Journal of Food Technology 6 (1): 9-13, 2008
ISSN: 1684-8462

Physico-Chemical Characteristics of Turmeric Genotypes Cultivated in Nigeria as Potential Sources of Commercial Colourants

U.J. Ukpabi, N.J. Ogbogu, H.A. Etudaiye and A.O. Olojede
National Root Crops Research Institute, Umudike, P.M.B 7006, Umuahia, Abia State, Nigeria

Abstract: Powdered dried rhizomes of the major turmeric genotypes (Cl-1, Cl-2) cultivated in Nigeria were physico-chemically analysed (with the aid of laboratory methods and local consumers) for their potential as sources of commercial colourants. Results showed that the colour of the dilute (0.5%) liquid extracts of the dried (at 50, 60 and 70°C) turmeric samples was generally yellow, yellow-orange, lemon-yellow and orange with cold water, hot water, acetone and ethanol, respectively. The organoleptic analysis with local food consumers showed that the experimental turmeric powder samples were generally liked. At the ratio of 1:2000 (turmeric powder: rice w/w), the yellowish cooked rice, coloured by the pigments in some turmeric powder samples was liked much by these local consumers. Furthermore, the commercial oleoresin content of the dehydrated curcuminoid rich turmeric rhizome samples was found to be 14.80 and 14.00% for NCl-1 and NCl-2 genotypes, respectively.

Key words: Turmeric, physico-chemical characteristics, colourants, oleoresin, Nigeria

INTRODUCTION

Turmeric (*Curcuma longa* Koenig Syn: *Curcuma domestica* Val) is a tropical spicy plant (Pulseglove *et al*., 1987; Borget, 1993; Chandarana *et al*., 2005). In addition to its importance as a spice, the turmeric rhizome is also valued as a source of yellowish colouring pigments (Pruthi, 1992; Borget, 1993; Buescher and Yang, 2000). The principle colouring components of turmeric rhizome are curcumin and to a lesser extent demethoxycurcumin and bisdemethoxycurcumin (Pruthi, 1992; Nakayama *et al*., 1993; Garg *et al*., 1999).

The phenolic curcumoids are largely responsible for the yellow-orange colour of turmeric powder and brownish-orange colour of turmeric oleoresin which gives a yellowish colour on about 10% dilution (Pruthi, 1992; Garg *et al*., 1999; Buescher and Yang, 2000). These biochemical colour pigments are also known to be in varying concentrations in turmeric rhizomes based mainly on the crops genotype and agro-climatology (Pulseglove *et al*., 1987; Borget, 1993; Garg *et al*., 1999). Furthermore, applied processing method (such as mechanical drying at about 60°C) and consumers' acceptability may also affect the commercial value of the rhizomes' colourants (Pruthi, 1992; Buescher and Yang, 2000; Gopalan *et al*., 2000). Though, many of the turmeric genotypes cultivated in tropical Asian countries have been identified as good commercial sources of these curcuminoid colourants, especially for the food industries (Pruthi, 1992; Borget, 1993; Buescher and Yang, 2000), not much is known about the African turmeric genotypes in this direction (Burkill, 1985; Igwe *et al*., 2005; Ukpabi *et al*., 2005).

In Nigeria (a tropical African country), the major turmeric genotypes (landraces) of economic importance that are found in farmers' field and the germplasm of National Root Crops Research Institute (NRCRI) Umudike, Abia State, Nigeria are NCl-1 and NCl-2. The aim of this study is to investigate the possibility of getting the commercial yellow-orange colourants from the rhizomes of major turmeric landraces cultivated in Nigeria. Relevant scientific methods or tools would therefore be needed to achieve this objective.

MATERIALS AND METHODS

Source of turmeric rhizomes: The 2 turmeric landraces (NCl-1 and NCl-2) used to obtain the experimental rhizomes were planted in the research field of the NRCRI, Umudike, Abia State, Nigeria in May 2006. The used turmeric rhizomes were harvested in January 2007, that is, at 8 months after planting.

Corresponding Author: Ukpabi Joseph Ukpabi, National Root Crops Research Institute, Umudike, PMB 7006, Umuahia, Abia State, Nigeria

Preparation of the turmeric powder: The unit and sub unit operations used in the preparation of the turmeric powder (with the experimental turmeric rhizomes samples) included: Sorting, washing, particle size reduction (longitudinal splitting), drying, milling and sieving. Drying of the split rhizomes to brittleness was done mechanically with an electric oven (Oven BS, Gallenhamp, England) at 50, 60 and 70°C. The dried samples were ground with an electric Thomas milling machine (Arthur H. Thomas Co., Philadelphia, PA, U.S.A) to such fineness that all of them passed through a 500 micron sieve. The obtained 6 turmeric powder samples, coded NCl-1-50, NCl-1-60, NCl-1-70, NCl-2-50, NCl-2-60 and NCl-2-70 (to indicate their respective genotype/drying temperature), were packaged with glass sample bottles and kept in a dark wooden cabinet for further analysis (within the same week of production in February, 2007).

Colour analysis of dilute turmeric liquid extracts: Dilute liquid extracts of the turmeric powder samples for the colour analysis was produced with cold water (29°C, pH 7), hot water (100°C, pH 7), acetone and ethanol. Clear liquid extracts of the experimental turmeric samples and solvents were obtained (in triplicates) by thorough shaking (with vortex mixer) of their respective dilute (0.5%) suspensions and centrifuging to sediment out their insoluble particles. Mechanical colour analysis (at λ420 nm) of the dilute (0.5%) liquid extracts from the 6 turmeric samples and a very dilute (0.01%) extract of turmeric samples dried at 60°C (NCl-1-60, NCl-2-60) was carried out with a uv/visible spectrophotometre (Jenway 6405, England). The 1cm cuvette used for the spectrophotometric analysis was also used to visually observe the colour of the dilute liquid extracts of the turmeric samples.

Consumers' analysis: Randomly selected 100 consumers (that were conversant with food colourings) were used for an organoleptic evaluation of the six turmeric powder samples with a 7-point Hedonic scale (Bainbridge *et al*., 1996; Iwe, 2002). The consumers were requested to physically examine the samples (especially for colour) and score according to their respective degree of likeness (Bainbridge *et al*., 1996; Iwe, 2002). In the used (1-7) scale, 1 = 'dislike extremely', 2 = 'dislike very much', 3 = 'dislike much', 4 = 'neither like nor dislike', 5 = 'like much', 6 = 'very much' and 7 = 'like extremely'. The selected consumers were also requested to use the same scoring scale to sensorily evaluate their degree of colour likeness of yellowish rice meal samples obtained by cooking polished white rice (Caprice brand, Thailand) in 1L glass beakers with turmeric powder samples (NCl-1-150, NCl-2-50) at the ratios of 1:1000 and 1:2000 (turmeric powder/rice w/w).

Chemical analysis: The dry matter content of the fresh turmeric rhizome samples was determined in quadruplicates with the standard AOAC method of drying the prepared samples to constant weight in the oven (AOAC, 1997). The oleoresin content of the turmeric powder was also determined in quadruplicates with the Soxhlet extractor apparatus (AOAC, 1997); using acetone as the extraction solvent. After the extraction, the solvent was removed with a rotary evaporator (Buchi Rotavapor R-114, Switzerland).

Statistical analysis: Statistical Analysis System (SAS) software version 8 (TS MO) licensed to International Institute of Tropical Agriculture, Ibadan, Nigeria (site 0022206002), was used for the mean separations and other statistical analysis.

RESULTS AND DISCUSSION

The shades of colour of the 0.5% liquid extracts from the deep yellow-orange turmeric powder samples are shown in Table 1. Generally, it was found that the yellow-orange colour expressed by NCl-2 samples was garish while that of NCl-1 was mellow. On the other hand, the shades of colour obtained for the very dilute (0.01%) liquid extracts (from the experimental turmeric samples) were light yellow, light lemon yellow and extremely light yellow for ethanol, acetone and hot water extracts , respectively. Pruthi (1992) and Borget (1993) stated that the attractive yellowish colour of many oriental cuisines, prepared with curry powder (a composite spicy powder), is attributable to its turmeric component. Good examples of these commercially viable dishes prepared with curry powder include 'chicken curry' and 'lamb curry' (Borget, 1993). As in natural colour perception and sensation (Schiffman, 1996), the yellow-orange colour of the turmeric liquid extract, observed in this study, became yellow on dilution and dark orange at higher concentrations. Additionally, the obtained visual colours (with 1cm cuvette) will vary to darker hues if the light paths is >1cm.(and lighter hues at <1cm) in obedience to Beer-Lambert Law in spectroscopy (Conn and Stumpf, 1976; Nelson and Cox, 2005).

The results of the spectrophotometric analyses are shown in Table 2. According to the natural law of spectroscopy above, higher absorbance readings at a specific wavelength indicate higher concentrations of the colour pigments of the solution in the cuvette. The linear relationship between the absorbance or Optical Density (OD) and concentration predicted by this experimental law at relatively low concentrations shows a remarkable deviation (that is, however, still indicative of superiority in concentration) at OD values approaching 1.999.

Table 1: Visual Colours of the dilute (0.5%) liquid extracts of the turmeric samples dried at different temperatures

Drying temp.	Hot water		Cold water		Acetone		Ethanol	
(°C)	NCl-1	NCl-2	NCl-1	NCl-2	NCl-1	NCl-2	NCl-1	NCl-2
50	Yellow-orange	Yellow orange	Yellow	Yellow	Lemon- yellow	Orange- yellow	Orange	Orange
60	Yellow-orange	Yellow orange	Yellow	Yellow	Lemon- yellow	Shiny-yellow	Orange	Orange
70	Yellow-orange	Yellow orange	Yellow	Yellow	Lemon- yellow	Orange- yellow	Orange	Orange

Table 2: Spectrophotometric readings of the dilute (0.5%) liquid extracts of the turmeric samples dried at different temperatures

	Absorbance (420 nm)							
Drying temp.	Hot water		Cold water		Acetone		Ethanol	
(°C)	NCl-1	NCl-2	NCl-1	NCl-2	NCl-1	NCl-2	NCl-1	NCl-2
50	0.874	1.275	0.525	0.806	2.265	2.266	2.272	2.256
60	1.146	1.284	0.703	0.936	2.526	2.335	2.260	2.264
70	1.065	1.074	0.646	0.695	2.450	2.289	2.255	2.271
*LSD $_{(P=0.05)}$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

*n.s. = not significant

Table 3: Consumers evaluation scores*# for the dry turmeric powder samples

Sample	Drying temperature	Colour	General acceptability
NCl-1	50°C	5.89^{a}	6.00^{a}
NCl-1	60°C	5.33^{a}	5.44^{ab}
NCl-1	70°C	5.33^{a}	5.33^{ab}
NCl-2	50°C	5.44^{a}	5.33^{ab}
NCl-2	60°C	4.33^{b}	4.33^{b}
NCl-2	70°C	5.33^{a}	5.00^{b}

*Values with the same letters do not differ significantly (p = 0.05), #Where 1 = dislike extremely; 4 = neither like nor dislike; 7 = like extremely

Table 4: Sensory assessors scores for the cooked rice coloured yellow with turmeric powder samples dried at 50°C

Samples	Turmeric powder:rice ratio (w/w)	Score*#
Ncl-1/rice	1:2000	5.50^{a}
NCl-1/rice	1:1000	4.75^{ab}
NCl-2/rice	1:2000	5.25^{ab}
NCl-2/rice	1:1000	3.75^{b}
Rice only (white)	-	4.50^{ab}

*Values with the same letters do not differ significantly (p = 0.05).
#Where 1 = dislike extremely; 4 = neither like nor dislike; 7 = like extremely

Table 5: Dry matter and oleoresin contents of the turmeric rhizome samples

Cultivar	Dry matter(%)	Oleoresin (%DM)
Ncl-1	19.60±0.07	14.80±0.13
NCl-2	16.47±0.06	14.10±0.17

At the lower concentration of 0.01%, the turmeric extracts of NCl-1-60 had mean absorbance values (at 420 nm) of 0.053 (hot water extract), 1.029 (acetone extract) and 0.788 (ethanol extract). The corresponding spectrophotometric values for the NCl-2-60 extracts (at the same conditions with those of NCl-1-60) were 0.066, 0.940 and 0.694, , respectively.

It could therefore be deduced from the findings in the colour analysis, that drying the tumeric rhizomes at >60°C might not give better colour (yellow-orange) development through high temperature induced non-enzymatic browning reaction pigments, as elucidated by Onimawo and Akubor (2005). Though sun drying is the traditional method of drying turmeric rhizomes (Pulseglove *et al*., 1987), 60°C has been considered as the optimum drying temperature for mechanical drying of split turmeric to be used in the food colourant industry (Pruthi, 1992). The results obtained from this work with the Nigerian turmeric genotypes did not negate the information that mechanical drying of the split rhizomes at about 60°C is beneficial. Infact, it had earlier been opined that drying turmeric at much higher temperatures may lead to unwanted discolourations of the extracts (Pruthi, 1992; Buescher and Yang, 2000).

In this investigation hot water seemed to be a better extractant of the turmeric colour pigments over cold water, while the polar solvents (acetone and ethanol) were found to be the superior extractants. Working with local turmeric rhizome samples in Asia, Chandarana *et al.* (2005) found that in addition to the polar solvents, heated water could also extract the biologically active pigments in turmeric rhizomes better than cold water. In Nigeria, Ukpabi *et al.* (2005) had earlier found that alkaline pH could vary the colour of the hot aqueous extracts of Nigerian turmeric rhizome samples to red-brown colouration.

Table 3 shows the degree of likeness of the yellow-orange turmeric powder samples by the local consumers used in the study. The general acceptability of the samples amongst the local consumers (Table 3) indicates possible marketability of the products. The result also tallied with the earlier findings that processing methods and genotype may affect consumers' acceptability of turmeric based products (Pulseglove *et al*., 1987; Pruthi, 1992; Buescher and Yang, 2000). During this study, the observed preference of our local food consumer for mellow colour shades may likely place the garish NCl-2 food products at a possible disadvantage (amongst some of the local consumers). We therefore suggest that the garish tinge in the colour principles of NCl-2 needs to be further investigated in an advanced laboratory.

Interestingly, comments from some of the consumers showed that these bright coloured pigments in NCl-2 samples, in addition to their food uses, could be used in the production of female nail polish (with organic solvents), harmless finger/thumb markers (for identifying individuals during immunization and census exercises) and coloured fabrics (for cloths).

However, the result of the organoleptic evaluation of cooked white rice, coloured yellowish with some turmeric powder samples, showed that both NCl-1 and NCl-2 samples could be used to get well liked dishes (Table 4). From the sensory scores (Table 4), it was found that the processing and genotype effects as observed by earlier researchers (Pulseglove *et al*., 1987; Pruthi, 1992) may still affect the level of acceptability of the yellowish dishes by the consumers.

The mean dry matter content (16.47-19.60%) of the experimental fresh turmeric rhizomes and the oleoresin content (14.00-14.80%) of the dehydrated samples are shown in Table 5. The oleoresin content of the experimental genotypes compare favourably with the 10-12% oleoresin contents found in typical dried turmeric rhizomes in the international market (Buescher and Yang, 2000; ASTA, 2002). From our results, the potential yield of marketable colourants that could be obtained from one metric tonne of turmeric rhizome in Nigeria would be 196kg turmeric powder (or 29.01 kg oleoresin) for the NCl-1 genotypes or 164.7 kg turmeric powder (or 23.06 kg oleoresin) for the NCl-2 genotype. If the 25 mt ha^{-1} mean rhizome yield (for the two cultivars) obtained in the well managed NRCRI, Nigeria experimental plots can be replicated in the local farmers' fields, Nigeria has a lot of potential as a source of these commercial turmeric colourants.

However, due to the fact that the curcumin rich turmeric oleoresin is generally marketed as a colourant based on its colour value or "curcumin content" (Buescher, and Yang, 2000; ASTA, 2002), there is still a need for future work on the curcumoid content of the desirable deep brown-orange viscous turmeric oleoresin obtained from the experimental rhizomes. As all turmeric oleoresin samples contain colouring matter (37%) and most contain flavouring matter, there might be a need to process out the latter materials which has aromatic substances and essential oil residues (Govindarajan, 1980; Pulseglove *et al*., 1987; Pruthi, 1992). The purified curcuminoid rich extract (usually prepared with non-petroleum solvents such as ethanol) is used to prepare coloured concentrates or formulations that are highly valued in some food and beverage industries; for their ability to impart uniform yellowish colouration to their respective products (Pulseglove *et al*., 1987; Buescher and Yang, 2000).

CONCLUSION

Rhizomes from the two major turmeric cultivars in Nigeria (NCl-1 and NCl-2) could be used in the production of marketable turmeric powder. The shades of yellowish colour observed in dilute liquid (aqueous, acetone and ethanol) extracts of the dry turmeric powder samples indicated their potential uses in some food and non-food concerns. The economic value of these local crop genotypes is further enhanced by the relatively high content of the curcumin rich turmeric oleoresin in their rhizome samples. Both turmeric powder and turmeric oleoresin are generally known as commercial colourants, especially in the food industry.

REFERENCES

AOAC, 1997. Official Methods of Analysis of Association of Official Analytical Chemists. William, H. (Ed.). Washington D.C.

ASTA, 2002. A concise guide to Spices, Herbs, Seeds and Extractives. American Spice Trade Association, Washington, D.C.

Bainbridge, Z., K. Tomlins, K. Wellings and A. Wesby, 1996. Methods of Assessing Quality characteristics of Non-Grain Starch Staples. Part 4-Advanced Methods. Natural Resources Institute, Chatham, U.K., pp: 43-78.

Borget, M., 1993. Spice plants. Macmillan Education, London, pp: 3-103.

Buescher, R. and L. Yang, 2000. Turmeric. In: Natural Food Colorants. Science and Technology. Lauro, G.L. and F.J. Fancis (Eds.). Marcel Dekker, New York, pp: 205-226.

Burkill, H.M., 1985. The useful plants of West Tropical Africa, Royal Botanic Gardens, Kew, Londo, 1: 119-120.

Chandarana, H., S. Baluja and S.V. Chanda, 2005. Comparison of antibacterial activities of selected species of Zingiberaceae family and some synthetic compounds. Turk. J. Biol., 29: 83-97.

Conn, E.E. and P.K. Stumpf, 1976. Outlines of Biochemistry. 4th Edn. John Wiley, New York, pp: 591-592.

Garg, S.N., R.P. Bansal, M.M. Gupta and S. Kumar, 1999. Variation in the rhizome essential oil and curcumin contents and oil quality in the land races of turmeric (*Curcuma longa*) of North India plains. Flavour Fragr. J., 14: 315-318.

Gopalan, B., M. Goto, A. Kodama and T. Hirose, 2000. Supercritical carbon dioxide extraction of turmeric (*Curcuma longa*). J. Agric. Food Chem., 48: 2189-2192.

Govindarajan, V.S., 1980. Turmeric chemistry, technology and quality. Crit. Rev. Food Sci. Nutr. (Furia, T.E. Ed.). CRC Press, Boca Raton, FL., U.S.A., 12: 199-301.

Igwe, C., E. Yayi and M. Moudachirou, 2005. Chemical Constituents of the Solvent Extracted and Hydrodistilled Essential Oils of African Nutmeg (*Monodora myristica*) and Turmeric (*Curcuma domestica*) from South West Nigeria. Nigerian Food J., 23: 21-32.

Iwe, M.O., 2002. Handbook of Sensory Methods and Analysis. Rejoint Communications Services, Enugu, Nigeria.

Nakayama, R., Y. Tamura, H. Yamanaka, H. Kikuzaki and N. Nakatani, 1993. Two curcuminoid pigments from *Curcuma domestica*. Phytochemistry, 33: 501- 502.

Nelson, D.L. and M. M. Cox, 2005. Lehninger Principles of Biochemistry. 4th Edn. W.H. Freeman and Company, New York, pp: 82.

Onimawo, I.A. and P.I. Akubor, 2005. Food Chemistry. Integrated Approach with Biochemical Background. AMBIK Press, Benin City, Nigeria, pp: 157-167.

Pruthi, J.S., 1992. Postharvest technology of spices: Pre-treatments, curing, cleaning, grading and packing. J. Spices Aromatic Crops, 1: 1-29.

Pulseglove, J.W., E.G. Brown, C.L. Green and S.R.J. Robbins, 1987. Spices Tropical Agricultural series. Longman Scientific and Technical, Harlow, England, 2: 176-192.

Schiffman, H.R., 1996. Sensation and Perception. 4th Edn. J. Wiley, New York.

Ukpabi, U.J., E. Oti and N.J. Ogbogu, 2005. Potentials of Turmeric as a Local Colouring and Flavouring Agent in Nigeria. In: Stimulating the Food Industry for National Development (Okoli, E.C., Ed.). Proceedings of the 29th Annual Conference of Nigeria Institute of Food Science and Technology. Abakaliki, Ebonyi State, Nigeria, pp: 147-148.