Kasetsart J. (Nat. Sci.) 44 : 123 - 130 (2010)

Preparation of Curcuminoid Powder from Turmeric Root *(Curcuma longa* Linn) for Food Ingredient Use

Vipa Surojanametakul*, Prajongwate Satmalee, Janpen Saengprakai, Dalad Siliwan and Ladda Wattanasiritham

ABSTRACT

The tumeric *(Curcuma longa* Linn) Chan variety possessed higher curcuminoid than the Dang-Siam variety. The result showed that the extracting solvent could significantly alter the curcuminoid as well as the total polyphenol content of the turmeric extract. Recommended conditions for curcuminoid extract from turmeric were: ethanol, solid:liquid ratio 1:50, at 70°C for 2 hr. Preparation of curcuminoid powder from turmeric extract was performed by entrapment of the natural turmeric compound "curcuminoid" with a polysaccharide, carboxymethyl cellulose, as a complex formation and mixed with maltodextrin, prior to drying. The curcuminoid content in the powder affected the product's qualities such as color, total phenolic compounds and antioxidant properties. Sensory evaluation of the products, in the form of turmeric tea, revealed that powder containing a level of curcuminoid of 411.28μg/g had the highest acceptance score. It also exhibited high water solubility (15g/100 ml). The total phenolic content and antioxidant capability of the product with the highest acceptance score was 13.27 as mg GAE/g and 14.46 as mg BHAE/g, respectively. The powder had a total plate count of yeast and mold <10 cfu/g and no pathogenic microorganisms were found. Storage of the powder in an aluminum foil bag at room temperature for four months only slightly changed the curcuminoid content, indicating the high stability of the product. Hence, curcuminoid powder could be used as a food ingredient for various health-drink products.

Key words: turmeric extracted, curcuminoid, curcuminoid powder, *Curcuma longa* Linn

INTRODUCTION

Turmeric (*Curcuma longa* L.) has been used as a food additive in curries to improve palatability and storage stability. Curcuminoid, a natural coloring agent, is recognized as a rich source of phenolic compounds, consisting of three different compounds: curcumin, demethoxycurcumin and bisdemethoxycurcumin. It also has potential as a pharmaceutical expient, since it possess antioxidant, anti-inflammatory, anti-mutagenic and anti HIV properties and can reduce-blood glucose (Du *et al*., 2006) and LDL (Fan *et al*., 2006). Curcumin, the major cucuminoid compound, is practically insoluble in water at acidic or natural pH, and while it is soluble in alkaline solutions (Tonnesen *et al*., 2002), it exhibits photodegradation and a high decomposition rate in alkaline media. Because of these properties, the use of curcumin/curcuminoid

Institute of Food Research and Product Development (IFRPD), Kasetsart University, Bangkok 10900, Thailand.
* Corresponding author, e-mail: ifrvis@ku.ac.th

Received date : 24/04/09 Accepted date : 21/09/09

is limited. However, it was reported that curcumin could have improved solubility in complex formations or as a result of interactions with various macromolecules (Tonnesen *et al*., 2002).

Carboxymethyl cellulose (CMC), a long chain polysaccharide, is a well-known polymer, which is used as a versatile, functional ingredient in a wide variety of processed foods, as a thickener, binding agent, stabilizer, protective colloid and suspending agent (Bar *et al*., 1995). CMC can dissolve well in water and produces a translucent solution. Its safety has been confirmed (JECFA, 1990; SCF, 1992). Thus, it was selected to be used in curcuminoid powder preparation.

The aim of this study was to extract the natural curcuminoid from turmeric by varying parameters such as the turmeric variety, extraction solvent, S/L ratio and extraction temperature. The curcuminoid content, as well as the antioxidant capacity of the extract, was also investigated. The water-soluble curcuminoid powder was also transformed by entrapment a curcuminoid with the polysaccharide, carboxymethyl cellulose, as a complex formation. The properties of the powder products have been extensively examined.

MATERIALS AND METHODS

Materials

Fresh turmeric, (the Chan variety), was purchased from Ratchaburi province, while the Dang Siam variety was obtained from Kasetsart University. Sodium carboxymethyl cellulose 1500 cps (USP24) was a product obtained from Germany.

Standard purified curcumin was a product of the USA (Sigma C1386). Other chemicals used in this research were food grade except for the chemicals for analysis that were either analytical grade or HPLC grade.

Dried turmeric preparation

Each variety of fresh turmeric roots was cleaned, steamed for 7 min and sliced into small pieces before drying in a hot air oven at 50°C for about 6 hr. Dry turmeric was collected and ground into fine powder using a high-speed blender. The dry, ground turmeric was packed in a plastic bag, sealed and kept in the refrigerator (5°C) until used.

Curcuminoid content of dry turmeric

An amount of 0.2 g of ground dry turmeric was weighed in a 15 ml screw-cap test tube, and 5 ml ethanol was added. The mixture was vortexed every 15 min for 2 hr and the mixture was centrifuged at 4,500 rpm/min for 10 min at room temperature. The clear supernatant was collected in a 25 ml volumetric flask. The extraction was repeated and the supernatant was deposited until a pale yellow solution was observed. The collected solution was then adjusted to volume with ethanol. The curcuminoid content in the extracted solution was investigated by a modified method of Jayaprakasha *et al*. (2005) using HPLC (Agilent 1100 series) equipped with synergi 4μ RP 80 A column, mobile phase; acetonitrile: 1% acetic acid (55:45), flow rate 1 ml/min, λ: 425 nm, inject volume: 4 μL and a temperature of 40°C. The turmeric variety with the higher curcuminoid content was selected.

Preparation of turmeric extract

A sample of 0.2 g of the selected, ground, dry turmeric of high curcuminoid variety was separately extracted by either ethanol or a mixture of ethanol and water (1:1). The extraction conditions were performed by factorial design as follows; solid:liquid (S/L) ratio 1:30, 1:40 and 1:50, extraction temperature 27°C, 50°C and 70° C, extraction time 2 hr. The extraction solution obtained from each set of conditions was filtrated through filter paper (Whatman No 1) and the clear supernatant was collected. Then the curcuminoid and total phenolic content were examined. The extraction conditions that provided the highest curcuminoid and total phenolic content were

selected for further experiment.

Curcuminoid powder preparation

In this study, water-soluble curcuminoid powders with different curcuminoid content were prepared. Various quantities of ground dry turmeric of 1.4, 3.20, 6.40, 7.80 and 15.60 g respectively were used; each was individually extracted under the selected conditions. After extraction, the mixture was filtered through nylon cloth (320 mesh). The clear solution was adjusted with ethanol to obtain a final volume of 200 ml, while any excess solvent from the extraction that exceed 200 ml was removed using a vacuum rotary evaporator (Buchii, Switzerland). The obtained solution was gradually added into 100 ml of 2% (wt/v) carboxymethyl cellulose (CMC) solution at pH~ 8-10, stirred for 20 min, thereafter it was adjusted to pH 4.0 with 20% ascorbic acid solution. Maltodextrin (DE = 11) 600 g was added and thoroughly mixed with the curcuminoid solution in a Kitchen aid. The viscous mixture was then subjected to drying using a double drum dryer. The drum operated at a surface temperature of 130°C, with clearances between the drum of 0.04 inch and a rotation speed of 2 rpm. Dried curcuminoid flakes from the drum dryer were then ground to fine powder and the yield was calculated.

Physical, chemical and sensory properties of curcuminoid powder

Physical properties

Color as L*, a* and b* values of the curcuminoid powder and its dissolved solution (1g/100 ml water) were investigated using a color instrument (Datacolor, Spectrafrash SF 600 plus, USA).

Chemical properties

The chemical properties of the powder, such as moisture content (AOAC, 1990) and Aw (Novasiana, Switzerland) were investigated. Curcuminoid in the powder was extracted and determined using a modified method of Jayaprakasha *et al*. (2005). The sample (0.5g) was dissolved in a small amount of water (2 ml); thereafter methanol (8ml) was added to separate the polysaccharides. The solution was centrifuged at 4,500 rpm for 15 min. The clear supernatant was separated and its curcuminoid content was determined using HPLC. Total phenolic content and antioxidant activity of the curcuminoid powder were also evaluated.

Total phenolic content of curcuminoid powder

The amount of total phenolic content in the powder was determined using Folin-Ciocalteu reagent by the modified method of Singleton and Rossi (1965). An amount of 320 µL of suitable diluted sample was added to 1600 µL of Folin-Ciocalteu reagent, which was previously diluted ten-fold with distilled water in a 15 ml glass test tube. After 3 min and before 8 min, 1,280 µl of 7.5 % sodium carbonate (Na_2CO_3) was added and mixed. Then 800 ål of distilled water was added and mixed again using vortex. The solution was heated in a water bath at 40°C for 30 min and absorbance was measured at 765 nm. The standard curve was prepared using gallic acid and the results were expressed as mg gallic acid equivalent/g of curcuminoid powder.

Antioxidant capacities of curcuminoid powder

The powder was evaluated for its antioxidant capacity using a modified method of Onichi *et al*. (1994). The free radical scavenging activity of the extracts was tested, indicated as bleaching of the stable 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical. A 270 µL suitably diluted sample was added to 1620 µL of 0.10 mM DPPH in 95% ethanol solution. The mixture was vortexed and allowed to stand at room temperature in the dark. After 20 min, the absorbance was measured at 517 nm; 95% ethanol solution was used as the control. The percentage of DPPH scavenging activity (%SA) was calculated from Equation 1:

(C - A) 100 / C (1)

where, C = absorbance of control and A = absorbance of extract.

Antioxidant capacity of the powder was reported as mg *t*-butylated hydroxyanisole equivalent (BHAE) per gram of the powder. A standard curve was obtained by plotting % SA of DPPH (x) against various BHA concentrations (y).

Sensory evaluation of curcuminoid powder

Sensory evaluation was performed on samples of natural turmeric tea. The tea samples were freshly prepared by dissolving curcuminoid powder in hot water at a ratio of 1:100 (w/v) and randomly served on testing. Twenty-five panelists selected from IFRPD staff participated in the test. Acceptance scores for appearance, color, clarity, flavor and overall liking were assessed using a seven-point hedonic scale.

Microbiological properties of curcuminoid powder

The sample proving the highest acceptance score was tested for microbiological properties including total plate count for *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus*, *Salmonella sp*. yeast and mold (AOAC, 1998).

Solubility and stability of curcuminoid powder

Solubility studies of the most-accepted powder were separately performed by gradually adding the powder into 100 ml of distilled water. The suspension was continuously agitated for 1 hr at room temperature and filtered through a filter paper and its solubility was estimated. The greatest amount of curcuminoid powder dissolved in the distilled water with no residue after filtration was reported as the solubility potential (g/100 ml). The curcuminoid stability of this powder was also investigated by packing it in aluminum foil bags and keeping it at room temperature (27°C).

Statistical analysis

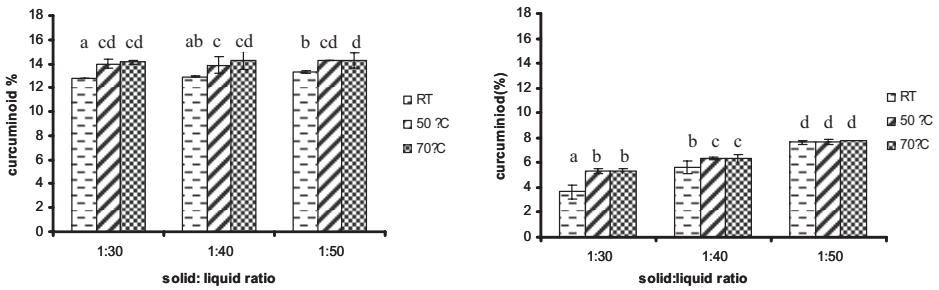
Data collected from the experiments were analyzed by complete randomized design (CRD) using SPSS Version 12.0.0. Analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) at P = 0.05 were used to determine the differences between treatments.

RESULTS AND DISCUSSION

Extraction condition of curcuminoid from dry turmeric

The ethanolic extraction yield of ground dry turmeric was between 35.06 and 38.10%. The curcuminoid content of the Chan variety (14.79±0.26%) was higher than that of the Dang Siam variety (8.75±0.35%). Hence, the Chan variety was selected for studying curcuminoid extraction. Results revealed that the type of solvent, the S/L ratio and the extraction temperature affected the curcuminoid content. Ethanol extraction produced higher curcuminoid yield than mixed ethanol and water (Figure 1). These results were attributed to polarities of the selected compounds in the turmeric root (Hayouni *et al*., 2007). The order of curcuminoid content in the extract obtained by various S/L ratios was: 1:50>1:40>1:30. As the extract temperature was increased, the curcuminoid content increased indicating that the compound was heat stable. Among the range of conditions tested, the highest curcuminoid yield (14.48±0.20%) was observed at S/L ratio 1:50 and an extracted temperature of 70°C.

Table 1 shows that the ethanol extraction of ground, dry, turmeric produced a greater total phenolic content than from the ethanol-water extraction. The Folin-Ciocateu method was reported to react not only with phenols, but also with any reductive substance present. However, the high content of total phenols in the extracts might refer to the high antioxidant properties (Yang *et al*., 2006). The extract condition with the highest total phenolic content was found to be the same as the one that had the highest curcuminoid content.



(a) (b)

Figure 1 Influence of extraction temperature and solid-liquid ratio (L/S) on total curcuminoid extraction yield from ground dry turmeric: (a) extracted with alcohol; (b) a mixture of water and alcohol at ratio of 1:1.

Table 1 Total phenolic content of turmeric (Chan variety) extracted under various conditions.

Solid/liquid ratio (g/ml)	Extraction temperature (°C)	Total phenolic content as mg gallic acid equivalent (GAE)/1g sample	
		Ethanol	Ethanol : Water
1:30	RT	115.50 ^{a}	101.63 ^{a}
	50	116.90 ^{a}	110.53^{b}
	70	120.34^{ab}	120.05^{c}
1:40	RT	128.13 ^{c}	100.92 ^{a}
	50	129.70 ^{c}	102.50 ^{a}
	70	138.37 ^{d}	121.36 ^{c}
1:50	RT	124.77 ^{bc}	108.87 ^{b}
	50	127.86 ^{c}	110.34 ^{b}
	70	146.65 ^{e}	122.14 ^{c}

Different letters in the same column indicate statistical differences ($p<0.05$) by DMRT.

Properties of curcuminoid powder

Table 2 shows the properties of the curcuminoid powders. All products had low Aw (0.21-0.27) and low moisture content (3.02-3.49%). Color values L*, a*and b* changed depending on the amount of ground, dry, turmeric used. Increasing the quantity of ground, dry turmeric in the extract increased the curcuminoid content as well as redness (a*) and yellowness (b*) values, while the lightness (L*) value tended to decrease. Dissolving the powders in distilled water produced acidic solutions (pH 3.68-3.75) that varied with their different color values. A deep yellow solution (high b* value) was obtained from the powder with high curcuminoid content (Tables 2 and 3).

Total phenolic content and antioxidant capacity

The total phenolic content and antioxidant capacity determined by DPPH assay are summarized in Table 4. All products showed significant differences in total phenolic content as well as in antioxidant capacity. Phenolic compounds, such as BHA and gallate are known to be effective antioxidants (Madhavi *et al*., 1996). Therefore, a powder with higher total phenol content might exhibit better antioxidant properties. A product with a higher curcuminoid content

Table 2 Properties of curcuminoid powder.

Ground dry turmeric used in the extract (g)	Moisture (%)	Aw	Yield (%)	Curcuminoid (µg/g)	Color value		
					L*	a*	b*
1.40	3.02^{a}	0.25^{b}	67.59^{c}	164.90 ^{a}	97.23^{b}	-9.22^{a}	50.00^{a}
3.20	3.49^{b}	0.25 ^{b}	63.15^{a}	411.28 ^{b}	95.17^{b}	-7.48^{b}	63.76^{b}
6.40	3.05^{a}	0.21 ^{a}	64.59^{ab}	821.40 ^{c}	93.63^{ab}	-5.05^{c}	69.75^{c}
7.80	3.05^{a}	0.27 ^{b}	66.57^{bc}	1,030.55 ^{d}	92.71^{ab}	-4.07^{d}	70.45^{cd}
15.60	3.39^{b}	0.22^{a}	64.18^{ab}	2,072.00 ^{e}	89.44^{a}	1.19^{e}	71.92^{d}

Different letters in the same column indicate statistical differences ($p<0.05$) by DMRT.

Table 3 pH and color values of dissolved curcuminoid powder in water (1g/100 ml water).

Ground dried turmeric used for extract (g)	pH ^{ns}	Color value		
		L*	a*	b*
1.40	3.69	95.23^{e}	-4.02^{c}	13.91^{a}
3.20	3.68	93.41^{d}	-7.00^{b}	26.69^{b}
6.40	3.74	86.76^{c}	-9.08^{a}	45.88^{c}
7.80	3.75	84.86^{b}	-6.85^{b}	63.26^{d}
15.60	3.72	68.75^{a}	2.39^{d}	74.46^{e}

Different letters in the same column indicate statistical differences ($p<0.05$) by DMRT.
^{ns} = not significant.

Table 4 Antioxidant capacity (DPPH method) and total phenolic content of curcuminoid powder.

Ground dry turmeric used for extract (g)	Antioxidant capacity as mg BHAE /g sample	Total phenolic content as mg GAE /1g sample
1.4	11.07 ^{a}	12.16 ^{a}
3.2	14.46 ^{b}	13.27 ^{b}
6.4	17.64 ^{c}	15.04 ^{c}
7.8	19.09 ^{d}	15.89 ^{d}
15.6	22.27 ^{e}	17.02 ^{e}

Different letters in the same column indicate statistical differences ($p<0.05$) by DMRT

possessed better antioxidant capacity than a product with a lower one. The results were consistent with Jayaprakasha *et al*. (2005), who found that curcumin could reduce oxygen free radicals. From the results, curcuminoid powder consumption might reduce oxidative damage of the human body system due to its high antioxidant properties, which is advantageous for good health.

Sensory evaluation

Acceptance scores of curcuminoid powder served as turmeric tea are in Table 5. The powder with 411.28µg/g curcuminoid had the highest score for appearance, color, clarity, flavor and overall liking. On the other hand, the powder, which contained the highest curcuminoid content (2,072.00µg/g), had the lowest score in all characteristics. In the experiment, the acceptance score of the product correlated with the score for flavor, appearance, clarity and color with r^2 values of 0.83, 0.82, 0.80 and 0.72, respectively. Therefore, the principal characteristics of turmeric extract drink were flavor followed by appearance and clarity.

Table 5 Acceptance scores (7 points) of curcuminoid powder dissolved in water (1 g/100 ml water).

Curcuminoid (μg/g)	Appearance	Color	Clarity	Flavor	Overall liking
164.90	4.95 ±1.00 ^{b}	5.10 ±1.33 ^{b}	5.90 ± 1.07 ^{bc}	4.65±1.53 ^{b}	5.20±1.01 ^{c}
411.28	6.10 ±0.96 ^{d}	6.15 ±0.81 ^{c}	6.15 ± 0.81 ^{c}	5.10±1.37 ^{b}	5.90±0.91 ^{d}
821.40	5.60 ±1.14 ^{cd}	5.70 ±1.26 ^{bc}	5.45 ± 1.19 ^{b}	5.10±1.12 ^{b}	5.10±1.25 ^{c}
1030.55	5.10 ±1.25 ^{bc}	5.50 ±1.27 ^{bc}	5.45 ± 1.14 ^{b}	4.50±1.40 ^{ab}	4.30±1.59 ^{b}
2072.00	3.90 ±1.25 ^{a}	4.05 ±1.46 ^{a}	3.45 ± 1.19 ^{a}	3.75±1.58 ^{a}	3.55±1.76 ^{a}

Different letters in the same column indicate statistical differences ($p<0.05$) by DMRT.
Where: 1 = dislike extremely; 7 = like extremely.

Microbiological properties of curcuminoid powder

Microbiological testing of the curcuminoid powder with the highest acceptance score revealed TPCs for yeast and mold were less than 10cfu/g. No other microorganisms, such as *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus* and *Salmonella* sp. were found.

Solubility and Stability of curcuminoid powder

Curcumin, the major curcuminoid compound, is practically insoluble in water (Tonnesen *et al*., 2002). The curcuminoid powder, on the other hand, exhibited high water solubility (15g/100ml) because curcuminoid was trapped with water-soluble polysaccharide, CMC, as a complex formation. The powder packed in an aluminum foil bag, kept at room temperature, showed no significant change in the curcuminoid content within a four month period (Figure 2).

CONCLUSIONS

The variety, extraction solvent and extraction condition (temperature and S/L ratio) affected the curcuminoid and total phenolic content, as well as the antioxidant activity of several extracts from dry turmeric *(Curcuma longa* Linn.). An inclusion of a complex formation of curcuminoid and carboxymethyl cellulose (CMC) improved the solubility of curcuminoid in water. The production process could provide curcuminoid powder with a specified quantity of curcuminoid, which possessed antioxidant properties. In addition, the curcuminoid in the product, packed in an aluminum foil bag, had good stability at room

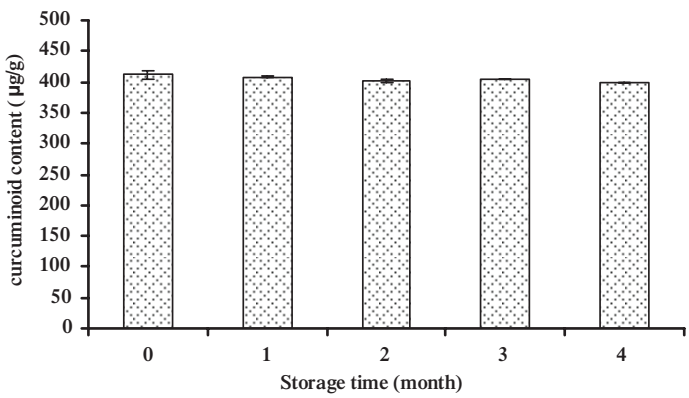


Figure 2 Curcuminoid content in the curcuminoid powder kept in an aluminum foil bag for four months at room temperature.

temperature. Therefore, the preparation of the turmeric extract "curcuminoid" in powder form gives it high potential for use as a food ingredient, especially for health-beverage products.

ACKNOWLEDGEMENT

This project was funded by the Institute of Food Research and Product Development (IFRPD), Kasetsart University.

LITERATURE CITED

Association of Official Analytical Chemists (AOAC).1990. **Official Method of Analysis**. 16th ed. Virginia. 1298 p.

Association of Official Analytical Chemists (AOAC).1998. **Bacteriological Analytical Manual (BAM)**, 8th ed. USA

Bar, A., B.V. Ommen and M. Timonen. 1995. Metabolic disposition in rats of regular and enzymatically depolymerized sodium carboxymethylcellulose. **Food. Chem. Toxicol**. 33: 901-907.

Du, Z.Y., R.R. Liu., W.Y. Shao, X.P. Mao, L.Q. Gu, Z.S. Huang and A.S.Chan. 2006. ∝-Glucosidase Inhibition of natural curcuminoids and curcumin analogs. **Eur. J. Med. Chem.** 41(2): 213-8.

Fan, C., X. Wo, Y. Qian, J. Yin and L. Gao. 2006. Effect of curcumin on the expression of LDL receptor in mouse macrophages. **J. Ethnopharmacol.** 105(1-2): 251-4

Hayouni, A.E., M. Abedrabba, M. Bouix and H. Hamdi. 2007. The effects of solvents and extraction method on the phenolic contents and biological activities *in vitro* of Tunisian *Quercus coccifera* L. and *Juniperus phoenicea* L. fruit extracts. **Food Chem.** 105: 1126-1134.

Jayaprakasha, K.G., L. Jaganmohan Rao and K.K.Sakariah. 2005. Chemistry and biological activities of C. *longa*. **Trends Food Sci. Technol.** 16: 533-548.

JECFA. 1990. Toxicological Evaluation of Certain Food Additives. pp. 104-123. ***WHO* Food Additives Series 26**. WHO, Geneva

Madhavi, D.L., R.S. Singhal and P.R. Kulkarni.1996.Technological aspects of antioxidants. pp. 159-265. *In* D.L. Madhiv, S.S. Deshpande and D.K. Salunkhe (eds.). **Food Antioxidants: Technological, Toxicological and Health Perspectives,** New York: Marcel Dekker.

Onichi, M., H. Morishita, H. Iwahashi, S. Toda., Y. Shirataki, M. Kimura and R. Kido.1994. Inhibitory effects of chlorogenic acids on linoleic acid peroxidation and hemolysis. **Phytochem.** 36: 579-583.

SCF. 1992. **Minutes of the 84th Meeting of the Scientific Committee for Food**. 18-19 June 1992 in Brussels (III/3472/92-EN)

Singleton, V.L. and J.A. Rossi.1965. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic reagent. **AM.J. Enol.Vitic.** 16: 144-158.

Tonnesen, H.H., M. Masson and T. Loftsson. 2002. Studies of curcumin and curcuminoids. XXVII. Cyclodextrin complexation: Solubility, chemical and photochemical stability **Int. J. Pharm.** 244(1-2): 127-35.

Yang, J. H., Y.H. Tseng, Y.L. Lee and J.L. Mau. 2006. Antioxidant properties of methanolic extracts from monascal rice. **LWT Food Science and Technology** 39: 740-747.