Chemical Analysis of Turmeric from Minas Gerais, Brazil and Comparison of Methods for Flavour Free Oleoresin

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ABSTRACT

Chemical analysis of turmeric (Curcuma longa L) cultivated in eight different cities in the state of Minas Gerais, Brazil was carried out. The levels of curcuminoid pigments varied from 1.4 to 6.14 g/100 g and of volatile oil from 0.97 to 7.55 mL/100 g (dry basis). Samples from Patrocínio, Arinos and Brasilândia contained higher pigment levels compared to the others. The sample from Patrocínio contained the highest volatile oil content. The mean levels of ethyl ether extract, protein, fiber, ash and starch were 8.51, 7.01, 7.22, 7.81 and 39.87 g/100 g dry basis, respectively. Laboratory extraction of flavour free oleoresin was performed in triplicate. A higher yield of pigment in the oleoresin was obtained when the volatile oil was extracted with water vapor and the oleoresin with ethanol. The oleoresin obtained was free of flavour and could be used in a wider range of food applications.

Key words: turmeric, curcumin, quality, flavour free oleoresin

INTRODUCTION

The interest for natural food colorants has increased significantly in the last few years due to the worldwide tendency for natural products and due to the concern over the safety of artificial colorants (Safford & Goodwin, 1985; Wissgott & Bortlik, 1996). There is an urgent need to substitute the synthetic food dye tartrazine (FD & C yellow No. 5), which has been associated with asthma and has teratogenic potential (Safford & Goodwin, 1985; Collins *Et Al.*, 1992; Kowai *et al.*, 1993).

A viable alternative is curcumin, the main pigment present in the rhizomes of *Curcuma longa* L., known in Brazil as 'cúrcuma, açafrão or gengibre dourada' (Martins & Rusig, 1992). The use of this herbaceous plant from the Zingiberaceae family is advantageous as it does not require special cultural practices, has good productivity (20 ton/hectare) and contains an average 6% curcuminoid pigments (Govindarajan, 1980). Another important constituent of turmeric is the volatile oil (up to 5%), which is rich in flavoring substances and is used in the food industry (Govindarajan, 1980; Viasan *et al.*, 1989).

Besides the low recommended daily dietary intake (2.5 and 0.1 mg/kg body weight) established for turmeric and curcumin, respectively (Carvalho, 1992; Bhavanishankar *et al.*, 1986), turmeric has been used for years without any apparent toxic effect. Furthermore, studies indicated that turmeric (500 mg/kg body weight) and its alcoholic extract (60 mg/kg body weight) did not cause any adverse effect in monkeys for 9 months and in rats for three generations (Bhavanishankar *Et Al.*, 1986; Bhavanishankar & Murthy, 1987; Sambaiah *et al.*, 1982). Studies have also indicated that curcumin has anti-carcinogenic, anti-inflammatory, antibacterial, antioxidant, choleretic, cholagoguic and hypocholesteremic properties (Bvanishankar & Murthy, 1987; Shirikanth-Reddy & Aggarwall, 1994; Semwal *et al.*, 1997; Osawa *et al.*, 1995).

There are three major turmeric products available commercially: turmeric powder, turmeric oleoresin and curcumin (Milán, 1992; Martins & Rusig, 1992). Turmeric powder is obtained by dehydration and grinding of rhizomes. Turmeric oleoresin, obtained by

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organic solvent extraction of turmeric, is a brownish-orange viscous oily product containing 30 to 55% curcuminoid pigments and 15 to 25% volatile oil. Both turmeric powder and oleoresin can only be used in food products in which the flavor characteristic of turmeric is desirable, e.g. pickles, mustard, mayonnaise, frozen fish fillet coating, meat products and pastries (Abea, 1984). Curcumin is the colorant without residual turmeric flavor. It is obtained by curcumin extraction from turmeric powder with solvent followed by washing and purification of curcumin by precipitation or crystallization (Govindarajan, 1980; Krishnamurthy *et al.*, 1976, Temmeler, 1938). Purified curcumin has been used in food products such as beverages, jelly, cheese, butter, ice cream and bakery products, in which the characteristic flavor of turmeric is not desired (Perotti, 1975). However, the cost associated with curcumin purification is high (Milán, 1992; Carvalho, 1992). An economically viable flavor free turmeric product is needed for use in food applications in which the flavor characteristic of turmeric is not desirable.

Brazil, a tropical country, has climate conditions favorable for turmeric cultivation. Turmeric production in Goiás, Mato Grosso and São Paulo varies from 8 to 12 ton of rhizomes/hectare with mean curcuminoid pigment levels of 3.8% (Oliveira *et al.*, 1992).

Variation in curcuminoid pigment levels can be related to diversity in cultivars and varieties, location, agricultural practices, use of fertilizers and degree of maturity (Govindarajan, 1980; Mathai, 1976; Krishnamurthy *et al.*, 1975; Donalisio, 1980). Studies are necessary to identify cultivars of higher productivity and pigment yield. Moreover, the technology employed in Brazil by natural colorant industries is not competitive with regard to quality and price. Therefore, the development of technology capable of reducing pigment extraction cost and of increasing standards of quality, constitutes a fundamental factor for expansion of Brazilian market and even to export. It may be more profitable to export high value products compared to raw material.

The objective of this study was to determine the chemical composition of turmeric cultivated in the state of Minas Gerais, Brazil as a natural colorant in food applications. Furthermore, the yields of flavour free oleoresin obtained using different methods were compared.

MATERIAL AND METHODS

Fresh turmeric (*Curcuma longa* L) rhizomes from eight different cities viz. Patos de Minas, Arinos, Patrocínio, Unaí, Brasilândia, João Pinheiro, Bonfinópolis de Minas and Buritis from the state of Minas Gerais, Brazil, were provided by the regional offices of EMATER MG (Empresa de Assistência Técnica e Extensão Rural, Minas Gerais). The rhizomes were washed, sliced and dried at 35 ± 1°C until 10% moisture content. Then, the rhizomes were ground, sieved (60 mesh) and analyzed. The solvents used were of chemically pure grade.

Characterization of turmeric cultivated in Minas Gerais. The samples were analyzed with respect to curcuminoid pigments at 425 nm in an UV-VIS 160 A spectrophotometer (Shimadzu, Kyoto, Japan) after extraction with ethanol (Takahashi, 1987). The concentration of pigments was calculated using curcumin (Merck, Darmstadt, Germany) standard curve: concentration = 0.0007.ABS ($R^2 = 0.9996$). The results were given in mg of curcuminoid pigments expressed as curcumin per 100 g of sample. The Clevenger distillation method (AOAC, 1980) was used for the determination of volatile oil. The samples were also analyzed for moisture, ethyl ether extract, protein, total ash and starch according to the methodology described by IAL (1986).

Comparison of methods for the production of flavour free oleoresin. The efficiency of different procedures for the production of flavour free oleoresin was investigated as described in Figure 1. Every step of the procedure was performed in triplicate and the extraction yields were compared by the Tukey test ($p \leq 0.05$).

Two procedures were compared for the extraction of volatile oil: water vapour distillation using the Clevenger apparatus (Zhang & Yang, 1988) and solvent extraction with hexane in a Soxhlet extractor (Sair & Klee, 1967), both of them for a period of 4 hours. The oil free turmeric was filtered and dried at 105°C. The oil free oleoresin was extracted from the dehydrated product with ethanol and acetone in a Soxhlet extractor for 4 hours (Krishnamurthy *et al.*, 1976; Govindarajan, 1980). The extraction efficiency was determined based on the percentage of oleoresin obtained, the level of pigments in the oleoresin and the level of pigments obtained per 100 g of turmeric. The pigments were determined at 425 nm, as described previously.

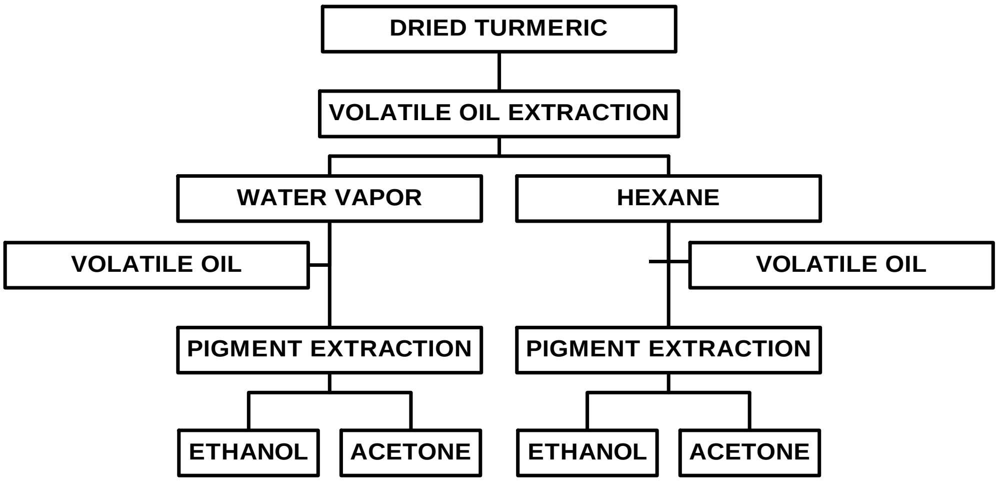

Figure 1. Flow diagram for the production of flavour free oleoresin.

RESULTS AND DISCUSSION

Characterization of turmeric cultivated in Minas Gerais

The levels of pigments and volatile oil in the different samples of turmeric cultivated in Minas Gerais are described in Table 1. Higher mean pigment levels were found in samples from Patrocínio, Arinos and Brasilândia and the lower in samples from Unaí. Overall mean curcuminoid pigment levels of turmeric cultivated in Minas Gerais (4.41 mg/100 g) were higher than those from São Paulo, Goiás and Mato Grosso (Oliveira *et al.*, 1992), however, similar to Indian varieties (Mathai, 1976; Govindarajan, 1980).

With respect to volatile oil, the sample from Patrocínio contained the higher level while the one from João Pinheiro contained the lower.

The levels of volatile oil detected in the samples from Minas Gerais were similar to those found in India (Govindarajan, 1980; Krishnamurthy *et al.*, 1975), except for the one from Patrocínio, which contained higher levels (7.55 mL/100 g) than those reported in the literature.

Table 1 - Levels of curcuminoid pigments and volatile oil (on dry weight basis) of the different turmeric samples cultivated in Minas Gerais

Sample origin	**Levels (mean ± standard deviation) on dry weight basis**	
	pigments[1] (g/100 g)	**volatile oil [2] (mL/100 g)**
Patos	3.59 ± 0.04	-
Arinos	5.43 ± 0.63	3.10 ± 0.56
Patrocínio	6.12 ± 0.04	7.55 ± 0.76
Unaí	2.47 ± 1.33	1.42 ± 0.50
Brasilândia	4.86 ± 0.11	2.53 ± 0.51
João Pinheiro	4.22 ± 0.01	1.09 ± 0.51
Bonfinópolis	4.13 ± 0.19	2.71 ± 0.43
Buritis	4.52 ± 0.51	3.10 ± 1.26
Mean values	4.41 ± 1.17	3.07 ± 2.13

[1] Curcuminoid pigments expressed as curcumin. [2] (-) Not determined.

The results obtained in the macro-components analysis of turmeric are described in Table 2. There was variation on results from sample to sample, however, mean levels of starch, protein and ash were similar to those detected in Indian varieties (Govindarajan, 1980). The variation observed on parameters analyzed could be related to differences in variety, degree of maturity, agricultural practices, harvest time, plant location and use of fertilizers (Govindarajan, 1980; Mathai, 1976; Krishnamurthy *et al.*, 1975; Martins & Rusig, 1992).

Starch was observed to be the major component of turmeric with an average of 40% of the dry matter. According to Mangalakumari & Mathew (1986), turmeric is relatively rich in starch. Viasan *et al.* (1989) reported that ash content could be used as a measure of turmeric quality. Based on this criterion, the sample from Patrocínio would be of best quality. Taking this information into account as well as pigment and volatile oil contents, the sample from Patrocínio is recommended for further cultivation and commercial exploitation.

Comparison of methods for the production of flavor free oleoresin

In order to prevent starch gelatinization and poor recovery of volatile oil during extraction with water vapour, an enzymatic treatment was performed to degrade the starch. It consisted of using 3.5 g of amyloglucosidase (Sigma, St. Louis, MO, USA) for 50 g of turmeric and 1 L of distilled water at 37 ± 1°C for 30 minutes.

Comparing yields of volatile oil obtained by the different procedures, it was observed that water vapour distillation provided 4.08 ± 0.38 mL/ 100 g of a light yellow oil and extraction with hexane 6.23 ± 0.17 mL/100 g of a dark yellow oil. These results indicated that hexane gave higher yield (Tukey test, $p \leq 0.05$) of volatile oil. Hexane extraction was also simpler and faster, however, since the volatile oil was darker, it was possible that pigments were also extracted by hexane.

Before extraction of the oleoresin, it was necessary to eliminate the excess of water incorporated into the sample during water vapour extraction through filtration and dehydration at 105°C. The results obtained in the extraction of oleoresin from turmeric are indicated in Table 3.

A significantly higher percentage of oleoresin was obtained with the combination of water vapour/acetone (Tukey test, $p \leq 0.05$).

Table 2 - Composition, on dry weight basis, of different turmeric samples cultivated in Minas Gerais, Brazil

Sample origin	**Levels on dry weight basis (g/100 g)**				
	ethyl ether extract	**protein**	**fiber**	**ash**	**Starch**
Patos	8.12 ± 0.48	8.18 ± 0.07	6.89 ± 0.06	7.69 ± 0.04	44.90 ± 0.04
Arinos	9.53 ± 0.32	6.93 ± 0.98	7.81 ± 1.42	7.82 ± 1.04	43.52 ± 13.18
Patrocínio	13.25 ± 0.02	6.65 ± 0.06	8.00 ± 0.10	5.39 ± 0.01	47.78 ± 0.34
Unaí	8.93 ± 1.64	8.09 ± 0.10	6.82 ± 0.70	9.55 ± 0.55	35.99 ± 7.21
Brasilândia	6.56 ± 0.11	7.53 ± 0.37	6.91 ± 0.55	7.36 ± 0.02	34.99 ± 0.39
João Pinheiro	4.57 ± 0.08	4.69 ± 0.74	6.86 ± 0.13	9.06 ± 0.02	32.00 ± 0.77
Bonfinópolis	8.21 ± 0.17	-	-	-	-
Buritis	8.90 ± 0.35	-	-	-	-
Mean values	8.51 ± 2.49	7.01 ± 1.29	7.22 ± 0.54	7.81 ± 1.46	39.87 ± 6.37

(-) Not determined.

Considering the levels of pigments present in the oleoresins obtained by the different procedures and calculating the respective yields related to the initial mass of turmeric (Table III), higher pigment yield was obtained when the volatile oil was extracted with water vapour compared to hexane. This result confirmed that pigments were removed by hexane along with the volatile oil. It was also observed that there was no significant difference between ethanol and acetone, regardless the type of solvent used for volatile oil extraction. However, the use of ethanol was preferred to acetone due to problems of the latter related to flammability, high recovery cost and possibility of causing off flavor problems by impurities (Govindarajan, 1980). Sensory evaluation of gelatin prepared with the flavour free oleoresin (0.001%) performed by 12 untrained panelists indicated that no extraneous flavour was perceived. Therefore, the flavor free oleoresin obtained could be used in a wider range of food applications.

Table 3 - Yield of oleoresin and of curcuminoid pigments using different procedures

Extraction of Volatile oil / pigment	**Oleoresin (%)**	**Pigments content (g/100 g)**	
		oleoresin	**per initial mass**
water vapour / ethanol	11.26 ± 1.69^{b}	62.51 ± 0.50^{a}	7.04 ± 1.11^{a}
water vapour / acetone	14.51 ± 1.38^{a}	52.87 ± 0.20^{c}	7.64 ± 1.60^{a}
hexane / ethanol	8.48 ± 0.74^{c}	47.50 ± 0.40^{d}	4.03 ± 0.39^{c}
hexane / acetone	10.07 ± 0.22^{bc}	56.94 ± 0.20^{b}	5.73 ± 0.15^{b}

Means (± standard deviations) with the same superscript in the same column do not differ significantly by the Tukey test ($p \leq 0.05$).

CONCLUSION

The levels of pigments and volatile oils in turmeric cultivated in Minas Gerais varied from 2.47 to 6.12 mg/100 g and 1.09 a 7.55 mg/100 mL, respectively. These values are similar to those reported in the literature for turmeric cultivated in India and higher than those from São Paulo, Goiás and Mato Grosso. A higher yield of pigment in the flavour free oleoresin was obtained using the combination water vapor and ethanol or acetone. However, the use of ethanol is preferred. The oleoresin obtained was free of the flavour characteristic of turmeric and could be used in a wider range of food applications. The volatile oil, by-product of the process, could also be used as food flavoring.

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RESUMO

Análise química de cúrcuma (*Curcuma longa* L) provenientes de oito municípios do Estado de Minas Gerais - Brasil foi efetuada. Os teores (base seca) de pigmentos curcuminóides variaram de 1,4 a 6,14 g/100 g e os de óleo volátil, de 0,97 a 7,55 mL/100 g. Amostras de Patrocínio, Arinos e Brasilândia continham os maiores teores de pigmentos e as de Patrocínio os maiores teores de óleos voláteis. Os teores médios (base seca) de extrato etéreo, proteínas, fibras, cinzas e amido encontrados foram 8,51; 7,01; 7,22; 7,81 e 39,87 g/100 g, respectivamente. Com o objetivo de obter corante amarelo isento de flavor, métodos de extração em laboratório foram comparados em triplicata. Um maior rendimento de pigmento na oleoresina foi obtido extraindo-se o óleo volátil com vapor d'água e a oleoresina com etanol. A oleoresina obtida é isenta de flavor e pode ser utilizada em um número maior de aplicações na indústria alimentícia.

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