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Enhancing the Quality of Virgin Coconut Oil Associated with Clarity by Reducing its Sediments

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ABSTRACT

Virgin Coconut oil (VCO) is a clear vegetable oil, with a distinct coconut flavour and aroma. In Sri Lanka, it is manufactured using fresh dry method, whereas wet-milling and fermentation methods are also used. Standards of the VCO are largely depending upon the type of processing and filter used in the process. The quality deterioration which occurs when the sediments/foots at the bottom of the bottle putting prospective buyers off as of the turbid appearance. Therefore this experiment was conducted to find out the reasons for sedimentation which cause quality deterioration in the final product aiming at enhancing the quality of VCO. Five treatments that characterize the performance of the filter types were taken and kept for a period of thirty days to settle the foots at the bottom of the bottle. Then the amount of sediment was quantified by measuring the height of the foot. The foots was tested for percentage of free fatty acid (% FFA) using 0.082 N potassium hydroxide solution. A test was done to enumerate the yeast and mold on the foots using SLS 516 standards. According to the results, the plate and frame filter press 1 and plate and frame filter press 2 exhibited significant filtration ability than that of the polish filter and the cartridge filter. The % FFA of the sediment resulted the high value and also there was a significant yeast and mold count. This concludes that the foots could be reduced by improving the filtration process. This study proposes to place the filter after the settling tank, which keep the oil for seven days as a measure to enhance VCO quality by improving clarity.

KEYWORDS: Cold pressed, Enumeration, Plate and frame filter press, Sediments, Virgin coconut oil

INTRODUCTION

Sri Lanka is the second largest land user for coconut (*Cocos nucifera*) as a plantation crop. Coconut in Sri Lanka is mostly under private ownership with a large majority classified as arable farm of less than 1.2 hectares. Coconut industry provides employment to some 135,000 people who involved in the production process and trading sectors (CDA, 2015). The annual necessity of coconut for national consumption, local and export oriented industries is around 3,650 million nuts. An income of Rs. 47,952 million was earned through exportation of coconut products in 2013. Yet the current annual production is around 2,400 to 3,000 million nuts (CDA, 2015). It was seen as a sustainable resource from which the harvested materials influenced every aspects of the lives. However about 80-85% of such production is absorbed for domestic consumption and the balance is utilized for commercial exploitation in the forms of desiccated coconut, coconut oil, coconut milk powder and coconut cream with more than 40 additional industrial products (CDA, 2015).

Virgin coconut oil (VCO) is the purest form of coconut oil. Introduced into the world market at the end of the 20th century, it is one of the highest value products derived from the fresh coconut (Rukunudin *et al.,* 1998). During the years of 1970s and 1980s, a number of coconut oil mills were modernized and new mills were established to produce virgin coconut oil supported by high export demand (Bawalan and Champman, 2006). Exports of virgin coconut oil in 2014 increased to 7,278 metric tons from 2,101 metric tons in 2013 (Central Bank of Sri Lanka, 2015).

Virgin coconut oil is extracted from fresh coconut meat and pressed using only physical and/or natural means. Virgin coconut oil can be produced directly from the fresh comminuted (grated, chopped, granulated) coconut meat, or from coconut milk, or from coconut milk residue. Then choice of the technology to be adopted depends to a great extent on the scale of operation, the degree of mechanization desired, amount of investment available and the demands of the prospective buyer (Douglas, 2010). The scale of operation to be implemented is significantly dependent on the available coconut supply base. Virgin coconut oil can be produced using four methods namely expeller, centrifuged, fermentation with heat and without heat fermentation. Mostly the VCO millers in Sri Lanka use the fresh coconut meat which is dried and pressed by an expeller to

extract VCO in fresh dry process without undergoing chemical refining, bleaching or deodorizing methods. It is extracted using cold press and unrefined process at low temperatures. By utilizing this method the greatest amount of nutrients are preserved. "Cold pressed" refers to the temperature at which the oil drips from the expeller. Therefore, "cold pressed" oil refers to the dripping temperature of the oil which is less than 60 °C (Honary, 2004).

Virgin coconut oil which can be considered as one of the healthiest oils in the planet. It contains natural vitamin E and has not undergone atmospheric and hydrolytic oxidation as attested by its low peroxide value and low free fatty acid content. It has a mild to intense fresh coconut aroma (Bawalan, 2011). The medium chain (C_8–C_{12}) fats in VCO are similar in structure to the fats in mother's milk that gives babies immunity from disease and have similar effects (Kabara, 2000). According to Fife (2004), coconut oil possesses anti-inflammatory, anti-microbial and antioxidant properties that work together to protect the arteries from atherosclerosis and the heart from cardiovascular disease.

Due to its nutritive value, it is not subjected to high temperature and solvents procedure. As an edible pure coconut oil, Virgin Coconut Oil market, whether local or international, should be protected and sustained by ensuring its quality. Quality characteristics namely colour, odor, taste, free fatty acid content and moisture content are kept properly for its better export quality (Bawalan and Champman, 2006). The colour of VCO also indicates that it has been processed at the right temperature and with strict quality control in handling the fresh coconut. It should be water-clear without any sedimentation. The odor and taste of VCO is sweet with no rancid smell (Bawalan and Champman, 2006).

Standards of VCO including quality characteristics, identity characteristics, allowable contaminants, hygiene, packaging, labeling and methods of sampling. Standards of the VCO depend on the processing steps. Maintenance of the temperature during the desiccated coconut manufacturing prior to VCO extraction is essential. It should be below 60 °C temperature. The expeller temperature during VCO extraction should keep below 50 °C. The extracted VCO is filtered through plate and frame filter press, polish filter and cartridge filter. The cloth material used in the plate and frame filter press and polish filter are Polypropylene, with the pore sizes of 8 µm or 5 µm and 3 µm respectively and the cartridge filter contains natural or synthetic yards which wounded around the central tube which has 1 µm pore size. Filters are in a fixed volume and batch operation which simply means that the operation must be stopped to discharge the filter cake before the next batch gets started. Its specific volume of solids can be held by the filters (Douglas, 2010).

The filtered VCO then stores in stainless steel conical shaped bottom tanks for seven days for sedimentation. Gravity is mainly associated with the slow sedimentation process of an immiscible mixture (Geankoplis, 2003). As a solution placing of filter after a storage tank will minimize the sediment percentage (Bawalan and Champman, 2006) or using of filter aid namely Perlite, diatomite can be used for better filtration (Perlmutter, 2009).

Even though, the sediment/foot is removed as it is, there is an unsightly white residue that settle at the bottom of VCO bottle in retail stores after one month time period. It reduces the clear appearance low consumer preference and finally creates low demand from consumers and thus lowers the export demand.

With this background, this study was conducted to identify the sediments that occur at the bottom of the bottle, through the evaluation of the efficiency of the filtering machines and to determine the percentage of free fatty acid of the sediment and the VCO layer. Further yeast and mold enumeration was done to identify the occurrence of unsightly residues (foots) at the bottom of the bottle due to the mold growth.

MATERIALS AND METHODS

The study was carried out at a Virgin Coconut Oil mill at Katana from December 2015 to May 2016.

Effect of Filters

First, 500 mL VCO samples were collected from the tanks including three replicates for each, and another 500 mL sample from the storage tank including three replicates. Those samples were kept for one month until it occurs sediments.

Tank 1- Sample from the tank before the plate and frame filter press 1

Tank 2- Sample from the tank after the plate and frame filter press 1(with the pore size of 8 µm)

Tank 3- Sample from the tank after the plate and frame filter press 2 (with the pore size of 5 µm)

Tank 4- Sample from the tank after polish filter (with the pore size of 3 µm)

Tank 5- Sample from the tank after cartridge filter (with the pore size of 1 µm)

Subsequently, that the height of the sediment was measured and the values were compared.

Determination of Fatty Acids

Five grams from sediment and five grams from pure oil were measured into a conical flask. Fifty milliliters of alcohol, 2-3 pieces of stones and 1-2 drops of Phynopthelyne indicator were added to it. Then it was boiled for 40 minutes. After that the solution was titrated with 0.082 N potassium hydroxide solution (KOH) (CDA, 2015). Free fatty acid percentage (% FFA) was calculated using the formula (Eq.1) recommended by Coconut Development Authority (CDA) of Sri Lanka,

$$FFA\% = \frac{(V1 - 0.1) \times 20 \times 0.082)}{W} \times 100 \quad (1)$$

Where,
V_1- Volume of the KOH
W- Weight of the Oil sample

Enumeration of Yeast and Mold

Ten samples from the storage tank were taken and kept for a period of 30 days. Then 0.25 mL of Peptone and 2 g of NaCl were mixed and prepared, two 80 mL of Peptone bottles. Then 9.5 g of Dichloran 18% (mass concentration) glycerol agar (DG18) was measured and prepared 300 mL of agar solution. Those were sterilized by autoclaving at 121 °C for 15 minutes. After sterilization 10 mL of Polyoxyethylene (20) Sorbittan Mono Oleate (Tween[a] -80) was added to each 80 mL of peptone solution. Then 10 mL of sediment sample and 10 mL of VCO sample (without sediments) were added separately for each 80 mL of peptone bottles. Shacked well and four petri dishes of 5 mL of the solution will be prepared of each treatment excluding the control. The plates are then aerobically incubated at 25 °C±1 °C for five days to seven days (Anon, 2013).

Data Analysis

The data generated from the experiment were statistically analyzed using the General Linear Model (GLM) procedure of SAS Statistical Analysis package, (SAS, 2006). Mean separation was done using Least Significant Difference (LSD) and relationship between the % FFA and mold growth was analyzed using Chi-square test and regression procedures.

RESULTS AND DISCUSSION

Performance of the Filters

There were significant difference between the heights of the sediment (HOS) recorded from the tank number 1, 2 and 3 of each and every day. Among the 20 days, the filter less control samples (Tank 1) was significantly difference from the value of other tanks each day (Table 1).

Height of the sediment recorded in tank 1, tank 2 and tank 3 were significantly different (Table 1). That reveals the plate and frame filter press 1 and plate and frame filter press 2 were filtering well. Height of the sediment recorded in tank 3 and tank 4 also were not significantly different, therefore it shows that the polish filter was not filtering the sediment well (Table 1). Also the height of the sediment recorded in tank 4 and tank 5 were not significantly different. Therefore it shows that the cartridge filter was not filtering the sediment well (Table 1). It may due to the fine particles which are smaller than the pore size of each filter may go through the

Table 1. Mean values of the height of the sediment recorded from each tank

Day	Tank Number						
	1(Control)(mL)	2(mL)	3(mL)	4(mL)	5(mL)	cv	LSD
1	0.300010^{a}	0.216670^{b}	0.156670^{c}	0.14000^{cd}	0.113330^{d}	2.306	0.0339
2	0.301231^{a}	0.200000^{b}	0.156667^{c}	0.160000^{c}	0.113333^{d}	2.306	0.0154
3	0.233221^{a}	0.180000^{b}	0.156670^{c}	0.110000^{c}	0.150000^{b}	2.306	0.0392
4	0.211567^{a}	0.113333^{b}	0.106667^{c}	0.07333^{cd}	0.073333^{d}	2.306	0.0172
5	0.202245^{a}	0.173333^{b}	0.130000^{c}	0.100000^{d}	0.093333^{d}	2.306	0.0224
6	0.299240^{a}	0.176670^{b}	0.14667^{bc}	0.130000^{c}	0.113330^{c}	2.306	0.0365
7	0.282120^{a}	0.140000^{b}	0.13000^{bc}	0.10667^{dc}	0.100000^{d}	2.306	0.0255
8	0.274511^{a}	0.140000^{b}	0.113333^{c}	0.100000^{c}	0.080000^{d}	2.306	0.0196
9	0.288800^{a}	0.150000^{b}	0.150000^{b}	0.120000^{c}	0.100000^{d}	2.306	0.0000
10	0.201220^{a}	0.170000^{b}	0.070000^{c}	0.080000^{c}	0.080000^{c}	2.306	0.0231
11	0.198809^{a}	0.153333^{b}	0.100000^{c}	0.100000^{c}	0.100000^{c}	2.306	0.0054
12	0.193455^{a}	0.130000^{b}	0.100000^{c}	0.093333^{c}	0.080000^{d}	2.306	0.0109
13	0.158456^{a}	0.073333^{b}	0.060000^{c}	0.046667^{c}	0.043333^{c}	2.306	0.0188
14	0.197760^{a}	0.140000^{b}	0.140000^{b}	0.093330^{c}	0.060000^{c}	2.306	0.0356
15	0.187780^{a}	0.126670^{b}	0.10333^{bc}	0.066670^{c}	0.050000^{c}	2.306	0.0639
16	0.234480^{a}	0.193330^{b}	0.140000^{c}	0.100000^{d}	0.100000^{d}	2.306	0.0272
17	0.189976^{a}	0.100000^{b}	0.09333^{bc}	0.08667^{bc}	0.080000^{c}	2.306	0.0154
18	0.319930^{a}	0.20000^{bc}	0.216670^{b}	0.170000^{c}	0.120000^{d}	2.306	0.0317
19	0.295899^{a}	0.200000^{b}	0.106667^{c}	0.070000^{d}	0.080000^{d}	2.306	0.0196
20	0.209230^{a}	0.140000^{b}	0.113330^{c}	0.086670^{d}	0.09333^{cd}	2.306	0.0249

Means followed by the same letter in each row are not significantly different at 0.05 probability level; cv- Critical value; LSD- Least significant difference

filter pores and shows as sediments. The filter material should clean with hot water when it shows the low filtering efficiency.

The cleaning process is done according to the manufactures, as an average, plate and frame filter press is cleaned once a week, polish filter is cleaned once a month and cartridge filter is cleaned once in a two months.

The blocking effect of the filter pores may occur inefficient filtering effect. Filter which is placed after a storage tank will minimize the percentage of sediment (Bawalan and Champman, 2006) or using of filter aid namely Perlite, diatomite filters can be used for better filtration of solid particles (Perlmutter, 2009).

Effect of FFA on Mold Count

The experiment conducted to determine the relationship between free fatty acid percentage (% FFA) and mold growth of the same sample of sediment layer and Oil layer shows, an increment of the % FFA (0.09±0.014%) and Mold count (32.2±5.45 CFU/g) of Sediment layer than % FFA (0.03±0.003%) and the mold count (17.5±9.52 CFU/g) of the oil layer (Table 2). The % FFA and the mold count of the sediment layer are significant at the 0.05 probability level. Also the % FFA and the mold count of the oil layer are significant at the 0.05 probability level (Table 2).

Table 2. Mean values of mold count and FFA percentage

Factor	Sediment layer	Oil layer
Mold Count (CFU/g)	32.2±5.45[a]	17.5±9.52[a]
FFA%	0.09±0.014[b]	0.03±0.003[b]

Means followed by the same letter in each column are not significantly different at 0.05 probability level, FFA-Free fatty acid, CFU- Colony forming units

When the model is fixed, sediment layer showed high response than the oil layer, consequently the effect of % FFA over the level of mold count is significantly higher in sediment layer (49%) than the oil layer (19%). It may be due to the mold which can be found whenever there is moisture, oxygen and a source of nutrients. Therefore the sediments which has high % FFA than oil layer shows significant mold count.

CONCLUSIONS

In the present study the results of filter performance conformed the filtering ability of the plate and frame filter press 1 and plate and frame filter press 2 were significant than the polish filter and the cartridge filter. Results from the free fatty acid test revealed that the free fatty acid (approximately 49%) are responsible for the mold growth on the sediment layer, than the free fatty acid (approximately 19%), on the Virgin Coconut oil layer. The rest of the percentage may be the moisture and other contaminants etc. Placement of the cartridge filter after the settling tank which kept the oil for seven days can be proposed as a measure to enhance VCO quality by improving its clarity.

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