Proceedings of Pakistan Society for Horticultural Science
2nd International Conference on Horticultural Sciences, February 18-20, 2016
Theme: Production Challenges and Food Security
Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab 38040, Pakistan

Mechanical Drying Influences Postharvest Quality of Turmeric Rhizomes

Ahmad Sattar Khan[1], Naveed Ahmad* [2], Habib Ahmad[3], Malik Abid Mahmood[2]
[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad, 38040, Pakistan
[2]Directorate of Floriculture (T&R) Punjab, Lahore, Pakistan
[3]Department of Agronomy, University of Agriculture, Faisalabad, 38040, Pakistan
Email: nahmad57@gmail.com (A.S.K)

Abstract

Proper drying of turmeric rhizomes is very important for the quality of final product. Therefore, studies were undertaken to examine the effect of different methods of drying on the physico-chemical composition and quality characteristics of turmeric rhizomes. Fresh turmeric rhizomes were subjected to drying by two different methods. In one method turmeric rhizomes were dried in open sun and in second method they were subjected to drying in mechanical dryer at 60°C. Results revealed that moisture content of samples was reduced from 82.4 to 9.2% within 29 days in sun drying method whereas it took only 3 days to dry the samples to 9.1% moisture level in mechanical dryer. Slightly higher percentages of curcumin and oleoresin were found in sun dried samples as compared to mechanical drying. Sun dried samples of turmeric were found contaminated with aflatoxin B_1 (120 µg/kg), while there were no contantminats in mechanically dried samples. The results revealed that mechanical drying is better than sun drying as it achieved the desired moisture and quality within 3 days compared to 29 days in sun drying, thus saving considerable time. There was no microbiological activity detected in mechanically dried samples. Hence, mechanical drying can safely be adopted for turmeric drying at commercial level.

INTRODUCTION

Turmeric (*Curcuma longa* L.) belongs to the family Zingiberaceae and is valued for its underground orange coloured rhizomes. It is used as natural colouring agent for food, cosmetics and dyes (Jilani *et al.*, 2012). It is an ancient spice and a traditional remedy that has been used as a medicine, condiment and flavouring. Curcuminoids, the active principles in turmeric rhizomes are known to have some medicinal properties and has been used efficiently in the treatment of circulatory problems, liver diseases, dermatological disorders (Semwal *et al.*, 1997). Apart from the rhizome's richness in curcuminoid pigments (6%) and essential oils (5%) it also contains 69.43% carbohydrate, 6.30% protein and 3.50% mineral on dry weight basis (Olojede *et al.*, 2005). Studies have indicated that curcumin is nontoxic to humans even at a dose of 8000 mg/day taken continuously (Cheng *et al.*, 2001).

Major turmeric producing countries are India, Pakistan, Malaysia, Myanmar, Vietnam, Thailand, Philippines, Japan, China, Korea and Sri Lanka (JRG 2011). In Pakistan, it is cultivated over an area of 4000 ha with an annual production of about 38,000 tons (GOP 2005). Pakistan is traditionally a turmeric-producing country. Punjab, Sindh, and Khayber Pakhtoon Khawa are the major provinces contributing in turmeric production. However, more than 80% turmeric production in Pakistan is shared by Kasur, district of Punjab province (Tahira *et al.*, 2010).

Processing of raw turmeric rhizomes is a challenge with respect to its final appearance and colour. The processing of turmeric rhizomes consists of three stages: curing, drying, and polishing. In the contemporary curing process, the cleaned rhizomes are boiled in water just enough to soak them. Boiling is stopped when froth comes out, with the release of white fumes having the typical turmeric aroma (Anandaraj *et al.*, 2001). The stage at which boiling is stopped largely influences the final colour and aroma of the final product. After boiling the rhizomes are allowed to dry. Traditionally used method of drying for turmeric rhizomes is sun drying. It is practiced widely in hot climates and in tropical countries, due to its low cost and simple technology. However, it is extremely weather-dependent and requires unduly long processing times (20 to 30 days) and the rhizomes are still prone to infestation, which is not acceptable for industry. Peel removal and slicing of rhizomes before drying can reduce drying time and obtain good quality product but cause 30% mass loss which is not affordable (Bambirra *et al.*, 2002). Drying using cross-flow hot air has been found to give a satisfactory product (Sivadasan and Shenoy, 1995). Solar driers can also be economically used for drying turmeric. However, the maximum temperature achieved by the drier depends on the outside climatic conditions. Satisfactory outputs cannot be achieved in regions where cloudiness and humidity are high. In Punjab harvesting of turmeric started at the end of December. Sun drying and solar drying of turmeric rhizomes is not feasible due to foggy and cloudy weather. Satisfactory end product cannot be achieved by sun drying due to cloudiness, high humidity and low temperature. Therefore,there is need to develop alternate drying method in order to get good quality product.

MATERIALS AND METHODS

Fresh turmeric rhizomes of the variety 'Kasur' with a moisture content of 82.4% were procured from Mian Farooq Agriculture Farm, Kasur, (31°12'N; 74°45'E) Punjab during January 2011 at commercial maturity and were transported to Postharvest Quality Assurance Lab, Honest Rice Mills and Foods, Sheikhupura Road, Muridke, Pakistan. The raw rhizomes were cleaned well and the rhizome samples used for various analyses were taken in triplicate. The raw samples, weighing 10 kg, were boiled in water for about 30 min, until frothing occurred and white fumes appeared and emitted a characteristic turmeric odour. The boiling was carried out in a steel pan. The drying was carried out under direct sun and in the mechanical dryer after keeping the samples in trays. Sun drying was carried out in a clear non-shadowed area. The sun drying was done from 8 am to 4 pm. The sample weights were recorded daily and subsequently analyzed for moisture content and biochemical constituents. Temperature and RH of mechanical dryer was recorded at one-hour intervals. The samples were dried until the moisture level in the samples was reduced to a safe storage level of less than 10%. The dried rhizomes (100

g) obtained from each of the two samples were powdered and were analyzed to determine moisture content (ASTA method 2.0, 1997) and oleoresin (ASTA method 4.0, 1975).

Aflatoxins were determined according to standard method of Association of Official Analytical Chemists (AOAC), by thin layer chromatography (AOAC, 2000). Fifty-gram sample were extracted with 250 mL acetone/water (85:15 v/v) using blender for 3 min and filtered. A 150 mL of filtrate was taken in 400 mL beaker. Then 170 mL of 0.02 N sodium hydroxide and 30 mL ferric chloride along with about 3 g basic copper carbonate added to the filtrate in 400 mL beaker, mixed well and added to the mixture in 600 mL beaker. This solution mixture was filtered and 150 mL transferred to 500 mL separating funnel. To this 150 mL 0.03% sulphuric acid was added and extracted twice with 10 mL of chloroform. Lower chloroform extract layer was transferred to another separating funnel and 100 mL of 0.02 M potassium hydroxide was added, swirled gently for 30 sec and left it for layer separation. Chloroform extract layer was collected in a vial. Of this 8 mL was evaporated to dryness at 45°C under gentle stream of nitrogen on a heating block. The residue was dissolved in 200 µL benzene/ acetonitrile (98:2 v/v) and subjected to thin-layer chromatography. Final identification and quantification of total aflatoxin were performed by one-dimensional TLC on pre-coated silica gel plates (Merck, Germany). The plates were developed in a saturated chamber with chloroform/xylene/acetone (60:30:10; v/v/v). The sample spots were observed under long wave ultraviolet light (λ = 365 nm) and determined by visual comparison with aflatoxins standard spots. Confirmation of the identity of aflatoxins was carried out with the spray of 50% sulphuric acid and using the Trifluoroacetic acid (TFA) reaction (Scott, 1984).

Curcumin content was determined by solvent extraction and spectrophotometric method (ASTA, 1997). A 100 mg of sample was taken in an extraction flask and 30 ml of 95% alcohol was added and refluxed for 3 h. The refluxed residue was cooled and filtered. A 20 ml of filtrate was taken and diluted to 250 ml with 95% alcohol. The absorbance of diluted sample and that of standard solution was measured at 425 nm by a spectrophotometer. Curcumin concentration of the samples was estimated using standard curve and expressed in percentage.

Samples were examined for total plate count (TPC), Yeast and Mold (Y&M) as per the procedure described by Vanderzant and Splittstoesser (1992).

The sensory attributes of turmeric samples were evaluated by 5 semi-trained panelists. A 7-point hedonic scale (1 = dislike extremely, 7 = like extremely) was used to evaluate the acceptability of product attributes (appearance, colour, flavour, texture and overall like).

The data were analyzed statistically by Statistix 8.1 for windows and mean separation was done by least significant difference (LSD) following significant ($P \leq 0.05$) F test. All assumptions of the analysis were checked to ensure the validity of statistical analysis.

RESULTS AND DISCUSSION

Foreign Matter and Weight Loss

Presence of foreign matter in the end product is critical from the point of view of export. Turmeric can pick up contamination during various stages from harvest to postharvest processing and storage. Main contaminants encountered during processing of turmeric are rodents, animals, and bird filth; field and storage insects; spiders, mites, extraneous materials and mycotoxins. As expected, higher amount of foreign matter was found in sun dried samples (2.23%) than mechanically dried samples (1.63%) (Figure 1). This higher amount of foreign matter in sun dried samples may be ascribed to the poor hygienic conditions during sun drying in the open field. In general animals and rodents can reach very easily in open sun drying since the drying floor is also unprotected and unhygienic. Sun dried samples of turmeric were found contaminated with foreign matter above the permissible level (2%) set by European Spice Association while mechanically dried samples were below that limit.

During drying weight loss in both drying methods was observed but more weight loss was recorded in sun dried samples than samples dried in mechanical dryer. As in sun drying method during night time, rhizomes are heaped and turning over of rhizomes required again and again ensuring uniformity in drying. During these operations a large quantity of rhizomes is wasted so more weight loss occur in sun drying method.

Curcumin and Oleoresin Contents

Ratnambal (1986) reported that curcumin is an important factor in developing and selecting cultivar or variety for turmeric production and in determining the price of turmeric. Higher level of curcumin contents were found in sun dried samples (7.3%) as compared to samples dried in mechanical dryer (5%) (Figure 2). This may be due to high temperature of the drier which was maintained at 60˚C due to which degradation of curcumin occur. There is only a small difference in the curcumin content of turmeric rhizomes dried in both the methods. This small difference in the curcumin content of turmeric rhizomes dried by two different methods (sun drying vs solar drying) was also observed by Gunasekar *et al. (*2006). Kumar *et al. (*2010) also found higher retention of total curcumin content in sun dried samples. The oleoresin contents of sun dried turmeric samples (8.4%) was higher than that of samples dried in mechanical drier (7.3%) (Figure 2). This may be due to high temperature of the drier which degrades the oleoresin content of mechanically dried samples of turmeric rhizomes but there is only a small difference in the oleoresin content of turmeric rhizomes dried in both the methods but there is advantage of less drying time required in mechanical drier oven drying which require only three days to bring moisture level below 10%. At this moisture level chances of microbial contamination are very rare.

Moisture Contents and Total Recovery

The moisture content of boiled rhizomes was reduced from 82.4% to 9.1% within 3 days in mechanical drying method, whereas, it took 29 days to dry the turmeric rhizomes to 9.1% in open sun (Table 2). Thus, mechanical drying was a faster and better method for drying turmeric as compared to sun drying as moisture (%) of whole lot of turmeric rhizomes dried by mechanical drier was almost same but a fluctuation in moisture (%) of same lot of turmeric rhizomes was observed due to different size of rhizomes as sun light could not penetrate in large and small size rhizomes equally. As expected both samples exhibited gradual decrease in moisture content with the passage of time but rapidly in oven drying because stable temperature of 60°C was available in oven drying while in sun drying interruption of night postponed drying till next day sun. The decrease in moisture during drying was initially rapid in both drying methods followed by gradual decrease in later part of drying which may be due to free water available in the rhizomes. Total recovery is the preliminary consideration of the processor. From the yield point of view, a high dry recovery percentage is desirable since the final yield in turmeric is the dried rhizomes. Total recovery (yield, %) of rhizomes dried by mechanical drier was slightly more (26.4%) than that of sun dried samples (25.1%) (Figure 3). This low yield of turmeric rhizomes may be due to the loss by birds and insect pest to the turmeric rhizomes which were dried under sun. The dry recovery of cured turmeric varies between 15–30% (Peter, 2001). The total recovery by both drying methods was satisfactory but slightly higher recovery was observed in oven drying which shows its superiority over sun drying in this regard. Ratnambal (1986) published the result of analysis of dry recovery in 180 accessions and maximum was in 'Pathavayal, Gudalur' (25.0%) which is not very different from our findings. Hence processing method was the chief factor in maintaining the recovery optimum.

Sensory Evaluation

The quality of turmeric mainly depends upon sensory characteristics. The aroma of sun dried samples was less intense than the mechanically dried samples. Mechanically dried samples exhibited higher (5.78) mean colour than sun dried samples (4.43) (Figure 4). The less intensity of colour in sun dried samples may be due to the direct effect of sun rays which faded the colour of turmeric. Anandaraj *et al.* (2001) also found that direct sunlight results in surface discoloration of turmeric rhizomes with poor quality powder. Appearance of the product is very important for consumer liking and disliking. Better appearance was observed in mechanically dried turmeric samples (5.87) as compared to sun dried samples (4.91). Hence the overall quality of product remained maintained in oven drying where as in open sun drying it gets deteriorated. Sharma *et al. (*2008) also found sun dried samples inferior in all the quality attributes viz. colour, flavor, appearance and overall acceptability whereas the laboratory processed samples were found superior in all respects.

Aflatoxins and Microbial Count

Another major issue in the postharvest quality of turmeric is the presence of aflatoxins. Aflatoxins are a group of secondary metabolites of the fungi and are rated as potent carcinogens. Inadequate and unhygienic drying leads to the growth of these fungi on the turmeric rhizomes. Turmeric rhizomes with moisture content above 10% was found to get infested with yeast and mold when store for long time. The sun dried samples of turmeric were found contaminated with aflatoxin B_1 (1.20 µg kg^{-1}), while mechanically dried samples did not show any contamination (Table 1). In sun drying method turmeric rhizomes take more time to bring moisture level below 10% therefore they were infested with mold and yeast (1.20 cfu/g). Furthermore sun drying samples need piling during night. Therefore internal temperature of piled rhizomes provides conducive circumstances for fungal contamination (3.20 cfu/g) which leads to aflatoxins production. These improper sun drying conditions are conducive for the biosynthesis of aflatoxins. The results also confirm the previous findings that processing methods, storage conditions and postharvest treatments are responsible for the microbial contamination. (Colak *et al.*, 2006). Mechanical drying take less time to get require moisture level and protected from environmental hazards so end product are free from any type of contaminants such as aflatoxin.

The results obtained in this study indicate the levels of curcumin, volatile oils, oleoresin and moisture level fall within the specified requirements and hence the product is fit enough for application and consumption. Although, the higher temperature in mechanical drying caused a slight loss of curcumin and oleoresin, the product is still satisfying the specified requirements. Furthermore, mechanical drying achieved the safe moisture content of 9.1% within 3 days as against 29 days in case of sun drying, thus, saved 26 days. Mechanically dried samples of turmeric did not show any aflatoxin contamination and low amount of foreign matter. It is also observed that mechanical drying of turmeric rhizomes is easier than sun drying method. Labour required for oven drying is half of the sun drying process. Hence, the mechanical oven drying method is the best possible option for drying of turmeric rhizomes.

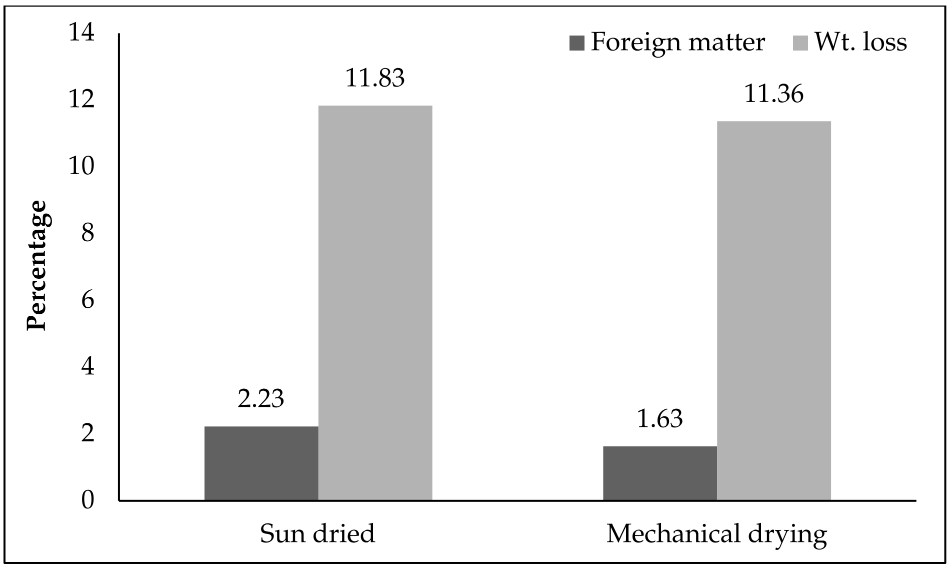

Figure 1: Effect of drying methods on the weight loss and foreign matter (%) of turmeric rhizomes.

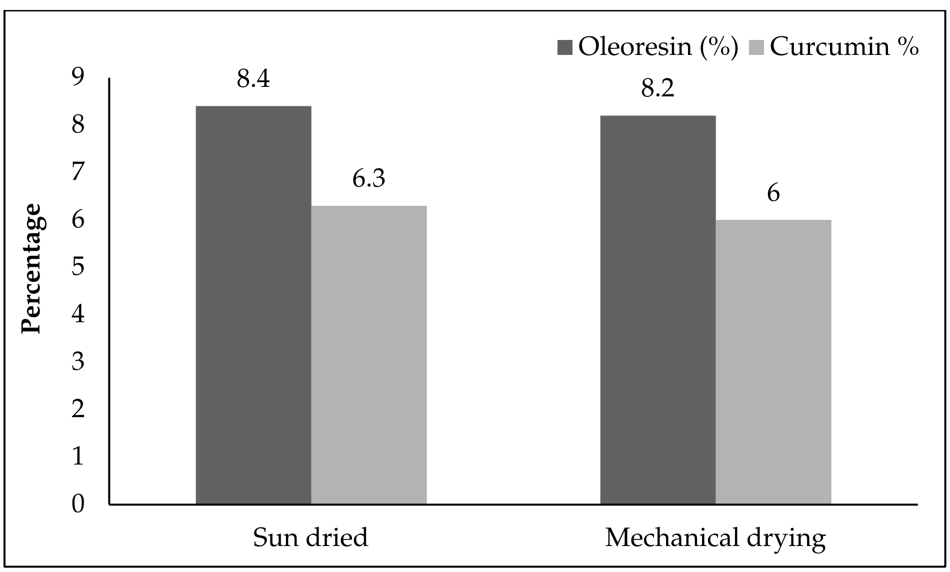

Figure 2: Effect of drying method on the curcumin and oleoresin contnets of turmeric rhizomes.

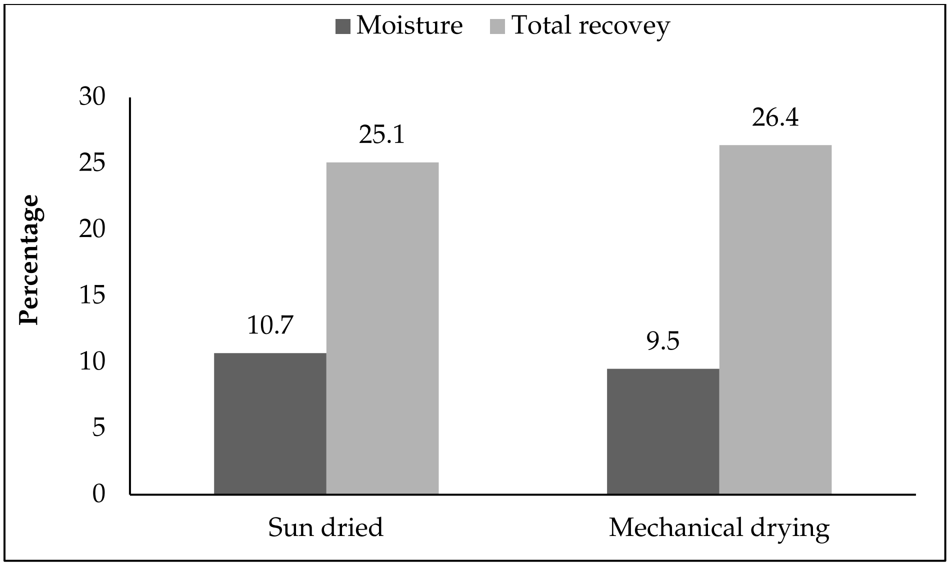

Figure 3: Effect of drying method on moisture contents and total recovery of turmeric rhizomes.

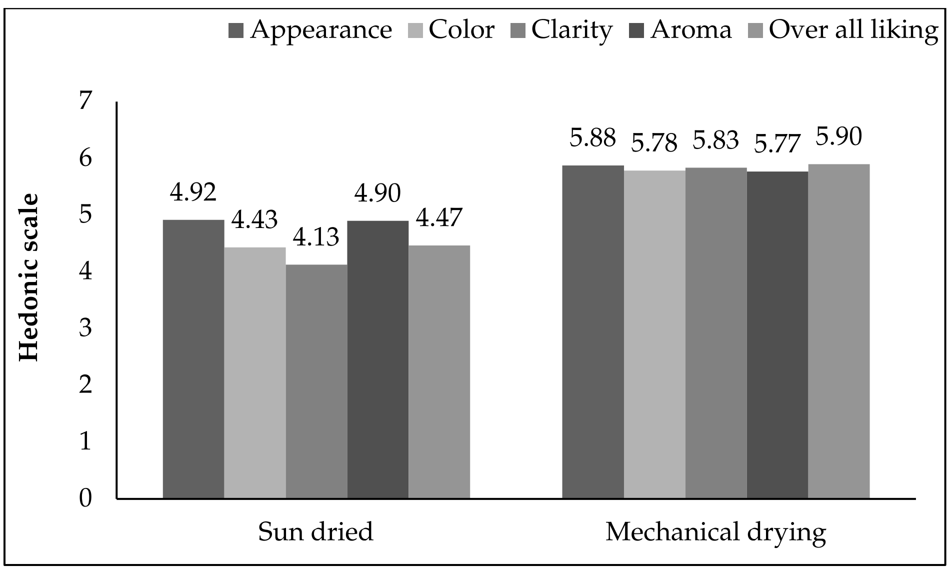

Figure 4: Effect of drying method on sensory evaluation of turmeric rhizomes.

REFERENCES

Anandaraj, M., T.J. Devasahayam, S. Zachariah, S.J. Eapen, B. Sasikumar and C.K. Thankamani. 2001. Turmeric (Extension Pamphlet). Indian Institute of Spices Research, Calicut, Kerala, India.

AOAC. 2000. AOAC Methods. Association of Official Analytical Chemists. Washington, DC, USA.

ASTA. 1997. Official Analytical Methods., American Spice Trade Association, Englewood Cliff, New Jersey, http://www.sciencedirect.com/science (Retrieved on 4th August 2012).

Bambirra, M.L., R.G. Junqueira and M.B.A. Gloria. 2002. Influence of postharvest processingconditions on yield and quality of ground turmeric (*Curcuma Longa* L.) Brazilian Arch. Biol. and Technol. p:423-429.

Cheng, A.L., C.H. Hsu, J.K. Lin, M.M. Hsu, Y.F. Ho, T.S. Shen, J.Y. Ko, J.T. Lin, B.R. Lin, W. Ming-Shiang, H.S. Yu, S.H. Jee, G.S. Chen, T.M. Chen, C. Chen, M.K. Lai, Y.S. Pu, M.H. Pan, Y.J. Wang, C.C. Tsai and C.Y. Hsieh. 2001. Phase I clinical trial of curcumin, a chemopreventive agent, in patients with high-risk or pre-malignant lesions. Antican. Res.21:2895-2900.

Colak, H., E.B. Bingol, H.A. Hampikyan and B. Nazli. 2006. Determination of aflatoxin contamination in Red-Scaled, Red and Black Pepper by ELISA and HPLC. J Food Drug Anal.14:292-296.

GOP. 2005. Agriculture Statistics of Pakistan. Ministry of Food, Agriculture and Livestock,Islamabad,Pakistan.

Gunasekar, J.J., S. Kaleemullah, P. Doraisamy and S. Kamaraj. 2006. Evaluation of solar drying for post harvest curing of turmeric (*Curcuma longa* L.). Agri. Mech. Asia Africa Latin Am. 37:9-13.

Jilani, M.S., K. Waseem, H. Rehman, M. Kiran, G. Ullah and J. Ahmad. 2012. Performance of different turmeric cultivars in Dera Ismail Khan. Pak. J. Agri. Sci. 49:47-51.

JRG. 2011. Turmeric Seasonal Report. JRG House, Ashoka Road, Kaloor, Kochi, Kerala – 682017. PP-2 Olojede, A.O., P. Iluebbey and A.G.O. Dixon. 2005. Collaborative germplasm and data collection on minor root and tuber crops in Nigeria. NRCRI Annual Report 2005, National Root Crops Research Institute, Umudike, Nigeria.: 77-81.

Peter, K.V. 2001. Handbook of herbs and spices. CRC PRESS. Woodhead Publishing Limited. Pp- 297. Ratnambal, M.J. 1986. Evaluation of turmeric accession for quality. Qual, Plantarum. 36: 243-252.

Scott, P.M. 1984. Effects of food processing on Mycotoxins. J. Food Protect. 47:489-499.

Semwal, A.D., G.K. Sharma, S.S. Arya. 1997. Antioxidant activity of turmeric (*Curcuma longa*) in sunflower oil and ghee. J. Food Sci. Technol. 34:67-69.

Sharma, P.D., S.M. Kumar, K. Vinay. 2008. Curing Characteristics and Quality Evaluation of Turmeric Finger. J. Agri. Engin. 45:58-61.

Sivadasan, C.R. and N.A.D. Shenoy. 1995. Quality Improvement of Turmeric, Spices Board, Kochi, India.

Tahira, J.J., S.N. Khan, R. Suliman and W. Anwar. 2010. Weed flora of *Curcuma longa* fields of district Kasur. Pakistan. Pak. J. Weed Sci. Res. 16:241-246.

Vanderzant, C., and D.F. Splittstoesser. 1992. Compendium of methods for the microbiologicalexamination of foods (3rd ed.). Washington: American Public Health Association.

Table 1: Effect of drying method on the the aflatoxin analysis of turmeric rhizomes.

Drying methods	Aflatoxin (μg/kg)				
	B1	B2	G1	G2	TOTAL
Sun drying	1.20	ND	ND	ND	1.20
Oven drying	ND	ND	ND	ND	ND

ND = not detected

Table 2: Effect of drying method on the moisture content (%) of turmeric rhizomes.

Days	**Sun drying**	**Oven drying**
1	82.4	82.4
2	72.2	50.2
3	65.3	30.1
4	59.2	9.1
5	55.9	
6	50.5	
7	46.2	
8	43.8	
9	42.8	
10	38.4	
11	35.7	
12	33.6	
13	31.1	
14	29.4	
15	25.3	
16	22.8	
17	20.9	
18	18.1	
19	17.4	
20	16.6	
21	15.6	
22	14.5	
23	13.3	
24	12.4	
25	11.2	
26	10.5	
27	10.3	
28	9.4	
29	9.2	

Table 3: Effect of drying method on the microbiological properties of turmeric rhizomes.

Drying methods	Microbial Count	
	Total plate count (log cfu/g)	Yeast and mould (log cfu/g)
Sun drying	3.12	1.20
Oven drying	ND	ND

ND = not detected