Production of Dried Pulverized Kernel for Virgin Coconut Oil Extraction:

Assessment on Particle Size Distribution, Drying Curve Pattern, and Quality Characteristics

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ABSTRACT

Virgin Coconut Oil is a unique product which enjoys a good international market. It can be produced either by wet or dry processing method. The present study evaluated the quality characteristics of dry kernel obtained from two steps in dry processing method.

(a) Pulverizing using an electrically operated pin cutter
(b) Drying method using a tray-type dryer

Both machines were locally fabricated.

Fully matured seasoned coconuts, three hundred each in two batches, were de-husked and de-pared. These were disintegrated into pulverized kernel using the pin cutter machine. An electrically operated tray type oven dryer was employed for dehydration at a temperature around 60^0C. It is observed that a gradual increase of drying rate during the 4^{th} hour and subsequently decreasing towards the end of the process.

Particle size distribution is another important parameter to evaluate the performance of the locally fabricated pin cutter. To make an evaluation of the particle size of the dry pulverized sample, a commercially available DC sample was used. According to the results, an average of 86.16% medium size and 13.84% large size particles could be found in a randomly selected sample. Storability of the dried kernel particles were carried out taking a commercial DC sample as the control. Dried pulverized kernel was compared with commercial DC with respect to various quality parameters. It is observed that large size particles contain higher moisture content than that of medium size particles. The moisture take up by the dried pulverized kernel was little higher than the commercial DC. It was observed that PV was not detected in the commercial DC samples during the first three weeks but in the case of dried pulverized kernel samples PV was detected from the second week onwards.

The shelf life of the dried pulverized kernel was three weeks as compared to the commercial DC which could be stored for six weeks. In the colour change study, the colour of the coconut turned in to off white in both commercial DC and dried pulverized kernel samples.

Keywords: *Coconut processing, virgin coconut oil, desiccated coconut*

INTRODUCTION

Virgin coconut oil (VCO) is a unique product of coconut. Due to an up surging market segment for VCO, there is a growing interest among the coconut producing countries for VCO production. VCO can be produced either by a wet or dry processing method. In the wet processing method, VCO is produced directly from the fresh comminuted coconut kernel by separating the milk. Coconut milk, thus, extracted is essentially an oil-in-water emulsion that is stabilized by proteins. For the recovery of oil, the protein bonds associated with the milk are broken down by application of heat, enzymes or some other mechanical force. Although, in this method, heat is not applied directly to extract oil, the extracted oil has to be dried in the final stage to remove residual moisture (Balawan and Chapman, 2006). VCO could also be produced through the intermediate moisture content (IMC) method. In contrast to the wet method, IMC method involves a partial dehydration of coconut kernel. In this method, coconut kernel is comminuted into fine particles and dried under controlled temperature condition to reach moisture content of 10 to 13%. The dried comminuted kernel is then subjected to hydraulic press extraction to recover VCO. Since the oil is extracted from the higher-moist raw material, the VCO produced may have higher amount of moisture. Although both of these methods are operationally simple and require low capital investment, their output capacity is not sufficient for a medium-scale operation. Secondly, in both these processing methods, occurrence of higher moisture in the final product is the major disadvantage. Therefore, eventually, excess of moisture has to be expelled from the oil by means of heat treatment, which ultimately leads some discoloration of the final product, which is disadvantageous.

An alternative dry processing method could overcome the above mentioned drawbacks effectively. In this method, coconut kernel has to be pulverized to the category of medium-size particles and then dehydrated at 60 °C until the moisture content reaches 2 – 3 %. In the recent years, the Coconut Research Institute of Sri Lanka has taken much effort to popularize the dry processing method through developing and introducing local machinery. These efforts have led to the fabrication of a pin-cutter and a low-pressure oil expeller, which are both affordable to the local VCO extraction industry. Since the fabrication of pin-cutter was done on a research and development basis, it may be useful to evaluate its performance through field test trials. In fact, preparation of dried-pulverized kernel is the key step in the production of VCO under dry processing method. The suitability of dried-pulverized kernel for VCO could be checked only through the conduct of field trials. Hence, the objective of this study was to conduct field test trials to evaluate the suitability of dried-pulverized kernel in terms of particle size distribution, drying curve pattern, and other physico-chemical and microbial quality parameters.

MATERIALS AND METHODS

Materials

Fully matured seasoned coconuts were collected from the Bandirippuwa Research Centre of the Coconut Research Institute. Samples of medium sized desiccated coconut were purchased from the Coconut Producers Co-operative Society of Marawila, Sri Lanka. All the chemicals used in this study were of analytical grade unless otherwise specified.

Methods

Pre-processing of coconuts

A batch of three hundred coconuts were de-husked and de-shelled to get wet kernel. After peeling-off the brown testa, the white kernel was split-open to remove water.

Pulverization of wet kernel

Split-halved kernels were broken manually into pieces and fed into a locally fabricated pin-cutter to pulverize into medium size kernel particles. The pin-cutter is a machine consists of two different kinds of cutters that are operated by 0.25 HP electric motors. The first cutter helps to disintegrate coconut kernel from bigger pieces to smaller pieces. It is equipped with precision ground concentric cutting teeth and blades fixed on a revolving drum and mounted horizontally into a screw type conveyer and is wide open to a funnel for the feeding of wet kernel. The cut pieces coming out of this are passed onto the second cutter through the screw type conveyer that is mounted vertically to the conveyer. The second cutter has its blades fixed onto a revolving drum to produce medium size kernel particles. When wet coconut kernel pieces are introduced to the center of the rotating unit, they are shredded and thrown towards the periphery by centrifugal action. Finally, the vertically mounted blade of the cutter helps to expel the pulverized kernel particles into a collection vessel kept at the bottom. All parts of the machine that are in contact with the food material is made of stainless steel (No.316).

Dehydration of pulverized kernel

The wet kernel pieces pulverized by the pin-cutter were loaded into an electrically operated tray-type dryer. The dryer consisted of a drying chamber, a power driven fan and an exhaust fan, equipped with facilities to adjust the temperature and pressure. Since the system is automatically controlled by means of thermostat, it is reliable for constant temperature dehydrations. In this system, the drying chamber is divided into two compartments with two doors for easy handling of trays which are made out of wooden frames with stainless steel wire mesh. When uploading, pulverized kernel is spread uniformly up to about 1-2 inches in the trays to ensure even drying for all particles and the thickness exceeding this limit might affect the uniformity of drying. The contents of the trays are turned over at the 4th hr of the drying process to ensure uniformity of drying of particles in the top and bottom layers. The drying process was carried out at 60^{0}C for 8 hr.

Packaging

Polythene was used as the packaging material to store dried pulverized kernel. The dried samples were packed in clean packages under hygienic condition, and sealed immediately to protect them from contamination.

Determination of Particle Size

The particle size distribution of the dried pulverized kernel samples were carried out using a sieve.

Determination of the drying curve

Pulverized kernel samples were drawn from the tray type oven dryer at the start of drying (0 h) and subsequently at half hourly intervals for a period of 8 h. Moisture contents of the samples were determined according to the standard oven method (AOAC, 1999).

Determining the basic quality parameters of dried pulverized kernel and commercial DC sample

Quality tests were carried out for the dried pulverized kernel, commercial DC, and residual oil cake samples according to standard test methods (AOAC, 1999; SLS 98: 1970).

Microbiological Analysis

Determination of aerobic plate count

After incubation for a period of 72 hr at 30^{0}C, duplicate plates were counted by naked eye and results were recorded as per dilution (AOAC1999; FDA1978) and number of colonies were multiplied by the dilution factor and reported as the number of colony – forming units (CFU) per gram of sample.

Determination of yeast and mould count

After incubation for a period of 72 hr at 30^{0}C, duplicate plates were counted by naked eye and results were recorded as per dilution (AOAC1985; FDA1978) and number of colonies were multiplied by the dilution factor and reported as the number of colony – forming units (CFU) per gram of sample.

RESULTS AND DISCUSSION

Pulverized coconut kernel required for VCO production was obtained by passing through a pin cutter machine, with a throughput capacity of 400 nuts per hour. The pulverized kernel was dried in an electrically operated tray type oven drier at 60°C for 8 hr.

Drying curve of the pulverized kernel

A drying curve was plotted using the data obtained for the variations in the moisture content of the pulverized coconut kernel Vs drying time as shown in Fig. 1.

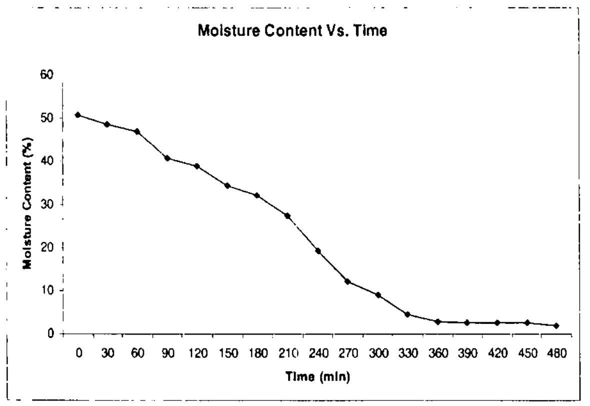

Fig. 1. *Drying Curve of Pulverized Coconut Kernel at 60 °C*

As seen with other materials, the drying rate of the pulverized kernel depends on several factors. Although higher temperatures are favorable for faster drying, there is limitation with regard to the increase of temperature, due to scorching and casehardening of the kernel particles. Therefore, a low temperature drying around 60° C is applied in this study maintained the quality of the kernel from undesirable color changes. According to Fig. 1, the rate of drying increased gradually to reach the maximum during time of 4 hr. Subsequently the drying rate was gradually decreasing towards the end of the process as shown in the Table 1.

Table 1. *Drying rate variation through out drying process of pulverized coconut kernel*

Time (h)	Drying Rate
1	0.065
2	0.13
3	0.12
4	0.21
5	0.17
6	0.10
7	0.003
8	0.013

Particle size distribution of dried pulverized kernel

Particle size distribution is another important parameter to evaluate the performance of the locally fabricated pin cutter. For this purpose, dried pulverized kernel samples were drawn from three different batches to assess the particle size distribution. According to the data presented in Table 2, in a randomly selected sample, on average, 86.2% were medium size particles and 14.8% were large size particles.

Table 2. *Particle size distribution in the dried pulverized kernel sample*

Trial number	Medium size particle (%)	Large size particle (%)
1	86.4±0.9	13.6±0.9
2	85.4±1.5	14.6±1.5
3	86.6±0.2	13.4±0.2
Mean ± SD	86.2±0.6	13.8±0.6

Commercial DC samples in the market contained 100 % of the medium size particles. In commercial DC operations, after drying, the whole product is conveyed on to an inclined vibratory mesh and passed through a screen where over burnt and charred particles are removed manually and in the subsequent step, the product is sorted into different particle sizes such as course, medium, and fine by a grading machine (RERIC, 2002).

With respect to their physical appearance, a distinct difference could be noticed between finer and bigger particles of the dried pulverized kernel. While the finer particles showing a creamy white color, the bigger particles showed an off-white color which may have resulted due to some scorching effect during dehydration. At this point, it is worthwhile to look into the drying efficiency of the particles of different sizes produced by the pin cutter. In the tray type dryer it might not be possible that all particles are dried in the same rate. Usually, smaller particles such as medium size particles may dry faster than the large particles. Hence, there is an apparent difference in their moisture contents as shown in the Table 3.

Table 3. *Moisture contents of large and medium size particles in a randomly selected sample*[1]

Particles	Moisture content
Large size particles	2.5±0.2
Medium size particles	2.1±0.0

[1]Each value in the table represents the mean ± standard deviation of duplicate analysis

Storability of dried pulverized kernel produced through pin cutter

To test the storability, dried pulverized kernel obtained through the locally fabricated pin cutter was compared with commercial DC with respect to various quality parameters. The shelf life of the samples was monitored for a period of six weeks.

Moisture content variation of the samples during storage

Moisture content is one of the principle factors, which govern the overall quality of desiccated coconut. Generally, rancidity and microbial contaminations may proportionately increase with the increase of moisture content of the sample. With the change in microbial quality, physical characteristics such as color may turn from creamy white to off-white. According to Fig.1, the initial moisture content of the wet pulverized kernel was 50.8%. After drying the kernel using the tray type dryer the moisture content was dropped to 1.8%. However, during the first week of storage, moisture content of the sample was found to rise to 2.8%, and this might be due to the equilibration effect. Although the samples were sealed in polythene bags, they may tend to absorb moisture and rise up during the storage period. As could be seen from the Table 4, moisture take up by the dried pulverized kernel was little higher than the commercial DC samples.

Table 4. *Variation of Moisture Content of Dried Pulverized Kernel and Commercial DC during Storage*[1]

Time(week)	Moisture Content of Dried Pulverized Kernel	Moisture Content of Commercial DC
0	1.8±0.0	2.0±0.1
1	2.8±0.4	2.2±0.0
2	2.8±0.0	2.5±0.0
3	3.1±0.1	3.0±0.0
4	3.3±0.2	3.1±0.0
5	3.4±0.1	3.2±0.0
6	4.0±0.1	3.4±0.0

[1]Each value in the table represents the mean ± standard deviation of duplicate analysis

According to the Codex standards and Sri Lanka standards for DC, the moisture content of DC shall not exceed 3% (w/w) (SLS 177: 1991). In the present study, both dried pulverized kernel and commercial DC were found to exceed this limit within the first two weeks of storage. To overcome this, an alternative packaging material which can act as effective barrier for moisture movement has to be selected.

Free fatty acid content variation of samples during storage

Due to excessive moisture, oil samples may be split into glycerol and component fatty acids by hydrolysis. This is what is known as hydraulic rancidity and because of this; a mild soapy flavor may develop in DC samples during storage. For the monitoring, FFA contents of oil samples extracted from the dried pulverized kernel and commercial DC samples were tested during the six week period of storage. The data presented in Table 5 showed that FFA content of dried pulverized kernel was always greater than that of the commercial DC. According to the Sri Lanka standards for DC, the total acidity of extracted oil from grated DC shall not be more than 0.3% (w/w), measured as lauric acid (SLS 177: 1991). In this study, the FFA of both dried pulverized kernel and commercial DC were within the recommended limits after a period of six weeks.

Table 5. *Variation of FFA Content of Dried Pulverized Kernel and Commercial DC during Storage*

Time (week)	*FFA Value ofDried Pulverized Kernel*	FFA Value ofCommercial DC
0	0.07	0.06
1	0.17	0.10
2	0.17	0.10
3	0.17	0.12
4	0.21	0.14
5	0.21	0.14
6	0.21	0.14

Peroxide value variation of samples during storage

The degree of oxidation that has taken place in a fat or oil can be expressed in terms of peroxide value (PV). When the double bonds of unsaturated fats become oxidized, hydro peroxides are formed as the primary products of oxidation. Upon standing these hydro peroxides may get fragmented leading to the formation of aldehydes, ketones and shorter chain fatty acids, which are responsible for the development of off-flavor (Min, 1998). In the present study, PV of oil samples extracted from the dried pulverized kernel and commercial DC samples were monitored for a period of six weeks.

Table 6. *Variation of PV of Dried Pulverized Kernel and Commercial DC during Storage*

Time (week)	*PV ofDried Pulverized Kernel*	PV of Commercial DC
0	0	0
1	0	0
2	0.64	0
3	0.72	0
4	0.80	0.22
5	1.18	0.36
6	1.20	0.38

According to the data presented in Table 6, in the commercial DC sample PV was not detected during the first three weeks but in the case of dried pulverized kernel samples PV was detected from the second week onwards. This showed that there was a higher tendency for the formation of hydro peroxides in the dried pulverized kernel when compared to the commercial DC samples. This difference could be due to the differences in their processing methods. In commercial DC production, addition of a bleaching agent and immersing of the wet kernel in hot water are two requirements prior to the pulverization step. Apart from these, various other hygienic practices are also adopted in the process to safeguard the quality of the final product. Further, the DC thus prepared is packaged immediately under air tight seal in order to minimize the exposure to oxygen. Hence, the commercial DC is less prone to hydroperoxide formation.

Variation of microbiological quality of dried pulverized kernel and commercial DC with time

Generally, coconut either in dry or wet form is a good nutrient medium for microbial growth (Thampan, 1993). Hence, sanitary precautions are necessary during processing to ensure longer shelflife of coconut products. To determine the microbiological quality of the samples, estimates of the bacterial colony count, and yeast and molds counts are used. This is based on the fact that living bacterial cells or clumps of cell will grow and increase in numbers in or on the surface of a suitable agar medium to visible colonies which can be counted. By this method, number of colony forming units (cfu) in the original sample can be determined. The data presented in Tables 7 and 8 show the estimates of aerobic plate count and yeast and moulds counts of the samples, respectively.

When DC is stored at ambient temperature conditions, microorganisms can multiply by taking nutrient from the DC. According to the specifications of Sri Lanka standards the aerobic

Table 7. *Estimated number of Aerobic Plate count in Dried pulverized kernel and Commercial DC during Storage*

Time (week)	Estimated No inCommercial DC	Estimated No in Dried Pulverized Kernel
0	N.D.	N.D.
1	$2.4*10^2$	$2.7*10^4$
2	$2.7*10^2$	$3.1*10^4$
3	$2.9*10^2$	$3.1*10^6$
4	$2.9*10^2$	$3.7*10^6$
5	$3.2*10^2$	$4.1*10^6$
6	$1.3*10^4$	$4.1*10^6$

Abbreviations: N.D., not determined;

Table 8. *Estimated number of Yeast and Moulds in Dried Pulverized Kernel and Commercial DC during Storage*

Time (week)	Estimated No inDried Pulverized Kernel	Estimated No in Commercial DC
0	N.D.	N.D.
1	$1.7*10^2$	$1.1*10^2$
2	$1.8*10^2$	$1.1*10^2$
3	$1.9*10^2$	$1.9*10^2$
4	$2.8*10^2$	$2.4*10^2$
5	$1.6*10^3$	$1.8*10^4$
6	$3.2*10^4$	$3.4*10^4$

Abbreviations: N.D., not determined;

plate count can not exceed the range 10^4 to 10^5 (SLS 98:1988). Data in Table 7 shows that the commercial DC was able to remain within this limit all through out the six weeks of storage. However, the dried pulverized kernel sample was able to remain within this limit only up to two weeks of storage. Likewise, the data presented in Table 8 shows the growth of yeast and mold in the two samples. According to the specifications of Sri Lanka standards, yeast and mould count can not exceed the range $1*10^2$ to $2*10^2$ (SLS 98:1988).

The data shows that the dried pulverized sample can remain within this limit only up to a period of three weeks time. Based on the overall microbiological quality, it can be said that the dried pulverized kernel sample demonstrates lower microbiological quality when compared to the commercial DC sample. The reason for this could be the poor hygienic practices prevailed in the processing of the dried pulverized kernel. In the first instance, there was no seal between the pre-processing area and kernel pulverizing and drying area. Contaminations could also be possible due to microbial population remaining in the equipments used for paring, splitting, and pulverizing of the kernel. Also, the possibility of contamination by human hands can not be ruled out.

On the contrary, in commercial DC manufacture better precautions are adopted to prevent the invasion of microbes at various stages of processing. The use chlorinated water and hot water dipping are two important practices adopted to bring down the microbial load of the wet kernel. Apart from this, steam sterilization is used at different point of the production line to prevent contaminations (RERIC, 2002).

Based on the above results, the dried pulverized kernel can keep good under ambient temperature conditions up to a period of 2 – 3 weeks. Therefore, if the dried pulverized kernel sample is to be used for VCO production, it is advisable to use it within two weeks from the day of production.

Color changes of Dried pulverized kernel and Commercial DC

With the increasing population of microorganisms color changes may also occur in these samples. Color changes could be the result of biochemical changes in the samples. Therefore, it is appropriate to monitor the color changes of these two samples during the six weeks of storage. For this purpose, samples kept in storage were taken for visual observation of color at weekly intervals. According to Table 9, in both samples there is a gradual change of colour.

Table 9. *Color Change of Dried Pulverized kernel and Commercial DC during Storage*

Time (week)	Dried pulverized kernel	Commercial DC
0	Cream White	Cream White
1	Cream White	Cream White
2	Cream White	Cream White
3	Yellowish White	Cream White
4	Yellowish White	Cream White
5	Off Cream White	Low Cream White
6	Off Cream White	Low Cream White

The dried pulverized kernel turn in to off color more rapidly than Commercial DC. It could keep the cream white colour only up to two weeks. From the third week on wards it turned into yellowish. Starting from the fifth week a complete off-white could be seen.

CONCLUSIONS

In this study, an electrically operated pin cutter and a tray type-oven dryer were assessed for their suitability to produce dry pulverized kernel for VCO extraction. The dryer had an operational capacity of 80 kg per batch. Its drying rate was gradually increasing to reach the peak during the fourth hour of dehydration, but subsequently it was gradually decreasing towards the end of the process.

The pin cutter has an operational capacity of three hundred nuts per hour. According to particle analysis, the dried pulverized kernel had an average of 86.16% medium size particles and 13.84% large size particles. From the storability test of dried pulverized kernel, the moisture take up by the dried pulverized kernel was little higher than the commercial DC samples. The FFA content of dried pulverized kernel was always greater than that of the commercial DC. PV was not detected during the first three weeks but in dried pulverized kernel sample, PV was detected from the second week onwards. Therefore, the dried pulverized kernel sample needs to be packed immediately under air tight seal to minimize the contact of oxygen. Further studies on the packaging materials to store dried pulverized kernel samples are recommended.

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