



Physical Quality of Dried Gouda Cheese with Different Drying Methods and Drying Time

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Abstract | The making of dried Gouda cheese products is needed to increase the economic value and prolong the shelf life of the Gouda cheese without reducing its nutrient value. The aim of this study was to evaluate the physical quality of the dried Gouda cheese produced by different drying methods and drying times. The 2 x 2 factorial completely randomized design (CRD) was applied: drying methods (oven and dry roasting) and drying time (60 and 120 minutes). The physical quality observed consists of water, fat, protein, ash contents, pH, and color (whiteness index). As a result, both drying methods and drying time treatment and its interaction were significantly ($p < 0.05$) affecting the water content and color. Additionally, the drying method treatment also influenced the protein content of dried Gouda cheese. The oven drying method and 60 minutes of drying time gave a better output of dried Gouda cheese based on its fat percentage and color than the dry roasting. In conclusion, the result of this study could be used for further application by household producers of dried Gouda cheese.

Keywords | Gouda cheese, Oven, Dry roasting, Drying, Time, Physical quality

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INTRODUCTION

Gouda cheese, originally from the Netherlands, has a distinctive taste and aroma and is classified as a semi-hard Cheese (Chen *et al.*, 2024). Gouda cheese is divided into young, medium, and old cheese based on its ripening period, which is commonly used as a premium ingredient complementing pastries (Fahrullah, 2021). In Indonesia, this cheese is produced in many places, including in Malang Regency. The high water content (41-43%) of Gouda cheese makes this product faster to spoil by microorgan-

isms when kept at room temperature (Widyastuti *et al.*, 2010). Therefore, there is a need to prolong the shelf-life of the Gouda cheese; one of the ways is by making dried Gouda cheese.

Drying cheese can be a solution to slow down the rate of deterioration of cheese because it has low water content (Erbay *et al.*, 2015). Some advantages of processing cheese into dried cheese are that it is not easily damaged, has a longer shelf life, and is easier to store and transport. Dried cheese is also practical and can be used as a raw material

for processed products (Izadi *et al.*, 2020). Several drying methods that can be used for drying cheese powder are oven, spray drying, and dry roasting (Felix da Silva *et al.*, 2017). The use of oven and roasting as drying methods has also been reported in other food products, such as kiwifruit (Orikasa *et al.*, 2014) and simplicia (Nursiam *et al.*, 2022). However, to our knowledge, no reports on drying using these methods on the Gouda cheese are found.

Gouda cheese has a critical point when drying because its fat content is quite high. Fats that melt easily cause the Gouda particles to clump quickly and rancid (Jo *et al.*, 2018). High temperatures also cause changes in color and aroma components, decreasing organoleptic and chemical quality (Erbay *et al.*, 2015; Izadi *et al.*, 2020). Therefore, it is necessary to pay attention to the drying method for Gouda cheese to produce a quality product. The method used should also consider ease of access for household scale processors to enable easy application and production of dried Gouda cheese. The development of the Gouda cheese drying method was expected to produce higher-quality dried Gouda cheese more efficiently. This research aims to determine the effect of different drying methods and drying times on the physical quality of Gouda cheese.

MATERIALS AND METHODS

EXPERIMENTAL SITE AND MATERIALS

The research was done in the Laboratory of Animal Products Technology, Faculty of Animal Science, Universitas Brawijaya. The material used in this research was old Gouda cheese with a ripening age of 8-12 months, produced by the Regional Technical Implementation Unit for Breeding and Processing of Animal Products (UPTD), Animal Husbandry and Health Service of Malang Regency. The physical content of Gouda cheese is presented in Table 1.

Table 1: The physical content of gouda cheese.

Parameter	Value
Water content (%)	16.04
Fat (%)	46.67
Protein (%)	36.73
Ash (%)	11.48
pH	5.36
Color	76.82

*: Analysis result from the food testing and food quality laboratory, Faculty of Agricultural Technology, Brawijaya University.

RESEARCH DESIGN

A 2 x 2 factorial completely randomized design (CRD) was applied for this research. The first treatment was the drying method: oven and dry roasting. The second treatment

was the drying time: 60 and 120 minutes. Every treatment used 100 g of Gouda cheese and was repeated 5 times. The process of making dried Gouda cheese in this study is explained in Figure 1.

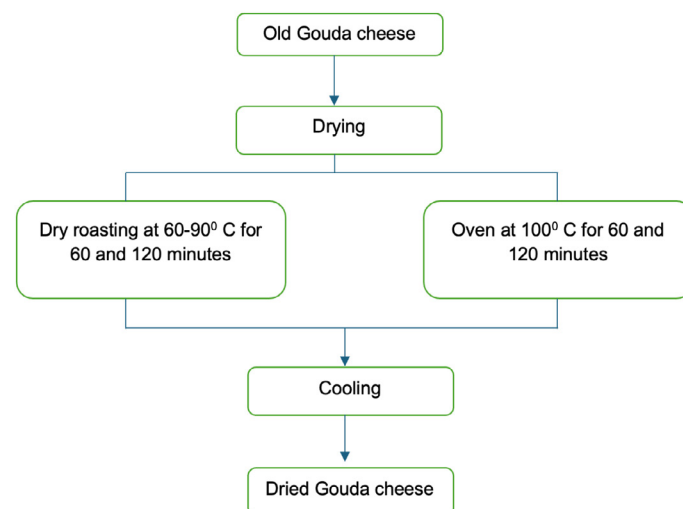


Figure 1: Dried Gouda cheese making process.

PARAMETERS ANALYSIS

The parameters observed were the water, fat, protein, ash contents, and pH values following the instructions from AOAC (2005). The color analysis was also tested using the Kamal-Eldin *et al.* (2020) method. The detailed methods were as follows:

WATER CONTENT (%): The porcelain cup was dried using an oven at a temperature of 100 °C -105 °C for 30 minutes, then cooled in a desiccator for 15 minutes to remove water vapor and weighed (A). The sample was weighed as much as 5 g in a dry cup (B) and then heated in an oven at a temperature of 100 °C -105 °C for 8 hours. The cup and sample were then cooled in a desiccator for 30 minutes and weighed (C). Water content is calculated using the formula:

$$\text{Water content (\%)} = \frac{B - C}{B - A} \times 100 \%$$

ASH CONTENT (%): A total of 1 gram of dried cheese sample was placed in a porcelain cup and burned in a kiln at 600 °C for 2 hours until complete ash processing. Next, the sample was cooled in a desiccator, weighed, and calculated using the formula:

$$\text{Ash (\%)} = \frac{\text{ash (g)}}{\text{sample (g)}} \times 100 \%$$

pH: pH measurements were carried out using a pH meter calibrated with a buffer solution at pH 4 and 7. The dried Gouda cheese was reconstituted using distilled water at a ratio of 8:10, and then the pH was measured.

FAT CONTENT (%): Five grams of dried Gouda cheese sample (W1) was put into filter paper with the ends covered with fat-free cotton and then wrapped in a fat sleeve. The wrapped sample was put into a fat flask, which was weighed at a constant weight (W2) and connected to a Soxhlet tube. The fat cartridge was inserted into the Soxhlet tube extractor chamber, doused with fat solvent (benzene), and then refluxed for 6 hours. The fat solvent in the fat flask was distilled until all the fat solvent had evaporated. The solvent was then collected in the extractor chamber during distillation and removed so that it did not return to the fat flask. The fat flask was dried in an oven at 105 °C, and the flask was cooled in a desiccator until the weight was constant (W3).

$$\text{Fat (\%)} = \frac{W3 - W2}{W1} \times 100 \%$$

PROTEIN: The cheese sample was weighed at 0.1 g, then 1 g K₂SO₄, 40 mg HgO, and 20 mL H₂SO₄ were added. The sample was boiled until the solution became clear and transferred to a distillation apparatus. The Kjeldahl flask was washed with 1-2 mL of water, then the washing water was put into a distillation apparatus and added with 8-10 mL of NaOHNa₂S₂O₃ solution. Positioned below the condenser, an Erlenmeyer flask was placed containing 5 mL of H₃BO₃ solution and 2-4 drops of indicator (a mixture of 2% methyl red in alcohol and 2% methyl blue in alcohol in a ratio of 1:2). The end of the condenser tube must be submerged in the H₃BO₃ solution. The contents of the Erlenmeyer flask were diluted to 50 mL and then titrated with 0.02 N HCl until the color changed to gray. Blank was prepared using distilled water. The protein content of the sample was calculated from the nitrogen content with the equation:

$$\text{Nitrogen (\%)} = \frac{(Va - Vb) \times N \text{ HCl} \times 14.007}{\text{sample (g)}} \times 100 \%$$

Where Va is mL HCl for sample titration, Vb is mL HCl for blank titration, N is the normality of standard HCl used, and 14.007 is the atomic weight of Nitrogen.

COLOR ANALYSIS: Color analysis was carried out using a colorimeter. The colorimeter was attached to the surface of the cheese; the reading button was pressed, then L* (brightness), a* (reddish), and b* (yellowish) appeared, and the reading results were recorded. Color measurements were done on 3 different surface parts of each dried cheese sample (triplo). The psychometric parameter used was the Whiteness Index (WI), calculated using color measurement results (L*, a*, and b* values) with the following formula:

$$\text{Whiteness index} = 100 - \sqrt{((100 - L^*)^2) - a^{*2} + b^{*2}}$$

DATA ANALYSIS

The research data were tabulated in the Excel program. The physical characteristics of the dried Gouda cheese were analyzed using analysis of variance (ANOVA) in Genstat software. Significant test results from treatments were followed with the Duncan Multiple Range Test (DMRT). The mathematical model for the analysis was as follows:

$$Y_{ij} = \mu + A_i + B_j + \gamma_{ij} + \varepsilon_{ijk}$$

Where;

μ : The overall mean response.

A_i : The effect due to the i-th level of factor.

B_j : The effect due to the j-th level of factor.

γ_{ij} : The effect due to any interaction between the i-th level of A and the j-th level of B.

Table 2: Physical characteristics of dried Gouda cheese at different drying methods and drying times treatment.

Parameter	Drying Method	Drying time (minutes)		
		60	120	Average
Water content (%)	Dry Roasting	2.64±0.24 ^b	2.18±0.06 ^a	2.41±0.29 ^A
	Oven	5.23±0.46 ^d	3.40±0.17 ^c	4.31±1.02 ^B
	Average	3.93±1.41 ^A	2.79±0.65 ^B	
Fat content (%)	Dry Roasting	48.14±0.68	48.84±0.31	44.49±0.62
	Oven	49.14±0.83	49.31±1.34	49.23±1.06
	Average	48.64±1.04	49.57±1.35	
Protein content (%)	Dry Roasting	40.37±1.03	40.42±0.45	40.39±0.75 ^B
	Oven	37.89±0.51	38.78±0.37	38.34±0.63 ^A
	Average	39.13±1.51	39.60±0.94	
Ash (%)	Dry Roasting	12.01±0.44	12.18±0.64	12.10±0.52
	Oven	12.25±0.54	12.40±0.29	12.32±0.41
	Average	12.13±0.48	12.29±0.48	
pH	Dry Roasting	5.12±0.43	5.27±0.03	5.19±0.30
	Oven	5.32±0.02	5.37±0.02	5.34±0.03
	Average	5.22±0.31	5.32±0.06	
Color (Whiteness Index)	Dry Roasting	53.53±0.50 ^b	50.33±0.61 ^a	51.93±1.77 ^A
	Oven	65.28±0.59 ^c	64.82±0.54 ^c	65.05±0.58 ^B
	Average	59.41±6.21 ^B	57.57±7.66 ^A	

^{A,B}: Superscripts within in the same row or column show significant differences between the single factor ($p < 0.01$); ^{a,b,c,d}: Superscripts showed significant differences between the interaction of treatments ($p < 0.01$).

RESULTS AND DISCUSSION

THE EFFECT OF DRYING METHODS ON WATER AND PROTEIN CONTENTS

In this study, it was found that the drying method had significantly ($p < 0.01$) different outputs in water content, protein content, and color, as shown in Table 2. On aver-

age, dry roasting had a lower water content ($2.41 \pm 0.29\%$) but higher protein content ($40.39 \pm 0.75\%$) than oven drying. This might be due to the direct contact between the samples and the surface of the roaster (pan). Heating with the dry roasting method often results in uneven heat, with some parts of the cheese perhaps getting more heat than others. This uneven heat can cause some proteins to denature more severely in hotter area [Budiarti et al. \(2021\)](#). added that the drying process is also influenced by the surface area of the material and the thickness of the layer being dried. Lower water content in cheese means it can be stored longer due to reduced water activity, which reduces the risk of growth of damaging microorganisms ([Alwazeer et al., 2020](#); [Schvartzman et al., 2011](#)). In the dry roasting method, the cheese is in direct contact with a hot surface, accelerating the denaturation and degradation of proteins in the contact area. This direct contact can cause some proteins to burn or undergo Maillard reactions, changing the protein composition ([Giroux et al., 2020](#); [Guinee, 2021](#)).

The drying process does not affect the total amount of protein in the cheese. However, drying causes water evaporation, which increases the protein concentration in dried cheese compared to the protein content in fresh cheese in [Table 1](#). Although protein denaturation and coagulation occur, this only changes the physical properties of the protein, not the amount. Thus, we can conclude that the drying process does not decrease the total amount of protein in dried cheese but increases its concentration per unit weight of cheese due to the reduction in water content ([Domínguez-Niño et al., 2018](#); [Schuck, 2014](#)).

THE EFFECT OF DRYING TIME ON WATER CONTENT AND CHEESE COLOR

The drying time also significantly ($p < 0.01$) affects the water content and color. The longer drying time (120 minutes) leads to lower water content ($2.79 \pm 0.65\%$) and darker color ($WI = 57.57 \pm 7.66$) of the dried Gouda cheese. Low water content is very effective in minimizing damage to food. [Spanneberg et al. \(2012\)](#) added that the higher the temperature given, the lower the water content of the cheese, but if the temperature is too high, it can damage the cheese's nutritional content due to the Maillard reaction. It is important to note that excessive drying time can also produce too hard or dry cheese, so this must be done carefully and according to the type of cheese desired ([Ho et al., 2022](#)).

The color of dried Gouda cheese plays an important role in influencing the acceptability of various products that use cheese as a base ingredient. This color perception was influenced by the chemical and physical properties of the cheese components themselves ([El-Nimr et al., 2010](#)). The color of Gouda cheese produced using the dry roasting and oven methods can be seen in [Figure 2](#). This picture shows the differences in the characteristics of dried Gouda cheese

produced using different drying methods and drying times. The combination of the dry roasting method and 120 minutes of drying time appeared to have the most different color (brown, darker than the other samples), which was also different from the color of Gouda cheese before roasting. The color of the cheese was darker at a drying time of 120 minutes compared to a drying time of 60 minutes. The texture of the roasted cheese looks rough; the particle size is relatively large and not uniform compared to oven-dried cheese (the color is slightly brighter, and the texture is smaller and more uniform).

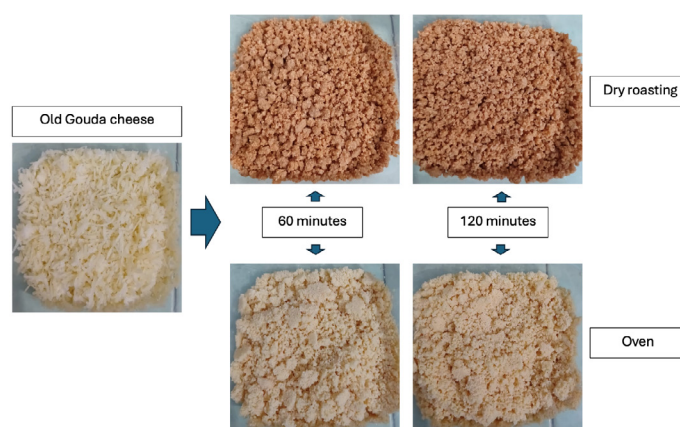


Figure 2: Color and texture variation of dried Gouda cheese.

An intense Maillard reaction and caramelization might cause this result due to the cheese being in direct contact with the heat source in the dry roasting method. In addition, the dry roasting method often causes faster evaporation and moisture loss, which can affect the texture and color of the cheese. Rapid moisture loss can accelerate chemical reactions that change the color of cheese, especially on the surface ([Luo et al., 2020](#); [Spanneberg et al., 2012](#)).

FAT CONTENT, pH, AND ASH CONTENT

Our findings showed that the drying method, drying time, and their interaction did not significantly ($p > 0.01$) affect dried Gouda cheese's fat content, pH, and ash content. However, the fat content of dried Gouda cheese ([Table 2](#)) is higher than fresh Gouda cheese ([Table 1](#)). This is caused by the evaporation of water in the drying process, leaving the other components with less volume. As a result, the percentage of fat to the total weight of the cheese becomes greater, even though the actual amount of fat does not increase ([Deshwal et al., 2020](#)). [Deeth and Hartanto \(2009\)](#), also stated that the increase in ash content in dry cheese is caused by the removal of water, which increases the relative concentration of minerals in the cheese.

Cheese could be recommended to increase shelf life. To maintain the sensory quality and functionality of proteins, drying at low temperatures and long periods of time is preferred. However, for commercial purposes focusing on pro-

duction speed, drying at high temperatures with the risk of physical quality changes may be considered. By understanding this relationship, cheese producers can optimize the drying process to achieve the desired quality in their final product.

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded that the drying method and drying time affect the water, fat, protein, and color of Gouda cheese. Based on the physical properties, the oven method mixed with 60 minutes of drying time produces the best fat content and color of dried Gouda cheese, among other treatments, compared with fresh Gouda cheese.

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NOVELTY STATEMENT

This study is the first to test the effect of different methods and drying times for making dried Gouda cheese.

AUTHOR'S CONTRIBUTIONS

All authors contributed equally to the manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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