ORIGINAL SCIENTIFIC PAPER

Isolation, characterization, and antimicrobial activity of curcuminoids from *Curcuma longa* L.

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Abstract

The isolation of curcuminoids from turmeric (*Curcuma longa* L.) was performed using different extraction methods and solvents. Obtained extracts were analyzed regarding the contents of curcumin, demethoxycurcumin and bisdemethoxycurcumin using HPLC. Furthermore, radical scavenging and antibacterial activities of extracts were also determined. Results show that the highest yield of the extract is obtained using conventional extraction with mixing in ethanol, resulting also with the highest concentration of curcuminoids. All obtained extracts show strong antifungal properties but low antibacterial activity.

Keywords: Turmeric, Curcuminoids, Extraction, HPLC, antimicrobial activity

Introduction

Curcuma longa L., also known as turmeric, is grown in warm, rainy regions of the world such as China, India, Indonesia, Jamaica and Peru. The rhizome of turmeric is an important source of a yellow natural pigment (Chassagnez-Méndez et al., 2000) which in the past has been used as a spice, a coloring agent in the food industry, for household medicine usage and as an insect repellent (Pothitirat et al., 2005). Turmeric is one of the most popular medicinal herbs, with a wide range of pharmacological activities, such as antioxidant (Martins et al., 2013), anti-protozoal and anti-venom activities (Lim et al., 2011) and properties, that have found to be anti-microbial (Péret-Almeida et al., 2005), anti-inflammatory, anti-proliferative, anti-angiogenic (Tapal et al., 2012), antitumor (Mukerjee et al., 2009) and anti-ageing (Zhan et al, 2011).

Turmeric has traditionally been used for medical purposes for many centuries in countries such as India and China (Zhan et al, 2011), for treatment of jaundice and other liver ailments. Also, it has been used to treat ulcers, parasitic infections, various skin diseases (scleoderma, psoriasis), sprains, autoimmune diseases (rheumatoid arthritis, psoriasis, inflammatory bowel disease) and for curing the symptoms of colds and flus (Jayaprakasha et al., 2005).

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The yellow color, which is characteristic for turmeric rhizome, is due to the presence of 3-5 % of curcuminoids (Wakte et al., 2011). Curcuminoids, represented by curcumin (C) (50-60 %), demethoxycurcumin (DMC) (20-30 %) and bisdemethoxycurcumin (BDMC) (7-20 %) (Chatterjee et al., 1999) have poor stability and low aqueous solubility (Martins et al., 2013). Curcumin (bis-α,β-unsaturated β-diketone), commonly called as diferuloylmethane, is a low-molecular-weight compound (Tapal et al., 2012). Curcumin is practically insoluble in water at acidic and neutral pH conditions. Although curcuminoids are soluble at alkaline conditions, they do however undergo rapid hydrolytic degradation at these conditions (Kaminaga et al., 2003).

Curcuminoids have immense biological properties, especially curcumin has been reported to possess many medicinal properties. Recently the analogs of curcumin were also reported for their biological activities. Demethoxycurucmin (DMC) was the best inhibitor of MCF-7 cells. Bisdemethoxycurcumin (BDMC) is active for modulation of MDR-1 gene expression (Revathy et al., 2011). DMC and BDMC are not commercially available. Therefore to study biological properties of individual curcuminoids they need to be isolated at high purity.

The supercritical fluid extraction (SFE) is an alternative and greener extraction method commonly used to extract chemicals or flavors from organic substrates, which attracted increasing interest over the past years (Hasan et al., 2013). SFE offers several advantages compared to conventional extraction methods, including reduced consumption of hazardous organic solvents, higher sample throughput, cleanliness and safety, environmental friendliness, expeditiousness, simplicity, quantitativeness and favorable solvation capacity which approaches that of a liquids (Asiabi et al., 2013).

Chassagnez-Méndez et al. (Chassagnez-Méndez et al., 2000) studied the extraction of curcuminoids and essential oil of turmeric with supercritical CO_2 and with supercritical CO2-ethanol co-solvent. Measurements were carried out at temperatures of 40 and 45 °C and pressures of 250 and 300 bar. The highest yield was obtained by using CO_2-ethanol co-solvent. Chang et al. (Chang et al. 2006) investigated the supercritical CO_2 extraction of turmeric at 60 °C and 300 bar. Total yield of extraction was 6.47 wt. %. Furthermore, Wakte et al. (Wakte et al., 2011) performed the extraction and purification of curcuminoids using supercritical CO_2, microwave, ultra-sound assisted and Soxhlet extraction techniques. The highest purity of curcumin extract was obtained by microwave extraction (90.47 %). Naz et al. (Naz et al., 2010) studied extracts of curcuminoids and essential oil of *Curcuma longa* for their antibacterial activity against four bacterial strains *Bacillus subtilis*, *Bacillus macerans*, *Bacillus licheniformis* and *Azotobacter* using agar well diffusion method. Two years later, Singh & Jain (Singh et al., 2012) studied the antibacterial activity of three isolated curcuminoids by Agar diffusion method against medically important bacteria *Bacillus subtilis*, *Klebseill pseumonia*, *Escherichia coli*, *Enterobacter aerogenes*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Proteus mirabilis* and antifungal activity against *Candida albicans* and *Aspergillus niger*. All three curcuminoids showed antibacterial and antifungal activities.

Table 1 represents a short literature review

Table 1 Short literature review of studies done in the field of curcuminoids extraction using different extraction techniques and solvents

Extracted compounds	Solvent	Pressure (bar)	Temperature (°C)	Yield of extract (%)	Purity of extract (%)	Reference
Curcuminoids and essential oils of turmeric	$SCCO_2$ $SCCO_2$-ethanol	250-300 250-300	45 45	4.50-6.51 13.42-22.58		Chassagnez-Méndez et al., 2000
Extraction and purification of curcuminoids	$SCCO_2$-ethanol Microwave UAE[a] Soxhlet extraction	300	50		69.37[b] 15.57-90.96[b] 6.57-71.47[b] 2.1[b]	Wakte et al., 2011
Extraction of turmeric	$SCCO_2$	260-300	47-77	0-6.47	0-71[c]	Chang et al., 2006
Extraction and purification of turmerones	$SCCO_2$	28.2-208	40-60	6.98	91.8[c]	Naz et al., 2010

[a]*Ultra-sound assisted extraction,* [b]*Turmerones content,* [c]*Curcumin content.*

of studies done in the field of curcuminoids extraction using different extraction techniques and solvents.

In this work different extraction techniques were applied for the isolation of curcuminoids from turmeric, namely supercritical fluid extraction, ultrasound-assisted solvent extraction and conventional solvent extraction with mixing and Soxhlet extraction. Supercritical extraction experiments were performed by semi-continuous flow apparatus using supercritical carbon dioxide (SC-CO_2) at pressures 200 bar and 300 bar and temperatures 40 °C, 60 °C and 80 °C. Solvent extractions were performed using ethanol and hexane, whereas ultra-sound assisted extraction was performed only with ethanol. Amount of curcuminoids present in curcuma extracts were determined by high performance liquid chromatography (HPLC). The aim of this study was also to investigate the antimicrobial (antifungal and antibacterial) activities of curcuminoids extracts obtained under the various extraction conditions using agar-well diffusion methods, and to evaluate their radical scavenging activities using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical-scavenging spectrophotometric method.

2. Materials and methods

2.1. Materials Materials

Turmeric rhizomes were purchased from the Slovenian market. CO_2 (>99.5% purity) was obtained from Messer (Slovenia). Solvents, absolute ethanol and hexane were purchased from Sigma-Aldrich (Germany) and J.T. Baker (Netherlands). Analytical-grade curcumin (≥65 %) (C), demethoxycurcumin (≥98 %) (DMC) and bisdemethoxycurcumin (≥98 %) (BDMC) were purchased from Sigma-Aldrich. Acetonitrile and acetic acid used for HPLC analysis were obtained from Merck (Germany). For the antifungal activity tests, potato dextrose agar (PDA; Merck, Cat. No. 1.10130.0500) was used and for the anti-microbial tests nutrient agar, based on meat, was used and was prepared from the following chemicals: sodium chloride (Cat. No. 1.06404.1000), meat extract (Cat. No. 1.03979.0500), peptone from meat (Cat. No. 1.07214.1000), which were purchased from Merck. D-(+)-glucose (Cat. No. G-5400) was supplied from Sigma-Aldrich.

2.2. Methods

2.2.1. Supercritical fluid extraction

The extraction experiments with dense CO_2 were performed on a semi-continuous flow apparatus, which is presented in Fig. 1. (Hadolin et al., 2001; Škerget et al., 2010). The apparatus was home build for a maximum pressure of 500 bar and a temperature of 100 °C. Approximately 10 g of powdered turmeric rhizome was charged into the extractor (V=60 mL). The temperature of the water bath was regulated and maintained constant (±0.5 °C, LAUDA DR. R Wobser GmbH & Co. KG, Lauda Königshofen, Germany). Liquefied CO2 was continuously pumped with a high pressure pump (ISCO syringe pump, model 260D, Lincoln, Nebraska, Pmax=450 bar) through the preheating coil and over the bed of sample in extractor. The solvent flow rate was measured with a flow meter (ELSTER HANDEL GmbH, Mainz, Germany). The product precipitated in a glass trap, where the separation was performed at 1 bar and at 0 °C. The product collected in the glass trap was weighted (±0.1 mg) and yield was calculated by using Eq. (1).

$$\text{Yield (\%)} = \frac{m_{extract}}{m_{raw\ material}} \cdot 100\ \% \qquad (1)$$

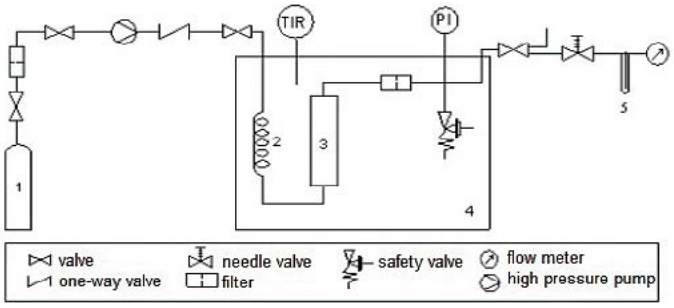

Figure 1 Apparatus for high pressure extraction (Škerget et al., 2010)
1, liquid CO_2 cylinder; 2, preheat coil; 3, extractor; 4, water bath; 5, trap

2.2.2. Soxhlet extraction

10 g of powdered turmeric was placed in a thimble, which was inserted into a Soxhlet apparatus and extracted with 250 mL of ethanol or hexane. The extraction was performed for 6 h. After the extraction period, the sample was collected and evaporated until dryness. Yield of extraction was calculated using Eq. (1).

2.2.3. Conventional extraction

Conventional extraction with mixing in solvent was performed using absolute ethanol and hexane. 10 g of powdered turmeric were weighed in a glass flask and 250 mL of solvent was added. After 6 h of mixing at room temperature, the solution was separated by vacuum filtration. Extract solutions were collected and the solvent was then removed by evaporation. Yield of extraction was calculated using Eq. (1).

2.2.4. Ultra-sound assisted extraction

Ultra-sound assisted extraction (UAE) was performed in an ultrasound bath (Iskra-Pio, Slovenia) at fixed power (400 W). 1 g of dry powder was placed in a 25 mL measuring flask and filled with ethanol (25 mL). The mixture was exposed to ultrasonic waves for 30 min at 20±1 °C. Extract solutions were collected and the solvent was then removed by evaporation. Yield of extraction was calculated using Eq. (1).

2.2.5. Analysis of curcuminoids

The extracts were analyzed by HPLC, using the method described by Lee and Choung (Lee et al., 2011). The Agilent 1100 HPLC system consisted of a binary pump, column heater, autosampler and variable wavelenght detector (VWD). The separation was achieved on chromatographic column Agilent Eclipse XDB-C18 (150 mm x 4.6 mm; 5 µm particle size). The mobile phases were 2 % acetic acid in water (elution A) and 2 % acetic acid in acetonitrile (elution B). The solvent gradient was as follows: 0-3 min, 10 % B; 8 min, 20 % B; 13 min, 25 % B; 18 min, 35 % B; 28-33 min, 55 % B and then held for 3 min before returning to initial conditions. The solvent flow rate was 1.0 mL/min and the column temperature was 30 °C. The volume of injection was 10 µL and peaks were monitored at 420 nm. Quantification of single curcuminoids was done using calibration curves obtained from curcuminoid standards. All measurements were performed in triplicate and averages were calculated.

2.2.6. DPPH radical-scavenging system

DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity was measured using the UV-VIS spectrophotometric method (Majhenič et al., 2007). Extract solutions were prepared by dissolving 1 mg of extract in 1 mL of methanol. The solution of DPPH in methanol (6 x 10⁻5 M) was prepared daily before measurements. To a dark flask containing 77 µL of extract solution, 3 mL of DPPH solution was added. The mixed solutions were kept in the dark for 15 min at room temperature and the absorbance was measured using UV-VIS spectrophotometer (Varian, USA) at 515 nm. Radical-scavenging activities of samples were calculated using Eq. (2).

$$\% \text{ inhibition} = \frac{A_B - A_A}{AB} \cdot 100\ \% \qquad (2)$$

where AB, is absorbance of blank sample (t = 0 min) and AA, is absorbance of extract solution (t=15 min). All measurements were performed in triplicate and averages were calculated.

2.2.7. Antimicrobial tests

2.2.7.1. Microbial strains

Microorganisms were obtained as lyophilized cultures from National Collection of Agricultural and Industrial Microorganisms (Hungary). The organisms used were as follows: three species of molds, namely *Aspergillus niger*, *Trichoderma viride* and *Penicillium cyclopium*, two species of Gram negative bacteria, *Escherichia coli* and *Pseudomonas fluorescens* and one species of Gram positive bacteria, *Bacillus cereus*.

2.2.7.2. Preparation of test microorganisms

Agar cultures of fungi and bacteria for antimicrobial tests were prepared as described by Majhenič et al. (Majhenič et al., 2007). The test fungi were stored on potato dextrose agar (PDA) slopes at 4 °C. Conidia were harvested in a sterile physiological salt solution containing approximately 105-107 conidia/mL. These conidial suspensions were used immediately after preparation for determining the antifungal activities of curcuma extracts.

For the antibacterial experiments, test bacteria were grown on meat nutrient agar slopes for 24 h at 28 °C, except for *E. coli,* which was grown at 37 °C and then stored at 4 °C. Before the bacterial experiments were carried out, liquid medium was inoculated with freshly harvested bacteria. These bacterial suspensions (approximately 106-107 cells/mL) were used to inoculate the test medium containing curcuma extracts.

2.2.7.3. Antifungal and antibacterial activity tests

Two different methods were employed for the determination of antimicrobial activities; agar well-diffusion method for the determination of antifungal activities and disk diffusion method for the antibacterial activity.

For antifungal activity test, each PDA sterile plate contained 19 mL of conidial suspension and 1 mL of methanol mixture of curcuma extracts (concentration 1 mg/mL). For control plates, instead of dissolved curcuma extract in methanol only pure methanol was used. The solid plates were inoculated with 0.1 mL of conidial suspension, measuring it into the holes (diameter 12 mm) in the center of medium. The plate was left incubated in the dark at 28 °C and the diameter of the mycelial growth was measured. Each test was performed in triplicate and averages were calculated.

The antibacterial activities of all samples were carried out by disk diffusion method. The Petri dishes containing 19 mL of meat nutrient agar were cultured with diluted bacterial strain. Sterile disk papers (diameter 9 mm) were placed on the culture medium. 30 µL of each sample was injected to the prepared disk. Negative control was prepared using methanol. Inoculated plates were incubated in the dark at 28 °C, except for *E. coli*, which was grown at 37 °C, for 24 h. The diameter of the zone around the disk was measured. Each test was run in triplicate and averages were calculated.

The antifungal and antibacterial activities were expressed in terms of percent of mycelial inhibition calculated by Eq. (3):

$$I = \frac{C - T}{C} \cdot 100\ \% \qquad (3)$$

Where *I* is inhibition (%), *C* is the colony diameter of the mycelium on the methanol control plate (mm), and *T* is the colony diameter of the mycelium on the test Petri plate (mm).

3. Results and discussion

3.1. Supercritical fluid extraction

The results of supercritical extraction of turmeric with CO_2 at pressures of 200 bar and 300 bar and temperatures 40 °C, 60 °C and 80 °C followed by one step separation are presented in Fig. 2. It can be observed that the operating conditions, i.e. pressure and temperature do not have a significant influence on the extract yield. At 40 °C the yield is approximately 3.48 – 3.59 %, whereas at 60 °C, the yield decreases with increasing pressure (200 – 300) bar from 3.27 to 2.89 %. At 80 °C, the yield is generally independent of pressure and equals to approximately 3.67 – 3.69 %.

In regards to CO_2 consumption, it seems that the lowest amount of CO_2 is required at 200 bar and 80 °C equaling to approximately 1.5 kg of CO_2/kg material. At 300 bar and 80 °C the required amount of CO_2 is more than three times higher and equals to approximately 5.5 kg of CO_2/kg material. It seems that for faster extraction kinetics lower pressures are favorable.

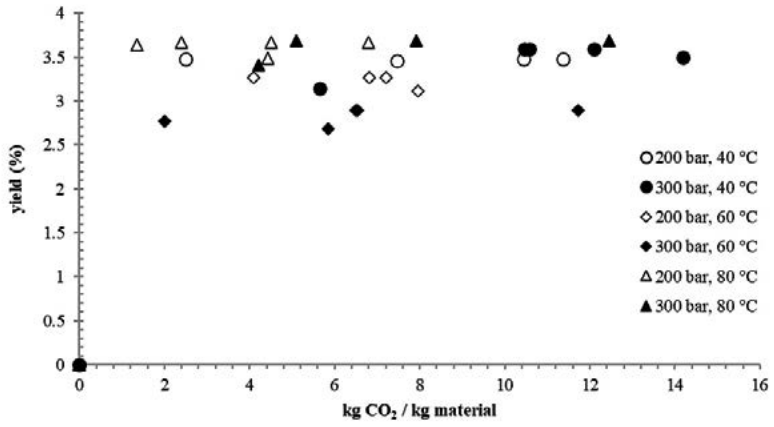

Figure 2 Kinetics of semi-continuous extraction of turmeric with dense CO_2

3.2 Soxhlet, conventional and ultra-sound assisted extractions

The highest yields of extraction (12.66 %) were obtained using Soxhlet extraction using ethanol as solvent. Less extract was obtained using ultra-sound assisted extraction (10.64 %) and conventional extraction (10.40 %) with ethanol. Significantly lower yields were obtained using hexane as solvent (less than 4 %). Obtained results therefore indicate that more polar solvents (e.g. ethanol) are more favorable in regards to extraction yield, whereas CO_2 and hexane have proven to be less suitable.

3.3 HPLC analysis

Extracts obtained were analyzed for curcuminoid content using HPLC. Results are presented in Table 2. It can be observed that the highest amounts of curcuminoids are obtained by the Soxhlet extraction using ethanol as solvent with total curcuminoid content in extract of approximately 39.75 %. Similarly, the conventional extraction with ethanol as solvent yields a total curcuminoid content in extract of approximatelly 35.13 %. Ultra-sound assisted ethanol extraction yields significantly lower total curcuminoids (10.64 %) and for extracts obtained using CO_2 and hexane, even lower yields are obtained. Curcuminoids seem to have low solubility in CO_2 and hexane, which would explain the low yields obtained. For SFE extracts the highest concentration of total curcuminoids in extract is achieved at 200 bar and 60 °C (2.66 %). CO_2 is probably more favorable for extraction of other types of compounds typically present in curcuma, namely turmerones and essential oils, the major constituents of turmeric oil (Kao et al., 2007).

Table 2 The contents of curcumin (C), bisdemethoxycurcumin (BDMC) and demethoxycurcumin (DMC) for various extraction conditions

	w_C [mg/g extract]	w_{BDMC} [mg/g extract]	w_{DMC} [mg/g extract]	Total curcuminoids [mg/g extract]
SCE 200 bar 40 °C	4.71±0.19	1.08±0.19	1.90±0.08	7.68±0.43
SCE 200 bar 60 °C	18.88±0.80	2.70±1.24	5.03±0.17	26.60±0.40
SCE 200 bar 80 °C	5.61±0.27	0.97±0.11	1.89±0.27	8.47±0.30
SCE 300 bar 40 °C	16.60±0.68	2.01±0.08	5.08±0.32	23.69±0.91
SCE 300 bar 60 °C	14.51±0.21	3.89±0.29	4.08±0.09	22.48±0.41
SCE 300 bar 80 °C	7.87±0.09	5.28±0.06	3.25±0.04	16.40±0.08
Soxhlet (ethanol)	161.27±0.35	111.04±0.12	125.24±0.14	397.55±0.60
Soxhlet (hexane)	11.72±0.16	6.89±0.65	2.56±0.15	21.27±0.94
Conventional (ethanol)	166.45±0.61	84.35±0.27	100.51±0.37	351.32±1.25
Conventional (hexane)	11.64±0.14	6.15±0.59	1.91±0.23	19.70±0.94
Ultra-sound (ethanol)	13.44±0.37	69.44±1.85	14.63±0.40	97.51±0.69

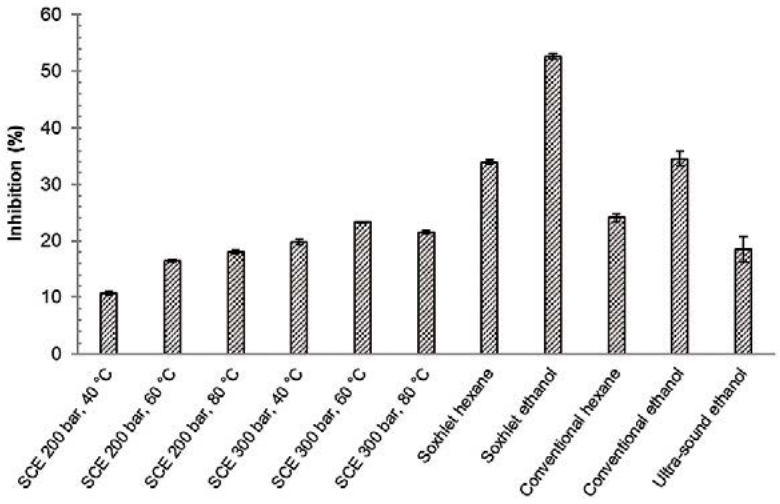

Figure 3 DPPH scavenging activities of curcuminoids extracts

3.4. Antioxidant activity

The results of DPPH radical-scavenging activities of the various curcuma extracts are represented in Fig. 3. The curcuma extracts show potent radical scavenging activities in range from 10.7 % to 52.6 %. The highest radical-scavenging activity was observed for the Soxhlet extract obtained with ethanol (~52.6 %). The lowest radical scavenging activity was observed for SFE extract obtained at 200 bar and 40 °C (~10.7 %). Generally, hexane and ethanol Soxhlet extracts were the most effective DPPH radical scavengers with inhibition being higher than 30 %.

3.5. Antifungal and antibacterial activities

Curcuma extracts were tested against three fungal strains, namely A. niger, T. viride and P. cyclopium. The results of the microbial growth applying three parallel measurements, are given. In the case of antifungal properties, all extracts exhibited a 100 % inhibitory effect on the growth of the three tested fungi. The results suggest that the curcuma extracts could be applied as an antifungal additive in food processing industry for improved food safety.

As can been seen from Table 3 the curcuma extracts showed low antibacterial activity (<40 %) against two health-damaging bacteria, i.e. the Gram negative bacteria *E. coli* and *P. fluorescens*, while no antibacterial activity was observed against the Gram positive bacteria *B. cereus*.

4. Conclusions

In the presented work the isolation of curcuminoids was performed using different extraction methods and solvents. Highest yields of extractions and highest purities of extracts with high antioxidant activities were obtained with extraction methods applying ethanol as solvent, whereas less polar solvents, namely CO_2 and hexane yielded significantly lower amounts of extract with insignificant curcuminoid content and low radical scavenging activities. All obtained extracts showed strong antifungal activities against all tested fungal strains, whereas antibacterial activities of the extracts were only mild or in some cases even negligible.

Further research has shown that turmeric has also a positive effect on meat. It improves the antioxidant capacity, slows lipid oxidation in order to enhance the shelf life of meat.

Table 3 Antimicrobial activities of curcuminoids extracts against selected bacteria strains

Bacterial strains	Colony diameter (mm)	24 h Percentage mycelial zone inhibition[a]										
	Blank	SCE 200 bar 40 °C	SCE 200 bar 60 °C	SCE 200 bar 80 °C	SCE 300 bar 40 °C	SCE 300 bar 60 °C	SCE 300 bar 80 °C	Soxhlet hexane	Soxhlet ethanol	Conventional hexane	Conventional ethanol	Ultra-sound assisted extraction with ethanol
E. coli	12.3	21.6±1.2	24.3±0.5	25.2±1.4	18.9±2.8	22.3±0.9	27.0±0.8	24.3±0.5	35.1±0.0	21.1±0.1	34.6±0.7	35.7±0.3
P.flourescens	5.5	27.3±0.5	18.2±0.8	27.6±0.8	14.5±0.3	20.9±0.3	24.5±1.0	36.4±0.5	40.0±0.3	25.0±0.8	45.1±0.3	29.3±0.5
B. cereus	3.0	-	-	-	-	-	-	-	-	-	-	-

[a]*Each value represents the mean ± standard deviation: (n=3). -, no inhibition*

Turmeric is one of the most popular spice used around the world and it is studied for its antioxidant power. The dietary supplementation of turmeric in pigs can increase meat quality and extend shelf-life. Turmeric extract improved the antioxidant capacity of lamb sausages and also slowed lipid oxidation and the generation of related volatile compounds. Moreover, physic-chemical parameters of lamb sausages were not greatly influenced by turmeric addition and concentration, except for yellow color. These findings showed that turmeric extract is effective against lipid oxidation and could be a good strategy to enhance the shelf life of lamb sausage (Francisco et. al, 2020)

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Izolacija, karakterizacija i antimikrobna aktivnost kurkuminoida iz *Curcuma longa* L.

Sažetak

Izolacija kurkuminoida iz kurkume (*Curcuma longa* L.) provedena je različitim metodama ekstrakcije i otapala. Dobiveni ekstrakti analizirani su s obzirom na sadržaj kurkumina, demetoksikurkumina i bisdemetoksikurkumina pomoću HPLC. Nadalje, utvrđeno je hvatanje slobodnih radikala i antibakterijska aktivnost ekstrakata. Rezultati pokazuju da se najveći prinos ekstrakta postiže konvencionalnom ekstrakcijom uz miješanje u etanolu, što rezultira i najvećom koncentracijom kurkuminoida. Svi dobiveni ekstrakti pokazuju jaka antifungalna svojstva, ali nisku antibakterijsku aktivnost.

Ključne riječi: kurkuma, kurkuminoidi, ekstrakcija, HPLC, antimikrobno djelovanje

Isolierung, Charakterisierung und antimikrobielle Aktivität von Curcuminoiden aus *Curcuma longa* L.

Zusammenfassung

Die Isolierung von Curcuminoiden aus Kurkuma (*Curcuma longa* L.) wurde durch verschiedene Extraktionsmethoden und Lösungsmittel durchgeführt. Die erhaltenen Extrakte wurden mittels HPLC auf den Gehalt an Curcumin, Demethoxycurcumin und Bisdemethoxycurcumin analysiert. Darüber hinaus wurde das Einfangen freier Radikale und die antibakterielle Aktivität der Extrakte ermittelt. Die Ergebnisse zeigen, dass der höchste Ertrag des Extrakts durch herkömmliche Extraktion unter Rühren in Ethanol erzielt wird, was zur höchsten Konzentration an Curcuminoiden führt. Alle erhaltenen Extrakte zeigen starke antimykotische Eigenschaften, aber eine geringe antibakterielle Aktivität.

Schlüsselwörter: Kurkuma, Curcuminoide, Extraktion, HPLC, antimikrobielle Aktivität

Aislamiento, caracterización y actividad antimicrobiana de curcuminoides de *Curcuma longa* L.

Resumen

El aislamiento de curcuminoides de la cúrcuma (*Curcuma longa* L.) se llevó a cabo mediante varios métodos de extracción y solventes. Fue analizado el contenido de curcumina, demetoxicurcumina y bisdemetoxicurcumina de los extractos obtenidos por HPLC. Además, fue encontrado el captura de radicales libres la actividad antibacteriana de los extractos. Los resultados muestran que el mayor rendimiento del extracto se logra mediante la extracción convencional con la mezcla en etanol, lo que da como resultado la mayor concentración de curcuminoides. Todos los extractos obtenidos muestran fuertes propiedades antifúngicas pero baja actividad antibacteriana.

Palabras claves: cúrcuma, curcuminoides, extracción, HPLC, actividad antimicrobiana

Isolamento, caratterizzazione e attività antimicrobica dei curcuminoidi da *Curcuma longa* L.

Riassunto

L'isolamento dei curcuminoidi dalla curcuma (*Curcuma longa* L.) è stato eseguito con vari metodi di estrazione e solventi. Gli estratti ottenuti sono stati analizzati riguardo al contenuto di curcumina, demetossicurcumina e bisdemetossicurcumina mediante HPLC. Lo studio ha riguardato anche il potenziale di scavenging dei radicali liberi e l'attività antibatterica degli estratti. I risultati mostrano che la resa più alta dell'estratto si ottiene mediante l'estrazione convenzionale con miscelazione in etanolo, che si traduce nella più alta concentrazione di curcuminoidi. Tutti gli estratti ottenuti mostrano spiccate proprietà antimicotiche ma scarsa attività antibatterica.

Parole chiave: curcuma, curcuminoidi, estrazione, HPLC, attività antimicrobica