 20.0% oil, 20.0% of caramel syrup, 6.5% garlic powder, and 6.3% of pepper) successfully met the national standard requirement. However, further development is required to improve taste, as well as to reduce the amount of insoluble solid residue.

Table 6 Comparison of sensory intensity and acceptance, solubility properties, color, and protein content of overripe tempe (OT) stock with commercial stock products.

Evaluation items	OT Stock	Commercial 1	Commercial 2
Sensory intensity ¹ :			
Aroma	5.52 + 2.50 ^a	6.55 + 1.73 ^a	5.55 + 2.00 ^a
Umami	5.65 + 1.64 ^a	7.68 + 1.78 ^c	6.81 + 1.35 ^b
Saltiness	5.35 + 1.64 ^a	8.16 + 1.07 ^b	5.58 + 1.71 ^a
Sensory acceptance ¹ :			
Color	5.06 + 1.95 ^a	4.94 + 2.02 ^a	5.58 + 1.80 ^a
Aroma	6.16 + 2.44 ^a	7.42 + 1.31 ^a	6.84 + 1.49 ^a
Taste	4.84 + 1.75 ^a	6.13 + 2.45 ^b	7.10 + 1.87 ^c
Overall	5.48 + 1.55 ^a	6.29 + 1.75 ^b	7.10 + 1.75 ^c
Solubility properties ¹ :			
Solubility time (s)	74.75 + 0.71 ^a	18.00 + 0.71 ^b	16.75 + 1.06 ^c
Soluble solid (% Brix)	1.15 + 0.07 ^a	1.55 + 0.07 ^b	2.05 + 0.07 ^c
Insoluble solid (% w/w)	42.75 + 1.75 ^a	20.00 + 0.75 ^b	6.00 + 0.50 ^c
Color (L*, a*, b*) ²	27.22; 1.95; 2.44	29.48; 1.06; 4.00	28.06; 0.85; 3.70
Protein content (mg BSA eq/ml)	8.99 + 0.56 ^a	11.42 + 0.43 ^c	10.14 + 0.27 ^b

¹Values were expressed as mean (n=3) ± standard deviation. Numbers with similar alphabet indicated no significant differences (p > 0.05) along the same row.

²L* (Lightness): dark (0) to white (100); a*: green (-80) to red (+80); b*: blue (-80) to yellow (+80)

Table 7 Trend of suggestion for improvement area and acceptance level in the suggested area

Suggestion on Improvement		Acceptance on Suggested Area of Improvement		
Area of improvement	Suggestion Trends ¹	Acceptance Level	Trend on Taste ²	Trend of High Insoluble Residue ²
Taste	83%	Like or like very much	30%	0%
Consistency	10%	Neither like nor dislike	40%	30%
Other	7%	Dislike or dislike very much	30%	70%

¹Values were expressed, as percentage of respondents that considered the attributes requires improvement in presented OT stock to create better sensory acceptance in comparison to total response

²Values were expressed, as percentage of respondents that chose a certain level of acceptance of presented OT stock in comparison to total response

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