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Optimization of process parameters for extraction of oil from kokum oil seeds by screw press mini oil mill

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Abstract
The seed of Kokum (*Garcinia indica*) oil, which remains solid at room temperature and is colloquially known as kokum butter. Kokum butter is obtained from its fruit kernel as a soft butter-like lipid. Kokum butter is considered nutritive, demulcent, astringent and emollient. It is suitable for ointments, Suppositories and other pharmaceutical purposes. Kokum butter is rich in vitamin E. Kokum butter is wonderful in skincare applications. It is now being used in cosmetics and medicines known as Vrikshamla in Kokum butter is suitable for use as confectionery butter. It is also suitable for making a candle and soap. Standardization of process parameters for extraction of oil from kokum seeds were decided on the basis of the results of preliminary trials and a review of literature, the levels of process variables of extraction of oil were decided such as moisture content (10, 15, and 20%), steaming (4, 6, and 8 min) of raw broken and unbroken kokum seeds. The highest oil yield of 42.9% (T_2WSuB_1) was achieved with a moisture content of 10% (db), while the lowest oil yield of 36.96% (T_2WSuB_3) was obtained at the highest moisture content of 20% (db) without steaming through broken. The treatment T_1SuB_2 (Extraction of kokum oil through steaming without broken at 15% moisture content) gives a higher value of oil yield to 40.76%, with 6 min steaming at 30 psi.

Keywords: Kokum seeds, seed kernel, Kokum oil, screw press mini oil mill

Introduction

Kokum (*Garcinia Indica*), in its natural habit, it comes up well in a hot humid climate under partial shade. The soil be and have good water holding capacity. However, the tree can also be grown on sandy, clay, loamy and lateritic soils which can hold moisture. Most favourable regions for kokum cultivation are warm and moderately humid zones. The reliable statistics regarding area and production of kokum are not available. However, Karnik *et al*., (2001) [5] reported 1200 ha area under kokum in Maharashtra and 10,200 MT production with the productivity of 8.50 T/ha. Temperature ranges from 20 °C to 35 °C, 60 to 80 percent humidity, and well-distributed annual rainfall ranging from 2500 to 4000 mm IS ideal for kokum. Extreme acidity is harmful to the tree. The yield of the kokum tree is about 30 kg to 173 kg per tree per year (Anon 2, 2012). Karnik (1978) [4] observed substantially high fruit sets in both open (natural cross) and hand (artificial cross) pollination in kokum.

The kokum fruit are oval in shape and vary in size, their weight also varies from 50 to 180. The fruits are globulus or spherical, 2.5 to 3.75 cm in diameter, dark purple when ripe. Enclosing 5-8 largely seeds. The fruit has 7-10 ridges and it takes about 8-10 years to reach the commercial bearing stage when grown from seeds. They are reddish-green in colour and turn into full red-purple colour in a day or two. (Nayak, and Rastogi *et al*., 2010) [6].

Kokum fruits contain rich amounts of anti-oxidants that combine with free radicals and aid oxidative damage to body cells. They also support cell regeneration and repair. Kokum juice is especially popular during scorching summer months as the cooling properties of kokum, oil of the fruit are used as emollient and antiseptic. It also helps in bringing down fever and allergic reactions. Kokum seeds contain a high percentage of oil that freezes to form Kokum butter at atmospheric temperature. Kokum butter is extensively used in the pharmaceutical and cosmetic industry. Kokum butter is soothing for burns, chaffed skin and scalds. Amrut kokum is a drink made of sugar syrup and is used to treat sunstroke.

The seed of kokum (*Garcinia indica*) contains 23 - 26% oil, which remains solid at room temperatureand is colloquially known as kokum butter. Kokum seed is very rich in stearic, oleic and stearic triglycerides (Dushyantha *et al*., 2010) [2]. The seeds yield a valuable, edible fat known in commerce as kokum butter.

It is extracted mostly as a cottage industry churning the crushed pulp with water. Kokum butter sold in market consists of egg-shaped lumps or cakes of light grey-yellowish colour with a greasy texture and a bland oily taste. Kokum butter obtained from its fruit kernel as a soft butter-like lipid. Kokum butter is wonderful in skincare applications. Kokum butter also helps reduce the degeneration of sl<in cells and restores elasticity, making it a good ingredient for soaps, balms, foot care products. Kokum butter is exported to Japan, Taiwan, USA, etc. From India and is used in conditioners are used in the preparation of confectionery. It is also used as an edible fat preparation. Kokum butter is not more popular as compared to other kinds of butter. The chemical compositions of kokum butter were determined to explain its potential uses. Kokum oil is extracted from kokum seed. Normally seed is not graded or cleaned. Therefore, quality of oil is not good. However, the value of kokum oil (butter) is high, so considering the need and uses of kokum butter (*Garcinia indica* Choisy)

Materials and Methods

Procurement of raw materials

Optimization of Process Parameters for Extraction of kokum oil seeds by screw press mini oil mill was conducted in the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, BSKKV Dapoli (MS).

Standardized process parameters for extraction of oil from kokum seeds

The information obtained during the survey was used for conducting the preliminary trials so as to decide the minimum and maximum levels of process parameters for the extraction of oil from kokum seeds.

Sample preparation

The kokum kernel samples to have desired moisture contents were prepared by adding required amount of distilled water and sealing them in separate polythene bags.

Experimental plan to standardized process parameters for extraction of oil from kokum seeds

On the basis of the results of preliminary trials and a review of literature, the levels of process variables of extraction of oil were decided such as, with steaming (10, 15, and 20%) of raw kokum broken and unbroken seeds. The experimental design was formulated after the selection of the ranges.

Table 1: Variables and their levels of moisture content and kokum oil seeds

Sr. No.	Independent Variables	Levels	Dependent variables
1.	Moisture content with spraying (%)	10,15, 20 (3 Level)	Extraction period, feed rate, oil yield (%), oil cake (%)
2.	Steaming time (min)	4, 6, 8 (3 Level)	
3.	Screw speed (rpm)	1	
4.	Temperature (°C)	1	
5	Pressure (Pa)	1	
6	Particle size (mm)	Broken and unbroken (2 Level)	
Total number of experiments = 12			

Process development for extraction of kokum oil seeds:

Kokum Fruit
↓
Cutting of fruits
↓
Separation of kokum seed from rind and pulp
↓
Sun drying of seed
↓
Shelling of kokum seed (by dehuller)
↓
Winnowing to separate kernel and shell
↓
Cleaning
↓
Steaming
↓
Moisture content (10 , 15, 20% (db))
↓
Setting of screw press
↓
Feeding → Deoiled cake
↓
Crude Oil
↓
Boiling of oil
↓
Scum raises an oil surface
↓
Separation of scum from oil
↓
Oil becomes solid (Butter)
↓
Next day, churning of butter in the mixture
↓
Formation of cubes / blocks of butter

Fig 1: Process flow chart for extraction oil kokum oil

Results and Discussion

Treatment 1: Extraction of oil through steaming with no broken

The experiments conducted involved the testing of various treatment combinations, as outlined in Table 2, to determine the impact of different input parameters on oil extraction efficiency. Based on the Table. 2, it was observed that oil yield ranged from 41.52 to 39.56%. The highest oil yield of 41.52% was achieved with a moisture content of 10% (db), while the lowest extraction efficiency of 39.56% was obtained at the highest moisture content of 20% (db). The similar trend was found by Utpala *et al.* (2014) [9]. The similar result was noted by Zhang *et al.* (2014) [10] for application of steam explosion in oil extraction of camellia seed.

In relation to the moisture content and weight of cake retained, it was observed that with increase in moisture content from 10 to 15%, the weight of cake retained decreases from 252.30 to 239.10 g. Conversely, according to Table 2, it was noted that losses increased from 45.1 g to 57.1 g when moisture content increased from 10% to 15%. However, when the moisture content increased from 15% to 20%, losses decreased from 57.1 g to 44.4 g. This variation can be attributed to the fact that higher moisture content reduces the requirement for barrel force to break down the seed cell wall.

Table 2: Extraction of kokum oil through steaming without broken kokum oil seeds

Sr. No.	Particulars	T_1SuB_1	T_1SuB_2	T_1SuB_3
1	Moisture Content (%)	10	15	20
2	Weight of sample (gm)	500	500	500
3	Weight of Oil (gsm)	202.6	203.8	202.8
4	Weight of Cake (gm)	252.3	239.1	252.8
5	Losses (gm)	45.1	57.1	44.4
6	Extraction Period (Min)	13.5	14.58	13.13
7	Oil Yield (%)	40.52	40.76	40.56
8	Steaming at 30 psi (min)	4	6	8
9	Extraction Efficiency (%)	96.47	97.04	96.57
S.E.(m)		3.64		
C.D. at 5%		7.94		
C.V. (%)		3.32		
T_1SuB_1	Extraction of kokum oil through steaming without broken at 10% moisture content			
T_1SuB_2	Extraction of kokum oil through steaming without broken at 15% moisture content			
T_1SuB_3	Extraction of kokum oil through steaming without broken at 20% moisture content			

Based on the data presented in Table2, it was evident that when the moisture content increases from 10% to 15%, the extraction time also increases from 13.5 to 14.58 min. However, when the moisture content increases further from 15% to 20% (db), the extraction time decreases from 14.58 to 13.13 min. This observation can be attributed to the influence of seed hardness on the extraction process. When the moisture content increases, it leads to shorter extraction times by increasing the steaming duration from 4 to 8 minutes. Therefore, it can be inferred that an increase in moisture content indirectly results in a decrease in the extraction period due to steaming. Similar result was found by Gangandeep *et al*. (2019) [3]. for canola seeds.

The experiments were conducted with various treatment combinations as given in Table 2 showed the effect of moisture levels of input parameters on oil extraction efficiency. The oil extraction efficiency was observed to be ranging between 96.47 to 97.04%. The maximum oil extraction efficiency of. 97.04% was observed at 10% moisture content. The minimum oil extraction efficiency of 96.47% was observed at 20% moisture content.

Treatment 1: Extraction of oil through steaming with broken kokum oil seeds

The experiments conducted involved testing various treatment combinations, as outlined in Table 3, to determine the impact of different input parameters on oil extraction efficiency. Based on Table 3, it was observed that oil yield ranged from 33.06 to 30.78%. The highest oil yield of 33.06% was achieved with a moisture content of 10% (db), while the lowest yield of 30.78% was obtained at the highest moisture content of 20% (db).Similar finding by Olayanju and Lucas (2004) [7].

Regarding the weight of the cake retained, an increase in moisture content from 10% to 20% resulted in a slight decrease in the weight of cake retained, with values ranging from 281.1 g to 255.6 g. Conversely, according to Table 3, it was noted that losses increases from 53.6 g to 90.5 g when moisture content increased from 10% to 20%. This can be attributed to the fact that higher moisture content reduces the requirement for barrel force to break down the seed cell wall.

Table 3: Extraction of oil through steaming with broken kokum oil seeds

Sr. No.	Particulars	T_1SB_1	T_1SB_2	T_1SB_3
1	Moisture Content (%)	10	15	20
2	Weight of sample (gm)	500	500	500
3	Weight of Oil (gm)	165.3	158.2	153.9
4	Weight of Cake (gm)	281.1	275.2	255.6
5	Losses (gm)	53.6	66.6	90.5
6	Extraction Period (Min)	14.35	12.76	18
7	Oil Yield (%)	33.06	31.64	30.78
8	Steaming at 30 psi (min)	4	6	8
9	Extraction Efficiency (%)	78.71	75.33	73.28
S.E.(m)		7.5		
C.D. at 5%		16.34		
C.V. (%)		6.68		
.T_1SB_1	Extraction of kokum oil through steaming with broken at 10% moisture content			
T_1SB_2	Extraction of kokum oil through steaming with broken at 15% moisture content			
T_1SB_3	Extraction of kokum oil through steaming with broken at 20% moisture content			

Based on the data presented in Table3, it is clear that an increase in moisture content from 10% to 15% leads to a decrease in extraction time from 14.35 to 12.76 minutes. However, when the moisture content further increases from 15% to 20%, the extraction time increases from 12.76 to 18 minutes. This trend can be attributed to the impact of seed hardness on the extraction process. As the moisture content increases, it results in longer extraction times due to an increase in steaming duration from 4 to 8 minutes. Consequently, it can be inferred that an increase in moisture content indirectly leads to an increase in the extraction period, primarily due to the steaming of broken oil seeds. The similar result was found by Gangandeep *et al*. (2019) [3] for canola seeds. The experiments were conducted with various treatment combinations as given in Table 3 showed the effect of moisture levels of input parameters on oil extraction efficiency. The oil extraction efficiency was observed to be ranging between 73.28 to 78.71%. The maximum oil extraction efficiency of 78.71% was observed at 10% moisture content. The minimum oil extraction efficiency of 73.28% was observed at 20% moisture content.

Treatment 2: Extraction of oil without steaming with no broken

The experiments conducted involved testing various treatment combinations, as outlined in Table 4, to determine the impact of different input parameters on oil extraction efficiency. Based on the Table 4, it was observed that oil yield ranged from 36.96% to 42.9%. The highest oil yield of 42.9% was achieved with a moisture content of 10% (db), while the lowest oil yield of 36.96% was obtained at the highest moisture content of 20% (db).

Similarly, Tavakoli *et al*. (2009) [8] stated in his study that the rupture energy of the grains increased in magnitude with an increase in moisture content, while rupture force decreased.

Regarding the weight of cake retained, an increase in moisture content from 10% to 20% resulted in a slight increase in the weight of cake retained, with values ranging from 263.3 g to 298 g. Conversely, according to Table 4, it was noted that losses decreased from 22.2 g to 17.2 g when moisture content increased from 10 to 20%. This can be attributed to the fact that higher moisture content reduces the requirement for barrel force to break down the seed cell wall.

Table 4: Extraction of oil without steaming with no broken

Sr. No.	Particulars	T_2WSuB_1	T_2WSuB_2	T_2WSuB_3
1	Moisture Content (%)	10	15	20
2	Weight of sample (gm)	500	500	500
3	Weight of Oil (gm)	214.5	201.3	184.8
4	Weight of Cake (gm)	263.3	280	298
5	Losses (gm)	22.2	18.7	17.2
6	Extraction Period (Min)	11.41	19.11	26.46
7	Oil Yield (%)	42.9	40.26	36.96
8	Extraction Efficiency (%)	96.42	91.66	88
S.E.(m)		8.09		
C.D. at 5%		17.63		
C.V. (%)		6.46		

Based on the Table 4, it was obvious that as the moisture content increases from 10 to 20%, the extraction time also increases from 11.25-26.28 min. This observation can be attributed to the fact that seed hardness plays a crucial role in determining the extraction period. When the moisture content increases, leading to longer extraction times. Therefore, it can be inferred that an increase in moisture content indirectly results in an increase in the extraction period.

T_2WSuB_1	Extraction of kokum oil without steaming without broken at 10% moisture content
T_2WSuB_2	Extraction of kokum oil without steaming without broken at 15% moisture content
T_2WSuB_3	Extraction of kokum oil without steaming without broken at 20% moisture content

The experiments were conducted with various treatment combinations as given in Table 4, showed the effect of moisture levels of input parameters on oil extraction efficiency. The oil extraction efficiency was observed to be ranging between 96.42 to 88.00%. The maximum oil extraction efficiency of. 96.42% was observed at 10% moisture content. The minimum oil extraction efficiency of 88.00% was observed at 20% moisture content

Treatment 2: Extraction of oil without steaming through broken

According to the data presented in Table 5, the extraction efficiency for kokum oil seeds using a screw press was investigated at different moisture content levels with broken kokum oil seeds. The results of oil recovery from different treatments were tabulated in the Table 5. From the Table 5, showed the extraction of kokum seed oil without steaming with broken obtained from mini oil screw press. From the Table 5,it was clear that oil recovery from screw press mini oil mill, the highest oil yield (38.52%) obtained at treatment T_2WSB_1due to the optimum moisture content, while lower oil yield (34.52%) obtained at treatment T_2WSB_3 is trend to decreases due to highest moisture content. The weight of cake retained at increase in moisture content from the Table 5, it was also observed that an increase in moisture content from 10 to 20%, the losses were decreases from 71.3 to 36.3 g, this may be due to that at higher moisture content the requirement of barrel force to break down the seed cell wall is least.

T_2WSB_1	Extraction of kokum oil without steaming through broken at 10% moisture content
T_2WSB_2	Extraction of kokum oil without steaming through broken at 15% moisture content
T_2WSB_3	Extraction of kokum oil without steaming through broken at 20% moisture content

Table 5: Extraction of oil without steaming through broken

Sr. No.	Particulars	$T_2W_SB_1$	T_2WSB_2	T_2WSB_3
1	Moisture Content (%)	10	15	20
2	Weight of sample (gm)	500	500	500
3	Weight of Oil (gm)	192.6	184.6	172.6
4	Weight of Cake (gm)	236.1	247.1	291.1
5	Losses (gm)	71.3	68.3	36.3
6	Extraction Period (Min)	22.23	20.26	18.78
7	Oil Yield (%)	38.52	36.92	34.52
8	Extraction Efficiency (%)	91.71	87.90	82.79
S.E.(m)		12.27		
C.D. at 5%		26.74		
C.V. (%)		9.81		

Based on the Table 5, it was obvious that as the moisture content increases from 10 to 20%, the extraction time also decreases from 22.23 to 18.78 minutes. This observation can be attributed to the fact that seed hardness plays a crucial role in determining the extraction period. When the moisture content increases, the broken seed hardness tends to decrease, leading to shorter extraction times. Therefore, it can be inferred that an increase in moisture content indirectly results in an increase in the extraction period.

The experiments were conducted with various treatment combinations as given in Table 5 showed the effect of moisture levels of input parameters on oil extraction efficiency. The oil extraction efficiency was observed to be ranging between 91.71 to 82.79%. The maximum oil extraction efficiency of. 91.71% was observed at 10% moisture content. The minimum oil extraction efficiency of 82.79% was observed at 20% moisture content.

Conclusion

1. It was concluded that the treatment T_1SuB_2 (Extraction of kokum oil through steaming without broken at 15% moisture content) gives a higher value of oil yield to 40.76%, with 6 min steaming at 30 psi.
2. It was concluded that the treatment T_1SB_1 (Extraction of kokum oil through steaming with broken at 10% moisture content) gives a higher value of oil yield to 33.06%, with 4 min steaming at 30 psi.
3. It was found that highest oil yield of 42.9% (T_2WSuB_1) was achieved with a moisture content of 10% (db), while the lowest oil yield of 36.96% (T_2WSuB_3) was obtained at the highest moisture content of 20% (db).
4. It was concluded that the highest oil yield (38.52%) obtained at treatment T_2WSB_1due to the optimum moisture content, while the lower oil yield (34.52%) obtained at treatment T_2WSB_3 is trend to decrease due to the highest moisture content.

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