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Evaluation of oil recovery, chemical and sensory quality of virgin coconut oil from different methods

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Abstract
The present investigation was carried out during 2021-2022 at the Post Harvest Technology Laboratory, College of Horticulture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, with the aim of developing functional coconut-based products by producing virgin coconut oil and evaluating its chemical and sensory qualities. The experiment was conducted in completely randomized design (C.R.D) with four treatments viz. cold extraction (M_1), hot extraction (M_2), chilling and thawing (M_3) and Ghana (local/traditional) method (M_4) with five replications. The VCO produced by hot extraction method recorded lowest acid value (0.36). The lowest iodine value and moisture percent was recorded by treatment M_1 *i.e.* 6.09 and 0.08 percent. The VCO developed by local (Ghana) method was found to be highest in oil recovery (30.26%), followed by chilling and thawing method (25.94%). Treatment M_1 showed highest average score (8.48) for overall acceptability.

Keywords: Virgin coconut oil, extraction methods, oil recovery, chemical properties, sensory evaluation

Introduction
Coconut is an important crop in the country, serving as a source of food, beverages and industrial raw material. Nearly 45 percent of the total coconut harvest is utilized in the form of raw nuts, the majority of which (around 70%) are directly consumed at the household level for culinary and domestic purposes. The remaining proportion of the harvest is directed towards industrial processing, where it is converted into a range of value-added products such as desiccated coconut, virgin coconut oil, and coconut milk, which have considerable demand in both domestic and international markets (Bhatt *et al*. 2020) [4].

Virgin coconut oil (VCO) has gained increasing global attention owing to its wide range of medicinal and health-promoting properties. It is characterized by a high proportion of medium-chain fatty acids, with lauric acid accounting for nearly 47-53 percent of the total fatty acid composition, depending on the coconut variety. Lauric acid is well recognized for its potent antimicrobial activity, contributing to the effectiveness of VCO against bacteria, fungi, viruses, and parasites. Beyond its antimicrobial role, the therapeutic significance of VCO has been extensively studied in relation to anti-HIV/AIDS treatments, anti-cancer therapies, and the management of neurodegenerative disorders such as Alzheimer's disease. In addition, VCO serves as an excellent natural remedy for various dermatological applications, particularly in infant skin care, due to its mildness and richness in vitamin E. Notably, VCO is regarded as the world's only natural, low-calorie fat (Bawalan, 2006) [3].

Virgin coconut oil (VCO) is widely recognized as the purest form of coconut oil, primarily due to its clear appearance, mild aroma, and natural enrichment with vitamin E. It is derived from fresh coconut kernel through two major approaches: either by granulating dried coconut or by processing coconut milk under strictly maintained hygienic conditions. Once extracted and filtered, the oil is directly suitable for human consumption without the need for additional processing. The aroma of VCO may vary from mild to intense depending on the extraction method employed, reflecting the natural characteristics of the coconut used. In contrast, conventional coconut oil obtained from copra must undergo refining, bleaching, and deodorization (RBD process) before becoming fit for human use, which often alters its natural qualities.

Because VCO retains its original properties without chemical treatment, it is regarded as superior in purity, safety, and nutritional quality. Furthermore, its minimal processing requirements, combined with health-promoting attributes, have made VCO one of the most sought-after coconut-based products in both domestic and international markets (Bawalan, 2006) [3].

Material and Methods

The experiment was conducted in completely randomized design (C.R.D) with four treatments viz. cold extraction (M_1), hot extraction (M_2), chilling and thawing (M_3) and ghana (local/traditional) method (M_4) with five replications, at the Post Harvest Technology Laboratory, College of Horticulture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) India.

Collection of raw material

Fully matured coconuts (10-11 months old) of cultivar banawali were selected, identified by their yellowish to brown husk and the sloshing sound when shaken. The nuts were collected from the Coconut Nursery, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.), India-415 712.

Extraction of VCO

The VCO was extracted by four different methods as cold extraction, hot extraction, chilling and thawing process and local method of extraction *i.e.* by wood pressed oil extraction machine. The major steps involved in the production of VCO are extraction of coconut milk and coconut oil.

Extraction of coconut milk

The process of production of coconut milk involves selection of nut, dehusking, deshelling, testa removal, washing, grating and lastly extraction of milk. The matured coconuts where dehusked followed by deshelling. The coconut milk for both the cold and hot extraction methods was produced by removing the testa with the help of peeler. Whereas in the chilling and thawing method coconut milk was extracted without removing testa. The coconut kernel was washed and grated with water in 1:1 proportion. Lastly the coconut milk was extracted from grated coconut with the help of muslin cloth (Srivastava *et al*., 2013) [16].

Extraction of virgin coconut oil

a) Cold Extraction Method

Coconut milk was allowed to stand for 24 hours in stainless steel vessel. On setting the coconut milk was separated into 4 different layers. The bottom layer was made up of gummy sediment. The next was watery layer *i.e*. skim milk which was no longer fit for consumption. Third layer was the separated oil and top fourth layer was of floating curd. For easy removal of oil the stainless steel vessel was refrigerated to harden the curd quickly. Then curd was scooped out with the help of spoon. The curd also contained a considerable amount of trapped oil. After being refrigerated the oil too hardens and hence easily separated from the two remaining layers but oil was bit wet hence it was slightly heated for a short time to remove moisture and was finally filtered with the sterilized filter paper by placing in big funnel (Srivastava *et al*., 2013) [16]. Oil was weighed, flushed with nitrogen and stored in dark brown glass bottles at ambient temperature *i.e*. 27 °C to 29 °C prior to analysis (Nurah *et al*., 2017) [9].

b) Hot Extraction Method

VCO was extracted by heating coconut milk at 100-120 °C for 60 minutes, until the water was completely evaporated. Due to heating, the proteins in coconut milk get denatured and destabilizes the milk emulsion. The coagulated protein was separated by filtering through muslin cloth and the remaining residue was further heated to extract more oil (Nivya *et al*., 2023) [8]. Then oil was filtered with the help sterilized filter paper by placing in big funnel (Srivastava *et al*., 2013) [16]. Oil was weighed, flushed with nitrogen and stored in dark brown glass bottles at ambient temperature *i.e*. 27 °C to 29 °C prior to analysis (Nurah *et al*., 2017) [9].

c) Chilling and Thawing Method

Coconut milk was centrifuged (Kubota-High Speed Refrigerated Centrifuge Machine) at 4000 rpm for 10 min and the upper layer of cream was removed for chilling. Chilling was done at 0° C for 6 hours and then the chilled cream was thawed slowly at room temperature to extract the oil (Raghavendra and Raghavarao, 2011) [11]. Coconut cream was further centrifuged at 12000 rpm for another 30 minutes to produce VCO. Then oil was filtered with the help of sterilized filter paper by placing in big funnel (Srivastava *et al*., 2013) [16]. Oil was weighed, flushed with nitrogen and stored in dark brown glass bottles at ambient temperature *i.e*. 27 °C to 29 °C prior to analysis (Nurah *et al*., 2017) [9].

d) Local Method

The fresh copra meat was oven-dried at 40-50 °C until the moisture is reduced from approximately 50 percent to the range of 2-5 percent. After drying the copra meat, the oil was extracted by cold press oil extraction machine (Naik *et al*., 2014). After extraction, oil was filtered with the help of filter paper, weighed, flushed with nitrogen and stored in dark brown glass bottles at ambient temperature *i.e*. 27 °C to 29 °C prior to analysis (Nurah *et al*., 2017) [9].

Observations recorded

The virgin coconut oil was evaluated immediately after preparation. The methods used for the estimation of different parameters are described below.

Chemical Analysis

The chemical analysis of virgin coconut oil (VCO) was carried out for different quality parameters. Acid value was estimated by titrating the oil sample against potassium hydroxide as suggested by Sadasivam *et al*. (2008) [14]. Iodine value was determined using the Hanus method described by Sadasivam *et al*. (2008) [14]. Moisture content in VCO was determined following the method of the American Oil Chemists Society (Firestone, 2009) [5]. The percent oil recovery was calculated on the basis of coconut meat weight and expressed in percentage.

Sensory evaluation

In sensory evaluation appearance, colour, odour and taste of the VCO was observed. The sensory qualities in terms of appearance, colour, odour, taste and overall acceptability were assessed by panel of 10 judges with 9 point Hedonic scale score (Amerine *et al*., 1965) [2]. The overall acceptability score was obtained by averaging the score of appearance, colour, odour and taste.

Statistical Analysis
The chemical composition and sensory qualities of virgin coconut oil was recorded at an interval of 3 months interval up to end of experiment (6 months) and data analysed by the method suggested by Panse and Sukhatme (1995) [10].

Result and Discussion
The chemical properties and sensory quality of virgin coconut oil extracted by different methods were evaluated and the results were statistically analyzed and are presented below.

Chemical properties
1. Acid value (mg KOH/g)
Significantly lowest acid value was recorded for treatment M_2 (Hot extraction method) (0.36 mg KOH/g), which was at par with M_1 (Cold extraction method) *i.e*. 0.38 mg KOH/g and M_3 (Chilling and thawing method) *i.e*. 0.40 mg KOH/g, while highest was recorded for treatment M_4 (Local ghana method) *i.e*. 0.54 mg KOH/g. The low acid value observed in treatment M_2 suggests that the enzymes responsible for hydrolysis, may have been inactivated during the extraction process, possibly due to the application of heat. These results align with the findings of Ramesh *et al*. (2020) [12] where they observed that the lowest acid value was observed for hot extracted method of VCO (0.307 mg KOH/g) as compared to coconut oil (0.900 mg KOH/g).

2. Iodine value (g I_2/100g)
The iodine value (IV) indicates the level of unsaturation in oils and fats. It is defined as the number of grams of iodine absorbed by 100 g of fat under the test conditions. (Nivya *et al*., 2023) [8]. The minimum iodine value was recorded for treatment M_1 (6.09 g I_2/100 g), which was significantly superior over other treatments, while maximum iodine value was recorded for M_2 (8.76 g I_2/100 g). The low iodine value of VCO produced by the cold extraction method indicates a higher level of saturation, making the oil more stable and helping to maintain its quality over time (Rohman *et al*., 2011) [13]. The rise in iodine value in treatment M_4 might be due to the slightly higher amount of unsaturated fatty acids (Nivya *et al*., 2023) [8]. Consistent findings were reported by Ajogun *et al*. (2020) [1], where lowest iodine value (5.72 g/100 g) was recorded for virgin coconut oil extracted by the cold press as compared to hot press method of VCO (6.05 g/100 g).

3. Moisture (%)
The lowest moisture percent was recorded for treatment M_1 (0.08%), which was at par with treatment M_2 (0.09%) and M_3 (0.09%), while highest moisture percent was recorded for treatment M_4 (0.25%). Without heat in the cold extraction process, enzymes that might hold moisture are less active. This helps separate the oil more effectively, resulting in oil with less moisture. Parallel outcomes were documented by Srivastava *et al*. (2013) [16] where they reported the lowest moisture content for cold-extracted virgin coconut oil (0.05%) as compared to hot extracted virgin coconut oil (0.06%).

4. Oil recovery (%)
The statistically highest percent oil recovery was recorded for treatment M_4 (30.70%), which was statistically superior over rest of the treatments, while lowest oil recovery was recorded for treatment M_2 (22.54%), which was at par with treatment M_1 (24.81%). The highest oil recovery for local ghana method, might be due to drying process that helps to concentrate the oil in the coconut meat. As water is removed, the oil becomes more concentrated in the dried flesh, leading to a higher yield when mechanical pressing is applied. This is particularly important because oil content in fresh coconut is lower, and drying increases the overall oil concentration. Similar findings were observed by Satheesh and Prasad (2012) [15], where they noted 36.3 percent of the oil recovery for VCO produced by dry method (by rotary/power ghani).

Sensory quality
1. Colour
The highest sensory score for colour was statistically recorded for treatment M_1 (9.00) and was at par with M_3 (8.95). The lowest sensory score for colour was observed for treatment M_4 (7.40). The cold extracted VCO recorded the highest score for colour because the cold extraction process preserves more of the oil's natural colour and clarity. This method avoids high heat, which can cause discoloration or cloudiness, resulting in a fresher and more appealing appearance. However, Nivya *et al*. (2023) [8] recorded the highest sensory score for colour (9.00±2.15) in virgin coconut oil (VCO) produced using the cold centrifugation method.

2. Odour
Statistically highest sensory score for odour was noted for treatment M_1 (8.10), which was at par with treatment M_3 (8.06), while lowest was noted for treatment M_2 (7.58).
As cold extraction method helps preserve the volatile organic compounds that give VCO its fresh coconut-like smell. Since these compounds are sensitive to heat and oxidation, the cold extraction method helps retain them more effectively.

3. Taste
The highest sensory score for taste was recorded for treatment M_1 (8.00) and it was found to be statistically superior to the other treatments. The lowest sensory score for taste was recorded for treatment M_4 (7.75). The cold extraction method (M_1) avoids high heat, preserving the natural coconut taste and aroma. This gentle process helps maintain the oil's pure and fresh flavour, making it highly appreciated in sensory evaluations for its authentic and pleasant qualities.

4. Appearance
The treatment M_1 recorded maximum sensory score for appearance as 8.80 and was found to be superior over rest of the treatments. Minimum sensory score was recorded for treatment M_4 (7.65). The highest sensory score for appearance of cold extracted VCO might be due to its minimal processing, which helps retain the oil's natural clarity and colour. This method avoids high temperatures, which can cause browning or cloudiness in the oil. As a result, more visually appealing, clear, and light-coloured appearance, leading to higher sensory scores for appearance. However, Ndife *et al*. (2019) [7] reported the highest sensory score for appearance (7.95) of VCO produced through the freezing and thawing method.

5. Overall Acceptability

The overall acceptability score was obtained by averaging the score of appearance, colour, odour and taste. Highest sensory score for overall acceptability was recorded for treatment M_1 (8.48), while lowest was recorded for treatment M_4 (7.59). The highest sensory score for overall acceptability in treatment M_1 might be the combined effect of appearance, colour, odour and taste.

Table 1: Chemical composition and oil recovery of VCO by different methods

Methods	Acid value (mg KOH/g)	Iodine value (g I_2/100 g)	Moisture%	Oil recovery (%)
Cold extraction	0.38	6.09	0.08	24.58
Hot extraction	0.36	8.76	0.09	22.02
Chilling and thawing	0.40	7.61	0.10	25.94
Local (Ghana method)	0.54	8.38	0.25	30.26
Average	0.42	7.71	0.13	25.70
F-Test	SIG	SIG	SIG	SIG
S.E.m±	0.02	0.25	0.02	0.79
CD at 1%	0.08	1.01	0.07	3.27

Table 2: Sensory evaluation of VCO by different methods

Methods	Colour	Odour	Taste	Appearance	Overall acceptability
Cold extraction	9.00	8.10	8.00	8.80	8.48
Hot extraction	8.60	7.65	7.75	7.85	7.96
Chilling and thawing	8.95	8.06	7.80	8.60	8.35
Local (Ghana method)	7.40	7.85	7.45	7.65	7.59
Average	8.49	7.92	7.75	8.23	8.09
F-Test	SIG	SIG	SIG	SIG	SIG
S.E.m±	0.04	0.03	0.04	0.04	0.03
CD at 1%	0.18	0.14	0.15	0.16	0.11

Conclusion

The extraction method had a significant influence on the oil recovery, chemical properties, and sensory quality of virgin coconut oil. Among the methods tested, cold extraction produced VCO of superior quality with desirable chemical parameters and the highest sensory acceptability, while the local (Ghana) method yielded maximum oil recovery but comparatively lower quality attributes.

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