Characteristic of Fermented Whey Beverage with Addition of Tomato Juice (Lycopersicum esculentum)

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Abstract. Whey is the liquid resulting from the coagulation of milk from cheese manufacture. The availability of lactose in whey and presence of other essential nutrients for the growth of microorganisms makes it one of the potential substrate for the production of different bio-products through fermentation process. Lactic acid production through fermentation from lactic acid bacteria could be an alternative processing route for whey lactose utilization. However, a problem with such approaches is the low total solids content. Sucrose and tomato juice added to increases the total solids content. The aim of this work was to study the characteristic of fermented whey beverage with different tomato juice concentration (5, 10, 15%) using probiotic bacteria Lactobacillus acidophilus and Lactobacillus plantarum. Lactic acid content, pH, antioxidant activity, and sensory properties of fermented whey beverage samples were examined after 18 hours fermentation. Fermented whey beverage with 5% tomato juice obtained the highest scores for color, aroma, flavor, texture and overall attributes. The lactic acid content and pH of fermented whey beverage ranged from 0.326 to 0.437% and from 4.13 to 4.64, respectively. The highest antioxidant activity (9.073%) was found in sample with 15% tomato juice concentration. The best formulation is the sample with 5% of tomato juice concentration.

1. Introduction

Whey is the liquid resulting from the coagulation of milk from cheese manufacture [1]. Whey treatment is indispensable for the prevention of environmental pollution, because in general the cheese whey just thrown away [2]. Sweet whey contains 6.3-7% of total solids and 4.6-5.2% of lactose [3]. The availability of lactose and presence of other essential nutrients for the growth of microorganisms make the whey one of the potential substrate for the production of different bio-products through biotechnological means [4]. The fermentation of whey by lactic acid bacteria allows the production of beverages with significantly improved characteristics [5].

However, a problem with such approaches is the low total solids content of whey, which reduces the efficiency of processing [6]. This situation causes fermented beverage products made from whey will be more watery than commercial fermented milk products, so it will affect the quality and...
characteristics of the product [2]. The total solid can be increased by adding of sucrose and fruit juice. Sucrose is the substrate used in the fermentation process as a carbon source and as a flavoring. Addition of 10% sucrose in fermented whey beverage produces good taste and have optimum level of lactic acid content and viable bacteria cells [7]. The addition of fruit juice can increase the total solid content and can disguise fresh whey flavour [8]. The addition of tomato juice on the fermented beverage substrate can stimulate and speed up the growth of *Lactobacillus acidophilus*, as well as increases the total number of bacteria. In addition, it can improve the utilization of sugar with plenty convert lactose into lactic acid, and also can lower the pH faster [9]. FAO/WHO recommended that the addition of fruit in yogurt drink ranged from 5 to 15%.

Fresh red tomato contains 4.64 g/100 g of carbohydrate, 19.1 mg/100 g of vitamin C and 4600 µg/100 g of lycopene [10]. Tomato is source of fructooligosaccharides (FOS). FOS will be fermented into lactic acid and short-chain carboxyl [11]. In addition, it has been proved that the FOS selectively stimulating the growth of *Bifidobacteria* and *Lactobacilli* [12]. Up till now, there was no study about the addition of tomato juice in fermented whey beverage. The aim of this study was to choose the best formulation of fermented whey beverage according to the sensory properties and chemical characteristic.

2. Materials and Methods

2.1. Materials

Mozzarella cheese whey waste was obtained from small and medium enterprises cheese industry in Central Java, Indonesia. Red tomato was obtained from Pasar Gede in Central Java, Indonesia and sucrose “Gulaku Premium” was use as material on the sugar addition treatment. Pure culture of *Lactobacillus acidophilus* FNCC 0051 and *Lactobacillus plantarum* FNCC 0027 were obtained from Center of Food and Nutrition Studies, Gadjah Mada University, Indonesia.

2.2. Preparation of mother culture

Each pure culture of *Lactobacillus acidophilus* FNCC 0051 and *Lactobacillus plantarum* FNCC 0027 propagated by taking 1 oose of bacterial culture then put in test tubes containing 5 ml of MRS broth sterile and then incubated at 37°C for 24 hours. The result of bacterial culture in MRS broth was then centrifuged at 1000 rpm for 10 minutes. 3 oose of obtained natan then inoculated in 5 ml of 10% skim milk solution which has passed the pasteurization process at 85°C for 30 minutes. Then incubated at 37°C for 24 hours.

2.3. Preparation of starter culture

100 ml of 10% skim milk pasteurized at 85°C for 30 minutes and then cooled to 37°C. After that, inoculated with 2% mother culture, then incubated at 37°C for 24 hours.

2.4. Preparation of tomato juice

Fresh red tomatoes weighed, cut in small parts and put in a blender for mashed, then filtered to obtain tomato juice.
2.5. Fermented whey beverage production
Cheese whey (100, 95, 90, 85%), tomato juice (0, 5, 10, 15%), and sucrose (10% w/v of the total volume of cheese whey and tomato juice) mixed and pasteurized at 75°C for 30 minutes, then add 0.7% high methoxyl pectin (w/v of the total volume of cheese whey and tomato juice). Subsequently cooled to 37°C and inoculated using 1% of starter culture *Lactobacillus acidophilus* FNCC 0051 and *Lactobacillus plantarum* FNCC 0027 with ratio of 1:1 (v/v of the total volume of cheese whey and tomato juice) with the number of bacteria $10^8$ CFU, then mixed until homogeneous. Furthermore incubated at 37°C for 18 hours.

Each formulation of fermented whey beverage has 3 repetitions of samples and 2 replications analysis. The pH values of the samples were determined using a pH meter (pH Testr 20), the lactic acid content were determined with NaOH titration, the antioxidant activity were determined using DPPH method. Twenty five semi trained panelists were selected for sensory evaluation using 5-points hedonic scale. The results were analyzed statistically by Analysis of Variance (ANOVA) using completely randomized design with significance at $p<0.05$. The analysis was performed using SPSS 16.0.

3. Results and Discussion

3.1. Sensory Characteristic of Fermented Whey Beverage with Addition of Tomato Juice

| Formulation | Parameter | Color | Aroma | Taste | Consistency | Overall |
|-------------|-----------|-------|-------|-------|-------------|---------|
| 0%          |           | 2.52±0.82<sup>a</sup> | 2.88±0.93<sup>ab</sup> | 3.28±1.02<sup>ab</sup> | 2.88±0.88<sup>ab</sup> | 3.12±0.78<sup>a</sup> |
| 5%          |           | 3.64±0.76<sup>b</sup> | 3.32±0.75<sup>b</sup> | 3.60±0.82<sup>b</sup> | 3.20±0.91<sup>b</sup> | 3.68±0.75<sup>b</sup> |
| 10%         |           | 2.84±1.18<sup>a</sup> | 2.72±0.79<sup>a</sup> | 2.68±1.31<sup>a</sup> | 2.64±0.70<sup>a</sup> | 2.76±1.05<sup>a</sup> |
| 15%         |           | 2.72±0.61<sup>a</sup> | 2.72±0.74<sup>a</sup> | 2.68±1.07<sup>a</sup> | 2.56±0.87<sup>a</sup> | 2.64±0.76<sup>a</sup> |

*Notation different letters in the same column indicate significant difference at a significance level of 5%

Score 1: extremely dislike, 2: dislike, 3: neutral, 4: like, 5: extremely like

3.1.1. Color

Color parameter for sensory assessment showed that the variation of tomato juice concentration provides the only significant difference in the concentration of 5% tomato juice only. The addition of tomato juice provides color red tinge on the sample. It can be seen that the panelists preferred the samples with the increased variety of tomato juice with a tinge of red compared to the sample without the addition of tomato juice with greenish yellow color.

3.1.2. Aroma

Aroma parameter showed that the variation of tomato juice concentration provides significant difference. The addition of 5% tomato juice on the fermented whey beverage can cover the undesireroma of whey. However, the addition of tomato juice with higher concentration (10 and 15%) less preferred because it produces too sour scent.
3.1.3. Taste
Taste parameter indicated that the variation of tomato juice concentration provides significant
difference in the 5% tomato juice. The addition of tomato juice on fermented whey beverage
formulations are preferred by the panelist than samples without the addition of tomato juice, because
the addition of tomato juice can mask the unfavorable taste of fresh whey. However, the addition of
tomato juice with higher concentration (10 and 15%) less preferred because it produces too sour taste.

3.1.4. Consistency
Consistency parameter showed that the variation of tomato juice concentration provides significant
difference in the 5% tomato juice. This is probably due to the influence of the other parameters so that
the panelists preferred the 5% tomato juice formulation as the sample with the most preferred
consistency.

3.1.5. Overall
Overall parameter showed that the variation of tomato juice concentration provides significant
difference in the sample with 5% concentration of tomato juice, it is similar to the other parameters
that placed the sample with the addition of 5% tomato juice as the most preferred formulations. Data
presented in Table 1 indicate that all parameters had the impact on the overall acceptance of the
fermented whey beverage. Disappearance of the cooked flavour and taste of fresh whey in the
examined new beverages could probably be related to the metabolising of n-hexanal and pentanal by
lactic acid bacteria as well as due to the masking effect of the new pleasant attributes, emerging after
fermentation and fruit supplementation [13]. Nonvolatile compounds may have contributed
significantly to explaining flavor variation, especially in differentiation of tomato juice concentrations.
These compounds should therefore be considered and analyzed further as some of them may be
relevant to the flavor of processed whey beverages [6].

3.2. Chemical Characteristic of Fermented Whey Beverage

| Table 2. Chemical characteristic of fermented whey beverage |
|-----------------------------------------------------------|
| Formulation  | pH        | Lactic acid content (%) | Antioxidant Activity (%) |
|---------------|-----------|-------------------------|--------------------------|
| 0%            | 4.64±0.03 | 0.326±0.00              | 8.703±0.15               |
| 5%            | 4.51±0.03 | 0.356±0.01              | 8.732±0.33               |
| 10%           | 4.37±0.02 | 0.390±0.01              | 8.987±0.14               |
| 15%           | 4.13±0.07 | 0.437±0.01              | 9.073±0.13               |

*Notation different letters in the same column indicate significant difference at a significance level of 5%*

3.2.1. pH
The result indicate there is statistically significant difference between all formulations of fermented
whey beverage samples. During the 18 hours of the fermentation process, the pH decreased from the
initial pH of cheese whey that is in the range of 5.6 to 6.12 to less than 4.7. Decreasing pH during the
fermentation process occurs because of the breakdown of lactose by β-galactosidase into lactic acid
thus increasing acid levels in line with the fermentation time. Increased lactic acid will be followed by
increase of H⁺, which means decrease in pH [14]. The addition of tomato juice causes the decreasing
of pH because of the characteristics of tomato juice itself is acidic, so the more tomato juice added, the
pH will be lower.
3.2.2. Lactic acid content
The result indicate there is statistically significant difference in the levels of lactic acid content in all formulations of fermented whey beverage samples. The more nutritional components in the material, then the metabolic activity of the lactic acid bacteria will be higher, so the pH level decreased and lactic acid content increased throughout the fermentation process [15].

3.2.3. Antioxidant activity
The result indicate there is statistically significant difference between the antioxidant activity. From the analysis it was found that the higher the concentration of tomato juice, the higher the antioxidant activity of fermented whey beverage. This is because in red tomatoes contained high antioxidant lycopene [16]. The antioxidant activity of fruit associated with the fenolic content, and will increase during fermentation by lactic acid bacteria. In addition, processing tomatoes will optimize antioxidant activity [10].

4. Conclusion
Variations of the tomato juice concentration had effect on the characteristics of the fermented whey beverage. The higher tomato juice concentration added, the higher the levels of lactic acid content and antioxidant activity. The higher tomato juice concentration added, the smaller pH value of fermented whey beverage. The best formulation of fermented whey beverage according to the sensory properties and chemical characteristic is the sample with 5% of tomato juice concentration.

Acknowledgments
This work was financially supported by research project of PNBP UNS No: 632/UN27.21/LT/2016 from Sebelas Maret University, Indonesia.

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