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EFFECT OF VARIOUS COOKING METHODS ON QUALITY AND SENSORY CHARACTERISTICS OF TEMPEH MADEFROM SOYBEANS AND CORN

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ABSTRACT

One variation of tempeh products is using corn. Tempeh made form soybeans with the addition of corn has obtained the best treatment with a ratio of soybean : corn namely (80 : 20)%. There is no research that discusses the character of soybean tempeh with the addition of corn during the processing. This study aims to determine the best cooking method (boiling, frying and steaming) for the quality and sensory characteristics of tempeh made from soybeans and corn. The ratio of soybean and corn used is (80;20)%. The research method used is an experimental method with descriptive analysis. The study was carried out with 4 treatments namely control, boiling tempeh at 100°C for 10 minutes, fryingat 162°C for 3 minutes, steaming at 90°C for 10 minutes, 3 replicates. Chemical analysis was carried out namely water content analysis, ash content, fat content, protein content, carbohydrate content, crude fiber content, total carotene and antioxidant activity of tempeh. Then the organoleptics test was carried out on the level of preference of the panelists on the parameters of aroma, color, taste and texture of tempeh. The results showed that the best cooking method was in treatment C, frying tempeh at a temperature of 162°C for 3 minutes with a moisture content of 41,33 %. Ash content of 1,43 %, fat content 33,60%, protein content of 17,80 %, carbohydrate content is 6,65%, total carotene is 7,67%, crude fiber contane is 5,75%, % inhibition is 23,85%. Sensory assessment of tempeh with several cooking methods, the most preferred, namely in treatment C (Frying at 162°C for 3 minutes) with aroma 4,25 (likes), color 4,20 (likes), taste 4,00 (likes)and texture 4,(30 likes).

Keywords :*Method, caratenoid, tempeh, kharacteristic, antioxidant activity*

INTRODUCTION

Currently functional food is no stranger to the public because it is known to have a good impact on health. This can give rise to a new paradigm for the development of food science and technology, as evidenced by various modifications of processed food products towards functional properties. Today's foodstuffs not only prioritize good nutritional content and an attractive taste and appearance, but also must have certain physiological functions for the body. According to BPOM (2005) functional food is defined

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as food that is natural or has undergone a processing process that contains one or more compounds that have certain physiological functions that are good for health. Functional food is classified into two, namely plant functional food and animal functional food. Vegetable functional food is functional food sourced from plants such as soybeans, brown rice, tomatoes, grapes and garlic. While animal functional food is functional food sourced from animal materials such as fish, meat and milk (Suter, 2013). Some foods that are made and produced by the community, have the potential to be varied as functional foods, the aim is to improve taste and add nutritional value to food products. Some native Indonesian foods that have this potential are tempeh, growol, soy sauce, curd and pickles (Nugraheni, 2011).

Tempe has been known as a functional food because it has certain ingredients that have a good effect on health. The functional value of tempe is mainly due to the presence of bioactive compounds that increase during the fermentation process such as free isoflavones, riboflavin, pyridoxine, niacin, biotin, folic acid, soluble protein, tocopherol and superoxide dismutase (SOD) (Polanowska *et al*., 2020; Tamam *et al*. ., 2019; Moa *et al.*, 2013; Nout and Kiers, 2005; Egounlety and Aworh, 2003; Wiesel *et al.,* 1997). Tempe contains folate, vitamin B1, isoflavones and is also rich in dietary fiber and calcium. The existing variations of tempe products are tempe that uses mixed ingredients, such as soybean tempeh with a mixture of cowpeas (Syam and Patang, 2018) and tempeh mixed with soybeans and corn (Jubaidah, Nurhasnawati and Wijaya, 2017),

Soybean tempeh with the addition of corn is known as a potential functional food because it consists of corn which has a high carotenoid content of 150 g/100 g, higher than soybean which contains 31 g/100 g of carotenoids (FAO, 1953; Watanabe, 2015). According to Eldahsan and Singab (2013) Carotenoids in corn consist of 22% -carotene and the rest is xanthophyll -carotene has a role as an antioxidant and anticancer while xanthophyll based on research by Moeller *et al*., (2000) has the potential to reduce the risk of blindness caused by cataract disease. Research has been carried out by Jubaidah *et a*l., (2017) on soybean tempe substitute for corn and obtained the best treatment of soybean: corn (80: 20) %.

Based on existing research, generally discussing the manufacture of tempe by mixing soybeans with other ingredients, there has been no research that looks at the character of tempeh mixed with soybeans and corn during the processing process. Meanwhile, different processing processes will affect the nutritional value of the resulting product. In the research of Aulia *et al*., (2017) different cooking methods can affect the nutritional content of green vegetables such as vitamin C and total phenolics. Different cooking processes also affect some of the nutritional content of meat such as fat, protein and cholesterol content (Nguju, 2018). Meanwhile, the carotenoid content in corn is known to be easily damaged during processing and storage due to heat (Puspita *et al*., 2021). Therefore, to find out the best cooking method that can maintain bioactive compounds in tempe, especially carotenoids, tempeh processing is carried out with several cooking methods. Boiling temperature of 100°C represents medium temperature, frying temperature of 162°C represents high temperature and steaming temperature of 90°C represents low temperature. Based on the above background, a study entitled "The Effect of Various Cooking Methods on Quality and Sensory Characteristics in Tempe Made from Soybean and Corn" was conducted.

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EKSPERIMENTAL SECTION

A. MATERIAL

The materials used in this study are soybeans (Glycine max) obtained from the market market of Padang, corn (Zea Mays) obtained from the village of pengambiran Lubuk Begalung, Padang City and tempeh yeast obtained from the market market of Padang. The chemicals used were concentrated sulfuric acid, selenium mix, 50% NaOH, distilled water, boric acid, hexane, acetone, isopropyl alcohol, methanol.

The instruments that used during the study were oven, furnace, soxhlet, measuring cup, beaker, aluminum cup, porcelain dish, analytical scale, fat flask, kjedahl flask, erlenmeyer, gegep (iron clamp), test tube, stove, pots, pans, plastic.

B. Method of Research

The research method used is an experimental method using descriptive data analysis, namely statistics used to analyze data by describing or describing the data that has been collected as it is. This research was conducted with 4 treatments and 3 replications. The following is the treatment of the cooking method used in this study, namely:

P0 : No cooking treatment

P1: Boiling tempeh for 10 minutes at 100°C (Purwandari *et al*., 2021)

P2: Frying tempeh is carried out at a temperature of 162°C for 3 minutes (Purwandari *et al*., 2021).

P3: Steaming at 90°C for 10 minutes (Utari *et al*., 2010).

C. Research Implementation

Preparation of soybean seeds (BSN Modification, 2009)

a. Sorting: Soybean seeds are first sorted to get quality

b. seeds, namely soybeans that are good, dense and contain. Sorting aims to get quality tempe products.

c. Washing soybean seeds: soybean seeds are washed with running water to clean soybean seeds from dirt and dust carried.

d. First soaking: clean soybean seeds are put into a bucket of 2 liters of water then soaked for 3 hours. The purpose of this immersion is to soften the soybean seeds due to the absorption of water into the soybean seeds. Then it also makes it easier to peel the epidermis

e. First boiling: soaked soybeans and then boiled in 2 liters of water at 100°C for 30 minutes or until they are almost half cooked. The first boiling aims to make the soybeans softer and facilitate the release of the epidermis.

f. Second soaking: Soybean seeds that have been boiled are soaked for 12 hours with the boiling water so as to produce acidic conditions that are suitable for the growth conditions of tempeh mushrooms.

g. Washing and peeling the epidermis: soybean seeds are put into water then the husk is removed until finally soybean chips are obtained.

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h. Second boiling: Soybeans without skin are put in a saucepan and added 2 liters of water then allowed to boil for 30 minutes. This boiling aims to ensure that the soybeans are completely cooked and kill contaminant bacteria that grow during soaking.

i. Cooling stage: Once cooked, remove and spread thinly on a winnowing tray. Wait until it cools down, the water drips and the soybean seeds dry out.

Corn preparation (Lestari and Mayasari, 2016)

a. Washing: The shelled corn is weighed as much as 200 grams and then washed with running water to remove dirt and remaining corn hair.

b. Boiling: Then boiled with 1.5 liters of water at a temperature of 100°C for 30 minutes until the skin splits to make the corn soft and cooked.

c. Soaking: Boiled corn is soaked for 12 hours with the boiled water to get really soft and full (swelling) corn.

d. The second washing: The corn is washed and the husks separated so that the fermentation can occur properly.

e. Cleavage: The corn is then split into two parts to balance the size of the soybeans

f. Steaming: The corn was steamed for 45 minutes (1000 ml water at 95^{o}C) and allowed to cool at room temperature.

Tempe Making Process (BSN Modification, 2009)

Soybean seeds were mixed with corn seeds in a ratio of soy and corn (80: 20) and inoculated with 1% tempeh yeast (1 gram of yeast for 100 grams of material) then stirred until smooth. Soybean seeds that have been given yeast are wrapped in plastic with holes on both sides and then incubated for 48 hours at room temperature.

Tempeh Cooking Process

After the fermentation process for 2 days, the tempeh is then cooked according to the treatment.

a. No cooking

Tempe which has been fermented for 2 days is then cut into pieces (4x4) cm and a thickness of 1 cm and then analyzed.

b. Boiling (Purwandari *et al*., 2021 Modification)

The tempeh is cut first with the same size (4x4) cm with a thickness of 1 cm then weighed ± 100 grams and boiled with 1000 ml of water at a temperature of 100°C. Boiling tempeh is done using a stainless steel pan.

c. Frying (Purwandari *et al*., 2021)

Tempe that has been cut then weighed ± 100 grams and fried at a temperature of 162°C for 3 minutes with 300 ml of oil. Frying tempeh is carried out using the Deep Frying method, which is a frying

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technique with a large amount of oil and all parts of the ingredients are submerged in oil. Frying is done using a frying pan.

d. Steaming (Utari *et al*, 2010)

Tempe that has been cut with a size (4x4) cm with a thickness of 1 cm then weighed ± 100 grams and steamed at 90°C for 10 minutes using a stainless steel pan. After ripe, the analysis was carried out.

D. ANALYSIS PROCEDURE

Water content gravimetric method (AOAC, 1995)

Clean empty aluminum cups are dried in a 105°C oven for 30 minutes. Then the saucer is cooled in the desiccator for 15 minutes and weighed (Wo) as much as 2 g of the sample weighed in an aluminum dish of known weight (W1). Drying is carried out in the oven at 105°C for 3 hours. Furthermore, the sample is cooled in a desiccator for 15-30 minutes and weighed until the weight is constant (W2), then calculated using the following formula:

$$KA(\%\ b/b) = \frac{\mathrm{W1-W2}}{W1-W0} X\ 100\ \%$$

Ash content analysis (Yenrina, 2015)

Prepare a canal dish, then dry in a kiln for 15 minutes then cool in a desiccator and weigh. Weigh the sample as much as 3-5 g in the saucer then burn it on a hot plate until it does not smoke. Put it in a canning kiln, and burned until gray ash is obtained or until the weight remains. Gasping is carried out in the first two stages at a temperature of about 400○C and the second at a temperature of 550○C. Cool in a desiccator then weigh. The ash content is calculated using the formula:

$$\%\ \text{Kadar Abu} = \frac{(\text{berat abu} + \text{cawan}) - (\text{berat cawan})}{\text{berat sampel}} X\ 100\%$$

Protein Content Analysis of the Kjeldahl Method (Syukri, 2021)

Weigh the sample by 1 g then put it in a kjeldahl flask then add 1.5 g (selenium mix / kjeldahl tablets) and 15 mL of concentrated sulfuric acid (H2SO4). Then it is destructed until the mixture becomes clear. Then cooled, after cooling it is put into a 100 mL measuring flask and diluted with aquades. Picketed 10 mL of the above solution into the kjeldahl flask and added 10 mL of 50% sodium hydroxide (NaOH). The kjedahl flask is attached to the distillation device, the distillation reservoir is prepared in an erlenmenyer of 100 mL which is 25 mL of boric acid (H3BO3) plus 4 drops of mm indicator: mb, the tip of the distillation tool must be submerged with boric acid solution. The solution is then titrated with 0.04 N hydrochloric acids (HCl) until a discoloration occurs from green to purplish-red. The protein content of the sample is calculated according to the formula:

$$\%N = \frac{(\mathrm{A-B})\ \times\ \mathrm{NHCl}\ \times\ 14{,}007\ \mathrm{x\ FP}}{\text{sample weight (mg)}} \times 100$$

Protein content = % N x Conversion factors

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$$\text{Lemak total (\%)} = \frac{\text{Pumpkin weight and extracted fat (g)} - \text{fat flask weight (g)}}{\text{sample weight (g)}} X\ 100\%$$

Analysis of carbohydrate levels by difference (Ristia, 2014)

Determination of carbohydrate levels is calculated by the method by difference, carbohydrate content analysis is calculated using a rough calculation (proximate analysis) or the so-called Carbohydrate by difference. The amount of carbohydrate content can be known through the following formulations:

Carbohydrate content: 100% -% (protein + fat + water + ash)

Analysis of crude fibers (Andarwulan, Kusnandar and Herawati, 2011).

A total of 2 g of samples that have been free of fat, then put into a 500 mL erlenmeyer. Then 200 mL of sulfuric acid (H2SO4) of 1.25% was added. Simmer for 30 minutes using an upright cooler. Then strain with filter paper. Residues left in the erlenmeyer are washed with boiling water. Wash the residue in filter paper until the water is no longer acidic. Transfer the remaining residue in the filter paper into the erlenmeyer. Then add 200 mL of sodium hydroxide (NaOH) 1.25%, until all residues enter the erlenmeyer. Simmer again for 30 minutes. In a hot state, it is filtered with filter paper of known weight (first dried at a temperature of 105○C for 30 minutes), while washed with a solution of potassium sulfate (K2SO4). The residue is washed again with boiling water and then with 95% alcohol 10 mL. Filter paper is dried at a temperature of 110○C for 1 hour until the weight is fixed. Then it is cooled in a desiccator and weighed.

$$\text{Crude Fiber Content} = \frac{\text{ResidPue (g)}}{\text{Sample Weight (g)}} X\ 100\%$$

Analysis of total carotene (de Carvalho et al., 2012)

A total of 1 g of sample was added to 2 mL of acetone then added 2 mL of hexane then put in a test tube and in an ultrasonic bath for 15 min. Then copy it to the centrifuge tube and centrifuge it at a speed of 3000 rpm for 10 minutes. Then the solvent is transferred and added another 2 mL of acetone and 2 mL of hexane and centrifuge again until a clear centrifuge result is obtained. The solvent obtained is transferred into a 20 mL measuring flask then add hexsane until the mark is then read using spectrophotometry at a wavelength of 450 nm.

$$\text{Total carotene (µg/g)} = \frac{\text{Absorbance X Total volume of extract (ml) X } 10^4}{A_{1\ cm}^{1\%} \text{X sample Weight (g)}}$$

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$$\% \text{ Inhibition } = \frac{\text{Blank Absorbance} - \text{Sample Absorbance}}{\text{Blank Absorbance}} X\ 100\%$$

Sensory Test (Setyaningsih, Apriyanto and Sari, 2010)

Organoleptic Test or called sensory test is a way of testing using human senses as the main tool for measuring the acceptability of products. Sensory tests on tempeh were carried out by 20 semi-trained panelists. The requirement for a person to be a panelist is not to be hungry or full because it can affect the results of sensory tests. This test is carried out to determine the level of the panelist's liking for the resulting product. The sensory test carried out is the observation of the color, aroma, taste, and texture of the product. The test parameters are scored as (1) very dislike, (2) dislike, (3) somewhat like, (4) like, and (5) really like. The procedure in sensory testing is as follows:

1. A white container is provided that has been coded with random numbers.
2. Each sample is put into the container, then the panelists are asked to observe the color and aroma first.
3. To observe the taste and texture of tempeh, panelists were told to drink the mineral water that had been provided before conducting taste and texture tests on each treatment
4. The test is carried out in a separate room between one panelist and another panelist so that there is no contact between the panelists.
5. The panelist is given a form of assessing the panelist's level of favorability towards the sample.
6. Panelists are asked to express their level of liking for the sample presented by giving values in the form of numbers 1,2,3,4 and 5 in each sample column by marking (√).

How to process sensory test data:

1. The results of the sensory test are tabulated in one table, for later analysis with ANOVA (Analysis of Variance) and further testing with Duncan's Multiple Range Test.
2. The results that have been obtained from the organoleptic assay are tabulated and calculated total treatment (Yi), total group (Yj), general total (Y), and calculated ΣY2 for each treatment and group.
3. Then variants are carried out to distinguish one example from another.

RESULT AND DISCUSSION

Moisture Content

Water is an important component in foodstuffs, all foodstuffs contain water in different amounts, both plant and animal foods. The content or amount of water contained in food ingredients is expressed as water content (Kusnandar, 2010). The results of observations on the water content of tempeh for each cooking method can be seen in Figure 1

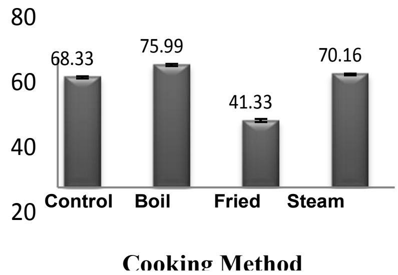

Figure 1. Average Value of Tempe Moisture Content of Several Cooking Methods

In Figure 1 it is known that the water content of tempeh increases after undergoing the cooking process of boiling and steaming, but decreases after the frying process. The highest water content was found in treatment B (boiling tempeh at 100^{o}C for 10 minutes) with a value of 75.99% then followed by treatment D (steaming at 90^{o}C for 10 minutes) of 70.16%. The water content was obtained in treatment C (Frying tempeh at 162^{o}C for 3 minutes) with a value of 41.33%. The results of the variance showed that each treatment was significantly different at the 5% (α) level of the water content of the tempeh produced.

After the boiling process there is an increase in the water content of tempeh from its raw form. This is because in the boiling process there is direct contact between tempeh and boiling water so that water is absorbed into the tempeh. This is supported by the statement of Lamid *et al*., (2015) that fermented soybean chips are able to absorb more boiled water. This is in accordance with research conducted by Setyani *et al*., (2017) that the water content of tempe (80% soybeans: 20% corn) in raw form ranges from 64.95-70.53% and after the boiling process the water content increases by 1 ,88%.

On cooking with frying, there was a significant decrease in the water content of the raw tempeh, namely 68.33% to 41.33%. This is caused by the evaporation of water that occurs during the frying process, where heat is transferred from the oil as a heat-conducting medium to the material. During the frying process, some of the oil enters the outside of the tempeh and then fills the empty space that was originally filled with water. Winarno (2007) which states that the higher the temperature used, the more water molecules come out of the surface and become gas.

While the value of the moisture content of steamed tempeh has increased from raw tempeh because in steaming there is evaporation of water so that water vapor can stick to food ingredients which can increase the water content of tempe. In accordance with the statement of Aulia *et al.,* (2017) that in the steaming process, the tissue matrix of the material tends to absorb water so that the water content is relatively higher than the raw material. This is evidenced by the wetness of the tempeh surface when removed after the steaming process.

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Ash Content

Ash is an organic substance left over from the combustion of an organic material. The ash content of a food material indicates that there is a mineral content of a material. Ash content is the material left behind when food ingredients are ignited and burned at temperatures around 500-800^{o}C (Lamid *et al*., 2015). Observations on the ash content of tempe for each treatment can be seen in Figure 2.

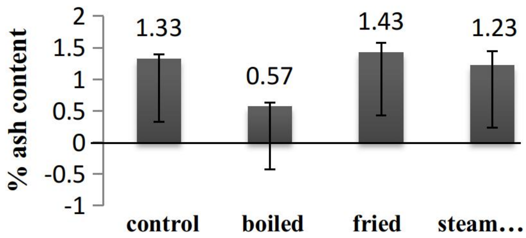

Figure 2. Average Value of Tempe Ash Content of Several Cooking Methods

The results of the analysis of tempeh ash content ranged from 0.57% to 1.43%. Based on Figure 2, it is known that the ash content of tempeh after the process has decreased after being boiled and steamed, while the ash content after frying has slightly increased. The highest ash content was found in treatment C (tempered frying at 162^{o}C for 3 minutes) which was 1.43%. The lowest ash content was found in treatment B (boiling tempeh for 10 minutes at 100^{o}C) of 0.57%. The results of variance showed that the ash content of raw or control tempe was not significantly different from boiled and fried tempeh. Meanwhile, tempeh with the steaming process was found to be significantly different from the control, boiled and fried at a level of (α) 5%. The decrease in the ash content of tempeh after boiling treatment was caused by the shrinkage of minerals during processing. In accordance with the statement of Purwaningsih *et al.,* (2011) that during the boiling process some minerals will be carried away with water vapor that comes out due to the rupture of mineral particles bound to water due to heating, especially minerals in the form of calcium and iodine. According to Yudiono (2020) Soybeans are a source of calcium, iron, zinc, phosphorus, magnesium, thiamine, riboflavin, niacin and folic acid. Meanwhile, some minerals, especially zinc, phosphorus, calcium and potassium can decrease during the boiling process (Lewu *et al*., 2010).

In the frying process there is an increase in the ash content of the raw tempeh, which is 1.33% to 1.43% after frying, this is because when frying there is more evaporation of water, so that the evaporated water can leave minerals in the ingredients. In previous studies, it was found that the ash content in the fish frying process increased, the ash content of fresh fish was 1.32% and after frying it became 4.93% (Utami *et al*., 2019). While in the steaming process there was a slight decrease in the ash content of the raw tempeh, namely 1.33% to 1.10%. According to (Harimurti *et al.,* 2021)

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The decrease in ash content in the steaming process is related to the water content of the material, a high water content in the steaming process proves that there is a little evaporation of water so that it leaves low minerals which make the ash content decrease, and vice versa, low water content causes the resulting ash content to be higher.

Fat Content

Fat is an important food substance for the health of the human body. Fat is also a more effective source of energy compared to carbohydrates and protein. Observations of fat content for each treatment can be seen in Figure 3

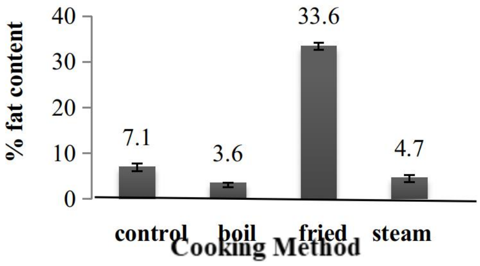

Figure 3. The Average Value of Tempe Fat Content in Several Cooking Methods

In Figure 3 it can be seen that the fat content of tempeh after undergoing the boiling and steaming process decreased from the raw tempeh and increased after the frying process. The highest fat content was obtained in treatment C (Frying tempeh at 162^{o}C for 3 minutes). with a value of 33.60% and the lowest tempeh fat content was obtained in treatment B (boiling tempeh at 100^{o}C for 10 minutes) of 3.60%. The results of the variance showed that each cooking method had a significant effect on the 5% (α) level of the fat content of the tempe produced.

In cooking by boiling, there is a decrease in the fat content of tempeh from raw tempeh. This decrease was due to changes in the structure of fat in tempeh caused by the hydrolysis of fat in which fat is converted into free fatty acids and glycerol. This is in line with Winarno (1997) in Putri *et al*., (2021) that by heating using water, fat can be hydrolyzed into glycerol and fatty acids which are then lost during boiling. In addition, boiling is carried out at high temperatures which can make the fat float along with the water. According to Lamid *et al*., (2015) the decrease in fat content after boiling is due to the nature of the fat that is not heat-resistant. During the cooking process, fat can melt and even evaporate into other components such as flavor. Wijayanti *et al*., (2014) stated that the decrease in fat content was caused during the processing process, most of the fat floats on the water surface and is lost with the water disposal process.

The fat content of tempeh before being given cooking treatment was 7.10% after frying the fat content increased significantly to 33.60% this was because in the frying process there was evaporation of water then the position of the water was replaced by the cooking oil used, causing the fat content in the

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frying pan. tempeh increases. According to research by Lamid *et al.,* (2015) the increase in fat in tempeh when frying is due to the presence of cooking oil that is absorbed by the ingredients during the frying process which results in increased fat content. It was found that the largest increase in fat content was found in tempeh, which was 17.26%.

Tempeh which is processed by the steaming method, the fat content of raw tempeh is 7.10% and after steaming it decreases to 4.70% this is due to the melting of fat in the tempeh steaming process. The decrease in fat content in the steaming process is due to the fat from the material being steamed melts and flows out into the steaming water. The decrease in fat content of steamed tempeh obtained was not as large as the decrease in fat of boiled tempeh, this is in accordance with the statement of Tamrin and Prayitno (2008) that the steaming process can cause a decrease in nutrients in a food ingredient but the decrease in nutrients that occurs is not as large as in the boiling process.

Protein Content

Protein is an important food substance for the body because it has a function as a building block and body regulator. Processing of food ingredients to create a better taste can be done by various cooking methods that can affect the nutritional value of food stuffs. Tempe protein content for each treatment can be seen in Figure 4

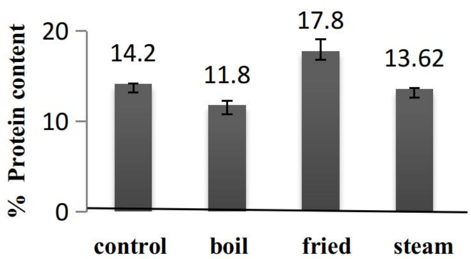

Figure 4. Average Value of Tempe Protein Levels in Several Cooking Methods

Based on Figure 4, the lowest tempe protein content was obtained in treatment B (boiling tempeh at 100°C for 10 minutes) of 11.80%. The highest tempe protein content was found in treatment C (Frying tempeh at 162°C for 3 minutes) of 17.80%. Meanwhile, in treatment D (steaming at 90°C for 10 minutes), the protein content of tempeh decreased slightly from that of raw tempeh, which was 13.62%. The results of the variance showed that each treatment was significantly different at the 5% (α) level of tempeh protein content.

The process of cooking tempeh by boiling can reduce the protein content of tempeh from 14.20% to 11.80%. This is due to the presence of water-soluble soy protein. According to Nurmala (2014) in the boiling process there is a decrease in protein due to the process of separating nitrogen compounds that dissolve into water. Soybean protein consists of globulin which is the largest soy protein content (90%) and the rest is albumin which is easily soluble in water. Winarno (2008) states the presence of several

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water-soluble proteins such as protamine, albumin and histones. The decrease in protein during boiling is also caused by protein denaturation.

The protein content of tempeh in the frying process increased from 14.20% and after frying it became 17.80%. This is because in the frying process there is a Maillard reaction which produces the final product in the form of malanoidin which contains nitrogen so that the protein content of tempeh increases when fried. The Maillard reaction is a non-enzymatic browning reaction between reducing sugars and amino acids that takes place in thermal food processing (Putra, 2016). In the study of Lamid *et al*., (2015) the protein content of raw soybean tempeh was 13.84% and after the frying process, there was an increase in protein content to 14.83%.

For steamed tempeh, the protein content after steamed decreased slightly from raw tempeh. The protein content of tempeh before steaming was 14.20% after steaming to 13.62%. In a previous study, the protein content of fresh and steamed rujangan meat was also found to decrease after the steaming process from 68.09% and after steaming it decreased to 66.63%. This is because steaming can result in the release of free water from the tissue material so that the texture of the material solidifies and the protein is denatured so that it forms a simpler structure and the amount decreases (Jacoeb and Lingga, 2012).

Carbohydrate Content

Carbohydrates have the main function as a source of energy for the body, other functions help the body's metabolism (Winarno, 2004). Tempe carbohydrate content with several cooking methods can be seen in Figure 5.

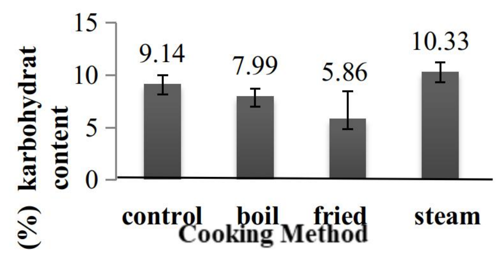

Figure 5 Average Value of Tempe Carbohydrate Content in Several Cooking Methods

The results of the analysis of variance showed that the treatment of different cooking methods had a significant effect on the 5% (α) level of the carbohydrate content produced. Based on Figure 5, the carbohydrate content of tempeh decreased after the cooking process. The lowest carbohydrate content was obtained in treatment C (Frying tempeh at 162^{o}C for 3 minutes) of 5.86%. The highest tempe carbohydrate content was found in tempeh D (steaming tempeh at 90^{o}C for 10 minutes) which was 9.14%. The decrease in the carbohydrate content of tempeh after the boiling process was caused by the presence of sugar molecules which were degraded into simpler sugar molecules, but it was also caused by the loss of some oligosaccharides during soaking and boiling (Putri *et al.,* 2021).

Tempeh carbohydrate value is calculated using the by difference method, which is a calculation involving the results of water content, ash content, fat content and protein content. Where the results of this carbohydrate analysis depend on other proximate test values. the higher the tempe proximate test results other than carbohydrates, the lower the carbohydrate value. Carbohydrate content was found to decrease by doing various cooking methods on tempeh.

Total Carotene

Observations on the total carotene in tempeh for each cooking method can be seen in Figure 6.

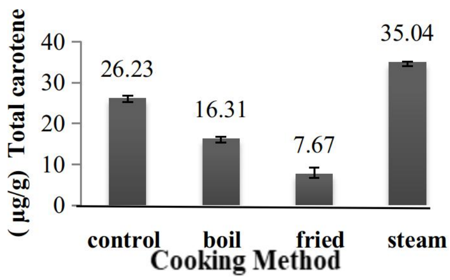

Figure 6 Average Value of Total Tempe Carotene in Several Cooking Methods

Based on Figure 6, it is known that the total carotene in tempeh decreased after the boiling and frying process but increased after steaming. The total carotene in raw tempeh was 26.23 g/g and after processing, the highest total carotene was obtained in treatment D (steaming at 90^{o}C for 10 minutes) of 35.04 g/g and the lowest total carotene was obtained in treatment C (Frying tempeh for 3 minutes). minutes at 162^{o}C for 3 minutes) of 7.67 g/g. The results of the variance showed that each cooking method had a significant effect on the 5% (α) level of the total carotene of tempe produced.

In the process of boiling tempeh there was a significant decrease in total carotene. Total carotene in raw tempeh obtained 26.23 g/g to 16.31 g/g. This decrease in total carotene occurred due to the release of carotene into boiling water during the boiling process. According to research conducted by Ramadhan and Aminah (2014) it was found that the total carotene in boiled carrots decreased from 237.9 mg/100 g to 221.6 mg/100 g. Meanwhile, the total carotene in tempeh after frying process was very low compared to the total carotene in raw tempeh. Total carotene in raw tempeh was found to be 26.23 g/g and after frying it decreased to 7.67 g/g.

In the frying process there is a higher loss of carotenoids due to the immersion process in high-temperature oil so that carotene degradation occurs during thermal processing. This is in accordance with research by Azizah *et al*., (2009) which states that the decrease in carotenoids in pumpkins with the frying process is higher than the boiling process, this is because carotenoids include compounds that are fat-soluble and easily soluble in oil, so that when frying takes place, it causes a decrease in carotenoids. In addition, the frying temperature used is also higher than the boiling temperature.

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In the steaming process there was an increase in total carotene from raw tempeh with steamed ones. Total carotene in raw tempeh was 26.23 g/g and after being steamed it increased to 35.04 g/g. According to Moreira *et al.,* (2019) the effect of cooking on carotenoid content in vegetables is still controversial, some authors report that cooking can cause a loss of carotenoids while others report an increase. While the data obtained showed that in the steaming process there was a significant increase in carotenoids. This increase could be due to the fact that in the steaming process the amount of trans-β-carotene and -carotene was higher than the cis form. The effect of heating can cause the isomerization of carotenoids from the trans to cis form, carotenoids in the trans-ß-carotene form are known to be more stable and have less solubility than the cis-ß-carotene form. Sani *et al.,* (2019) also found higher levels of -carotene in steamed broccoli than boiled broccoli, -carotene in boiled broccoli 5.86 g/100 grams, and steamed broccoli 7.09 g/100 grams.

Crude Fiber Content

Crude fiber is a part of food that cannot be hydrolyzed by strong acids or bases (Fitria *et al.,* 2013). Based on the analysis of variance at the 5% (α) level, it was found that the treatment of several cooking methods had no significant effect on the crude fiber content of the tempe produced. The results of tempeh crude fiber content can be seen in Figure 7

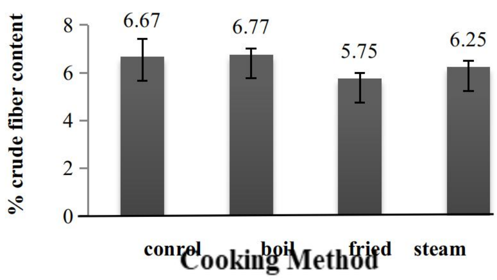

Figure 7 Average Value of Crude Fiber Content of Tempe in Several Cooking Methods

The crude fiber content of tempeh after being given cooking treatment ranged from 5.75% to 6.77%. The highest crude fiber content was obtained in treatment B (boiling at 100°C for 10 minutes) with a crude fiber content of 6.77%. While the lowest crude fiber content was obtained in treatment C (Frying tempeh at 162°C for 3 minutes) with a value of 5.75%. The results of the crude fiber content in raw tempeh obtained in this study were slightly higher than the crude fiber content obtained by Setyani *et al.,* (2017) with the same ratio of soybeans and corn, the crude fiber content of tempeh before cooking was 6.19%. This result is higher than the quality standard of soybean tempeh (SNI 01-3144-2009) the crude fiber content of soybean tempeh is maximum 2.5% (w/w). The high crude fiber content of tempeh obtained was due to the use of added raw materials according to Suarni and Firmansyah (2005), the crude fiber content of corn was 2.7%.

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The crude fiber content of raw tempeh and after boiling was obtained almost the same, namely 6.67% and 6.77% this was because during boiling with boiling water the crude fiber did not decompose even for a long time. According to Winarno (2002)cellulose and hemicellulose are more difficult to decompose, have properties that are not soluble in cold or hot water and cannot be digested by human digestion. The properties of crude fiber can help digestion of food by breaking down starch into glucose by certain enzymes and microbes. The crude fiber content of tempeh after frying was found to have decreased from the raw tempeh, which was 6.67% to 5.75%, this decrease was due to damage to the crude fiber during frying with heating. Heating crude fiber will cause fiber damage so that the starch content will decrease (Sundari *et al*., 2013 in Putra and Sjofan, 2021).

The crude fiber content of steamed tempeh was found to be slightly lower than the crude fiber content of raw tempeh. In raw tempeh obtained crude fiber content of 6.67% and after the steaming process it became 6.25% this was due to the cell wall of tempeh which decomposed during the steaming process. This is in accordance with the statement of Sipayung (2015) which states that the decrease in crude fiber during steaming occurs because the cell walls of the material decompose during processing which causes a decrease in the crude fiber content of the material.

Antioxidant Activity

The results of analysis of variance showed that different cooking methods had a significant effect on the average % inhibition at the level of =5%. The results of % inhibition of tempeh can be seen in Figure 8.

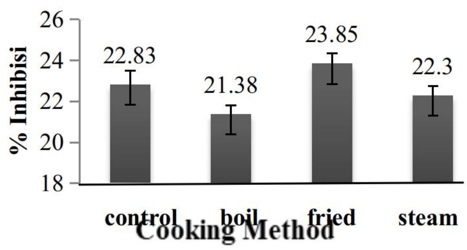

Figure 8. Average % Inhibition of Tempe in Several Cooking Methods

Based on Figure 8, it is known that the inhibition of tempeh with various cooking methods ranged from 21.38% - 23.85% in a concentration of 1000 ppm or 1000 mg/L. The highest % inhibition was found in treatment C (Frying at 162^oC for 3 minutes) of 23.85% and the lowest % inhibition was found in treatment B (boiling at 100^oC for 10 minutes) of 21.38%. In the boiling process, the inhibition percentage of tempeh decreased slightly from the raw tempeh. This is because boiling using water media with high temperature heating can damage compounds containing antioxidants. Natural antioxidants in soybeans are isoflavones which belong to the group of flavonoid compounds. According to Saikia and Mahanta (2013) flavonoids are very unstable compounds that are easily degraded and released into cooking media at high temperatures. Cheng *et al*. (2006) in Narsih & Agato, (2018) stated that high heat can result in the decomposition of antioxidant compounds into other forms, which results in a decrease in antioxidant activity. Apart from soy antioxidants also come from carotenoids and vitamin E from corn. This vitamin functions as a micronutrient and acts as a natural antioxidant that can increase body immunity and inhibit cell degenerative damage (Suarni and widowati, 2010). In the frying method, the % inhibition of tempeh was found to be higher than that of raw tempeh. In raw tempeh, 22.83% inhibition was obtained and after frying it became 23.85%. This is caused by the effect of heating during frying which can cause a non-enzymatic browning reaction (maillard), the maillard reaction produces compounds that play a role in increasing antioxidant activity. higher than raw tempeh this is due to the heating process which can form a Maillard reaction, namely the reaction between amino acids and glucose which can produce melanoidin compounds.Melanoidin compounds are a group of Maillard reaction products that play a role in increasing antioxidant activity.

The method of cooking by steaming showed that the % inhibition slightly decreased from that of raw tempeh, which was 22.30%, while the % inhibition of raw tempeh was 22.83%. According to Utari *et al.,* (2010) the content of isoflavones in steamed soybeans decreased slightly compared to cooking by boiling. The steaming method also allows tempeh not to come into direct contact with water during the cooking process so that the antioxidant content can be maintained. The steaming method is better able to maintain antioxidant activity, this is because antioxidants are easily damaged at high temperature heating.

Organoleptic Test

a. Scent

Aroma testing on food products is considered important because the aroma or smell can provide an assessment of the product related to whether a product is accepted or not. The preference for aroma is an important organoleptic parameter as well as an added value for a product (Pintadiati, 2018). Observations on the sensory aroma of tempeh for each treatment can be seen in table 1.

Table 1 Average sensory aroma of tempeh

Treatment	Aroma (Average ± Standard Deviation)
A (Boiled)	3,25 ± 0,72 a
B (Fried)	4,25 ± 0,72 b
C (Steamed)	4,05 ± 0,51 b
KK	14,73 %

Information : A= Boiling tempeh at 100oC for 10 minutes. B= Frying tempeh at 162oC for 3 minutes, C= Steaming at 90oC for 10 minutes. 1 = dislike very much, 2 = dislike, 3 = somewhat like, 4 = like, 5 = like very much.

Based on table 1, it is known that the sensory value of tempeh aroma with several cooking methods ranges from 3.25-4.25 (slightly like to like). The lowest average value in treatment A (boiling temperature 100°C for 10 minutes) with an average value of 3.25 (somewhat like). The highest average value was obtained in treatment B (Frying temperature 162°C for 3 minutes) with an average value of 4.25 (like). Soybean fermentation with *Rhizopus oligosporus* produces tempeh with a fragrant aroma that masks the aroma of soybeans in general because yeast has very high proteolytic and lipolytic activity so that it is able to hydrolyze protein and fat to produce amino acids, fatty acid esters, ethanol, acetyl dehide, ethyl acetate, and ethyl butyrate which is a component of flavor and aroma. The aroma produced has a smaller size and molecular weight than the initial material so that the components are more volatile and can smell like tempeh (Rizal and Kustyawati, 2019).

Based on the variety of different cooking methods had a significant effect on the level (α) 5% on the aroma of tempeh. The difference in the aroma of tempeh after frying occurs because food containing carbohydrates and protein when heated will experience non-enzymatic browning which can produce a pleasant aroma or smell. This is in accordance with Aminah's (2010) statement that the aroma that arises after frying can be influenced by the use of cooking oil and due to the Maillard reaction. The carbonyl components formed during the cooking process can react with amino acids, amines, and proteins to produce the desired flavor (Negroni et al., 2001 in Lumbong *et al.,* 2017). The aroma of steamed tempeh was also liked by the panelists because it produced a specific aroma during the steaming process. This is because the odor-producing compounds are volatile so that when steaming they evaporate along with the free water contained in the food ingredients (Lumbong *et al*., 2017).

b. Color

The organoleptic test on tempeh color was conducted to determine the panelists' preference for tempeh color using several cooking methods. The results of the panelists' average preference for tempeh color can be seen in table 2.

Table 2 Average sensory color of tempeh

Treatment	**Color (Average ± Standard Deviation)**
A (Boiled)	3,30 ± 0,73 a
B (fried)	4,20 ± 0,62 a
C (steamed)	3,65 ± 0,88 b
KK	17,45 %

Information: A= Boiling tempeh at 100oC for 10 minutes. B= Frying tempeh at 162oC for 3 minutes, C= Steaming at 90oC for 10 minutes. 1 = dislike very much, 2 = dislike, 3 = somewhat like, 4 = like, 5 = like very much.

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Table 2 shows that the highest average value of tempeh color was obtained in treatment B (Frying temperature of 162°C for 3 minutes) of 4.20 and the lowest average of assessment was found in treatment A (boiling temperature of 100°C for 10 minutes) of 3.30. The color of tempe before cooking is white and there is a little yellow part of the corn. According to Iskandar (2011) the yellow color in corn is caused by the yellow pigment from beta-carotene. After steaming the bright yellow color of the corn is stronger than raw tempeh and after being boiled. This is because the steaming process does not damage the color of steamed tempeh, in accordance with the statement of Truong *et al.,* (2012) that steaming can inactivate anthocyanase, polyphenol oxidase and peroxidase enzymes so that they do not degrade anthocyanins so that the color can be maintained. The results of the variance showed that each cooking method had a significant effect at the 5% (α) level on the color of tempeh.

Panelists prefer the color of fried tempeh because the color change of tempe is more dominant than boiled and steamed tempe. The color of tempeh after frying becomes brown is caused by the heating process which results in a Maillard reaction that forms melanoids, which are dyes that make tempeh yellow-brown (Lumbong *et al*., 2017). This is in line with the opinion of Zahra *et al*., (2013) that cooked food not only becomes ripe, but because of the use of a high enough temperature so that it becomes dark brown in food ingredients.

c. Taste

Taste is an organoleptic attribute that involves the five senses of taste (tongue). Taste is the main component of the assessment of a food product. The average sensory value for tempeh can be seen in table 3.

Table 3 Average sensory taste of tempeh

Treatment	Test (Average ± Standard Deviation)
A (Boiled)	3,00 ± 0,73 a
B (Fried)	4,00 ± 0,92 b
C (steamed)	3,15 ± 0,88 a
KK	21,59 %

Information: A= Boiling tempeh at 100oC for 10 minutes. B= Frying tempeh at 162oC for 3 minutes, C= Steaming at 90oC for 10 minutes. 1= dislike very much, 2 = dislike, 3 = somewhat like, 4= like, 5 = like very much.

Table 3 shows that the average value of the tempeh taste in various cooking methods ranges from 3.00-4.00 (rather like-like) with the highest value in treatment B (Frying temperature of 162°C for 3 minutes) which is 4.00 (like) and the lowest was obtained in treatment A (boiling at 100°C for 10 minutes) of 3.00 (somewhat like). The results of the variance showed that each cooking method was significantly different at the level (α) 5% of the tempeh taste.

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The panelists preferred fried tempeh to boiled and steamed tempeh. This is because of the influence of cooking oil which functions as a heat conductor, adds savory taste and has nutritional and caloric value in food ingredients. (Wijaya, 1993 in Ngaju *et al.,* 2018). In addition, the taste of fried tempeh is also influenced by the sweet taste of the sugar in the corn.

d. Texture

The average sensory value of the tempeh texture can be seen in table 4.

Table 4 Average sensory texture of tempe

Treatment	**Texture (Average ±Standard Deviasiation) (%)**	
A (Boiled)	3,45 ± 0,51	a
B (Fried)	4,30 ± 0,47	b
C (steamed)	3,75 ± 0,44	a
KK	10,75%	

Information : A= Boiling tempeh at 100oC for 10 minutes. B= Frying tempeh at 162oC for 3 minutes, C= Steaming at 90oC for 10 minutes. 1 = dislike very much, 2 = dislike, 3 = somewhat like, 4 = like, 5 = like very much

In table 4, it is known that the average value of the panelists' assessment of the tempeh texture with several cooking methods ranges from 3.45-4.30. The panelists' highest average rating was in treatment B (Frying temperature of 162^{o}C for 3 minutes) which was 4.30 (like) and the lowest average in treatment A (temperature of 100^{o}C for 10 minutes) was 3.45 (somewhat like). The results of analysis of variance showed that different cooking methods had a significant effect on the 5% (α) level of tempeh texture. The tempeh texture that the panelists liked the most was tempeh which was cooked using the frying method.

Tempe after frying has a harder texture than boiled tempeh and steamed tempeh. this is supported by the statement of Purwandari *et al*., (2021) which states that tempeh with wet cooking such as boiling and steaming produces a softer tempeh texture compared to frying. In the method of steaming, the texture of tempeh is denser than boiled because of the denaturation of the protein and carotene complex which causes changes in the structure of the material so that the resulting texture becomes denser. Moreira *et al.*, (2019). Based on the results of the analysis of the aroma, color, taste and texture of tempeh with several cooking methods, the best product according to the panelists was obtained, namely treatment C (Frying tempeh at 162oC for 3 minutes). The percentage of panelists' acceptance of the aroma, color, taste and texture of tempeh can be seen in Figure 9.

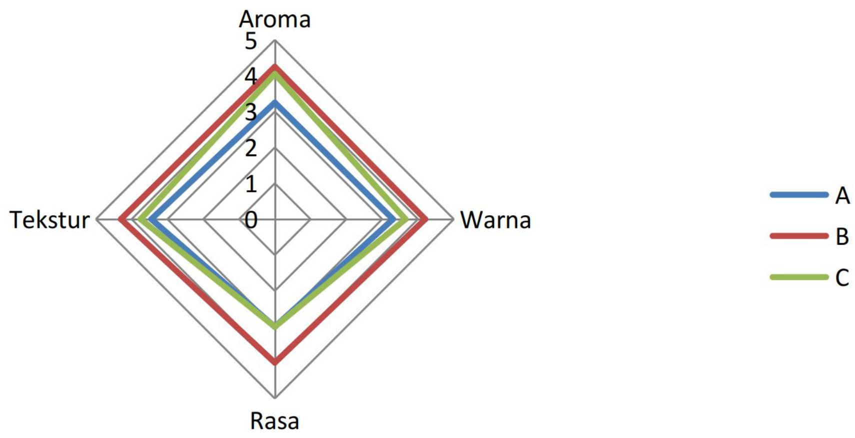

Figure 9. Radar Graph of Panelist Acceptance of Aroma, Color, Taste and Texture of Tempe with Several Cooking Methods

From the radar chart above, in general, the tempe that the panelists prefer is the treatment of tempe by frying (temperature of 162^{o}C for 3 minutes). In terms of aroma, color, taste and texture, it can be seen that the panelists prefer fried tempeh than boiled and steamed tempeh. On average, all panelists gave a rating in the like category. For tempeh which was given steaming treatment in terms of aroma, it was also classified as what the panelists liked but in terms of taste it was considered normal.

CONFLICT OF INTEREST

The authors had no conflict of interest

CONCLUSIONS

Based on the research that has been done, it can be concluded:

1. Treatment of several cooking methods of tempeh obtained the best cooking method, namely in treatment C (Frying temperature 162^{o}C for 3 minutes) with the following quality characters: water content of 41.33%, ash content of 1.43%, fat content of 33.60 %, protein content 17.80%, carbohydrate content 6.65%, total carotene 7.67%, crude fiber content 5.75%, % inhibition 23.85%.
2. Based on the sensory assessment of tempeh with several cooking methods the most preferred, namely in treatment C (Frying temperature of 162oC for 3 minutes) with an aroma of 4.25 (likes), color 4.20 (likes), taste 4.00 (likes) and texture 4.30 (like).

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