Tauco, fermented Indonesian soybean, processing and the nutritional value

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Abstract. Tauco is a culturally and culinarily significant traditional fermented soybean condiment in Indonesia. Its production methods vary across different regions. This study aims to examine and compare the processing methods and proximate composition of tauco from three key regions: Cianjur, Pekalongan, and Singkawang. The production process involves sequential steps, including soybean soaking, boiling, solid fermentation, brine fermentation, and drying. Regional variations in fermentation duration and environmental conditions influence the final product characteristics. Proximate analysis of tauco samples evaluated protein, fat, ash, titratable acidity measurement and crude fiber content. The results indicate significant differences in the proximate composition of tauco across the regions. Tauco from Pekalongan exhibited the highest protein content (29.31% db) and the lowest fat content (0.87% db), which may be attributed to a shorter fermentation period. Singkawang tauco had a higher moisture content (73.31% db) and lower protein levels (11.08% db), resulting from prolonged fermentation leading to liquid product. For ash content Singkawang and Pekalongan has a same content but Cianjur has the highest ash content 14.26%. The titratable acidity measurement had different in result in sample 1.80; 1.28; 0.89 for Cianjur, Pekalongan and Singkawang respectively. Fiber content of Cianjur sample was the highest 6.86 and followed by Singkawang and Pekalongan 3.86 and 3.83 respectively. These regional variations in tauco production and composition reflect differences in fermentation practices and climatic conditions, significantly impacting the nutritional properties of the product. The findings provide valuable insights for improving fermentation practices and enhancing product consistency in future commercialization efforts.

1 Introduction

Fermented foods are ubiquitous in Indonesia. Tempeh, tape, peyeum, and food seasonings like tauco, soy sauce, shrimp paste, and many more are examples of fermented goods that are commonly consumed. Soybeans are the primary ingredient of fermented dishes such as tauco, soy sauce, and tempe. Tauco is frequently used in cooking as a flavor enhancer, therefore it should not be used directly in food but rather as a seasoning. After the soybeans are boiled, they are fermented to make tauco. Mold fermentation and salt fermentation are the two fermentation processes that tauco come on . Typically, fermented food are made in a simple conventional fermentation, either naturally or with the help of culture. In addition, the fermentation process performs a crucial role in generating tauco with the appropriate flavor and aroma. Tauco itself is semi solid, with some of it in the shape of a paste that still retains soybean grains, which can have a sweet or salty flavor (1). Mold fermentation typically involves drying soybeans for several days, thereafter immersing them in a salt solution with approximately 10-20% concentration (2). The attributes of tauco goods vary among craftsmen, influencing both the final form of the tauco product and its nutritional content. Tauco producers are geographically dispersed across many regions of Indonesia. Cianjur, Pekalongan, Singkawang, and Medan are the principal producers of tauco, although each city may also manufacture its own regional variant of tauco. Each producer's method of generating tauco exhibits unique characteristics. The processing method will affect the nutritional composition of tauco product. The water, protein, and fat content of a food may vary according to changes in the processing method. The fermentation process modifies the nutritional composition of a product, requiring an understanding of the differences among various tauco products. Therefore, it is crucial to understand the processing methods and physicochemical characteristics of the tauco product.

2 Material and Method

2.1 Material

The tauco samples were obtained from three regions: Cianjur, Pekalongan, and Singkawang. The tauco

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sample collected is from the end of fermentation process. Analytical balance (Sartorius, Germany), oven (Memmert, Germany), centrifuge (Hermle, Germany), UV-Vis spectrophotometer UV 2450 (Shimadzu, Japan), magnetic stirrer (Steroglass, Italy), pH meter (Honiba, Japan), sodium hydroxide (Merck, Germany), sulfuric acid (Merck, Germany), hexane (Merck, Germany), 1% phenolphthalein indicator (Merck, Germany), ethanol (Merck, Germany), oxalic acid (Merck, Germany), aquadest. Proximate composition consisting of ashes, crude proteins, crude fats, was carried out in accordance with the AOAC procedure (AOAC, 2015). Titratable acidity (SNI, 2981:2009). Fiber content (AOAC 926.09. 2005 with modified). All this sample was triplicate and if there is significant $p<5$ than the duncan's test conducted.

2.2 Method

2.2.1 Survey and Process of Tauco Production

First, a survey of tauco-producing areas from the literature was conducted, followed by the selection of tauco producer. The selection of producer was based on the ease of accessing information on tauco making, having a well-known name in the city where the business is located and having a business licence and even obtaining a Household Industry Food Production Certificate number (SP-IRT) in the Cianjur, Pekalongan and Singkawang areas. Interviews concerned the process of making tauco from the beginning to the end process (solid fermentation/mold fermentation and salt fermentation/brine fermentation).

2.2.2 Proximate Composition Analysis

For crude proteins, total nitrogen is determined. Samples weighed 0.5 g and placed into a Kjeldahl flask. After that, 10 mL of sulfuric acid and 2 g of catalyst (a mixture of copper sulfate and potassium sulfate = 1:8) were added. Then, digestion is carried out until turns green color. The destruction product is placed into a 100 mL volumetric flask and distilled water is added up to the 100 mL. A 10 mL aliquot of the destruction product solution is pipetted and placed into the Kjeldahl. Then, 10 mL of sodium hydroxide was added to it and distilled for approximately 30 minutes. The distillation product, contained with 0.1 N hydrochloric acid, is added with 5 drops of methyl red indicator and then titrated directly using 0.1 N sodium hydroxide solution, showed pink to yellow color.

For crude fats, 3 g of tauco were placed into a bag made from filter paper and sealed with lint-free cotton. Then it is placed into the Soxhlet apparatus. After that, the flask and condenser were installed. Tauco is extracted with 30 40 mL of n-hexane (boiling point 60-70°C) over a water bath until the n-hexane appears clear, the extraction is carried out for approximately 4 hours. Next, the flask containing the residue (fat) is evaporated and dried in an oven at 105-110 °C for 1 hour.

For ash content, weigh ±1 g of sample and put it into a porcelain ash cup. The cup was then burned on an electric stove until it was smokeless and put into an ash furnace at 600°C for 4 hours. The cup was placed in a desiccator and left to cool and then weighed.

2.2.3 Fiber Content and Titratable Acidity

For titratable acidity using 0.1 N NaOH as a titrant and phenolphthalazin as an indicator, volumetric titration was used to assess the total acids, which were titratable acids. Since lactic acid was employed as the primary indication of organic acids in a comparable fermented soybean product, the total acids were determined as lactic acid equivalent.

For fiber content, 1 g of sample was dissolved in 100 mL H2SO4 1.25%, heated until boiling then followed by digestion for 30 minutes. Then filter it with filter paper in Buchner funnel. The residue was rinsed with 20-30 mL boiling water and 25 mL water three times. The residue was digested again with 1.25% NaOH for 30 minutes. Then filter as above and rinsed successively with 25 mL of 1.25% H_2SO_4 boiling, 25 mL of water three times and 25 mL alcohol. The residue and filter paper were transferred to a cup porcelain and dried in an oven at 130 ^oC for 2 hours. After cooling, the residue along with the porcelain cup weighed, then placed in a furnace at 600 ^oC for 30 minutes, cooled and weighed again.

All results were reported in the form of mean ± standard deviation of triplicate analysis for moisture content and ash content, crude proteins and fats, as % dry weight basis (% dw) or g/100 g dry matters of tauco, except moisture content as % wet weight basis (% ww) org/100 g fresh tauco. Statistical analysis with one-way analysis of variance (ANOVA) SPSS v.23 (IBM, USA) was used to determine the differences in the analysis results between samples. Further tests using Duncan's test at a 95% confidence interval were carried out if there was a significant difference.

3 Result and Discussion

Tauco is a fermented substance akin to Japanese miso, Chinese dajiang, or South Korean doenjang (4,5, 6). Tauco is a miso-like product that undergoes two production stages: koji (solid fermentation) and moromi (salt fermentation). Every artisan has a distinct technique for converting soybeans into tauco; nonetheless, the fermentation process typically involves mold fermentation and salt fermentation (2).

Fig 1. Cianjur Tauco Fementation Process

Solid-state fermentation is a procedure that entails the desiccation of boiling soybeans. The drying duration typically spans from 3 to 7 days, contingent upon weather conditions and sunlight exposure, until mold manifests on the product (1). The use of equipment (tempeh making containers) that have already been overgrown with tempeh molds or in which tempeh laru is added during the process, allows the molds to grow well resembling koji fermentation in miso making which contains *Aspergillus oryzae* molds (2). Similarly, doenjang fermentation naturally grows molds such as Aspergillus on the soybean material found in meju fermentation(6). This process is not different with Dajiang or Doenjang fermentation. In spontaneous fermentation, microorganisms grow more diverse compared to the addition of a starter culture such as yeast. An example is the production of doenjang that uses meju as the main ingredient in the doenjang fermentation process. In the manufacture of dajiang, due to the development of business and economic, in northeast China the use of artificial inoculation or the use of pure cultures is preferred because it produces products with uniform characteristics and the same quality, although for aroma and flavour, the use of traditional spontaneous fermentation is preferred (6).

Figure 2. Pekalongan Tauco Fermentation Process

The fermentation of Cianjur tauco involves solid state fermentation without the addition of microorganisms in soybeans, which are dried on bamboo trays for 2 to 3 days in clear, hot weather, the drying process is prolonged during rainy season(1). No culture was added for Pekalongan same as Cianjur in solid fermentation (mold fermentation). In Singkawang, commercial tempeh starter is added, and the soybeans are then fermented by being placed on bamboo trays covered with cloth until they are covered in tempeh mold for three days, after which the fermentation process persists.

Figure 3. Singkawang Tauco Fermentation Process

Following the onset of mold, salt fermentation will occur through submersion in a saline solution, allowing it to ferment for the prequisite duration as determined by the tauco artisan. Salt fermentation is conducted by many artisans using differing salt concentrations, often ranging from 10% to 20%. The salt fermentation process for Cianjur tauco employs a 10% salt concentration and is aged for approximately 90-100 days in clay barrels called patiman (1), followed by sun-drying. In contrast, Pekalongan utilizes a 9,5% salt concentration and is stored for 30 days in plastic barrels, while Singkawang employs a 13,8% salt solution for 25 days in plastic barrels.

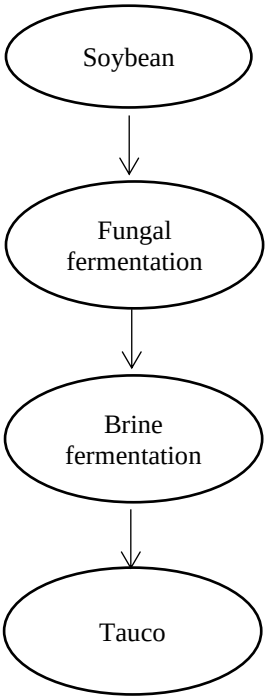

Figure 4. Process of Soybean into Tauco

The resulting product from Cianjur has a slightly solid texture with a tauco aroma (fermented soybean aroma) and a dark colour due to the long fermentation time and drying process. Too long fermentation will affect the characteristics of the product, sun drying will significantly reduce the salt solution making the product denser and the taste will also be more salty, because the mixing between salt and soybeans becomes more uniform and evenly distributed.

For Pekalongan tauco, after boiling and added with rice flour, it is formed into a hand-sized sphere and permitted to cultivate mold for three days, dried by simply being aired and not exposed to direct sunlight. After 3 days, the mixture of soybeans and rice flour is crushed into small pieces and then soaked in a 20% (w/v) salt solution and fermented for 30 days in a plastic barrel before being dried. After being fermented with salt, the tauco turns brownish and has a distinctive white rice flour mixture that gives it a unique appearance. The aroma more fragrant with ethanol aroma and colour of

the tauco are also brighter than the other two types of tauco. Ethanol aroma predicted from yeast activity(7).

Tauco Singkawang is a type of tauco that is made using the same fermentation process as traditional tauco, which involves the use of mold and salt. The first step involves boiling soybeans, followed by mold fermentation using 1.2% tempeh starter culture. The mold fermentation process is carried out by storing soybeans that have been inoculated with fungi in a wooden container at room temperature for 3 days without drying until the soybeans are covered with fungi and then covered with a cloth to maintain hygiene. The use of starter culture or yeast facilitates uniform results as well as standardized aromas and characteristics of the products do not differ much from each other as is done in the mass production of dajiang (8). They are soaked in a salt solution for 25 days in a plastic barrel without exposure to sunlight and kept covered. This process should be carried out to ensure the desired flavour and texture of the final product without exposure to sunlight and with plenty of outside air. Brine fermentation is commonly done by soaking in a salt solution for a certain period of time or by being left in a closed container for a period of time.

Upon completion of fermentation, additional processing typically occurs, with the exception of Pekalongan tauco, which remains unprocessed and is packaged in standard plastic, accompanied by supplemental packaging crafted from woven pandan leaves. After the salt fermentation process is complete, the soybeans become dry tauco which is then cooked with added water, brown sugar, and specific seasonings. The process for producing tauco is illustrated in Figure 4.

Table 1. Protein, Fat and Ash Content

Samples	Protein (%db)	Fat (%db)	Ash (%db)
Cianjur	32.29a± 2.75	4.54a± 0.87	14.26a±1.14
Pekalongan	29.31a± 1.41	0.87b± 0.14	9.60b±0.07
Singkawang	11.08b± 0.27	1.65b± 0.68	9.15b±0.51

The results of the proximate analysis for protein, fat, and ash can be seen in the Table 1. Soybean contains high protein and become a source of protein from plant based besides animal based protein. The protein content of Cianjur, Pekalongan, and Singkawang was 32.29%, 29.31%, and 11.08% (dry basis) respectively. Cianjur and Pekalongan have similar protein levels while Singkawang is different from the others. The low protein content based on dry basis of Singkawang is likely due to the ratio of water added during brine fermentation and there was no sun drying in brine fermentation. The protein content of ready to use tauco samples obtained from different producers in Indonesia ranging from 9,72 % to 32,60% in dry basis (9). The protein content of soybeans is approximately 36-40%. Complex protein is derived from the protein content of the soybean (10).

Variations in protein, excluding those originating from soybeans, may also result from the composition of supplementary materials and the activity of microorganisms engaged in fermentation (11). The incorporation of alternative materials in tauco fermentation does not entail any additives; rather, it likely results from the degradation of proteins into simpler constituents, facilitating analysis. Protein catabolism may encompass degradation and oxidation.

Tauco from the three cities in Indonesia showed varying levels of fat content. Based on dry weight, tauco Cianjur has the highest fat content (4.54%), followed by Singkawang (1.65%), and Pekalongan (0.87%). Dried soybeans contain approximately 19% lipid (12). The microorganism in fermentation involved during tauco fermentation is believed to have lipolytic activity. Lipases break down complex lipid components into simpler lipid in the product. On mold fermentation of soybean, mostly triggers growth of the mold and one of the molds is Aspergillus has the ability to breakdown lipid. Lipid breakdown affects the formation of the aroma in tauco.

Ash content is a mineral and inorganic content. The total ash is total ash residue from samples. Total ash content is a proximate analysis used to determine nutritional value a food ingredient, as well as showing total minerals contained in the material. Ash content from Cianjur the highest ash content 14.26% and Pekalongan not significantly differ from Singkawang. All treatments indicated that Cianjur exhibited the highest ash content. This occurs due to the presence of several contaminants, as Cianjur tauco is dried in an open environment that facilitates entry of dirt (13).

Table 2. Crude fiber content and acid titration

Samples	Titration acidity	Crude fiber (%)
Cianjur	1.80a±0.11	6.86a±1.14
Pekalongan	1.28b± 0.07	3.83b±0.51
Singkawang	0.89c±0.02	3.86b±0.18

The total titratable acidity is the concentration of both free protons and undissociated acid in a solution that can react with a strong base and be neutralised. The results of the total titratable acidity analysis for all samples are significantly different. The Cianjur sample has the highest total titratable acidity content compared to the Pekalongan and Singkawang samples, which are 1.8, 1.28, and 0.89, respectively. The fermentation process of Cianjur tauco takes a long time, approximately 90 days, and results in an increasing level of titrated acid. The total titrated acid content in fermented food will continue to increase as the fermentation process progresses. The titratable acidity level increases as the fermentation time of soybeans increases on fermented soybeans (9). Therefore, longer fermentation can increase the total titratable acidity of the fermented product. The activity of microorganism made the acid from samples lower because degradation of the carbohydrate or any nutrition in samples (14).

The crude fiber content originates from food. Crude fiber content is a form of crude fiber deficient of nutritional value nevertheless contributes to health.

Certain foods, particularly vegetables, grain, cereal, bean are food contain high crude fiber. The crude fiber analysis reveals that the Cianjur sample possesses the highest fiber content at 6.86%, whilst the Pekalongan and Cianjur samples have comparable values of 3.83% and 3.86%, respectively.

4 Conclusion

Every tauco producer has distinct attributes in their conversion of soybeans into tauco. Nonetheless, all tauco processing methods often employ identical fermentation processes, specifically mold fermentation and brine fermentation.
The proximate analysis from Cianjur tauco exhibits elevated quantities of protein, fat, ash, titratable acidity, and fiber. This shows that the microbial fermentation process over time will alter the nutritional composition of the food.

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