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EXTRACTION AND CHARACTERIZATION OF OIL FROM AVOCADO APPLE USING STEAM DISTILLATION.

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ABSTRACT

This paper presents an improvised process for the production of high quality oil from the pericarp (peels) of avocado apple using steam distillation at three different heating rates. Variations in time and volume of water used to generate the steam for the process are given as follows: 30, 60, 90 and 120 minutes and 1000ml, 1250ml and 1500ml respectively. The active principle (oil) was further processed by treating it with activated clay and heating to a constant temperature of 100°C for 30 minutes to produce high quality refine oil. Finally, the crude and refine oils were characterized in other to determine their suitability for industrial applications. The results revealed that the heating rate of 2.57ml/min (moderate) gave the maximum oil output of 59.8% whereas 4.72ml/min (low) and 4.94ml/min (high) heating rates gave oil yields of 38.7% and 39.6% respectively. The physicochemical analysis of the refined oil showed that the oil has a saponification value of 196.4, iodine value of 67.7, free fatty acid value of 0.0872, acid value of 5.653, peroxide value of 1.27mg/kg, specific gravity of 0.90261g/ml, viscosity of 181.180cp, refractive index of 1,600, melting point of 65°C and boiling point of 89°C. Based on the conformity of these properties to the international standards (ISO/TR 21092, ISO/TR 210, ISO 212, AOCS), the present oil is a potential substitute for most oils used for cosmetics and pharmaceutical drugs productions.

Keywords: *Avocado apple pericarp, extraction, characterization, steam distillation.*

INTRODUCTION

Avocado apple (Persea americana) variously called avocado, avocado pear, alligator pear, ahuacatl or agvacate is a highly nutritional fruit rich in proteins, fats and oils and low in sugar (Martin *et al*, 1987). The total food value is high providing nearly twice the energy of an equivalent weight of meat as well as an abundance of several vitamins such as A, B, C, D and E. A typical composition of the avocado apple shows a 65% mesocarp (flesh), 20% endocarp (seed) and 15% pericarp (peels). Other well-known members of the laurales of which the persea americana belong are Cinnamon, Sassatras, gratissima and greenheart (Samson, 1986).Three different species have been identified. These are Mexican, Guatemalan and West Indian prevalent in the subtropical, semitropical and tropical climate areas respectively (Martin *et al*, 1987). All the three species are largely cultivated and produced to varying degrees in the tropical rainforest and Savannah belts of Nigeria. With the abundant production of avocado apple, in Nigeria, 15% of avocado apple (pericarp) is discarded as waste which ought to have been a potential source for production of oil for industrial applications (Irvine, 1970; Opeke, 1987).The method of extraction of oil from the avocado apple peel is as varied as the species (Coke, 1996; Romeo, 2000), though of most important is the use of steam distillation. Steam distillation is the process that involves the use of steam to percolate and vaporize out the oil from the sample material with the subsequent condensation of steam and oil prior to their separation using a settling tank, separating funnel or a any similar vessel (Reverchon, 1997). A necessary condition for the application of steam distillation is that the desired product (whether for volatile material passing over from the still or the non-volatile residue remaining in the still) must be practically immiscible with water (McGraw *et al*, 1999). Therefore, the aim and objectives of the present work was to find possible uses of the avocado apple's peel (Pericarp) that are hitherto discarded as wastes. Specifically, the work is aimed at producing oil from the pericarp of the avocado apple using steam distillation at three different heating rates using an improvised process. More so, the aim covered the characterization of the oil extracted from the avocado apple pericarps/peel.

MATERIALS AND METHODS

Procurement and Pretreatment of Avocado Apple and Peels (Pericarp)

The avocado apple was sourced locally form Obollo-Afor market, Nsukka, in Enugu state of Nigeria. The fruits were thoroughly washed and screened to remove foreign bodies. The pericarp/peel was removed from the mesocarp and the endocarp (seed). The pericarp/peel was dried at room temperature (25°C) for five days to eliminate moisture. The dried pericarp was thereafter reduced to particle sizes ranging from 0.75mm to 2.00mm

Steam Distillation of Oil from AVOP

1000 ml of water was introduced into the bottom chamber of the still. The chamber was covered with a perforated metal plate in which a white filter cloth was

placed. 10 g of AVOP was then placed on the filter cloth. This was further covered with white filter cloth. The last perforated metal plate was placed on the top compartment. Finally, the still was made air tight with the last covering to prevent the escape of the steam oil mixture during heating. The set-up was then connected to a condenser via a pipe fixed at the top of the extraction still where an opening had been made. The delivery tube from the condenser led to the separating funnel to receive the mixture of steam and oil on condensation. The set-up was then mounted and connected to three heating sources alternatively for extraction times of 30, 60, 90 and 120minutes respectively. At the end of the time intervals, the set-up was switched-off and allowed to cool. The water-oil mixture was decanted to separate the oil from the water at the water-oil boundary. Thereafter the mass of the AVOP after extraction and drying in an electric oven was recorded. The mass of oil extracted was also recorded. This procedure was repeated for 1250 ml and 1500 ml of water respectively.

Refining of crude oil

Subsequently, the crude oil was refined with activated clay (bleaching earth) which was previously sieved to 70 5 microns. 0.1% by weight of the clay was added to 10g of the oil sample. The mixture was then heate constant temperature of 100°C with stirring f minutes. The oil was then filtered at the temperature and the filtrate characterized.

Characterization of the Crude and Refined Oils

The free fatty acid,acid value,iodine value,pero value,saponification value,specific gravity refractive index were determined using stand methods AOCS (1989).The viscosity was determ following the method described by (Nelson Gate,1990).

RESULTS AND DISCUSSION

The yields of steam distillation of avocado ap pericarp at various thermodynamic condition particle sizes of the avocado's pericarp are give Tables 1-10. The physicochemical properties of t crude and refined oils are given in Table 11.

Table 1: Yields of Oils at Varying Steam Heating Rates and 1000ml of Water

Volume of water (ml)	Mass of AVOP	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1000	10	30	7.78	20.54	0.69	2.64	2.22	22.2
1000	10	60	7.25	59.60	0.99	8.22	2.75	27.5
1000	10	90	6.86	181.65	2.02	26.48	3.14	31.4
1000	10	120	6.47	247.15	2.06	38.20	3.53	35.3

In Table 1, the yields of oils at varying steam heating rates are given. At the extraction time of 120 minutes an 1000ml of water, the maximum oil yield was 35.3%. From the results in Table 1, at a higher time, there was corresponding increase in yields of oils.

Table 2: Yields of Oils at Varying St eam Heating Rates and 1250ml of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam-sample ratio (ml/g)	Steam rate (ml/min)	Mass of oil (g)	% yield
1250	10	30	7.68	39.94	5.20	1.44	2.32	23.2
1250	10	60	7.37	94.48	12.82	1.57	2.63	26.3
1250	10	90	6.84	195.62	28.60	2.17	3.16	31.6
1250	10	120	6.26	268.43	42.88	2.24	3.74	37.4

At 1250ml of water for steam generation, the steam heating rate increased at the corresponding time interval and hence the volume of steam. However, the yield of oil (37.4%) was still maximum at the highest extraction time (120 minutes) which was in accordance with the value (Table 2).

Table 3: Yields of Oil at Varying Steam Heating Rates and 1500ml of Water

Volume of water used (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam used (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1500	10	30	7.62	76.35	2.55	10.02	2.38	23.8
1500	10	60	7.12	214.45	3.57	30.12	2.88	28.8
1500	10	90	6.56	407.25	4.53	62.08	3.44	34.4
1500	10	120	6.13	566.04	4.72	92.34	3.87	38.7

Table 3.0 gives the yields of oils at varying steam heating rates and 1500ml of water. From the table, maximum oil yield was achieved at 120 minutes extraction time and this was 38.7%. The volume of steam used over the time increased progressively due to the volume of water used. Similarly, there was a corresponding increase in oil yield with time (Table 3).

Table 4: Yields of Oils at Varying Stea m Heating Rates and 1000ml of Water

Volume of water (ml)	Mass of sample (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1000	10	30	7.47	103.76	3.46	13.89	2.53	25.3
1000	10	60	7.14	301.59	5.03	42.24	2.86	28.6
1000	10	90	6.82	463.62	5.15	67.98	3.15	31.8
1000	10	120	6.20	597.87	4.98	96.43	3.80	38.0

Table 4 shows the optimal oil yields of 38.0% from 10 grams of avocado's pericarp at 120 minutes extraction time and 1000ml of water for steam generation. The optimal steam heating rate to the sample was 4.98ml/min. The result from the table showed that the percentage oil yields were time dependent which was in accordance with literature value (Table 4).

Table 5: Yields of Oils at Varying Steam Heating Rate and 1250ml of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1250	10	30	7.56	122.77	4.09	16.24	2.44	24.4
1250	10	60	7.11	332.18	5.54	46.72	2.89	28.9
1250	10	90	6.52	458.23	5.09	70.28	3.48	34.8
1250	10	120	6.04	592.77	4.94	98.14	3.96	39.6

In Table 5, at 1250ml of water used for steam generation, the highest yield of oils was 39.6% at a steam rate of 4.94ml/min. This was at the extraction time of 120 minutes (Table 5).

Table 6: Yields of Oils at Varying Steam Heating Rate and 1500ml of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1500	10	30	7.64	153.03	5.10	20.03	2.36	23.6
1500	10	60	7.27	365.54	6.09	50.28	2.73	27.3
1500	10	90	6.62	519.47	5.77	78.47	3.38	33.8
1500	10	120	6.25	616.75	5.14	98.68	3.75	37.5

From Table 6, oil yield of 37.5% was obtained from 10g of avocado's pericarp. This was at 120 minutes and 1500ml of water for steam generation at a rate of 5.14ml/min. This was the optimal oil yield at the highest time for the experiment. This was in accordance with literature (Table 6).

Table 7: Yields of Oil at Varying Steam Heating Rates a nd 1000ml of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1000	10	30	7.20	63.36	2.11	8.80	2.80	28.0
1000	10	60	6.20	173.60	2.89	28.00	3.80	38.0
1000	10	90	5.82	302.64	3.36	52.80	4.18	41.8
1000	10	120	4.02	308.98	2.57	76.86	5.98	59.8

In Table 7 above, the yields of oils at varying steam heating rates are presented. At the extraction time of 120 minutes and 308.9ml of steam, the maximum oil yields was 59.8%. From the table, it could be seen that yields of oils increased with time to the maximum depending on the steam supply rate.

Table 8: Yields of Oils at Varying Steam Heating Rates and 1250ml of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1250	10	30	7.33	71.83	2.39	9.80	2.67	26.7
1250	10	60	6.38	183.74	3.06	28.80	3.62	36.2
1250	10	90	5.88	366.91	4.08	62.40	4.12	41.2
1250	10	120	5.28	463.58	3.86	87.80	4.72	47.2

Table 8 gives oil yields from 1250ml of water at varying steam heating rates. From the table, the steam rate of 3.86ml/min gave the optimal oil yield of 47.2% and at the highest time of 120 minutes which conforms to literature (Table 8)

Table 9: Yields of Oils at Varying Steam Heating Rates and 1500ml of Water.

Volume of water used (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam used (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1500	10	30	7.20	86.40	2.88	12.00	2.80	28.0
1500	10	60	6.43	24.34	4.07	38.00	3.57	35.7
1500	10	90	4.98	358.56	3.98	71.99	5.02	50.2
1500	10	120	4.12	403.76	3.36	98.00	5.88	58.8

In Table 9 maximum oil yield was achieved at 120 minutes extraction time and this was 58.8%. The volume of steam used over the time increased progressively due to the volume of water used. Similarly, there was a corresponding increase in oil yields with time up till the maximum oil yield at 120 minutes. This conforms to literature value on the influence of time on extraction.

Table 10 : Yields of Oils at Varying Steam Heati ng Rates and Varying Volumes of Water

Volume of water (ml)	Mass of AVOP (g)	Time (mins)	Mass after extraction and drying (g)	Volume of steam (ml)	Steam rate (ml/min)	Steam-sample ratio (ml/g)	Mass of oil (g)	% yield
1000	10	120	6.47	247.15	2.06	38.20	3.53	35.3
1250	10	120	6.26	268.43	2.24	42.88	3.74	37.4
1500	10	120	6.13	566.04	4.72	92.34	3.87	38.7
1000	10	120	6.20	597.87	4.98	96.43	3.80	38.0
1250	10	120	6.04	592.77	4.94	98.14	3.96	39.6
1500	10	120	6.25	616.75	5.14	98.68	3.75	37.5
1000	10	120	4.02	308.98	2.57	76.86	5.98	59.8
1250	10	120	5.28	463.58	3.86	87.80	4.72	47.2
1500	10	120	4.12	403.76	3.36	98.00	5.88	58.8

In Table 10, the yields of oils at the highest extraction time (120 minutes) varying steam heating rates and varying volumes of water are presented. From the table, the maximum oil yields of 59.8% was achieved from 1000ml of water at a steam rate of 2.57 ml/min which represented the moderate heating rate; 2.06 ml/min and 4.94ml/min representing low and high heating rates respectively with oil yields of 35.3% and 39.6% (Table 10).

Table 11 : Physicochemical Properties of Crude and Refined AVOP Oil

Properties	Crude Oil	Refined Oil	Standard Value (AOCS)
Saponification value	198	196.4	185-206
Iodine value	72.4	67.7	70-90
Peroxide value (mg/kg)	3.07	1.27	<10
Free fatty acid value	0.08729	0.0872	.....
Acid value (%)	6.8943	5.653	.....
Specific gravity (g/ml)	0.9162	0.90261	0.901-0.9034
Refractive index	1,456	1,600	1.452-1.470
Viscosity (cp)	172.43	172. 43	.....
Boiling Point (°C)	89 - 90	89	.....

Table 11 gives the values of the physiochemical properties of the refined AVOP oil which are most commonly used to establish the identity of oils. Each of the property was chosen to measure a specific characteristic of the oils.

From Table 11 the properties of the oil such as saponification value, iodine value, peroxide value, free fatty acid value and acid value are mostly used to specify the characteristics of the oil. The others are empirical in nature though they also give useful guidance in identifying the oil. Comparison in Table 11 shows that the difference in saponification value between the crude and refined oils was less than 1% (0.81%). This is attributable to the fact that the oils' many natural constituents are still present and hence little lipase activity. Also, from the tables a 65% level decrease in iodine value between the crude and refined oils implied that less amount of hydrogen would be required in converting the unsaturated components of the oils into saturated oils for industrial use.Similarly, the lower peroxide value (58.63%) of the refined oil implied that the oil cannot be easily decomposed and neither can it become rancid as a result of the presence of triglyceride esters of the oil to form peroxide when compared to the crude oil.An acid value of less than 10 enhances the stability of most oils and both values lie within this range. Thus, the refining quality of the oil is enhanced. The low value of the FFA for both the crude and refined oils implied that the oil contains acid that are

uncombined with glycerol, and thus, do not easily decompose nor become rancid; indicating little lipase activity.

CONCLUSIONS

In conclusion, the results of this investigation based on the yields of oils obtained showed that high quality oil could be obtained from the pericarp of the avocado apple which hitherto had been discarded as waste. A steam distillation process at steam rate of 2.57ml/min (moderate) gave the highest oil yield of 59.8% from the pericarp at extraction time of 120 minutes. The effect of particle size variation was not significant on the steam distillation process as smaller particle sizes (< 2.00mm) formed lumps on percolation of the steam through them making extraction difficult. The physicochemical properties of both the crude oil and refined oils were found comparable with oils of similar structural constituents used for industrial applications.

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