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Quality of Goat's Milk Exposed Ultraviolet and High Pulsed Electric Field

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Abstract. The study of microbial inactivation using HPEF method under long treatment's time at static system had significant effect ($P < 0.01$) towards physicochemical properties. In order to increase inactivation rate and to maintain its physicochemical properties, HPEF method was combined with UV which has been proved enable to decrease the total microbe population. The research was objected to obtain information related the frequency treatments (10, 15 and 20 Hz) under UV-HPEF combination toward physicochemical properties and microbiological properties. The statistical analysis was conducted using Complete Randomized Design. The result showed that insignificant difference was occurred among frequency treatments at 10, 15 and 20 Hz. The decreased of total microbe was 30.00; 89.49 and 85.67%, respectively. Inactivation rate at each frequency was 0.15; 0.98 and 0.84 log cycle or 3.49; 22.04 and 19.01 log cfu/ml/hour, respectively; D value was 6.46; 1.02 and 1.19 hour, respectively; while k value was 0.36; 2.25 and 1.94 hour⁻¹, respectively. The best treatment was obtained by HPEF-UV series treatment at 15 Hz.

1. Introduction

The success of industrial development and marketing of goat milk products depends on information on the composition and physical chemical properties, since the development and marketing of goat milk product in Indonesia is still under cow's milk product. The agribusiness growth of fresh goat milk in the community, has caused many capital owners to also participate in developing goat breeders. On the other hand, the unpreparedness of facilities and infrastructure, knowledge and skills of breeders caused the goat's milk to be easily contaminated. Some of the main pathogenic bacteria that cause poisoning in milk are Salmonella sp, Staphylococcus, and Escherichia coli [1].

The community habit in consuming fresh goat milk needs special attention on its guarantee for safety of fresh goat milk food products. Pathogenic bacteria in fresh goat milk cause milk to be bad for consumption, so it is necessary to meet consumer demand for safe fresh goat milk products.

Non thermal pasteurization is an alternative technology in answering the above problem. Research conducted by [2] with HPEF technology which produces a microbial inactivation rate at the electrode distance treatment in a room temperature process temperature of 0.33 log cfu / ml / hour and on the Salmonella Thyphimurium bacterium ATCC 14028 with the best treatment at a frequency of 15 Hz with an inactivation rate of 0.10 log cfu / ml / hour. The highest application of UV technology in reducing microbes in goat milk is achieved in UV application arranged in series through 3 reactors with an inactivation rate of 0.51 log cycles or 69.55%.



Thee efforts to increase the rate of microbial inactivation need to be done by a combination of HPEF and UV methods which are expected to significantly reduce total microbial but still be able to maintain the nutritional quality of goat milk.

2. Working Methodology

2.1 Materials and Research Tools

The material used is goat milk obtained from the Ciampea Islamic Boarding School in Bogor. The equipment used is milk vessel, UV-C reactor output of Kadind GPH 180T5L / 10W made by Kada (USA) Inc. combined with HPEF, milkotester, pH meter and conductivity meter.

2.2 Research Methods

The selected UV reactor system (series system) is combined with the HPEF unit as shown in Figure 1. A liter of goat milk sample is passed to the UV-C series reactor system and passed through the treatment chamber of HPEF unit, milk sample taken as much as 100-200 ml to be tested the physical, chemical and total bacterial properties by the TPC method compared to the control.

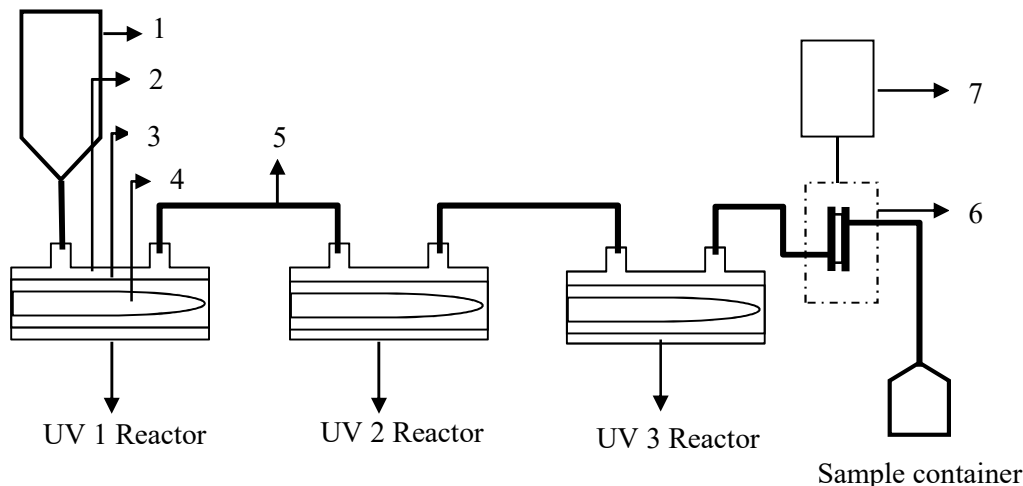


Figure 1. Schematic of combination testing equipment of UV series - HPEF

Note :

1 = separating funnel; 2 = UV reactor; 3 = quartz tube; 4 = UV lamp; 5 = "food grade" silicone hose
6 = treatment chamber; 7 = HPEF unit

2.3 Research Design

The research design used is a Completely Randomized Design (CRD) with UV-HPEF combination treatment using three replications. The results are analyzed by variance (ANOVA), if only the analysis results show a real effect, LSD (Least Significant Difference) test then proceed. The mathematical design model is according to Steel and Torrie (1991).

$$Y_{ij} = \mu + P_i + \varepsilon_{ij}$$

Where :

Y_{ij} : value of observed combination of UV and HPEF to i-th and j-th replication
 μ : general of mean
 P_i : influence of i-UV-HPEF combination treatment
 ε_{ij} : trial error to i-th treatment and j-th replication.

2.4 Research Observations

Observation parameters of physical and chemical properties include: specific gravity, freezing point, fat content, non-fat dry matter content, protein content, and lactose content which is carried out with Minimaster brand Milkotester, viscosity using the method [3], conductivity measured by conductivity meter AZ brand, The pH measured by the Scoth brand pH meter, the specific heat calculated by the method [4], the peroxide number test using the method [5], the protein test using the electrophoresis method and the total bacterial test based on [6].

3. Results and Discussion

3.1 Physical and Chemical Properties

The physical and chemical properties of goat milk exposed by a combination of UV-C light series system and 15 Hz HPEF are listed in Table 1 and 2.

Table 1. Physical properties of goat milk exposed to UV-C 253.7 nm combination system of UV-HPEF

Testing	Treatment			
	Control	UV series + HPEF 10 Hz	UV series + HPEF 15 Hz	UV series + HPEF 20 Hz
Viscosity	1.75 ± 0.08a	1.76 ± 0.19a	1.75±0.20 ^a	1.80±0.31 ^a
pH	6.46 ± 0.02a	6.49 ± 0.07a	6.46±0.07 ^a	6.46±0.03 ^a
Densisty	1.0303 ± 0.0018a	1.0298 ± 0.0025a	1.0302±0.0021 ^a	1.0303±0.0020 ^a
Conductivity	4.49 ± 0.25a	4.43 ± 0.29a	4.43±0.27 ^a	4.50±0.22 ^a
Freezing point	-0.496 ± 0.026a	-0.486 ± 0.039a	-0.494±0.029 ^a	-0.496±0.029 ^a
Specific heat	3.76 ± 0.03a	3.77 ± 0.02a	3.77±0.02 ^a	3.77±0.02 ^a

Note: Numbers followed by the same letter on the same line show values that are not significantly different at the test level <0.05

Table 2. Chemical properties of goat milk exposed to UV-C 253.7 nm combination system of UV-HPEF

Testing	Treatment			
	Control	UV series + HPEF 10 Hz	UV series + HPEF 15 Hz	UV series + HPEF 20 Hz
Lipid level	6,57±1,13 ^a	6,40±0,86 ^a	6,44±1,08 ^a	6,46±0,93 ^a
BKTL	9.88±0.40 ^a	9.71±0.61 ^a	9.84±0.46 ^a	9.87±0.46 ^a
Protein content	5.40±0,17 ^a	5.30±0.27 ^a	5.37±0.18 ^a	5.38±0.20 ^a
Lactose content	3.55±0.21 ^a	3.49±0.03 ^a	3.55±0.25 ^a	3.56±0.24 ^a
Dry weight	16.44±0.99 ^a	16.11±0.66 ^a	16.28±0.79 ^a	16.32±0.72 ^a
Water content	83.56±0.99 ^a	83.90±0.66 ^a	83.72±0.79 ^a	83.68±0.72 ^a

Note: Numbers followed by the same letter on the same line show values that are not significantly different at the test level <0.05

While the effect of pasteurization combination of UV-HPEF on physical and chemical properties at goat temperature is shown in Figures 2 and 3.

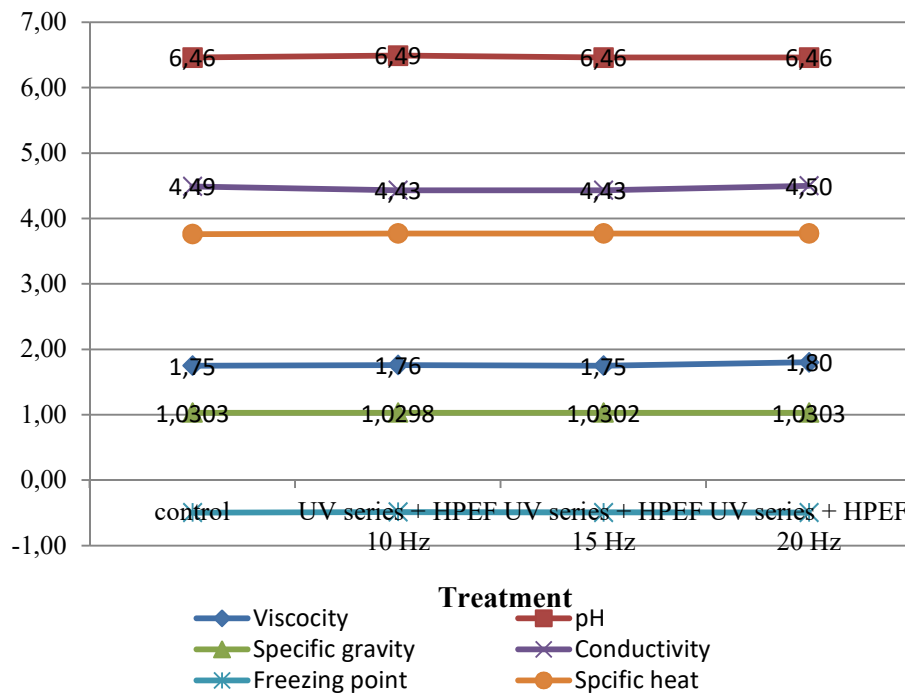


Figure 2. Physical properties of goat milk exposed to a combination of UV-C series and HPEF

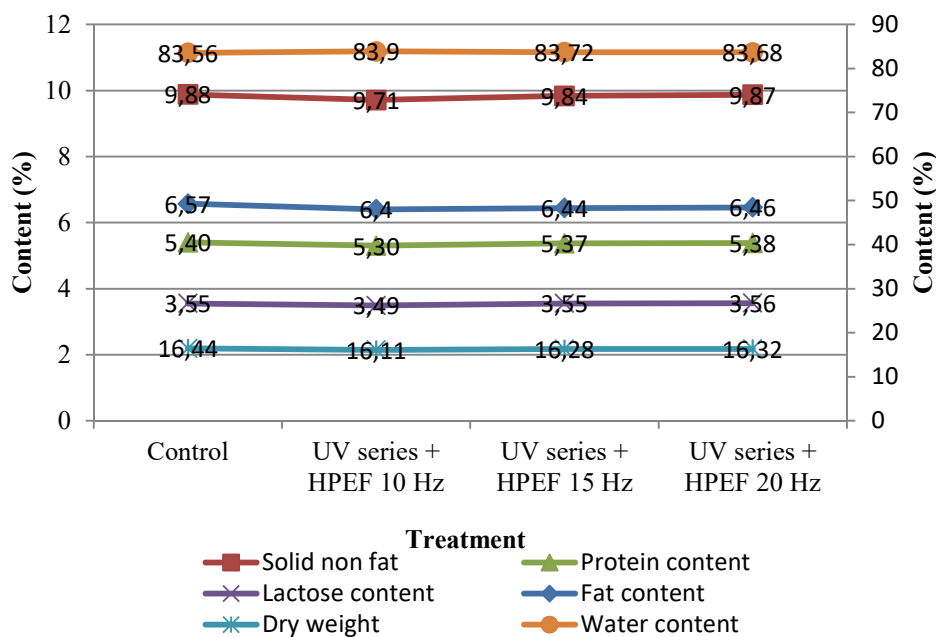


Figure 3. Chemical properties of goat milk exposed to a combination of UV-C series and HPEF

In general, UV-HPEF treatment does not cause changes in physical properties (viscosity, pH, density, conductivity, freezing point and specific heat) and chemistry (lipid content, BKTL, protein content, lactose content, dry weight, and water content) goat milk as shown in Tables 1 and 2, shows that the pasteurized goat's milk combination system of UV-HPEF resulted of various physical and chemical properties have no significant effect ($P > 0.05$), so that the UV-HPEF treatment is acceptable.

High voltage electric shock on the electrode gap can inactivate microbes that are suspended in milk. When a high voltage electrical jump is passed on goat's milk, physical effects (damage of cell wall due to the increase of permeability) and chemical (electrolysis) results, which cause the bacteria to be inactivated. Chemical changes in milk product treated by the HPEF method depend on the type and number of initial microorganisms, the volume of media material used, and the type of electrodes used [7].

3.2 Peroxide Value Test

The results of the control peroxide value and goat milk treated with UV-HPEF are listed in Table 3.

Table 3. Peroxide Value test results

No.	Example Type	Unit	Test result	Method
1	Goat milk control	meq / kg	0.00	SNI 01-3555-1998 (Titrimetry)
2	Goat Milk treatment	meq / kg	0.00	SNI 01-3555-1998 (Titrimetry)

Peroxide value test is carried out to determine the presence of free radicals as a result of combination treatment of UV and HPEF pasteurization. Free radicals are molecules that are very reactive because they have one or more unpaired electrons. Free radicals in excess in the body are highly dangerous and are toxic because they can cause damage to cells, nucleic acids, proteins, and fat tissue. Milk is a nutrient that has high nutrition and contain a lot of lipid. Lipid and compounds that are fat soluble are very susceptible to oxidation. Peroxide value test results based on [6] which refers to the Titrimetry method states that the combination of UV and HPEF pasteurization does not have a carcinogenic effect.

Table 4. The main characteristics of milk protein

Protein concentration	Concentration (g / L)	Molecular Weight (kDa)
20% Whey (5 g / L)		
• 10% BLG	3-4	18.3
• 5% ALA	1-1.5	14.2
• 3% immunoglobulins	0.6-1.0	150
• 1% BSA	0.1-0.4	66.3
• 1% Lactoferrin	0.09	80
80% casein (30g / L)		
• 32% -1 casein	12-15	23.6
	3-4	25.2
• 10% -2 casein	9-11	24.0
	3-4	19.0

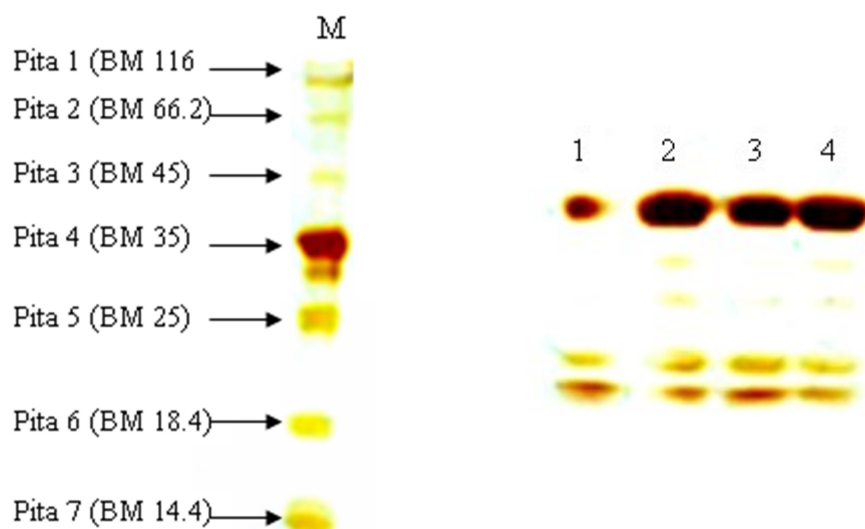
Source: <http://www.phadia.com/Allergens/ImmunoCAP-Allergens/Food-of-Animal-Origin/Milk--constituents/Cows-milk/>

Note: ALA: α Lactobumin, BLG: β Lactoglobulin; BSA: Bovine serum albumin

3.3 Electrophoresis Test

The quality of goat milk is strongly influenced by protein content and is one of the main criteria in the sale of goat milk in many countries. Milk protein can be divided into two types namely casein and whey. Goat milk has a casein and whey ratio of 80:20. Casein is the largest constituent of milk protein consisting of four types of polypeptides; α s1-, β -, α s2- and κ -casein. The main characteristics of milk protein and molecular weight are listed in Table 4.

Electrophoresis results of control goat milk with UV-HPEF goat milk treated are shown in Figure 4.



Information:

M = Marker

1 = goat milk control (without treatment)

2 = pasteurized goat milk combination of UV seri-HPEF 10 Hz

3 = pasteurized goat milk combination of UV seri-HPEF 15 Hz

4 = pasteurized goat milk combination of UV seri-HPEF 20 Hz

Goat milk protein is composed of alpha s1 casein, alpha s2 casein, beta casein, kappa casein, beta lactoglobulin and alpha lactalbumin with BM respectively 23.6, 25.2, 19, 18.3 and 14.2. Based on the results of the electrophoresis test (Figure 4) it appears that the control goat milk consisted of three components which were thought to be α -s2 casein, β -lactoglobulin and α -lactalbumin with molecular weights of 29.87, 15.07 and 13.90 kDa, whereas in goat milk with UV-HPEF treatment there are five components of the protein that are thought to be α -s2 casein, α -s1 casein, β -casein, β -lactoglobulin and α -lactalbumin with molecular weights of 29.87; 23.46; 19.97; 15.07 and 13.90 kDa. The UV-HPEF treatment gives rise to two new types of proteins namely α -s1 casein, β -casein, due to changes in the distribution of casein and whey concentration as the main components of the protein constituent. The UV-HPEF treatment causes changes at the molecular level (changes in protein molecular weight distribution) but does not cause changes at the physicochemical level. In general, the results of UV-HPEF pasteurization treatment testing do not show any difference when compared to control.

Food products that are exposed to UV radiation exposure do not cause toxic and genetic damage in animal and human consumer [8]. WHO recommends using doses of <10 kGy or equivalent to food

product. The radiation dose is symbolized by rad, where one rad is defined as the amount of ionic radiation which results in absorption of 100 ergs per gram of UV applied material. Radiation units are more commonly classified into gray (Gy), where 1 Gy is equal to 100 rad. 1 kg of food that absorbs 1 joule of energy (1 joule = 107 erg) will receive a dose of 1 Gy. International health and safety authorities says that food irradiated up to 10,000 Gy (10 kGy) is considered a safe limit from the use of radiation in food handling. A medium dose of 1-10 kGy can be used to eradicate spoilage microbes and pathogens in food products to improve the safety and stability of refrigerated products or foods (stored in refrigerators) [8].

The UV-C series dose used in this study is 0.62 J/cm^2 with a wavelength of 253.7 nm or equivalent to 0.62 Gy.kg/cm^2 . According to [9] referred to [10], the specific gravity of goat milk ranges from 1,029-1,039 g/cm^3 , so if the average density is taken at $1,034 \text{ g/cm}^3$, a dose value of 600.58 Gy/cm or below the dose value recommended WHO by 10 kGy.

3.4 Total Microbial Test

Total inactivation of goat milk microbes exposed by a combination of the UV-C system series and HPEF method is shown in Figure 5.

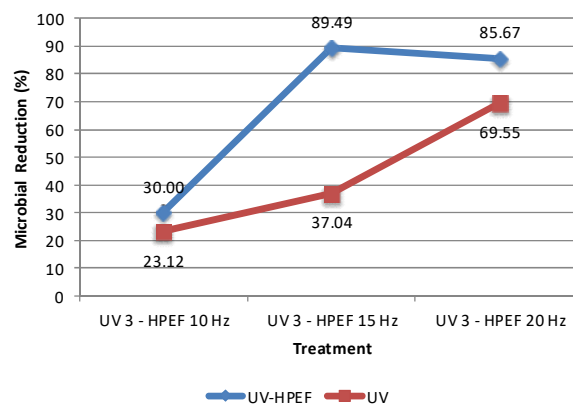


Figure 5. Microbial inactivation of series UV – HPEF treatment

Figure 5 shows the contribution of pasteurization of HPEF system, where pasteurization of the UV system in reactors 1, 2 and 3 has total microbial inactivation values respectively 23.12%, 37.04% and 69.55% whereas when combined with pasteurization of HPEF-10 Hz, HPEF-15 Hz and 20 Hz HPEF increases to 30.00%; 89.49% and 98.67%. The selected UV-HPEF pasteurization combination is 15-HPEF series UV.

4. Conclusions

The research conclusions obtained from a combination of UV exposure and HPEF in goat milk are:

- The combined treatment of UV exposure -HPEF shows that physical properties (viscosity, pH, density, conductivity, freezing point and specific heat) and chemical properties (lipid content, BKTL, protein content, lactose content, dry weight, water content, peroxide value test and electrophoresis test) are not significantly different from control.
- In general, the physical and chemical properties of treated goat milk still meet the requirements of [11], [12] and [13].

- c. The selected treatment is a combination of UV exposure of 3 reactors arranged in series with 15% HPEF with a total microbial reduction value of 89.49%.

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