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Effects of Sun Drying, Shade Drying, Blanching and Cooking on the Nutrient Composition of Turmeric Rhizome (*Curcuma longa)*

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Abstract

The study determined the effect of sun drying and shade drying on the nutrient composition of turmeric (*Curcuma longa).* Two kilograms of fresh turmeric rhizomes were purchased from a local market (Ogige) in Nsukka Local Government Area of Enugu State. The samples were trimmed and thoroughly washed under running water to remove debris, peeled, and thinly sliced. The sample was divided into two portions. The first portion was sundried while the other portion was shade dried. The two samples were processed into powder and packaged in a well-labeled airtight container for analysis. Association of Analytical Chemists and other analytical methods were used to determine the nutrient composition of the samples. Data were analyzed with Statistical Product for Service Solution (version 22) using ANOVA and Duncan's New Multiple Range test at P<0.05. The findings of the study revealed that the sun-dried sample had the highest value for carbohydrate (55.51%), ash (8.03%), and moisture (18.50%) while shade dried sample had the highest protein (8.61%) and fat (7.21%). The raw shade-dried sample had the highest values for Beta carotene (20.10 mg/100g) and Vitamin C (3.60mg/100g), while the boiled sun-dried sample had the highest values for potassium (40.82mg/100g), iron (9.79mg/100g) and calcium (595.7mg/100g). Therefore, sun-drying and shade-drying processing methods on the turmeric should be encouraged as they conserve more nutrients.

Keywords: Nutrients composition, turmeric, sun drying, shade drying,

Introduction

Turmeric (*Curcuma longa*) Linn is a tropical perennial monocotyledonous herbaceous plant belonging to the Zingerberaceae family (Jilani et al., 2012). It has its origin in the South and South-eastern Asia but it is grown primarily in tropical regions of Bangladesh, China, Thailand, Cambodia, Malaysia, Indonesia, Philippines, and Nigeria (Taoheed et al., 2007). The root or rhizome of turmeric has a tough brown skin and bright orange flesh which is pungent and bitter (Ahaotu& Lawal, 2019). It has been applied in folk medicine for the treatment of inflammations, cancerous symptoms, diabetics, abdominal pains, high cholesterolemia, and wounds and as a blood purifier (Ahaotu& Lawal, 2019). They are known to contain a significant number of natural antioxidants and bioactive components (Singh & Dubey, 2015). The rhizome of turmeric when dried and ground can be used as a spice ingredient in food preparation for flavouring, colouring, and preservation of food (Jiang, 2019).

Curcumin which is a yellow-colored active ingredient is a potent antioxidant responsible for the biological activities of turmeric. Curcumin also contains vital compounds such as vitamin C, beta-carotene, polyphenol, fatty acids, and essential oil (Ikpeama et al., 2014). Turmeric is used as a carminative. It can be used to promote

digestion, and reduce gas, and bloating in foods such as rice and bean dishes. It is a cholagogue, which helps stimulate bile production in the liver while also facilitating bile evacuation through the gallbladder. Turmeric is recommended for people who suffer from persistent digestive issues and/or congestion (Debjit et al., 2009). The leaves are known as a great source of vitamins and minerals (Chattopadhyan et al., 2003).

Cooking and other postharvest processing operations of turmeric such as washing, cleaning, curing or blanching, drying, polishing, size reduction, and packaging may have detrimental effects on the quality of turmeric powders (Jose & Joy, 2009). Over-cooking spoils the colour of the final product while under-cooking renders the dried product brittle (Kamble & Soni 2009). Drying has been recognized as the most useful processing technique for prolonging the durability and quality of food crops including spices (Dissa et al., 2011). The rhizome of turmeric when dried and ground can be used as a spice ingredient in food preparation for flavouring, colouring, and preservation of food (Jiang, 2019).

The biggest challenge in food processing is subsequent nutrient loss. Actual losses depend on various factors such as food type, temperature, and cooking time. Nearly all food preparation and preservation methods lead to losses. However, the quality of turmeric powder is also determined by the processing methods employed which might lead to nutrient loss and contamination due to poor handling during processing (Emelike et al., 2017).Processing of foods in these wet and humid environments brings special difficulties for the management of the product. Processing the foods to ensure a stable stored product is of particular importance in wet and humid environments this creates the need for efficient and effective drying methods (UNIDO & FAO, 2005).

In Africa and Nigeria in particular, the problems of many rhizomes (ginger, turmeric), and bulbs (garlic, onion), especially the indigenous ones, results in wastage during the in-season and limited supply during the off-season. This leads to high prices for these commodities because of their seasonality and not being available all year round (Omayio et al., 2020). Appropriate preservative and postharvest methods should be performed to prolong the consumption of such nutrient-rich foods all year round (Chavasit et al., 2002). Hence there is a need for research studies to be explored extensively in curtailing these shortfalls.

Objectives of the study

The objectives of the study were to;

1. determine the proximate composition (ash, moisture, fat, crude protein, crude fibre, and carbohydrate) of raw, blanched, and cooked sundried and shade-dried turmeric samples;
2. determine the vitamin (vitamin C and beta-carotene) composition of the turmeric samples; and
3. determine the mineral (phosphorus, calcium, iron, and potassium) composition of the samples.

Materials and methods

***Study design*:** The study was pure experimental design.

***Procurement of raw materials*:** The stems of *Curcuma longa* (Turmeric), were purchased from a local market (Ogige) in the Nsukka Local Government area of Enugu State. The turmeric rhizomes were bought from five different sellers in the local market by random sampling to get a better representation of the sample.

***Sample preparation*:** Undamaged fresh rhizomes of turmeric were selected. They were sorted to remove roots, sand, and other debris. The nodes were detached from the

parent rhizomes to enhance proper cleaning thereafter, they were washed thoroughly in clean water to remove soil particles on them and then divided into three samples. This sample was blanched for 10 minutes at 100° C. It was then strained, peeled, and thinly sliced. It was divided into two portions. The first potion was sun-dried, and the second potion shade dried until a constant weight was obtained. Sample Awas blanched for 10 minutes by scalding the turmeric in boiling water at 100°c. It was cooled under running water, strained, peeled, and thinly sliced. It was divided into two portions. The first potion was sun-dried and the second potion shade shade-dried until a constant weight was obtained. Sample B sample was cooked for 30 minutes until the aroma became very strong. It was strained, peeled, and thinly sliced. It was divided into two portions. The first portion was sun-dried, and the second portion shade dried until a constant weight was obtained. Sample C sample was peeled and thinly sliced without any form of heat treatment. It was divided into two. The first portion was sun-dried, and the other portion shade dried until a constant weight was obtained. All samples were labelled appropriately for chemical analysis.

***Proximate composition*:** The proximate composition of the turmeric samples was determined using standard methods: The moisture content of the sample was determined using the hot air oven method (AOAC, 2010).Ash determination was carried out using the standard procedure of the Association of Official Analytical Chemists (AOAC, 2010). The micro Kjedahl method described by AOAC (2010) was used for crude protein determination. Crude fibre was determined using the method described by AOAC (2010). The AOAC (2010) method was used for crude fat determination. The total carbohydrate was obtained by difference:

100%- (% Moisture + % crude protein + % crude fat + % crude fibre + %Ash)

***Vitamin analysis*:** The AOAC (2010) method was used to determine the Vitamin C (ascorbic acid) content of the samples.The quantity of B-carotenein the samples was determined using the Harbone method as described by Jakutowicz et al. (1997).

***Mineral Analysis*:** Calcium was determined using the dry ashing method described by AOAC (2010). The AOAC (2010) method was used to determine the iron content of the sample. Magnesium content was determined by atomic absorption spectrophotometer as described in the official method of the Association of Official Analytical Chemists (AOAC, 2010). The method of flame photometry described by AOAC (2005) was used to determine the potassium content of the samples.

Statistical Analysis: Data obtained were statistically analysed using Statistical Package for Service Solution (SPSS) version 21. Values were reported as mean and standard deviation (SD) and the means were analysed using analysis of variance (ANOVA). Duncan's new multiple range test (DMRT) was used to separate the means of the samples at a 5% probability level ($p<0.05$).

Results

Proximate Composition of the Samples

Table 1.1 shows the proximate composition of the different samples. The carbohydrate content of the samples ranged from 53.01-61.37%. The cooked sundried sample (CSD) had the highest (61.37%) carbohydrate value while the raw shade dried sample had the lowest value (53.01%). The protein content ranged from 4.17 -9.74%. The raw shade-dried sample had the highest protein value (9.74%) while the cooked sun-dried sample had the lowest value (4.17%). Ash content oscillated between 7.07-8.03%. The cooked shade-dried sample had the highest ash value

(8.03%) while the raw sun-dried sample had the lowest value (7.07%). The fat content ranged from 5.81 to 7.80%. The raw shade dried sample had the highest fat value (7.80%) while the cooked sundried sample had the lowest value 5.81%. The moisture content ranged from 14.48-18.50%. The cooked shade dried sample had the highest moisture value (18.50%) while the raw sundried samplehad the lowest value (14.48%). The crude fibre content of the samples varied; the values ranged from 3.99-6.78%. The raw sun-dried samples had the highest fibre value (6.78%) while the cooked shade-dried samples had the least value (3.99%).

Table 1: Proximate composition of the samples

Parameter	Carbohydrate (%)	Protein (%)	Ash (%)	Fat (%)	Moisture (%)	Fibre (%)
BSD	57.55±0.11	7.06±0.04	7.90±0.04	6.39±0.01	15.93±0.01	5.18±0.02
BShD	55.93±0.06	7.51±0.06	7.21±0.03	7.00±0.01	17.57±0.01	4.80±0.01
CSD	61.37±0.08	4.17±0.01	7.25±0.04	5.81±0.03	17.03±0.05	4.38±0.01
CShD	58.33±0.05	4.97±0.04	8.03±0.04	6.19±0.01	18.50±0.04	3.99±0.01
RSD	55.51±0.50	8.61±0.04	7.07±0.04	7.21±0.03	14.48±0.00	6.78±0.02
RShD	53.01±0.11	9.74±0.07	7.48±0.10	7.80±0.01	15.41±0.03	6.57±0.03

Values = Mean ± SD of sample in duplicates. Key: BSD – Blanched sundried, BShD – Blanched shade dried, CSD – Cooked sun-dried, CShD – Cooked shade dried, RSD – Raw sundried, RShD – Raw shade dried.

Mineral Composition of the Samples

Table 4.2 shows the mineral composition of the samples. The phosphorus content of the samples oscillated between 0.12-0.37%. Raw shade dried sample had the highest phosphorus content (0.37%) while cooked sundried sample had the lowest value (0.12%). The potassium content ranged from 11.66 to 46.66mg/100g. Cooked sun-dried sample had the highest potassium content (46.66 mg/100g) while raw shade dried sample had the lowest value (11.66mg/100g). The iron content of the samples increased from 3.95-9.75mg/100g. Boiled sundried sample had the highest iron content of (9.79mg/100g) while the cooked sundried sample had the list value (3.95mg/100g). The calcium content of the samples varied from 595.74±55.89mg/100g. The boiledsun-dried sample had the highest value (595.74mg/100g) while the raw sun-dried sample had the lowest value (55.41mg/100g).

Table 2: Mineral composition of the samples

Parameter	Phosphorus (%)	Potassium (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)
BSD	0.20+0.00	40.82+3.54	9.79+2.65	595.7+5.89
BShD	0.32+0.00	37.07+5.30	5.83+0.59	65.19+2.06
CSD	0.12+0.00	46.66+4.12	3.95+1.47	107.6+0.98
CShD	0.21+0.01	37.07+5.30	9.16+2.63	65.19+2.06
RSD	0.27+0.01	31.04+6.19	6.46+0.88	55.41+4.12
RShD	0.37+0.01	11.66+1.77	7.29+0.29	73.53+2.06

Values = Mean ± SD of sample in duplicates. Key: **BSD** – Blanched sundried, **BShD** – Blanched shade dried, **CSD** – Cooked sun-dried, **CShD** – Cooked shade dried, **RSD** – Raw sundried, **RShD** – Raw shade dried.

The Vitamin Composition of the Samples

Table 3 shows the vitamin composition of the different samples. The Beta-carotene value ranged from 12.70-20.10µg/100g. Raw shade dried sample had the highest value (20.10µg/100g) while the cooked sun-dried sample had the lowest value (12.70µg/100g. Vitamin C increased from 1.30 - 3.60mg/100g. Raw shade dried samples had the highest value of Vitamin C (3.60mg/100g) while cooked sun dried sample had the lowest value (1.30mg/100g).

Table 3: Vitamin composition of the samples

Parameter	B-carotene (µg/100g)	Vitamin C (Mg/100g)
BSD	16.10±0.14	2.10±0.14
BShD	17.65±0.21	2.80±0.00
CSD	12.70±0.14	1.30±0.14
CShD	13.10±0.14	1.70±0.14
RSD	18.55±0.07	3.10±0.14
RShD	20.10±0.14	3.60±0.00

Values = Mean ± SD of sample in duplicates. Key: **BSD** – Blanched sundried, **BShD** – Blanched shade dried, **CSD** – Cooked sundried, **CShD** – Cooked shade dried, **RSD** – Raw sundried, **RShD** – Raw shade dried.

Discussion

Proximate Composition of the Sample

The effects of sun drying and shade-drying processing methods on the nutrient composition of raw, cooked, and blanched turmeric (*Curcuma longa*) were investigated. The cooked shade dried sample had the highest moisture content (18.50%) when compared to other processed samples. This increase in moisture content is not in line with the findings of Ikpeama et al. (2014), who found low moisture content of steamed turmeric at 8.92% and 11.80% respectively. The low moisture of cooked shade-driedsample is desirable and indicative of a longer shelf life and will slow down the growth of microorganisms.

The protein content of the raw shade-dried sample was higher when compared to other samples. This is similar to the findings of Ikpeama et al. (2014) who reported 9.40% of steamed turmeric. Cooked sun-dried and cooked shade-dried samples had the lowest protein concentration; this could be a result of protein solubilization and nitrogenous material leaking out during the cooking process. Incorporating this sample into one's diet can provide a considerable amount of protein, which has several advantages, including the development and repair of biological tissues, the maintenance of fluid balance, and hormone synthesis (Nwamarah et al., 2015).

Ash content determines the presence of minerals in any food material (Sarke et al., 2021). Cooked shade-dried sample had the highest ash value (8.03%). This differed from the 2.86% ash content of shade-dried sample reported by Harbor (2020). This could be a result of duration of the cooking process. The 8.03% ash content shows that the cooked shade dried sample would contain an appreciable amount of minerals.

The fat content of the sample ranged from 5.81 -7.80%. This is within the range of 7.11% reported by Abara et al. (2021). The sun-dried sample was found to have the lowest fat content which implies that when turmeric is cooked and sundried, the fat content is depleted, reducing the shelf life. Denaturation of lipids and breakdown into glycerol and fatty acid by heat could also

have been the reason for the observed lower value for fat.

The raw sun-dried sample had the highest value for crude fibre compared to the processed samples. Ahaotu and Lawal (2019) similarly reported a decrease in the crude fibre content of dried turmeric. This indicates that some amount of crude fibre is lost during the processing of turmeric. Fibre helps to cleanse the digestive tract by removing potential carcinogens from the body and prevents extra cholesterol from being absorbed (Ikpeama et al., 2014)

The carbohydrate values in this work are similar to the studies reported by Ahaotu and Lawal, (2019) and Harbor, (2020) whose values were 64.58% and 67.50% respectively. This shows that turmeric is a good source of carbohydrates. Carbohydrate contributes to the proper functioning of your brain, kidneys, heart muscles, and central nervous system.

Mineral Composition of the Samples

The high quantities of calcium, potassium, and iron in the sample demonstrated that turmeric is a rich source of these minerals. The levels of calcium 0.21mg/100g, potassium 0.46mg/100g, and iron0.045mg/100g reported by Ikpeama et al. (2014) were lower when compared to the values in this work. Calcium and potassium reduce the risk of cardiovascular and other ailments if consumed regularly. Phosphorus, when combined with calcium, aids in the development of strong, healthy bones as well as the overall wellness of your body. Iron performs many important functions in the body. It is primarily involved in the transfer of oxygen from the lungs to tissues. However, iron also plays a role in metabolism as a component of some proteins and enzymes (Haschka et al., 2021).

Vitamin Composition of the Sample

Raw shade-dried sample has a significant amount (20.10µg/100g) of beta-carotene and this is the highest among the other values reported in this study. Beta-carotene is a precursor of Vitamin A, which is essential for eye health and eyesight, as well as healthy skin, growth and development, and immune system function (Newman, 2017).

Cooked sun-dried and cooked shade-dried samples had lower vitamin C levels than the other samples, however, the shade-dried sample had higher vitamin C (3.60mg/100g) than the sundried samples. This is because vitamin C is a water-soluble, temperature-sensitive vitamin, and cooking and drying induce more loss (Harbor, 2020). Victor et al. (2020) reported a higher value for vitamin C (19.47mg/100g) compared to the values recorded in this study. This could be a result of differing methodologies for determining vitamin C composition.

Conclusion

The nutrient value of the different samples increased with the drying methods. The increase or decrease of nutrients may be attributed to the removal of water molecules by drying. The findings of this study showed that among these diverse processing methods, raw shade dried tumeric samples were more nutritious in terms of nutrient conservation than other processing methods. The nutrients were all more positively affected by shade-drying method compared to sun drying method.

Recommendations

1. The processing of raw turmeric should be highly encouraged as it conserves more nutrient
2. The use of shade drying method processing method is recommended as it has been found to retain more nutrients.

References

Abara, P.N, Adjeroh, L.A, Nwachukwu, M.O., &Osinomumu, I.D. (2019). Diffentiation between two spices *Zingiberofficinale* (Ginger) and *Curcuma longa* (Turmeric); their proximate, mineral and vitamin content. *IAA Journal of Scientific Research*. 7(1), 17-24. https://www.researchgate.net/publication/351946004_Differentiation_between_two_Spices_Zingiber_officinale_Ginger_and_Curcuma_longa_Tumeric_their_Proximate_Mineral_and_Vitamin_Contents.

Ahaotu, E. O. & Lawal, M., (2019). Determination of proximate and minerals content of turmeric (*Curcuma longa Linn*) leaves and Rhizomes. *Journal of Food, Nutrition and Packaging*, *6*, 1-4. https://www.jakraya.com/journal/pdf/6-jfnpArticle_1.pdf

Association of Official Analytical Chemists (AOAC) (2010). Official method of analysis. Washington DC: Association of analytical Chemists

Chattopadhyan, L., Biswas, K., Bandyo-padhyay, U., & Banerjee, R.L. (2003). Turmeric and curcumin: Biological action and medicinal applications. *Current Science, 87*(1), 44-53. https://www.researchgate.net/publication/237635269_Turmeric_and_Curcumin_Biological_actions_and_medicinal_applications#:~:text=These%20include%20its%20antiinflammatory%2C%20antioxidant,antiulcer%2C%20hypotensive%20and%20hypocholesteremic%20activities.

Chavasit, V., Pisaphab, R., Sungpung, P., Jittinandana, S., &Wasantwisut, E. (2002). Changes in β-carotene and vitamin a contents of vitamin A rich foods in Thailand during preservation and storage. *Journal of Food Science*, *67*, 375-379. https://doi.org/10.1111/j.1365-2621.2002.tb11413.x

Danso, B. E. (2013). Effect of drying methods on nutrient quality of Basil (*Ocimumviride*) leaves cultivated in Ghana. *International Food Resource Journal*, *20*(4), 1569-1573. https://www.researchgate.net/publication/287742977_Effect_of_drying_methods_on_nutrient_quality_of_basil_ocimum_viride_leaves_cultivated_in_Ghana

Debjit, B., Chiranjib, Sampath, K., Margret, C., & Jayakar, B., (2009). Turmeric: A herbal and traditional medicine. *Scholar Research Library, 1*(2) 86-108.https://www.scholarsresearchlibrary.com

Dissa, O.A., Bathiebo, D.J., Desmorieux, H., Coulibaly, O., &Kouliati, J. (2011). Experimental characterization and modelling of thin layer direct solar drying of Amelie and Brooks mangoes. *Energy, 36*(5), 2517-2527. https://doi.org/10.1016/j.energy.2011.01.044

Emelike, N. J. T., Akusu, M. O. &Ujong, A. E. (2017). Antioxidant and physicochemical properties of oils extracted from cashew (*Anarcadium occidentale*) kernels. *International Journal of Food Science and Nutrition*, *2*(6), 122-128. https://www.foodsciencejournal.com/assets/archives/2017/vol2issue6/2-6-31-367.pdf

Emelike, N. J. T., Ujong, A. E. &Achinewhu, S. C. (2020). Effect of ginger and cinnamon on the proximate composition and sensory properties of corn ogi. *European Journal of Nutrition and Food Safety*, *12*(7), 78-85. https://doi.org/10.9734/ejnfs%2F2020%2Fv12i730253

Emelike, N. J. T. (2020). Functional and physicochemical properties of turmeric powder as affected by processing methods. *Asian Food Science Journal*, *19*(2), 1-10. http://dx.doi.org/10.9734/AFSJ/2020/v19i230232

Enemor, V., Ogbodo, U., Nworji, O., Ezeigwe, O., Okpala, C., &Iheonunekwu, G. (2020). Evaluation of the nutritional status and phytomedicinal properties of dried rhizomes of turmeric (*Curcuma longa*). *Journal of Biosciences and Medicines*, *8*(8), 163-179. http://dx.doi.org/10.4236/jbm.2020.88015

Harbor, C.I. (2020). Effect of traditional processing methods on the nutrient and antinutritional composition of turmeric (*Curcuma longa). Nigerian Agricultural Journal, 5*(1), 125-131. https://www.ajol.info/index.php/naj/article/view/196631

Haschka, D., Hoffmann, A., & Weiss, G. (2021). Iron in immune cell function and host defense. *Seminars in Cell and Developmental*

Biology, 115, 27-36. https://doi.org/10.1016/j.semcdb.2020.12.005

Ikpeama, A, Onwuka, G. I., & Nwankwo, C. (2014). Nutritional composition of turmeric (*Curcuma longa*) and its antimicrobial properties. *International Journal of Scientific and Engineering Research*, *5*(10), 1085-1089. https://www.researchgate.net/publication/327288405_Nutritional_Composition_of_Turmeric_Curcuma_longa_and_its_Antimicrobial_Properties

Jiang, T.A. (2019). Health benefits of culinary of herbs and spices. *Journal of AOAC International, 102*(2), 395-411.https://doi.org/10.5740/jaoacint.18-0418

Jilani, M.S., Waseem, K., Habib-Ur-Rehman, Kiran, M., Ghazanfarulla, & Ahmad, J. (2012). Performance of different turmeric cultivars in Dera Ismail Khan. *Pakistan Journal of Agricultural Science*, *49* (1), 47-51. https://www.cabidigitallibrary.org/doi/pdf/10.5555/20123130414

Jakutowicz, K., Tomick, Z.I., & Leokadia (1997). Determination of total plasma tocopherol in the presence of carotene. *Poland Archeology of Water*, *20,* 45-57. https://www.sdiarticle4.com/

Jose, K.P., & Joy, C.M. (2009). Solar tunnel drying of tumeric (Curcuma longa linn. Syn. C. domestica val.) for quality improvement. *Journal of Food Processing and Preservation, 33*(s1), 121-135.http://dx.doi.org/10.1111/j.1745-4549.2008.00287.x

Newman, T, (2017, December, 12). *All you need to know about betacarotene*. MedicalNewsToday. https://www.medicalnewstoday.com/articles/252758.

Nwamarah, J. U., Otitoju, O., Otitoju, G. T. O. (2015). Chemical composition and anti-diabetic properties of *Jatropha curcas* leaf extract on alloxan indused diabetic rats. *African Journal of Biotechnology, 14*(12), 1684-5315. https://doi.org/10.5897/AJB2015.14432

Omayio, D. G., Abong', G. O., Okoth, M. W., Gachuiri, C. K., &Mwang'ombe, A. W. (2020). Trends and Constraints in Guava (*Psidium Guajava* L.) Production, Utilization, Processing and Preservation in Kenya. *International Journal of Fruit Science*, *20*(sup3), S1373–S1384.https://doi.org/10.1080/15538362.2020.1791304

Sarker, A.K, Rashid, M., Roy, D.C., Musarrat, M., & Bithi, H. (2021). Ginger (*Zingiberofficinale) powder from low temperature drying techniques. Bangladesh Journal of Scientific and Industrial Research. 56(2), 133-140.*http://dx.doi.org/10.3329/bjsir.v56i2.54320

Singh, R., & Dubey, A.K. (2015). Endophytic actinomycetes as emerging source for therapeutic compounds. *Indo Global Journal of Pharmaceutical Sciences, 5*(2), 106-116. http://dx.doi.org/10.35652/IGJPS.2015.11

Kamble, K.J., & Soni, S.B. (2009). A study of improving turmeric processing. *Karnataka Journal of Agricultural Sciences, 22*, 137-139.https://www.semanticscholar.org/paper/A-study-of-improving-turmeric-processing.-Kamble-Soni/5de68ae6cb0d592992db282539701c6f4fdfccf2

Taoheed, A.A., Tolulope, A.A., Saidu, A.B., Odewumi, O.G., Sunday, R.M., & Usman, M.H. (2017). Phytochemical properties, proximate and mineral composition of curcuma longa linn. and zingiber officinale rosc.: A comparative study. *Journal of Scientific Research and Reports, 13*(4), 1-7.https://doi.org/10.9734/JSRR/2017/32623

UNIDO and FAO (2005) Herbs, spices and essential oils, post-harvest operations in developing countries. http://www.fao.org/3/a-ad420e.pdf