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Characteristics of Liquid Soap Based on Used Cooking Oil Sources

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ABSTRACT

Fats and oils that have been used in the cooking and frying process in food processing industries such as restaurants or fast food, households or at the consumer level are called Used Cooking Oil (UCO). Bali Province produced 3.3 million L/month of UCO and has not been managed properly, which has a disadvantageous impact on the environment (soil, water, and agricultural land. To overcome that, it was necessary to conduct research on processing UCO into non-food products, such as liquid soap. This study aimed to determine the effect of UCO sources on the characteristics of liquid soap and the best characteristics of liquid soap from UCO sources. A simple Randomized Group Design (RGD) with treatment UCO Sources grouped into UCO From Vegetable Food Processing, UCO From Animal Food Processing, and UCO from Mixed Food (Vegetable and Animal) processing was used in this research. The data obtained was analyzed with Minitab 19. The best results were obtained from UCO from animal food processing which produced the best liquid soap characteristics with a viscosity value of 549.20 m.Pas; pH of 7.49; specific gravity of 1.12 g/ml; humidity of 93.40%; the foam height at the 0th minute was 3.45%; the foam height at the 5th minute was 2.88%, with foam stability of 82.63%.

Keywords

Liquid Soap, Refining, Used cooking oil, food, Biological Oxygen Demand

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Introduction

Used Cooking Oil (UCO) is one of the results of processing waste in the food processing industry, such as restaurants, fast food, and consumer and household levels, in the form of fat or oil and has been used for cooking or frying (EUBIA, 2020). According to Arini (2013), UCO cannot be reused when frying food ingredients if it has been used more than three times in the frying process and can damage the environment if disposed of carelessly. Bali province has a high potential for producing UCO. Sadyasmara *et al.,* (2022) reported that Bali Province has the potential to produce UCO of around 1 million liters/month from the average use of cooking oil of 3,050.052 liters/month, with the largest supply coming from households.

UCO, if not managed properly, has the potential to pollute the environment. According to Djaeni (2002) this is due to the increase in Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels in waters, and it also causes foul odors due to biological degradation. In addition, the frying process that uses high temperatures >120^{o}C causes the formation of carcinogenic compounds such as acrylamide in UCO sourced from carbohydrate-containing foods. Sengke *et al.,* (2013) reported that the Food and Drugs Administration (FDA) classified acrylamide compounds as cancer-causing compounds in humans.

In general, cooking oil is used to fry food from various sources, such as frying animals (meat), vegetables (vegetables and nuts), or a mixture of animal and vegetable. So far, many studies on the characterization and utilization of UCO have been reported. Suroso (2013) only reported the characteristics of UCO without processing UCO into products. Meanwhile, research on UCO processed into various products without the characterization process has also been reported, including soap (Wijana *et al.,* 2010; Silsia *et al.,* 2017).

Processing UCO into products such as liquid soap can certainly provide added value to the UCO. This is in accordance with the report from Yuarini *et al.,* (2021) that the utilization of UCO into liquid soap can increase the added value of UCO by 47.38%. The added value given to the product is not only in economic terms but also reduces environmental pollution and reduces the utilization of UCO for human consumption. With the added value that can be given to UCO, it is very necessary to carry out proper and sustainable management of UCO waste.

From the results of these studies, characterization was only carried out on UCO, which had been mixed together, without grouping UCO based on the sources of fried ingredients. The novelty carried out in this study is the grouping of used cooking oil based on the source of fried ingredients which are then utilized as liquid soap. In this regard, research on the effect of the source of used cooking oil on the characteristics of liquid soap needs to be done.

Materials and Methods

The research was conducted at the Process Engineering and Quality Control Laboratory, Food Processing Laboratory, and Food Analysis Laboratory of the Faculty of Agricultural Technology, Udayana University, from July to September 2023.

The materials used in this study are materials for purifying UCO such as activated charcoal and liquid soap making materials, namely UCO that has been categorized, KOH, sucrose, aquades, glycerin dan tween 80.

The tools used for making liquid soap include measuring cups, beakers, erlenmeyers, waterbath shakers, tissues, spatulas, aluminium foil, digital scales, thermometers, stoves, plastic funnels, stirring rods and filter paper, and tools used for analyzing the variables observed in liquid soap, namely volumetric pipettes, viscometers, digital scales, pH maters, cosmetic bottles, and water baths.

This study uses a simple Randomized Group Design (RGD) with 1 treatment, namely Used Cooking Oil (UCO) which is grouped into:

S1 = Vegetable Food UCO

S2 = Animal Food UCO

S3 = Mixed Food (Vegetable and Animal) UCO

Each Treatment was repeated 5 times, resulting in 15 experimental units. Parameters observed included pH, foam height, foam stability, water holding capacity/humidity, viscosity, and specific gravity. Data from this experiment were analyzed using the Minitab 19 program, and if there is a treatment that significantly affects the results ($P<0.05$), then it will be continued with Tukey's difference test.

Results and Discussion

Viscosity (m.Pas)

The results of variance showed that the source of UCO had no significant effect ($P>0.05$) on the viscosity of liquid soap. The average results of the liquid soap viscosity test from various UCO sources can be seen in Table 1. Based on Table 1. The highest viscosity value was obtained in the Animal Food UCO treatment of 549.20 ± 267.94 m.Pas, for the lowest value obtained from Vegetable Food UCO of 379.60 ± 156.16 m.Pas.

According to Anggraeni *et al.,* (2020), viscosity measurement is carried out to determine the consistency of liquid soap, which affects the application of soap, and the ease of pouring, but not easily spilled. The viscosity value of liquid soap obtained from the three UCO source treatments has met the general viscosity standard of liquid soap products set at 400-4000 mPas (Williams and Schmitt, 2002).

pH

The results of variance showed that the source of UCO had no significant effect (P>0.05) on the pH of liquid soap. The average results of the pH test of liquid soap from various UCO sources can be seen in Table 2. Based on Table 2., the highest pH was obtained in the animal food UCO treatment of 7.49 ± 0.05 and the lowest pH was obtained from vegetable food UCO of 7.38 ± 0.07. The pH value obtained on average ranges from pH 7.

The quality of liquid soap produced can be seen based on pH. This is because the use of liquid soap is in direct contact with the skin. This statement is supported by Irmayanti *et al.,* (2014) that direct contact of liquid soap with the skin can cause problems if the pH value of the resulting liquid soap does not match the skin's pH.

Based on (SNI 06-4085-1996), the required pH value of liquid soap ranges from 6-8. The results of testing the pH of liquid soap made from UCO from various sources averaged around 7, and this range has met the SNI 1996 liquid soap.

When compared with the research reported by Meizalin and Paramita (2021), the average pH value of soap made from UCO sources has the same pH range as liquid soap made with Virgin Coconut Oil (VCO) as a base material. This can indicate that liquid soap produced with UCO from various sources has a pH quality similar to liquid soap produced with VCO as a base material.

Specific Gravity

The results of variance showed that the treatment of UCO sources had no significant effect (P>0.05) on the specific gravity value of liquid soap. The average results of the specific gravity test of liquid soap from various UCO sources can be seen in Table 3.

Based on Table 3. The highest specific gravity value was obtained in the Animal Food UCO treatment of 1.12 ± 0.09 g/ml, and the lowest value was obtained from Vegetable Food UCO of 1.06 ± 0.09 g/ml. Specific gravity shows the ratio between the weight of liquid soap and the weight of water at the same temperature and volume (Anon., 1996). The specific gravity obtained is directly proportional to the viscosity value. If the viscosity value of a product is higher, the specific gravity of a product will be higher. Based on (SNI 06-4085-1996) the specific gravity value of liquid soap ranges from 1.01-1.10 g/ml. In general, the specific gravity of liquid soap from all UCO source treatments has met the established SNI standards.

Water Holding Capacity (WHC)

The results of variance showed that the treatment of UCO sources had no significant effect (P>0.05) on the moisture value at hours 1 and 2 but had a significant impact (P<0.05) at hours 3 and a very significant effect (P<0.01) at hours 4 and 5.

The average results of the liquid soap moisture test from various UCO sources can be seen in Table 4. Based on Table 4. The highest moisture value obtained in animal UCO was 99.27 ± 0.62% (T1), 98.05 ± 0.65% (T2), 96.34 ± 0.52% (T3), 94.82 ± 0.26% (T4) and 93.40 ± 0, 40 % (T5) for the lowest moisture value obtained from UCO Nabati Pangan respectively 98.73±0.30 % (T1), 97.47±0.34 % (T2), 95.14±0.40 % (T3), 93.46±0.35 % (T4) and 92.03±0.34 % (T5).

Liquid soap made from animal UCO has a higher average moisture when compared to other treatments. This is because the viscosity value of animal UCO is higher than other UCO sources. According to Schmitt (1996), the high viscosity of the material causes particle movement to be difficult. Liquid soap products with high moisture indicate that the ability of liquid soap to maintain weight against the influence of sunlight.

Low weight loss suggests that liquid soap has high humidity and vice versa. The moisture value also shows that liquid soap has a good ability to maintain its weight stability (Oktari *et al.,* 2017).

Foam Height

The results of variance showed that the treatment of the UCO source had a very significant effect (P<0.01) on the height of liquid soap foam at the 0^{th} minute (T1) and 5th minute (T2). The average value of liquid soap foam height (T1 and T2) can be seen in Table 5 and Table 6, respectively.

Based on Table 5 and Table 6, the highest foam height values (T1 & T2) were obtained in the Animal Food UCO treatment at 3.45 ± 1.45 cm (T1), and 2.88 ± 1.31 cm (T2), respectively, while the lowest foam height values were obtained from Mixed Food UCO at 1.11 ± 0.50 cm (T1) and 0.92 ± 0.34 cm (T2).

Table.1 Average Results of Liquid Soap Viscosity Test

Source Oil	Group					Average
	1	2	3	4	5	
Vegetable	273.00±156.16	638.00±156.16	263.00±156.16	413.00±156.16	311.00±156.16	379.60±156.16^{a}
Animal	675.00±267.94	316.00±267.94	306.00±267.94	944.00±267.94	505.00±267.94	549.20±267.94^{a}
Mixed	260.00±243.04	278.00±243.04	739.00±243.04	766.00±243.04	461.00±243.04	500.80±243.04^{a}
KK (%)	48.00					

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Table.2 Average Results of Liquid Soap pH Test

Source Oil	Group					Average
	1	2	3	4	5	
Vegetable	7.37±0.07	7.46±0.07	7.37±0.07	7.27±0.07	7.43±0.07	7.38±0.07^{a}
Animal	7.53±0.05	7.48±0.05	7.53±0.05	7.39±0.05	7.5±0.05	7.49±0.05^{a}
Mixed	7.35±0.09	7.32±0.09	7.52±0.09	7.51±0.09	7.36±0.09	7.41±0.09^{a}
KK (%)	1.16					

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Table.3 Average Results of Specific Weight of Liquid Soap

Source Oil	Group					Average
	1	2	3	4	5	
Vegetable	1.09±0.09	0.98±0.09	1.14±0.09	0.96±0.09	1.16±0.09	1.06±0.09^{a}
Animal	1.13±0.09	1.25±0.09	1.10±0.09	1.14±0.09	0.98±0.09	1.12±0.09^{a}
Mixed	1.09±0.17	1.17±0.17	0.77±0.17	1.08±0.17	1.24±0.17	1.07±0.17^{a}
KK (%)	13.24					

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Table.4 Average Moisture Results of Liquid Soap

Oil Source	Average				
	T1	T2	T3	T4	T5
Vegetable	98.73±0.30^{a}	97.47±0.34^{a}	95.14±0.40^{b}	93.46±0.35^{b}	92.03±0.34^{b}
Animal	99.27±0.62^{a}	98.05±0.65^{a}	96.34±0.52^{a}	94.82±0.26^{a}	93.40±0.40^{a}
Mixed	99.02±0.36^{a}	97.80±0.22^{a}	96.15±0.47^{a}	94.45±0.67^{a}	93.21±0.74^{a}
KK (%)	0.46	0.52	0.58	0.46	0.60

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Table.5 Average Results of Foam Height (T1) of Liquid Soap

Treatment	Group					Average
	1	2	3	4	5	
Vegetable	1.90±0.64	1.90±0.64	1.45±0.64	2.88±0.64	1.18±0.64	1.86±0.64^{b}
Animal	4.45±1.45	3.90±1.45	4.18±1.45	3.83±1.45	0.88±1.45	3.45±1.45^{a}
Mixed	1.98±0.50	1.05±0.50	0.73±0.50	0.88±0.50	0.9±0.50	1.11±0.50^{b}
KK (%)	38.53					

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Table.6 Average Results of Foam Height (T2) of Liquid Soap

Treatment	Group					Average
	1	2	3	4	5	
Vegetable	1.35±0.57	1.30±0.57	1.00±0.57	2.40±0.57	1.00±0.57	1.41±0.57[b]
Animal	4.00±1.31	2.65±1.31	3.55±1.31	3.48±1.31	0.70±1.31	2.88±1.31[a]
Mixed	1.50±0.34	0.95±0.34	0.63±0.34	0.78±0.34	0.75±0.34	0.92±0.34[b]
KK (%)	43.21					

Notes: Values followed by the same superscript behind the mean value indicate no significant difference (P>0.05)

Liquid soap from animal food UCO tends to have a relatively higher foam height compared to liquid soap from other UCO sources. This is thought to be caused by animal food UCO having higher FFA levels compared to other UCO sources. This statement is supported by Piyali *et al.,* (1999) which states that fatty acids that bind less Na + or K + ions will produce soap with a lot of foam content. In addition, Oktari *et al.,* (2017) also reported that the foam height of liquid soap from coconut oil, palm oil, and VCO was 1.12 cm, 0.87 cm, and 0.30 cm, respectively. Meanwhile, several previous studies related to liquid soap from UCO sources produced foam heights of 1.03-1.14 cm (Fatimah and Satria, 2019), 1.80-2.00 cm (Wijana *et al.,* 2010) and from patchouli oil 2.67-3.23 cm (Anggraeni *et al.,* 2020).

The higher the foam indicates a greater amount of foam (Hutauruk *et al.,* 2020). In addition, foam is also an indicator of consumer liking for a liquid soap product. The difference in the foam height of liquid soap produced from several studies is due to differences in the source and content of oil and the formulations used.

Foam Stability

The results of variance showed that the treatment of the UCO source had no significant effect (P>0.05) on the stability of liquid soap foam. The average value of liquid soap foam stability can be seen in Table 7. Based on Table 7, the foam stability value ranged from 75.30% - 84.90%. The highest foam stability was obtained in the Mixed Food UCO treatment at 84.90 ± 5.76%, while the lowest foam stability value was obtained from Vegetable Food UCO at 75.30 ± 8.05%.

The level of foam stability with an average of above 70% can be classified as a good level of stability. This is due to the presumably high content of myristic acid and lauric acid in UCO, so it can produce a lot of foam (Widyasanti *et al.,* 2017). This is in accordance with a report from Putri *et al.,* (2017) that used cooking oil contains lauric acid at 33.72% and myristic acid at 56.81%. In addition, the high content of palmitic acid and stearic acid is also thought to be owned by UCO. This statement is also supported by a report from Putri *et al.,* (2017) which reported that used cooking oil contains palmitic acid of 27.89%. In addition, Cao *et al.,* (2018) reported that identification using GC-MS on used cooking oil is suspected that used cooking oil contains stearic acid. According to Cavitch (2001), these two fatty acids play a role in maintaining foam stability.

Foam stability is not related to the soap's cleaning ability. However, foam stability is related to consumer perception and aesthetic value. According to Fitriarni (2017), consumers tend to prefer liquid soap that produces a lot of foam and is stable compared to liquid soap that produces little or unstable foam. This is in accordance with the report from Piyali *et al.,* (1999) that one of the factors affecting foam stability is the formulation in making liquid soap, precisely the ratio between the concentration of bases and fatty acids or oils used. This is because the stronger the bond between Na+ ions and fatty acids, the less foam the soap produces (Piyali *et al.,* 1999).

It can be concluded from the research carried out that the source of used cooking oil (MBG) used has no significant effect on viscosity, pH, specific gravity, foam stability, and moisture values at hours -1, 2, but has a significant effect (P < 0.05) at hour 3, and a very significant effect (P < 0.01) at hours 4 and 5 and on the height of liquid soap foam at minutes 0 and 5.

Used cooking oil for animal food produces the best liquid soap characteristics, namely a viscosity value of 549.20 m.Pas; pH of 7.49; specific gravity of 1.12 g/ml; humidity of 93.40%; foam height at minute 0 of 3.45%; foam height at minute 5 of 2.88%; and foam stability of 82.63%.

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Author Contributions

Dewa Ayu Anom Yuarini: Investigation, formal analysis, writing—original draft. G. P. Ganda Putra: Validation, methodology, writing—reviewing. Anak Agung Putu Agung Suryawan Wiranatha:—Formal analysis, writing—review and editing. Luh Putu Wrasiati: Investigation, writing—reviewing. I Gede Arie Mahendra Putra: Resources, investigation writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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