Chemical and microbiological quality of fermented goat meat dendeng with different levels of \textit{L. plantarum}

A K Umam\textsuperscript{1}, L E Radiati\textsuperscript{1}, A Susila\textsuperscript{1} and R N Hapsari\textsuperscript{2}

\textsuperscript{1} Lecturer of Animal Product Technology Department, Faculty of Animal Science, Brawijaya University, Malang
\textsuperscript{2} Student of Animal Product Technology Department, Faculty of Animal Science, Brawijaya University, Malang

Corresponding author: lilik.eka@ub.ac.id

Abstract. \textit{Lactobacillus plantarum} is one of lactic acid bacteria that more resistant to acidic condition so that potentially used to extend dendeng shelf life. The purpose of this research was to evaluate the quality of fermented goat meat dendeng with \textit{L. Plantarum} at chemical and microbiological quality. Three different levels of \textit{L. plantarum} (0, 0.3, 3, and 30 mL) were applied to goat meat dendeng at room temperature. Results showed a significant different in pH, titratable acidity (TA), and Total Plate Count (TPC) on fermented goat meat dendeng, except for total lactic acid bacteria (LAB). At 30 mL, \textit{L. plantarum} application showed better characteristics on chemical quality, with lowest values of pH 5.16±0.25, highest Titratable Acidity 22.66±0.73 highest number of microbiological quality including Total Plate Count (TPC) 6.34±0.56 CFU/g and Total Lactic Acid Bacteria (LAB) 6.84±0.69 CFU/g, respectively. From the study it is concluded that addition of \textit{L. plantarum} resulted better characteristics on chemical and microbiological quality, and it is possible to be applied for commercial production of fermented goat meat dendeng.

1. Introduction

One type of the processed meat product widely known in Indonesia is “dendeng giling” which was well introduced in around 1990. Dendeng giling is traditionally made from meat added with coconut sugar, salt, and some additional spices, and then dried [1]. Nowadays, in most of Indonesian market it was only providing dendeng made from beef. Goat meat having potential to be for dendeng raw material and might have more advantages than beef. According previous report [2] in the last years, several new products of goat meat was successfully produced including nuggets, dry-cured sheep and goat meat, mantas, fermented sausages, and sausages. Fermentation process using Lactic Acid Bacteria (LAB) can be applied during the manufacturing process of dendeng that could improve the nutritional quality.

\textit{Lactobacillus plantarum} is one of the lactic acid bacteria that more resistant to acidic condition so that potentially used for controlling the growth of spoilage bacteria, then able to prolonging the shelf life of dendeng. Organic acids, diacetyl, hydrogen peroxide, antimicrobial peptides, and bacteriocins as antimicrobial compounds is the result of the fermentation process on the product with \textit{Lactobacillus plantarum} added [3].
The purpose of this research was to evaluate the chemical and microbiological quality of goat meat dendeng giling fermented with \textit{L. plantarum}, and the result could be used as information for producing commercial fermented goat meat dendeng.

2. Materials and methods

2.1. Materials

Goat meat as raw material was obtained from Kebalen Traditional Market, Malang. Meat was selected from edible part of goat meat muscle (\textit{Biceps femoris}) of kambing kacang (\textit{Capra hircus}). The \textit{Lactobacillus plantarum} FNCC 0027 bacteria as starter was purchased from Microbiology Laboratory Center for Food and Nutrition Studies of Gadjah Mada University Yogyakarta, then directly propagated on the de Man Rogosa Sharp Agar (MRS-A) (Merc & Co. New Jersey, America), de Man Rogosa Sharp Broth (MRS-B) (Merc & Co. New Jersey, America), skimmed milk (Fonterra Co., Auckland, New Zealand), and sugar. Additional ingredients including brown sugar, salt, garlic, coriander, pepper, galangal, and cumin also purchased from the local market.

2.2. Methods

The goat meat dendeng was manufactured using the following step: (1) milled goat meat and spices (2) application of different levels of \textit{Lactobacillus plantarum} inoculated on raw meat dendeng, covered with aluminium foil then incubated for 24 hours in 37°C, (3) next was to press well fermented dendeng until 3 millimeters of the thickness. The drying process was done using oven with temperature at 40°C for 9 hours, while packed and labeled after 15 minutes in room temperature.

The Chemical and Microbiological quality of the fermented goat meat dendeng was evaluated in pH analysis, TA analysis was used the method of Sabadoš (1996) [4], TPC and Total LAB was enumerated according to way of Shori and Baba (2012) [5].

In this study, the experiment was designed as Completely Randomized Design (CRD) with four treatments of \textit{L. Plantarum} dosage application (T0 = 0 mL, T1 = 0.3 mL, T2 = 3 mL, and T3 = 30 mL) and each four replicates. Data were analyzed using ANOVA followed with Duncan’s Multiple Range Test (DMRT) for post hoc analysis. Statistic evaluation was done by the help of SPSS for windows 16.

3. Results and discussion

3.1. pH

According to Table 1, the addition of different level of \textit{L. plantarum} gave significantly effect (P<0.05) to pH value of fermented goat meat dendeng (Table 1). The higher level of \textit{L. plantarum} addition reducing pH value. The fermentation process leads to the change of pH value because of the change of carbohydrate or sugar compounds into acid and water compounds [6]. The addition of \textit{L. plantarum} as lactic acid bacteria have capability to produce acid, then reducing the pH value. Previous study about the fermentation of goat meat sausage [7], showed similar result that pH of the sample was decreased rapidly from the initial pH 6.3 to 4.7 - 5.0. It because an increase in lactic acid concentration. In fermented meat product manufacturing process, lactic acid bacteria will produce lactic acid during glycolysis process then could decrease the pH [8].

The pH value of fermented goat meat dendeng with 30 mL of \textit{L. plantarum} (5.16 ± 0.25) was selected as best treatment. Meat processed product with lower pH is potentially has longer shelf life because acid condition able to inhibit microbial spoilage growth. According to Desmazeaud (1991) [9] acids had role as antimicrobial by diffusion process of moving the acid through the organism membrane that located at hydrophobic un-dissociated form, then stopping the metabolic activity that caused by decreased of cytoplasmic pH. Low pH value (5.1 – 6.1) results in an opened meat structure more resistant to damage caused by microorganism. Some bacterial were growth naturally during the fermentation process and change the pH value due to the growth of pathogens [10].
Table 1. Chemical and microbiological quality of fermented goat meat dendeng with different levels of *L. plantarum*

| Treatment | pH     | TA (%)  | TPC (log CFU/g) | LAB (log CFU/g) |
|-----------|--------|---------|-----------------|----------------|
| T0        | 6.03±0.41<sup>a</sup> | 19.11±0.88<sup>a</sup> | 4.95±0.21<sup>a</sup> | 5.93±0.66<sup>a</sup> |
| T1        | 5.99±0.42<sup>ab</sup> | 21.69±0.23<sup>b</sup> | 5.25±0.88<sup>a</sup> | 6.29±0.42<sup>b</sup> |
| T2        | 5.60±0.43<sup>b</sup> | 22.27±0.34<sup>b</sup> | 5.52±0.14<sup>ab</sup> | 6.40±0.64<sup>b</sup> |
| T3        | 5.16±0.25<sup>b</sup> | 22.66±0.73<sup>a</sup> | 6.34±0.56<sup>b</sup> | 6.84±0.69<sup>b</sup> |
| Mean±SD   | 5.70±0.41 | 21.43±1.60 | 5.52±0.60 | 6.37±0.37 |

Mean in the same column with different superscripts differ significantly (p<0.05).

3.2. **Titratable acidity**

The titratable acidity value of fermented goat meat dendeng was expressed as % total amount of lactic acid. The result of the analysis showed that the addition of different level *L. plantarum* gave a significant effect (P<0.05) to TA Value (Table 1). The higher level of *L. plantarum* addition resulted in higher TA Value. T0 as control treatment resulted in the lowest TA Value (19.11%) then the addition of 30 mL *L. plantarum* improved 22.66% of TA, higher percentage level of *L. plantarum* resulted in higher total acidity. During the fermentation process, lactose was broken down into glucose and galactose, then glucose will be converted to lactic acid and organic acid compounds [7]. Several factors including number of starters, the type of starter, and the environmental conditions could affect the activity of lactic acid bacteria for producing of lactic acid. Food preservation was correlated with the formation of inhibitory metabolites during fermentation including lactic acid, acetic acid, formic acid, propionic acid, ethanol, and bacteriocins [8].

3.3. **Total plate count**

Total plate count is the method for analysis of all types of non-specific bacteria in the product. In this study various level of *L. plantarum* gave significantly different (P≤0.05) to the TPC value of fermented goat meat dendeng (Table 1). A higher level of *L. plantarum* could improve number of bacteria in fermented goat meat dendeng. The higher number of TPC indicated that not only lactic acid bacteria could grow in fermented meat.

The research performed by [9] application of *L. plantarum* 21B on sourdough bread could produce phenyl lactic acid that had the antifungal activity to inhibit the growth of fungi *Aspergillus niger*. Moreover, several types of *L. plantarum* could produce Antifungal compounds such as benzoic acid, methyl hydantoin, mevalolactone, hydroxyphenyl lactic acid, and hydroxy fatty acids [10].

According to [11] meat is the source of protein that classified as perishable food that will present pathogenic and nonpathogenic microbes during the fermentation process. The fermentation process in meat was involved in several, including, anaerobic acidophilic, catalase negative, and mostly gram-positive [12]. The addition of 30 mL *L. plantarum* resulted in the highest number of TPC value 6.34±0.56 log CFU/g then followed by 3mL *L. plantarum* and 0.3 mL *L. plantarum* with 5.52±0.14 and 5.25±0.88 log CFU/g, respectively. This result is similar with the previous study [13] which found the total viable count of microorganism in smoked fermented bush meat, fresh fermented bush meat, and fermented sausages about 5.079 to 6.447 log CFU/g.

3.4. **Lactic acid bacteria**

The total lactic acid bacteria of fermented goat meat dendeng was presented in Table 1. Fermented goat meat dendeng with the addition of various levels *L. plantarum* showed no significant differences (p>0.05) in a total of LAB. The addition of 30 mL *L. plantarum* improved 6.84±0.69 log CFU/g of LAB of fermented goat meat dendeng, the higher level of *L. plantarum* resulted in higher total LAB. The multiplication of LAB is higher because of the proteolytic activity resulted in the availability of amino acids, which have been reported to be the essential growth factor for bacteria. Lactic acid
bacteria is a gram-positive, anaerobic, acidophilic, and classified as fermentative microorganisms. Several type of Lactic acid bacteria such as *Lactobacillus*, *Pediococcus*, *Leuconostoc*, *Streptococcus*, and *Enterococcus* are easy to found and grow in fermented meat product [14].

*Lactobacillus plantarum* has an adaptable characteristic at high fermentation temperatures (37-40°C) and resistant to grow in acidic condition with the highest number of populations present in the final stages of the fermentation process [15]. pH value is one of the factors that could affect the lactic acid bacteria capability for surviving the external condition when the pH value dropped suddenly at the time during fermentation, and it will decrease the lactic acid bacteria numbers [16]. Previous research [17] on fermented goat meat sausage with LAB count of sample increase from 6.4 to 6.92-9.26 log CFU/g. on fermented goat meat sausage with LAB count of sample increase from 6.4 to 6.92-9.26 log CFU/g. The increasing of LAB count is equivalent to the increase in fermentation temperature.

The addition of *L. plantarum* in fermented goat meat product is expected for controlling the growth of spoilage bacteria that can extend the shelf life of dendeng. According to [17] Lactobacilli utilizes the carbohydrate portion of the meat to produce acids and thus lower the pH, improving the texture of the products, providing stability against the proliferation of food pathogens and producing some aromatic compounds. The acidic condition could inhibit the growth of decomposing microorganisms [18]. Indigenous *Lb. plantarum* was able to produce bacteriocins plantains as antimicrobial peptides that could decrease the spoilage bacteria or foodborne pathogens [19].

A study about curing and fermentation of various meat [20] were observed the inhibitory effect of water activity, pH and the produced lactic acid bacteria (LAB) on the pathogenic bacteria during the fermentation process. The recent study about fermented meat [21] resulted that these products are an excellent source of microorganisms with probiotic characteristics.

4. Conclusion
From the research, it can be concluded that the addition of *L. plantarum* on fermented goat meat product resulted in a significantly different result of pH, TA, and TPC, except for total LAB. Application of 30 mL. *L. plantarum* indicated the better characteristics concerning chemical quality and resulted in a high number of microbiological qualities that could be used as a formula for producing commercial fermented goat meat dendeng.

References
[1] Purnomo H, Buckle K A and Edwards R 1984 J. Food Sci. Tech 21 326–8
[2] Teixeira A, Severiano S and Sandr R 2019 Adv. Food Nutr. Res. 1–66
[3] Arena M P, Silvain A, Normanno G, Grieco F, Drider D, Spano G and Fiocco D 2016 Front. Microbiol. 7 1–10
[4] Sabadoš D 1996 Croat. Dairy Union 166–169
[5] Shori A B and Baba A S 2012 J. Assoc. Arab Univ. Basic Appl. Sci. 11 50–5
[6] Desmazeaud M 1991 Lait 72 525–41
[7] Kumalasari K E D, Legowo A M and Al-Baarri A N 2013 J. Apl. Teknol. Pangan 2 165–8
[8] Bourdichon F, Casaregola S, Farrokh C, Frisvad J C, Gerds M L, Hammes W P, Harnett J, Huys G, Laulund S, Ouwehand A, Powell I B, Prajapati J B, Seto Y, Ter E, Boven A Van, Vankerekhoven V, Zgoda A, Tuijtelaars S and Bech E 2012 Int. J. Food Microbiol. 154 87–97
[9] Lavermicocca P, Valerio F, Evidente A, Lazzaroni S, Corsetti A and Gobbetti M. Appl Environ Microbiol. 66 4084–4090
[10] Muhialdin B J, Hassan Z and Sadon S K 2011 Annals, Food Sci. Tech. 12
[11] Steinkraus K H 1994 Food Res. Int. 21 259–61
[12] Egan A F 1983 Antonie Van Leeuwenhoek 49 327–36
[13] Zakpaa H D, Imbeah C M and Mak-mensah E 2009 African J. food Sci. 3 340–6
[14] Doyle P M, Beuchat R L and Montville J T 2001 Food microbiology (Washington, DC, U.S.A.;
ASM Press)

[15] Fardiaz S 1992 Mikrobiologi Dasar (Jakarta: PT. Gramedia Pustaka Utama)
[16] Shah N P 2000 J. Dairy Sci. 83 894–907
[17] Mukherjee R S, Chowdhury B R and Chakraborty R 2006 African J. Biotech. 5 1499–504
[18] Pratama A Y, Febriani R N and Gunawan S 2013 Jurnal Teknik Pomits 2 90–2
[19] Sabo S, Vitolo M, Gonzales J M D and Oliveira R P 2014 Food Res. Inter. 64: 527–536
[20] Paleari A, Bersani M, Moretti C, Beretta V and Giuseppe 2002 Food Control 195–7
[21] Marco M L, Heeney D, Binda S, Cifelli C J, Cotter P D, Foligne B, Kort R, Pasin G, Pihlanto A, Smid E J and Hutkins R 2017 Curr Opin Biotechnol. 44:94–102