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# Effect of Different Processing Methods (Fermentation and Boiling) on Fatty Acid Profile of Turmeric (*Curcuma Longa*)

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## Abstract

The study determined the effect of different processing methods (fermentation and boiling) on the fatty acid profile of turmeric (*Curcuma longa*). Freshly harvested turmeric (2kg), purchased from Gwagwa market, Abuja was washed and divided into three portions (samples A, B and C). Sample A was boiled at 100$^0$C while sample B was fermented for 4 days after which both samples were dried in a hot conventional oven at 55$^0$C for 60 minutes. Samples C which served as the untreated control was also dried. The samples were grounded into a fine powder using a Thomas-Wiley laboratory hammer mill and packed in airtight labelled containers. All the samples were stored at room temperature of 28±2$^0$C. The packed samples were subjected to oil extraction using ethanol as a solvent in a sozhlet extractor. Data were analysed using mean and standard deviation. The results showed that boiled (64.64mg) and fermented (46.24mg) turmeric contains a higher ($p < 0.05$) amount of omega 3 fatty compared to fresh turmeric. The result also showed that boiled and fermented turmeric had higher ($p < 0.05$) fatty acid (0.72mg and 0.56mg) respectively than fresh turmeric (0.42mg). The fresh and boiled turmeric had no significant difference in their unsaturated fatty acid (40.58mg and 40.32mg) content while fermented turmeric had higher ($p < 0.05$) Oleic acid (42.32mg). The study concludes that boiling and fermentation increased the fatty acid profile of turmeric. Therefore, the use of boiled and fermented turmeric should be popularized because of its promising nutritional potential.

**Keywords:** Processing methods, Turmeric, Fermentation, Boiling, Fatty acid.

## Introduction

Turmeric is a perennial plant that grows 5 - 6 feet high in the tropical regions of Southern Asia, with trumpet-shaped, dull yellow flowers. Its roots are bulbs that also produce rhizomes, which then produce stems and roots for new plants (Blumenthal et al., 2000). *Curcuma longa* is a perennial plant with a short stem and large leaves that bears ovate, pyriform, or oblong rhizomes that are brownish-yellow in colour and often branched (Chattopadhyay et al., 2004) Turmeric is fragrant and has a bitter, somewhat sharp taste. Although it grows in many tropical locations, the majority of turmeric is grown in India, where it is used as a main ingredient in curry (Blumenthal et al., 2000). Turmeric is known as the "Golden spice" as well as the "Spice of life" (Ravindran et al., 2007).

Turmeric (*Curcuma longa*), belongs to the *Zingiberaceae* family and has been traditionally used as a medicinal herb, dietary spice, food source, food preservative, colouring and flavouring agent in many Asian countries (Kim, 2013; Rajkumari & Sanatombi, 2017). Turmeric is a mild digestive and being aromatic, it can serve as a stimulant and a carminative. The active ingredient in turmeric is *curcumin.* As one of nature's most powerful healers, it has been used extensively in the Indian system of medicine as well as Chinese traditional medicine for centuries as an anti-nociceptive, anti-inflammatory, and anti-shock agent (Kim et al., 2016). The activities of turmeric constituents that have been demonstrated include their capabilities to fight against Alzheimer's disease, arthritis, allergies, digestive ailments, depression and cancer (Anantharaman et al., 2014).

Turmeric contains 3–5% volatile oil, which is obtained by steam distillation of turmeric powder, for about 8–10 hours. Turmeric leaves also yield oil which is pale yellow in colour with a peppery and aromatic odour. The oil contains about 60 % turmerone, 25% zingiberene and small quantities of d-phellandrene, d-sabinene, cineole and forneol (Yu, 2006). Turmeric leaf oil, obtained from the distillation of dry leaves, has applications in the aroma therapy, perfumery, cosmetics and soap industries (Syamkumar, 2008). Antioxidants present in turmeric are recognized for their potential in promoting health and lowering the risk of cancer, hypertension and heart disease (Wolfe & Liu, 2003). The uses of natural antioxidants from plant extract have experienced growing interest due to some human health professionals and consumers' concern about the safety of synthetic antioxidants in foods (Suhaj, 2006). Antioxidant activities in plants have been identified by many researchers (Hinneburg et al., 2006). Curcumin, a powerful antioxidant, is thought to be the most bioactive and calming component of turmeric, with antioxidant, anti-inflammatory, anti-platelet, cholesterol-lowering, anti-bacterial, and anti-fungal properties (Ikpeama et al., 2014).

Nutritionally, turmeric contains 8.92% moisture, 2.85% ash, 4.60% crude fibre, 6.85% fat, 9.40% crude protein and 67.38% carbohydrate (Ikpeama et al., 2014). The function of essential fatty acids (linoleic and alpha-linoleic acid) and their metabolites in human and animal health is a subject of scientific attention today (Shahid et al., 2015). As a result of inadequate omega-3 polyunsaturated fatty acid intake in the human diet, research work has been focused on producing animal and plant food products enriched with a healthy fatty acid profile (Kang, 2008). Total omega-6 fatty acids were significantly influenced by the inclusion of various antioxidants in omega-3-enriched diets. Antioxidant properties of herbs can stimulate the metabolic pathway of essential fatty acids like omega-3 and omega-6 (Hayat et al., 2010). The antioxidant activity of wild turmeric and fermented wild turmeric was attributed to the presence of phenolic compounds, flavonoid compounds, and volatile oil compounds (Xiong et al., 2017).

Solid-state fermentation (SSF) has gained attention in recent years from biotech industries including in bioremediation; biofuels; the production of lipids, flavours, and aromas for food; and the production of bioactive compounds (Saleh-E-In & Roy, 2007). Solid-state fermentation involves the growth of microorganisms on a solid substrate with a low moisture content (Holker et al., 2004). Fungi are the main group of microorganisms used for solid-state fermentation (Saleh-E-In & Roy, 2007). Solid-state fermentation has several advantages over submerged fermentation including high volumetric productivity, product concentration, simplicity, and low sterilization cost (Jimenez-Quero et al., 2020). Generally, fermentation has been used to improve product properties. The micro-organisms modified the plant constituents during fermentation (Katina et al., 2007a). Many biochemical changes occur during fermentation, leading to alter the bioactivity and digestibility properties of the plant components. Solid-state fermentation (SSF) had been used to increase the phenolic contents in foods followed by enhancing their antioxidant activity (Katina et al., 2007b).

Turmeric is a liposoluble compound and can be easily dissolved into organic solvents such as methanol, ethanol, and acetone. However, poor water solubility often limits its biomedical uses using aqueous systems (Hettiarachchi et al., 2021). During the isolation and purification of turmeric from oleo resin, the volatile oil present in turmeric solubilizes *curcumin* creating problems in the recrystallization process (Urošević et al., 2022). To eliminate the interference of volatile oil and resolve the problem of recrystallization, the present research work was undertaken. Addressing the problem of food insecurity, several agricultural development institutions were set up and special programmes and projects were launched and fashioned to develop agriculture, reduce rural poverty and earn foreign exchange (Omeje & Ogbu, 2015). However, little or no information is known about the quality characteristics of cooking oil extracted from turmeric. The researchers believe that good knowledge of it will enhance the utilization of the oil in different home and industrial applications as well as its potential to replace palm oils and groundnut oil whose high demand has surged a high market cost.

Furthermore, essential fatty acid insufficiency is a fundamentally problematic model that has likely resulted in greatly overestimating linoleate requirements due to the concurrent absence of dietary alpha-linolenic. The common "non-essential" fatty acids (palmitate, stearate, and oleate) are more easily replaced in tissue lipids than linoleate and alpha-linolenate, which are also beta-oxidized more quickly. In many cases, more carbon from linoleate and alpha-linolenate is recycled into palmitate and cholesterol than is needed to create long-chain polyunsaturated fatty acids (Cunnane, 2003). These data highlight several issues with the idea of an "essential fatty acid," a word that denotes a fatty acid that is more protected and significant than others that can be produced endogenously. There is undoubtedly a lot more interconnection between the metabolism of essential and non-essential fatty acids than was previously thought. The term "essential fatty acid" could be replaced with more neutral terminology, such as polyunsaturated, omega-3 or omega-6 polyunsaturated, or the specific fatty acid(s) in question, which would increase clarity and possibly encourage more research into the functional and health benefits of polyunsaturated fatty acids (Cunnane, 2003). In addition to the stated problem, there is little information on the quality characteristics of oil extracted from turmeric. Hence, this study aims at extracting turmeric oil and determining the total fatty acid in fresh, boiled and fermented turmeric in other to have a basis for recommending it for culinary use.

**Objectives of the study**

The broad objective of the study was to determine the effect of different processing methods (fermentation and boiling) on the fatty acid profile of turmeric (*Curcuma longa*). The specific objectives were to;

1. determine the unsaturated fatty acid content of fresh, fermented and boiled turmeric;
2. determine the effect of boiling and fermentation on the fatty acid profile of turmeric; and
3. determine the omega-3 and omega-6 fatty acid contents of boiled, fermented and fresh turmeric.

**Scope of the study**

Fatty acids can be saturated or unsaturated. However, this study was delimited to the unsaturated fatty acid contents of the turmeric oil produced after boiling and fermentation.

**Materials and method**

***Study design*:** The study adopted an experimental research design. Experimental design is the process of carrying out research in an objective and controlled fashion so that precision is maximized and specific conclusions can be drawn to establish the effect that a factor has on a dependent variable (Bell, 2009).

***Collection of sample materials*:** Two kilograms of freshly harvested turmeric was purchased from Gwagwa market, Federal Capital Territory, Abuja Nigeria. The plant (turmeric) was taken to the Department of Plant Science and Biotechnology Department, Faculty of Biological Sciences, University of Nigeria Nsukka for identification.

***Preparation of samples for chemical analysis*:** Two kilograms of turmeric was sorted and washed with clean running water and put in the colander to drain the water. The drained turmeric was peeled and cut into smaller sizes to increase easy grinding. The 2kg turmeric was divided into three equal portions. Sample A was subjected to boiling, sample B was subjected to fermentation and sample C was untreated (raw) and taken as the control. Sample A was boiled at 100°C and dried. Sample B was fermented for four days and dried in a hot conventional oven at 55°C for 60 minutes and dried. All the samples (A, B and C) were ground into a fine powder using a Thomas-Wiley laboratory hammer mill, sieved and packaged in an air-tight transparent plastic container and labelled. The turmeric powders (samples A, B and C) were stored at room temperature (28±2C).

***Extraction of turmeric oil*:** 2kg fresh turmeric was sorted and washed with clean running water and put in a colander to drain the water. The drained turmeric was peeled and cut in top smaller sizes for easy grinding. The clean dried turmeric was milled using a Thomas-Wiley laboratory hammer mill into a paste. The paste was dissolved in ethanol using soxhlet extractor. The oil extracted from the turmeric was packaged in an airtight container and stored at 28±2°C.

***Chemical analysis***

***Determination of total fat*:** Total fat was determined using the Kjeldahl method (AOAC, 2010). A 500ml capacity round bottom flask was filled with 300ml petroleum ether and fixed to the soxhlet extractor. Two grams of sample were placed in a label thimble. The extractor thimble was sealed with cotton wool. The heat was applied to reflux the apparatus for six hours. The thimble was then removed with care. The petroleum ether was removed and dried at 105°C for one hour in an oven. The flask was then cooled in a desiccator and weighed.

$$\% \text{ Fat} = \frac{\text{weight of fat}}{\text{weight of sample}} \times \frac{100}{1}$$

***Determination of the fatty acid profile*:** Fatty acid profile was determined by using a gas chromatograph (boiling). The fresh turmeric was washed with clean water and boiled for a duration of 30 minutes in a beaker at 100° C. Turmeric was dried thoroughly and ground. The sample was passed to a 0.1mm sieve and stored in a cool dry container, 5g of the boiled turmeric sample was measured into the conical flask, and 50 ml of ether was added into a conical flask. It was mixed thoroughly and allowed to stand for 30mins, filtered and kept for fatty acid analysis. The fatty acids were analyzed at different columns of the equipment which recorded the quantity of each fatty acid.

The fatty acid profile was determined by using a gas chromatograph (fermentation). Fresh turmeric was washed and soaked in water for 4 days. The soaked turmeric was covered properly for the fermentation process to take place. After 4days of fermentation, turmeric was dried and ground. Fermented turmeric was passed to a 0.01mm sieve and stored in a dry container. Then 5g of the fermented turmeric was measured in a conical flask, and 50 ml of ether was added to the conical flask. The mixture was shaken thoroughly to mix, allowed to rest for 30 minutes and filtered.

***Determination of omega 3 fatty acid and omega 6 fatty acid*:** The omega 3 and 6 fatty acids are a class of polyunsaturated fatty acids (PUFAs) characterized by the presence of two or more cis-double bonds, with the position of the first double bond six carbon atoms from the methyl end of the molecules (*Mori & Hodgson, 2013*). Omega 3 and 6 fatty acids were determined using different spectrophotometers. Methylated turmeric samples are measured at different wavelengths with methanol standard. Omega 3 fatty acid = 520nm. Omega 6 fatty acid = 320nm.

$$\frac{\text{Wave lenght of the standard}}{\text{Wave leght of the sample}} \times 100 = \text{ \% Fatty acid}$$

***Statistical analysis*:** Data obtained was subjected to statistical analysis using the Statistical Product and Service Solution (SPSS) version 23.0. Values were reported as mean, and standard deviation and data were analysed using analysis of variance (ANOVA) for separation of the mean. Duncan's multiple range test was used to determine significant differences between means of variables at a 5% probability level ($p < 0.05$).

**Result**

**Unsaturated fatty acid contents of fresh, fermented and boiled turmeric**

Table 1 presented the amount of unsaturated fatty acid in the fresh, boiled and fermented turmeric samples. The result revealed that boiled turmeric had the highest unsaturated fatty acid content (0.72) followed by fermented turmeric (0.56). At $p < 0.05$, there was a significant difference between the fatty acid content of the boiled and fresh turmeric. There was also a significant difference between the fatty acid content of fermented and fresh turmeric.

**Table 1: Unsaturated fatty acid contents of fresh, boiled and fermented turmeric (per 100g)**

| Samples | Unsaturated fatty acid |
|---|---|
| FT | $0.42 \pm 0.01^{b}$ |
| BT | $0.72 \pm 0.01^{a}$ |
| FtT | $0.56 \pm 0.03^{a}$ |

The values are ± Standard Deviation (SD) of triplicate determination. Mean on the same row with different superscript are significantly different at $p < 0.05$ FT= Fresh turmeric; BT= Boiled turmeric; FtT= Fermented turmeric; Mean ± Standard Deviation (SD).

**Effect of boiling and fermentation on the fatty acid profile of turmeric**

Table 2 shows the effect of boiling and fermentation on the fatty acid profile of turmeric. The result revealed that boiling had no significant effect on oleic acid contents of turmeric. There was higher ($p < 0.05$) palmitic acid (5.63mg) in fresh turmeric than boiled sample (2.15mg).

Fresh turmeric also had higher ($p < 0.05$) linoleic (10.63mg) and myristic (16.15mg) acid than boiled turmeric which had 8.63mg and 4.21mg respectively. Boiled turmeric had higher ($p < 0.05$) ecosenoic (3.44mg) and linolenic (15.64mg) acids than the fresh turmeric. The table also shows that there was significant difference in the unsaturated fatty acid profile of fermented and fresh turmeric. Fermented turmeric had higher ($p < 0.05$) oleic (42.32mg), linoleic (11.29mg) and linolenic (22.48mg) acid than the fresh turmeric which had 40.58mg oleic, 10.63mg linoleic and 10.06mg linolenic acids. The fresh turmeric had higher ($p<0.05$) palmitic (5.63mg), ecosenoic (2.73mg) and myristic (16.15mg) acid than fermented turmeric.

**Table 2: Fatty acid profile of fresh, boiled and fermented turmeric (per 100g)**

| Unsaturated Fatty Acid | FT | BT | FtT |
|---|---|---|---|
| Oleic acid (mg) | 40.58 ± 0.94[a] | 40.32 ± 0.32[a] | 42.32±0.31[a] |
| Palmitic acid (mg) | 5.63 ± 0.03[a] | 2.15 ± 0.11[b] | 0.01±0.01[b] |
| Linoleic acid (mg) | 10.63 ± 0.04[a] | 8.63 ± 0.14[b] | 11.29±5.73[a] |
| Ecosenoic acid (mg) | 2.73 ± 0.04[b] | 3.44 ± 0.03[a] | 1.59±0.13[b] |
| Myristic acid (mg) | 16.15 ± 0.10[a] | 4.21± 0.10[b] | 11.54±0.10[b] |
| Linolenic acid (mg) | 10.06 ± 0.05[b] | 15.64 ± 0.03[a] | 22.48±0.04[a] |

The values are ± Standard Deviation (SD) of triplicate determination. Mean on the same row with different superscript are significantly different at $p < 0.05$; FT= Fresh turmeric; BT= Boiled turmeric; FtT= Fermented turmeric; Mean ± Standard Deviation (SD)..

**Omega-3 and omega-6 fatty acids contents of boiled, fermented and fresh turmeric**

Table 3 shows the omega-3 and omega-6 fatty acids contents of fresh, boiled and fermented turmeric. There was significant ($p < 0.05$) difference between the omega 3 fatty acid of fresh and boiled samples. Boiled turmeric had higher omega 3 fatty acid (64.64mg) than fresh turmeric which had 33.83mg. The quantity of omega 6 fatty acid in fresh turmeric was 0.24mg while that of boiled turmeric was 0.42mg. The result also showed significant difference ($p < 0.05$) in the quantities of omega 3 and 6 fatty acids of fresh and fermented turmeric. The fermented turmeric had higher ($p < 0.05$) omega 3 (46.84mg) fatty acid than the fresh sample (33.83mg). Fermented turmeric had higher omega 6 (0.47mg) than the fresh turmeric (0.24mg).

**Table 3: Estimation of the quantity of omega 3 and omega 6 fatty acids on fresh and treated turmeric**

| Samples | Omega 3 | Omega 6 |
|---|---|---|
| FT | 33.83±6.58 [a] | 0.24±0.02[b] |
| BT | 64.64±11.76[b] | 0.42±0.2[a] |
| FtT | 46.84±24.53[a] | 0.47±0.00[a] |

The values are ± Standard Deviation (SD) of triplicate determination. Mean on the same row with different superscripts are significantly different at $p < 0.05$; FT= Fresh turmeric; BT= Boiled turmeric; FtT= Fermented turmeric; Mean± Standard Deviation (SD).

**Discussion**

Demand for quality oils and fats is increasing all over the world. To cope with the increasing demand for oils and fats, non-conventional sources are gaining importance. Boiling and fermentation as methods of processing food bring about several changes in the physical characteristic as the well chemical composition of food items. These processing methods according to Srinivasan (2005) change the bioavailability of protein, carbohydrates, vitamins and lipids. Findings showed that boiled and fermented turmeric samples had higher significant quantities of unsaturated fatty acid content compared to the fresh sample. This suggests that boiling and fermenting turmeric significantly increases its total unsaturated fatty acid content. According to Schweichler (2022), unsaturated fats, which are liquid at room temperature, are considered good fats because they help enhance blood cholesterol levels, alleviate inflammation, stabilize cardiac rhythms, and play a variety of other beneficial roles. This result is in line with the study of Indira et al. (2021) which revealed that the release of essential oil by enzymatic action through the fermentation process of residue was three times greater than the control. Similarly, findings of a study by Cortez et al. (2020) showed that boiling preserved potential health-promoting phenolic compounds and some unsaturated fatty acids in turmeric. A study by Biandolina et al. (2021) showed that boiling the sample was valuable and beneficial as it resulted in lower levels of less favourable fatty acids in addition to improving the favourable fatty acids.

The study revealed that fermenting and boiling had no significant effect on the oleic acid content of turmeric even though fermented turmeric had higher oleic acid. This implies that although fermenting turmeric increases its oleic acid contents, the increase was not significant. According to Charalampopoulous et al. (2002), fermentation is a process which is influenced by the activities of microorganisms and enzymes. The findings of this present study showed that oleic acid was the major fatty acid found in the turmeric oil samples higher than other fatty acids present in the oil samples with a value of 40.58mg. This finding contrast with that of Paula et al. (2011) who reported that turmeric gotten from three different regions in Bangladesh contained higher quantities (58.88mg, 56.24mg and 56.99mg) of oleic acids respectively. The difference in the results may be due to the diverse climate, weather conditions and area in which the samples were collected. Yanishlieva-Maslarova and Heinonen (2001) reported that high oleic acid as contained in the study samples helps to reduce the raised level of total plasma cholesterol without reducing the high-density lipoprotein (HDL) cholesterol level. There was significantly higher palmitic and mysritic acid in fresh turmeric than in boiled and fermented samples. This suggests that processing turmeric by boiling and fermenting reduces its palmitic and myristic acid content. According to Verruck et al. (2019), consuming myristic acid in moderation raises the amounts of long-chain omega-3 fatty acids in plasma phospholipids, which may improve cardiovascular health indicators in humans. Levy (2020) reported that when taken in reasonable quantities, palmitic acid may have benefits such as supporting skin health, acting as an anti-inflammatory, and potentially supporting metabolic health.

Findings further showed that boiling significantly reduced the linoleic content of turmeric while fermentation increased the linoleic content, albeit in a negligible amount. Supporting this, the findings of Cortez et al. (2020) showed that boiling caused the loss of some phenolic compounds such as linoleic acid in turmeric. Linoleic acid is crucial in the preservation of the epidermis' transdermal water barrier, and its deficiency can cause scaly skin lesions and growth retardation, among other problems according to Whelan and Fritsche (2013). Boiling significantly increased the ecosenoic acid content of turmeric while fermentation reduced it, although in a negligible amount. Linolenic acid content of turmeric was significantly increased by boiling and fermentation. Linolenic acid is an essential fatty acid that is mainly derived from plant sources such as nuts and seeds and is used for endogenous synthesis of long-chain omega-6 fatty acids (Chowdhury et al., 2016). One compound that has been demonstrated to exert neuroprotective, anti-inflammatory, and antidepressant properties is $\alpha$-linolenic acid (Blondeau, 2015).

Omega-3 and omega-6 fatty acids are two polyunsaturated fatty acids essential for health. They are termed essential because they cannot be manufactured by the body and must be obtained from food (Kaur et al., 2014). Findings showed a significant difference between the omega 3 fatty acid of fresh and boiled turmeric samples. Boiled and fermented turmeric had higher omega-3 and omega-6 fatty acids than the fresh sample. This suggests that the essential fatty acid contents of turmeric will increase significantly when it undergoes processing methods such as boiling and fermentation. Fermentation and boiling methods added value to the omega-3 and omega-6 contents of turmeric oil. That is, higher polyunsaturated fatty acids in turmeric oil were due to the processing methods (fermentation and boiling) applied. This result is in line with that of Saleh-E-In and Roy (2007) who reported that turmeric oil possesses a high proportion of unsaturated fatty acid. Fermentation and boiling methods added value to the omega-3 and omega-6 contents of turmeric oil. That is, higher polyunsaturated fatty acids in turmeric oil were due to the processing methods (fermentation and boiling) applied. This result is in line with that of Saleh-E-In and Roy (2007) who reported that turmeric oil possesses a high proportion of unsaturated fatty acid. Omega-3 fatty acids have important functions such as improving heart health, supporting mental health, reducing weight and waist size, decreasing liver fat, supporting infant brain development and fighting inflammation. Some omega-6 fatty acids have shown benefits in treating symptoms of chronic disease (Richter, 2023).

**Conclusion**

The study provided some comparative information on the effect of fermentation and boiling processing methods on the fatty acid profile of turmeric. The study concludes that boiling and fermenting turmeric significantly increases its total unsaturated fatty acid content. Although fermenting turmeric increases its oleic acid contents, the increase was not significant. Processing turmeric by boiling and fermenting results in a marked reduction in its palmitic and while fermentation reduces it, although in a negligible amount. Linolenic acid by boiling and fermentation. The amount of essential polyunsaturated fatty acid (omega-3 and omega-6) contents of turmeric increases reasonably when turmeric undergoes processing methods such as fermentation and boiling.

**Recommendations**

Based on the present study, the following recommendations were made.

- ❖ The use of turmeric both by boiling and fermentation processing myristic acid content. Boiling significantly reduces the linoleic content of turmeric while fermentation increases the linoleic content, albeit in a negligible amount. Boiling significantly increases the ecosenoic acid content of turmeric content of turmeric was significantly increased methods should be popularized by nutritionists and dieticians as it improves some fatty acids contained in it. Either method can be recommended depending on the nutritional goals and health conditions of the subject.
- ❖ Further research should be carried out on the proximate composition of fresh, boiled and fermented turmeric.
- ❖ Research regarding the shelf life of turmeric oil should be done to establish its use for different purposes.

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