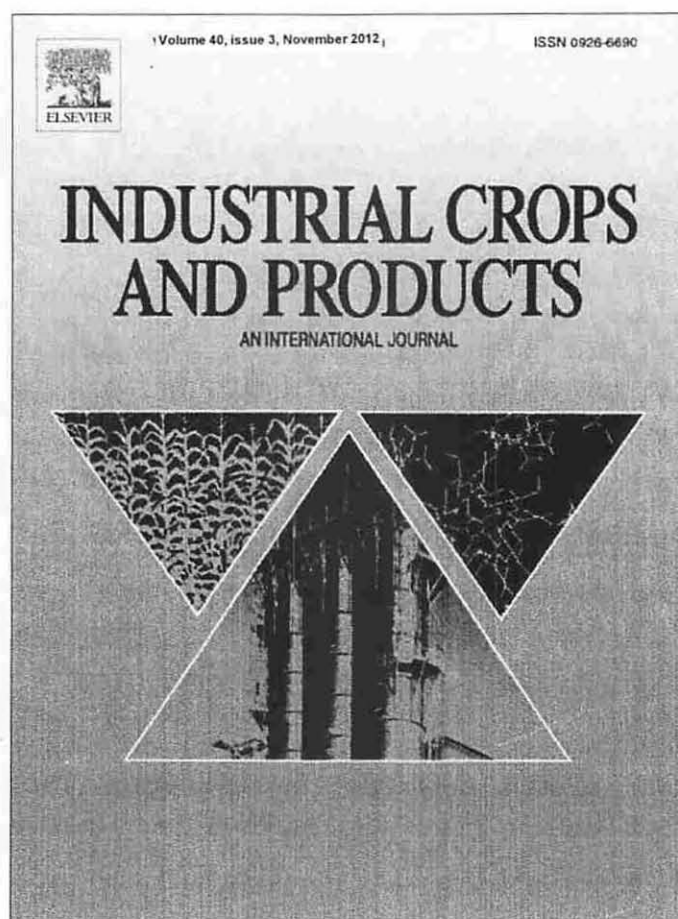


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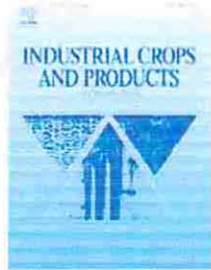


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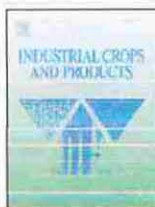
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Volume 40, Pages 1-366 (November 2012)

articles 1 - 54

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- Volumes 41 - 43 (2013)
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- Volume 40**
pp. 1-366 (November 2012)
- Volume 39
pp. 1-218 (September 2012)
- Volume 38
pp. 1-176 (July 2012)
- Volume 37, Issue 1
pp. 1-560 (May 2012)
- Volume 36, Issue 1
pp. 1-614 (March 2012)
- Volume 35, Issue 1
pp. 1-318 (January 2012)
- Volume 34, Issue 5
pp. 1399-1654 (November 2011)
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pp. 1251-1398 (September 2011)
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- Volume 34, Issue 1
pp. 785-1250 (July 2011)
- Volume 33, Issue 3
pp. 559-784 (May 2011)
- Volume 33, Issue 2
pp. 259-558 (March 2011)
- Volume 33, Issue 1
pp. 1-258 (January 2011)
- Volume 32, Issue 3
pp. 175-700 (November 2010)
- Volume 32, Issue 2
pp. 77-174 (September 2010)
- Volume 32, Issue 1
pp. 1-76 (July 2010)
- Volume 31, Issue 3
pp. 427-562 (May 2010)
- Volume 31, Issue 2
pp. 203-426 (March 2010)
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- 2 **Editorial Board**
Page ii
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- 3 ***In vitro* and *in vivo* studies of natural products: A challenge for their valuation. The case study of chamomile (*Matricaria recutita* L.)** Review Article
Pages 1-12
Silvia Petronilho, Marcelo Maraschin, Manuel A. Coimbra, Silvia M. Rocha
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- Highlights**
 - Scarce information on real human health benefits of natural products is available. ► Several health benefits have been reported for chamomile extracts and *M. recutita* L. ► The models used to evaluate the biological activities were classified: *in vitro* and *in vivo*. ► *In vitro* and animal studies are very promising, however their extension to human trials is essential. ► Chamomile-related sesquiterpenic compounds seem to be involved in a network of biological effects.
- 4 **Condensed tannins from grape pomace: Characterization by FTIR and MALDI-TOF and production of environment friendly wood adhesive** Original Research Article
Pages 13-20
Lan Ping, Antonio Pizzi, Zhou Ding Guo, Nicolas Brosse
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- Highlights**
 - Condensed tannins were extracted from grape pomace using a water medium. ► Extracts were characterized by FT-IR, thermomechanical analysis and MALDI-TOF spectrometry. ► Different formulations were used to press one layer particle board. ► It has been shown that the extraction processes largely affect the structure and the adhesive properties of the extracts.
- 5 **Determination of 27 chemical constituents in Chinese southwest tobacco by FT-NIR spectroscopy** Original Research Article
Pages 21-26
Jia Duan, Yue Huang, Zuhong Li, Bo Zheng, Qianqian Li, Yanmei Xiong, Lijun Wu, Shungeng Min
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Highlights

- Rapid determination of 27 chemical constituents in tobacco by NIR. ► Monitor quality of



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- 26  [Production of xyliitol and ethanol by *Hansenula polymorpha* from hydrolysates of sunflower stalks with phosphonic acid](#) Original Research Article
Pages 160-166
M^a Lourdes Martínez, Sebastián Sánchez, Vicente Bravo
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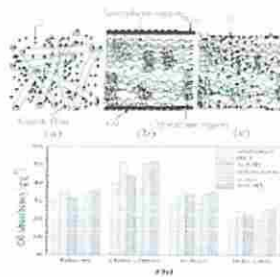
- 27  [Microwave dehydration of three citrus peel cultivars: Effect on water and oil retention capacities, color, shrinkage and total phenolic content](#) Original Research Article
Pages 167-177
Nesrine Ghanem, Daoued Mihoubi, Nabil Kechaou, Nourhène Boudhrioua Mihoubi
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Highlights

► The citrus peel cultivars studied are mandarin, thompson and lemon. ► Their microwave drying time depends on microwave power levels and on cultivars. ► The initial colors were preserved at the low microwave power levels. Drying at 100 and 300 W gives the maximal water retention capacities. ► Microwave drying at 450 and 600 W preserves the highest total phenolic contents.


- 28  [Effect of kapok fiber treated with various solvents on oil absorbency](#) Original Research Article
Pages 178-184
Jintao Wang, Yian Zheng, Aiqin Wang
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Graphical abstract



Highlights

► Kapok fiber treated with various solvents can change the oil absorption capability. ► NaClO₂-treated kapok fiber shows the highest oil absorbency. ► The removal of waxy on kapok fiber surface can not reduce the oil absorption capacity. ► The variation of surface morphology and crystallinity of kapok fiber is related to its oil absorbency. ► The HCl, NaClO₂ and water-treated kapok fiber exhibits better reusability.

- 29  [Developing an agro-climatic zoning model to determine potential production areas for castor bean \(*Ricinus communis* L.\)](#) Original Research Article
Pages 185-191
Silvia L. Falasca, Ana C. Ulberich, Eliana Ulberich
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Graphical abstract



Highlights

► Argentine agroclimatic aptitude was defined based on Castorbean bioclimatic needs. ► Optimal, very suitable, suitable, marginal and not apt areas were defined and mapped. ► Cultivation not advisable in optimal and very suitable eastern areas of Argentina. ► It can be cultivated in subhumid areas classified as suitable 1, 2 and 3. ► Complementary irrigation is not recommended for this energy crop.

tobacco during the cigarette production. ► Feasible online prediction of chemical constituents of tobacco. ► PLS modeling on the 500 samples of tobacco from different cultivation locations in Southwest China. ► First apply to determination of heavy metals in tobacco.

- 6  [Influences of plant density on the seed yield and oil content of winter oilseed rape \(*Brassica napus* L.\)](#) Original Research Article
Pages 27-32
Shujie Zhang, Xing Liao, Chunlei Zhang, Huajun Xu
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Highlights


► Seed oil content of main raceme higher than branch raceme about 1%. ► Seed oil content was increased with the plant densities. ► The 1000 seed weight of main raceme much higher than branch raceme. ► Plant density mainly affects on branch raceme and less on main raceme.

- 7  [R.-C. Sun, Cereal Straw as a Resource for Sustainable Biomaterials and Biofuels—Chemistry, Extractives, Lignins, Hemicelluloses and Cellulose \(2010\) Elsevier 288 pp., ISBN: 978-0-444-53234-3](#)
Pages 33-34
Bogdan Marian Tofanica
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- 8  [Chemical composition of essential oil of *Artemisia nanschanica* Krasch. from Tibetan plateau](#)
Pages 35-38
Z.H. Shang, Y. Hou, R.J. Long
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Highlights

► We analysis the chemical composition of the essential oil of *Artemisia nanschanica* Krasch. ► GC-MS method was used in identifying of chemical compound. ► We compare 30 others species of *Artemisia* with *A. nanschanica* ► *A. nanschanica* has special compound of medicine raw in its essential oil.

- 9  [Evaluation of antioxidant activity of dilute acid hydrolysate of wheat straw during xylose production](#) Original Research Article
Pages 39-44
Ozlem Akpinar, Serdal Sabanci, Okan Levent, Abdulvahit Sayaslan
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Highlights

► Wheat straw was used for the production of xylose and phenolic compounds. ► The production conditions of xylose and phenolic compounds were optimized. ► The yield of sugar and soluble phenolics were dependent on operational conditions. ► The optimum reaction conditions were 4.7% acid concentration, 120 °C and 45 min.

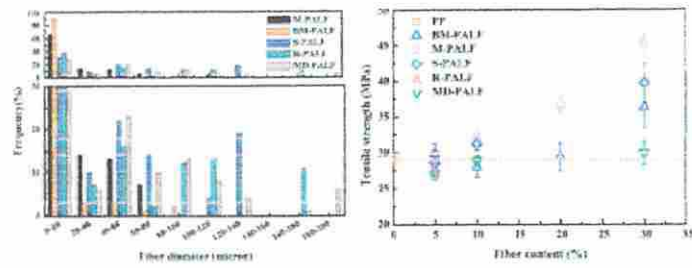
- 10  [Preparation and characterisation of composites from starch and sugar cane fibre](#) Original Research Article
Pages 45-54
William N. Gilfillan, Danny M.T. Nguyen, Peter A. Sopade, William O.S. Doherty
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Highlights

► Composites of two types of starch with milled sugar cane fibres were prepared. ► Cast and hot-pressed methods compared. ► Hot-pressed starch films have twice as much crystals than cast starch films. ► Addition of bagasse fibre to both starch types reduced moisture uptake by 30%. ► Addition of 5 wt% fibre increased the tensile strength and Young's modulus.

- 11  [Utilisation of pineapple leaf waste for plastic reinforcement: 1. A novel extraction method for short pineapple leaf fiber](#) Original Research Article
Pages 55-61
Nanthaya Kengkhetkit, Taweechai Amornsakchai
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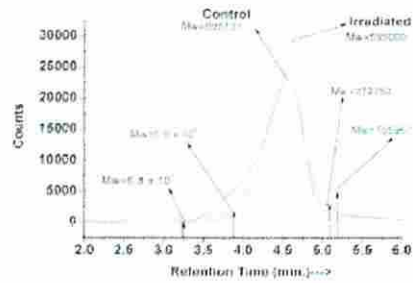


Highlights

► A simple and novel method to produce pineapple leaf fiber (PALF). ► The method provides high yield and fine and high quality short fibers for plastic reinforcement. ► The method is potentially scalable. ► PP-PALF composites display high modulus and strength.

12 [Gamma irradiated sodium alginate induced modulation of phosphoenolpyruvate carboxylase and production of essential oil and citral content of lemongrass](#) Original Research Article
 Pages 62-68
 Mohd Idrees, Shafia Nasir, M. Naeem, Tariq Aftab, M. Masroor A. Khan, Moinuddin, Lalit Varshney
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Graphical abstract



Highlights

► Gamma irradiated sodium alginate enhanced PEP carboxylase activity. ► Irradiated sodium alginate showed growth promoting activity. ► Irradiated sodium alginate at 60 mg L⁻¹ enhanced the essential oil production and citral content.

13 [Particulate composite based on coconut fiber and castor oil polyurethane adhesive: An eco-efficient product](#) Original Research Article
 Pages 69-75
 Juliano Fiorelli, Diego Donizetti Curtolo, Nbia G. Barrero, Holmer Savastano Jr., Eliria Maria de Jesus Agnolon Pallone, Ryan Johnson
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Highlights

► Particleboards of coconut fiber. ► Particleboards with agro industrial wastes and castor oil-based adhesive. ► Durability of particleboards.

14 [Direct somatic embryogenesis from hypocotyl segments of *Digitalis trojana* Ivan and subsequent plant regeneration](#) Original Research Article
 Pages 76-80
 Sandeep Kumar Verma, Gunce Sahin, Buhara Yucesan, Ismail Eker, Nevin Sahbaz, Songul Gurel, Ekrem Gurel
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Highlights


► An effective protocol for direct somatic embryogenesis was developed. ► TDZ alone at 0.5 or 1.0 mg/l was more effective for somatic embryo induction. ► IAA was more effective than NAA or IBA for somatic embryogenesis. ► Combination of low IAA and high TDZ was more effective for somatic embryogenesis. ► Plantlet development was achieved after culturing on half-strength MSO medium.

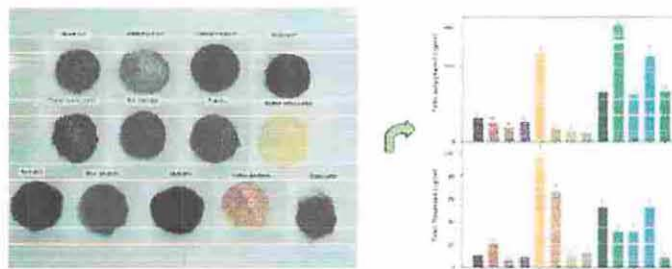
15 [Antioxidant activity and physico-chemical properties of Tunisian grown pomegranate \(*Punica granatum* L.\) cultivars](#) Original Research Article
 Pages 81-89
 Faten Zaouay, Pedro Mena, Cristina Garcia-Viguera, Messaoud Mars

Pages 122-128

Meena K. Cheruvathur, A.R. Sivu, N.S. Pradeep, T. Dennis Thomas

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- 22  [Extraction and characterization of some natural plant pigments](#) Original Research Article
Pages 129-135
Hee-Ock Boo, Sung-Jin Hwang, Chun-Sik Bae, Su-Hyun Park, Buk-Gu Heo, Shela Gorinstein
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Graphical abstract**Highlights**

► Pigment properties from natural plants, which are used as an important alternative to synthetic colors, were examined ► Polyphenols were from 404 µg/ml to 11 µg/ml with the highest for onion peel and the lowest for Chinese foxglove pigments. ► Antioxidant activity varied from 89 to 18% with correlation between polyphenols, flavonoids and their antioxidant activity. ► High antimicrobial activities showed purple aweet potato, mulberry, grape peel and blue gardenia ► Plant crops with active functional components can be used as excellent materials for natural cosmetics and food supplements.

- 23  [Extremely low sulfuric acid catalyst system for synthesis of methyl levulinate from glucose](#) Original Research Article
Pages 136-144
Lincai Peng, Lu Lin, Hui Li
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Highlights

► Extremely low sulfuric acid catalytic system was found to be a promising strategy. ► An available kinetic model on the synthesis of methyl levulinate was developed. ► Side reaction on methanol dehydration into undesired dimethyl ether was slight. ► The catalyst system had a relatively less corrosive to equipment as solid acid. ► The catalytic strategy is facile, efficient, economical and environmentally benign.

- 24  [Genetic diversity of the main progenitors of sugarcane from the RIDESA germplasm bank using SSR markers](#) Original Research Article
Pages 145-150
João Messias dos Santos, Luiz Sérgio Costa Duarte Filho, Marina Lyra Soriano, Paulo Pedro da Silva, Velber Xavier Nascimento, Geraldo Veríssimo de Souza Barbosa, Adriana Reis Todaro, Cicero Eduardo Ramalho Neto, Cicero Almeida
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Highlights

► The chance of finding two individuals with the same genotype in a population is almost zero. ► The genetic similarity of the principle genitors of sugarcane from RIDESA is low. ► The majority of the combination pairs reached a genetic similarity between 0.17 and 0.45. ► It was observed that no group of genitors in particular stood out.

- 25  [Biorational glycol diesters as dietary toxins versus bioefficacy of sucrose octanoate against lepidopteran larvae](#) Original Research Article
Pages 151-159
Opende Koul, Gurmeet Singh, Rajwinder Singh, Anshu Middha, Suresh Walia, Paraj Shukla, V.K. Kaul
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Highlights

► This is first study to determine efficacy of glycol diesters as biorational effective compounds for lepidopteran larvae. ► C-8 compounds are most active. ► The compounds are dietary physiological toxins when administered in feeding. ► These ecofriendly compounds could lead to the development of new class of biorational insecticides. ► They may also lead to biocidal formulations in combination with other natural products.

- 30  [Statistical optimization for the production of lichenase by a newly isolated *Bacillus licheniformis* UEB CF in solid state fermentation using pea pomace as a novel solid support](#) Original Research Article
Pages 192-198
Fatma Chaari, Amel Kamoun, Fatma Bhirj, Monia Blibech, Raoudha Ellouze-Ghorbel, Semia Ellouz-Chaabouni
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Highlights

► This research focused on the SSF by pea pomace for lichenase production by a newly isolated *Bacillus* strain. ► The optimum conditions were attained from the design of experiment via Doehlert design. ► They were cultivation time (84 h), L/S ratio (4 ml/g), inoculum volume (0.8 ml, 8×10^7 CFU/ml) and culture temperature (44 °C). ► Our results contribute new knowledge towards the alternative use of pea pomace as a cheap substrate in fermentation processes for the production of industrial enzymes.

- 31  [Morpho-quantitative and qualitative traits of *Arnica montana* L. wild accessions of Trentino, Italy](#) Original Research Article
Pages 199-203
Nicola Aiello, Renato Bontempo, Carla Vender, Valentina Ferretti, Gabriella Innocenti, Stefano Dall'Acqua
[Show preview](#) | [PDF \(363 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► Wild arnica accessions were morphologically and phytochemically analyzed. ► Kruskal–Wallis' test, PCA and cluster analysis were performed to estimate differences between accessions. ► Some accessions resulted more developed by a morphological point of view. ► Large differences emerged in the active principles content.

- 32  [Rapid separation of carotenes and evaluation of their *in vitro* antioxidant properties from ripened fruit waste of *Areca catechu* – A plantation crop of agro-industrial importance](#) Original Research Article
Pages 204-209
Mahesh Kumar, Utkarsh Ravindra Moon, Adinpunya Mitra
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Highlights

► A rapid reverse phase-thin layer chromatography (RP-TLC) based technique was validated and used for separation of carotenes from pericarp waste of *Areca catechu*. ► Solid phase extraction was successfully used for quick isolation of β -carotene from the total carotene mixture of *A. catechu*. ► Promising antioxidant capacities of the carotenes isolated from fruit (pericarp) waste of *A. catechu* were demonstrated using DPPH, FRAP, ABTS and DNA nicking assays.

- 33  [Chemical and elemental composition of big bluestem as affected by ecotype and planting location along the precipitation gradient of the Great Plains](#) Original Research Article
Pages 210-218
Ke Zhang, Loretta Johnson, Richard Nelson, Wenqiao Yuan, Zhijian Pei, Donghai Wang
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Highlights

► Big bluestem has been considered as potential feedstock for biofuels. ► Ecotype, location and their interaction significantly affect the biomass compositions. ► Location had a greater effect than the ecotype and location–ecotype interaction. ► Up to 97% of the variations in composition can be explained by annual precipitation.

- 34  [Laticifer tissue-specific activation of the *Hevea SRPP* promoter in *Taraxacum brevicorniculatum* and its regulation by light, tapping and cold stress](#) Original Research Article
Pages 219-224
Sandeep Kumar Tata, Jun Young Choi, Ji-Yul Jung, Ka Yung Lim, Jeong Sheop Shin, Stephen Beungtae Ryu
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Highlights

► The *SRPP* promoter induces gene expression primarily in laticiferous tissues. ► The *SRPP* promoter responds to external conditions including light, tapping, and cold. ► The *SRPP* promoter is suitable for the latex-specific expression of a target gene(s) such as key rubber biosynthetic genes.

- 35  [Production, purification and characterization of oligosaccharides from olive tree pruning autohydrolysis](#) Original Research Article
Pages 225-231
Cristóbal Cara, Encarnación Ruiz, Florbela Carvalheiro, Patricia Moura, Ignacio Ballesteros, Eulogio Castro, Francisco Girio

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Highlights

► Olive tree pruning is an interesting raw material for oligosaccharide production. ► Autohydrolysis at 180 °C allows to obtain a high oligosaccharides yield. ► Interesting fractions are obtained by gel filtration chromatography. ► The proposed process can be a contribution to develop olive-biomass biorefinery.

- 36  [Producing low-cost cellulose nanofiber from sludge as new source of raw materials](#) Original Research Article
Pages 232-238

Mehdi Jonoobi, Aji P. Mathew, Kristiina Oksman

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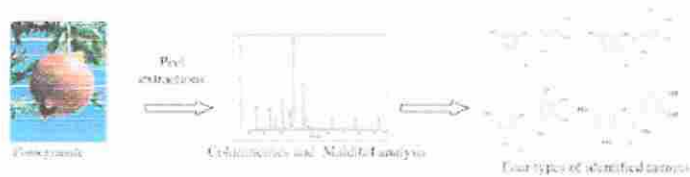
► The preparation and characterization of cellulose nanofibers from sludge as new source have not been previously reported. ► The current research showed that the isolation of nanofibers from sludge may be considered an economic, energy efficient and viable alternative to generate value-added product from cellulose sludge while minimizing the sludge disposal issues.

- 37  [Characterization of pomegranate peels tannin extractives](#) Original Research Article
Pages 239-246

H. Saad, F. Charrier-El Bouhtoury, A. Pizzi, K. Rode, B. Charrier, N. Ayed

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Graphical abstract



Highlights

► The pomegranate peels has been identified as a source of tannins. ► Fluctuating phenolic contents from 10 to 18% depending on cultivars, has been observed. ► We have also observed strong differences between hydrolysable and condensed tannins concentrations. ► We have identified four types of condensed tannins by MALDI-TOF analysis.

- 38  [Optimization of total phenolic content extracted from *Garcinia mangostana* Linn. hull using response surface methodology versus artificial neural network](#) Original Research Article
Pages 247-253

Choon Yoong Cheok, Nyuk Ling Chin, Yus Aniza Yusof, Rosnita A. Talib, Chung Lim Law

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Highlights

► Mangosteen hull has great potential for its bioactive compounds have many medicinal benefits. ► This paper investigates the extraction process of total phenolic contents from mangosteen hull. ► The process of extraction is studied using modelling techniques of RSM and ANN. ► RSM is proven useful for modelling of the extraction process and optimizing the factors of extraction conditions. ► However, ANN has been proven a better technique in data fitting and estimation of total phenolic contents extracted than the RSM.

- 39  [Essential oils from *Alpinia purpurata* \(Zingiberaceae\): Chemical composition, oviposition deterrence, larvicidal and antibacterial activity](#) Original Research Article
Pages 254-260

Geanne K.N. Santos, Kamilla A. Dutra, Rosângela A. Barros, Claudio A.G. da Câmara, Diana D. Lira, Norma B. Gusmão, Daniela M.A.F. Navarro

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Highlights

► The hydrodistillation products from *Alpinia purpurata* flowers are biologically active. ► The floral oil and aqueous extract are potent larvicides against the dengue mosquito. ► The oil and extract exhibit oviposition deterrent effects against *Aedes aegypti*. ► The oil is a strong growth inhibitor of gram-positive and gram-negative bacteria. ► Active products can be produced from discarded flowers of non-commercial quality.

- 40  [Chemical composition, anti-insect and antimicrobial activity of *Baccharis darwinii*](#)

essential oil from Argentina, Patagonia Review Article

Pages 261-267

Rita R. Kurdelas, Sandra López, Beatriz Lima, Gabriela Egly Feresin, Julio Zygadlo, Susana Zacchino, María Liza López, Alejandro Tapia, Monica L. Freile

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► The flora from Patagonia Argentina is a potential source of bioactive compounds. ► *B. darwinii* essential oil were rich in limonene, thymol and 4-terpineol. ► The oil showed good anti-insect properties against *T. infestans* and *C. capitata*. ► The essential oil has a high content in the recognized antifungal limonene.

- 41  [Effect of fixed bed drying on the retention of phenolic compounds, anthocyanins and antioxidant activity of roselle \(*Hibiscus sabdariffa* L.\)](#) Original Research Article
Pages 268-276

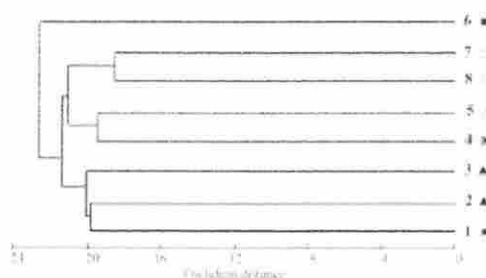
D. Leyva Daniel, B.E. Barragán Huerta, I. Anaya Sosa, M.G. Vizcarra Mendoza

[Show preview](#) | [PDF \(1770 K\)](#) | [Related articles](#) | [Related reference work articles](#)**Highlights**

► Fixed bed drying was used for the roselle calyxes residue. ► The all chemical parameters evaluated, were maintained in the dried product. ► The lixiviated roselle calyxes are an alternative source of bioactive compounds.

- 42  [Chemical and genetic variability of *Thymus algeriensis* Boiss. et Reut. \(Lamiaceae\), a North African endemic species](#) Original Research Article
Pages 277-284

Imen Ben El Hadj Ali, Arbi Guetat, Mohamed Boussaid

[Show preview](#) | [PDF \(401 K\)](#) | [Related articles](#) | [Related reference work articles](#)**Graphical abstract****Highlights**

► 47 terpenoids and 154 RAPD markers amplified are used to investigate the differentiation of 8 Tunisian populations of *Thymus algeriensis*. ► Essential oil composition varied among populations and five chemotypes according to main compounds have been distinguished. ► A high genetic diversity within and among populations, based on RAPDs, was revealed. ► The population structure performed on the two sets of data was similar to that shown using RAPDs. ► Conservation strategies should take into account genetic diversity and chemical variation levels in relation to bioclimatic and geographic location of populations.

- 43  [Assessment of genetic diversity among alfalfa \(*Medicago sativa* L.\) genotypes by morphometry, seed storage proteins and RAPD analysis](#) Original Research Article
Pages 285-291

Bogović Živković, Jasmina Radović, Dejan Sokolović, Branislav Šiler, Tijana Banjanac, Ratibor Štrbanović

[Show preview](#) | [PDF \(539 K\)](#) | [Related articles](#) | [Related reference work articles](#)**Highlights**

► Three methods were used to compare alfalfa cultivars. ► Morphological analysis grouped cultivars according to geographic origin. ► RAPD and protein markers gave highly correlated results.

- 44  [Chemical composition and amoebicidal activity of *Piper hispidinervum* \(Piperaceae\) essential oil](#)
Pages 292-295

Ismael Pretto Sauter, Guilherme Evaldt Rossa, Aline Machado Lucas, Samuel Paulo Cibulski, Paulo Michel Roehe, Luiz Antônio Alves da Silva, Marilise Brittes Rott, Rubem Mário Figueiró Vargas, Eduardo Cassel, Gilsane Lino von Poser

[Show preview](#) | [PDF \(273 K\)](#) | [Related articles](#) | [Related reference work articles](#)**Graphical abstract**



Highlights

► The essential oil from *Piper hispidinervum* presented 85.08% of safrole. ► The essential oil was active against *Acanthamoeba polyphaga* trophozoites. ► The essential oil at the concentrations of 10–0.125 mg/mL was lethal to 100% of the trophozoites. ► The essential oil was not cytotoxic to mammalian cells until the concentration of 0.25 mg/mL.

- 45 [Stability for oil yield and variety recommendations' using AMMI \(additive main effects and multiplicative interactions\) model in Lemongrass \(*Cymbopogon* species\)](#) Original Research Article
Pages 296-301
R. K. Lal
[Show preview](#) | [PDF \(826 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► AMMI model used first time in lemongrass. ► This model is found suitable for partitioning the $G \times E$ in lemongrass. ► Based on the AMMI model, variety Suwarna, showed the widest adaptability. ► This was due to its ability to tolerate wide environmental conditions.

- 46 [Bioactive compounds from the bark of *Eucalyptus exserta* F. Muell.](#) Original Research Article
Pages 302-306
Jingjing Li, Hanhong Xu
[Show preview](#) | [PDF \(375 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► A new phenolic lactone and nine known compounds were isolated from the bark of *Eucalyptus exserta*. ► Compounds 4–6 and 8 exhibited moderate molluscicidal activity against *Pomacea canaliculata*. ► Compound 4 showed potent cytotoxicity against *Spodoptera litura* cells. ► Compounds 2, 4–6 and 8 exhibited nematicidal activity against *Meloidogyne incognita*. ► *E. exserta* is a promising source of valuable active constituents.

- 47 [Cultivation of cow cockle \(*Vaccaria hispanica* \(Mill.\) Rauschert\): An industrial–medicinal weed](#) Review Article
Pages 307-311
Aspasia Efthimiadou, Anestis Karkanis, Dimitrios Bilalis, Nikolaos Katsenios
[Show preview](#) | [PDF \(245 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► The bioactive components of cow cockle seeds include phenolis, cyclic peptides and saponins. ► Large potential exists to use cow cockle as source of pharmaceutical products or as medicinal plant. ► Plant saponins are widely distributed and have a wide range of biological properties. ► The basic objective of breeding in cow cockle is the development of a variety with high saponin content. ► Cow cockle crop can tolerate clethodim and isoxaflutole herbicides.

- 48 [Variation of the chemical composition of floral volatiles in the endangered Tunisian *Pancratium maritimum* L. populations \(Amaryllidaceae\)](#) Original Research Article
Pages 312-317
Adnen Sanaa, Abdennacer Bouilla, Afef Bejaoui, Mohamed Boussaid, Najeh Ben Fadhel
[Show preview](#) | [PDF \(415 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► Eighteen volatile compounds were isolated from the flower of *Pancratium maritimum* firstly. ► High chemical variation was observed in the Tunisian *P. maritimum* populations. ► Four chemotypes could be reported in the Tunisian *P. maritimum* populations. ► *P. maritimum* populations showing high amounts of minor compounds should be preserved.

- 49 [Characterization of *Cynara cardunculus* L. stalks and their suitability for biogas production](#) Original Research Article
Pages 318-323
Ivo Oliveira, Jorge Gominho, Santino Diberardino, Elizabeth Duarte
[Show preview](#) | [PDF \(542 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► The results achieved show that *Cynara* stalks are a good substrate for biogas and methane production in Mediterranean countries. ► *Cynara* stalks cumulative methane yield is higher than 0.3 L CH₄/g VS_{added} depending on the pre-treatment applied. ► Mechanical and thermal pre-treatments with NaOH greatly improved VS reduction and cumulative methane yield.

50  Development of TILLING by sequencing platform towards enhanced leaf yield in

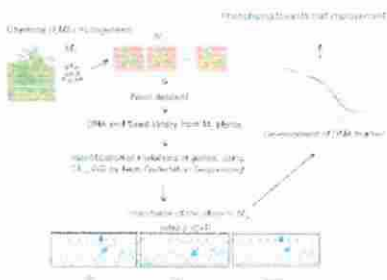
nicotiana: Original Research Article

Pages 324-335

Thamalampudi Venkata Reddy, Samresh Dwivedi, Navin Kumar Sharma

[Show preview](#) | [PDF \(2098 K\)](#) | [Supplementary content](#) | [Related articles](#) | [Related reference work articles](#)

Graphical abstract



Highlights

► TILLING by sequencing platform in tobacco was established. ► Mutants with traits such as more leaves and broader leaves were selected from the population. ► Seven mutations in the selected genes (*NtW2.2*, *NILs*, *NtMYb12* and *NIGGR*) were identified. ► All the mutations identified in *NtW2.2* gene inherited to M₃ generation. ► High Resolution Melting (HRM) DNA marker developed for *NtW2.2-1* allele. ► Mutants with beneficial phenotypes identified in this study are useful for crop improvement.

51  Secoiridoid glycosides as a marker system in chemical variability estimation and chemotype assignment of *Centaureum erythraea* Rafn from the Balkan

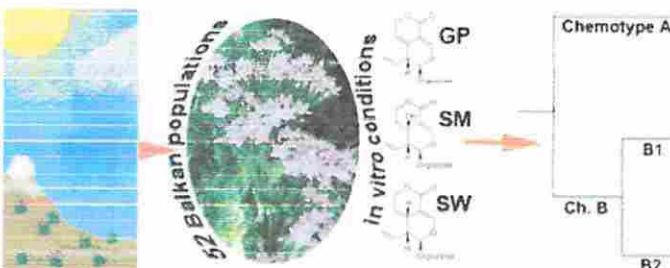
Peninsula: Original Research Article

Pages 336-344

Branislav Šiler, Stevan Avramov, Tijana Banjanac, Jelena Cvetković, Jasmina Nestorović Živković, Aleksandra Patenković, Danijela Mišić

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Graphical abstract



Highlights

► Secoiridoid glycosides were used to investigate the phenotypic variability of 52 Balkan populations of *Centaureum erythraea*. ► Significant inter-population chemical variability was revealed. ► Existence of two basic chemotypes was established using cluster analysis. ► Moisture on natural habitats is proven to boost chemical variability. ► The results facilitate the selection of populations with enhanced accumulation of secondary metabolites of interest.

52  High efficiency canthaxanthin production by a novel mutant isolated from *Dietzia natronolimniana* HS-1 using central composite design analysis: Original Research Article

Pages 345-354

Seyed Mohammad Taghi Gharibzadeh, Seyed Hadi Razavi, Seyed Mohammad Mousavi, Vida Moayedi


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Graphical abstract




Highlights

► We improved the yield of canthaxanthin production from *Dietzia natronolimnaea* HS-1. ► Mutagenesis and response surface methodology (RSM) used to enhance the production. ► The ethyl methanesulfonate (EMS) mutants had better growth rate than to UV mutants. ► The polynomial equations obtained by RSM were efficient to predict the responses. ► Developed empirical models adequately verified experimental results.

- 53  [Extraction of coriander oil by twin-screw extruder: Screw configuration and operating conditions effect](#) Original Research Article
Pages 355-360
Jazia Sriti, Kamel Msaada, Thierry Talou, Mamadou Faye, Ika Amalia Kartika, Brahim Marzouk
[Show preview](#) | [PDF \(353 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► This study investigated the effect of screw speed and flow rate on oil extraction from coriander fruits. ► This is the first report to extraction vegetable oil of coriander by twin-screw extruder. ► A systematic increase in oil extraction yield was observed as the screw rotation speed was decreased and the seed input flow rate was increased. ► Effect of the operating parameters on oil quality was unimportant. In all experiments tested, the oil quality was very good.

- 54  [Optimization of wool dyeing with rutin as natural dye by central composite design method](#) Original Research Article
Pages 361-366
Navid Nasirizadeh, Hamed Dehghanizadeh, M. Esmail Yazdanshenas, Masoud Rohani Moghadam, Ali Karimi
[Show preview](#) | [PDF \(548 K\)](#) | [Related articles](#) | [Related reference work articles](#)

Highlights

► Rutin as a natural dye belongs to flavonoid families which play a significant biological role in plant pigmentation and possess anti-cancer and anti-viral properties. ► Rutin has been used for dyeing wool for the first time. ► In order the dyeing to be environmental friendly, metal mordants were not used and dyeing condition was set to give dyed sample good washing fastness. ► Central Composite Design was used to optimize the dyeing condition which can considers all effective factors at the same time.

articles 1 - 54

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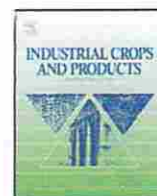
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Extraction of coriander oil by twin-screw extruder: Screw configuration and operating conditions effect

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ARTICLE INFO

Article history:

Received 12 January 2012

Received in revised form 26 March 2012

Accepted 27 March 2012

Keywords:

Twin screw extruder

Coriander

Oil extraction

Fatty acid

Sterol

ABSTRACT

A new process, in which coriander fruits are pressed in a co-rotating twin-screw extruder, is examined here. Six tests were examined to define the best performance (oil extraction yield, and oil quality) by studying the influence of operating conditions, screw speed and flow rate. The screw speed and flow rate affected oil extraction yield. An increase of oil extraction yield was observed as the screw speed was increased (100 rpm) with a decreased flow rate of fruit (2.27 kg/g). Highest oil extraction yield was obtained under operating conditions of 50 rpm and 2.27 kg/h. Effect of the operating parameters on fatty acid composition was less important. Ten fatty acids were identified, with petroselinic acid accounting for 66–75%, followed by linoleic, oleic and palmitic acids, accounting for 13–19%, 5–7% and 4–5%, respectively, of the total fatty acids. β -Sitosterol was the major sterol in all oils with 31% of total sterols.

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1. Introduction

Coriander (*Coriandrum sativum* L.) is an annual herb, commonly used as a condiment or a spice. Coriander is believed native to eastern Mediterranean and from there spread to India, China and rest of the world. The fruit has been used as a traditional medicine in many cultures to treat various medical conditions, including drug for indigestion, against worms and as a component of embrocations for rheumatism and pains in the articulations. Indeed, the fruits of coriander are: alterative, antibilious, antispasmodic, aphrodisiac, appetizer, aromatic, carminative, diaphoretic, diuretic, refrigerant, stimulant, stomachic and tonic (Norman, 1990).

The composition of coriander fruit can vary depending on several factors such as the growing region and maturity stages (Msaada et al., 2009). Previous research focused mainly on the seed oil fatty acid composition, triacylglycerols, and glycerophospholipids (Ramadan and Morsel, 2002; Sriti et al., 2010) or tocopherols and tocotrienols (György et al., 2006) or effects on plasma lipids (Tahvonen et al., 2005). The primary fatty acid constituent in *C. sativum* oil is petroselinic (9Z-octadecenoic) acid and comprises 31–75% of the fatty acid profile, and which is an uncommon isomer of oleic acid and is found at high levels in a restricted range of seed oils mostly from the Apiaceae family (Gunstone et al., 2007).

Oil seeds have been examined for fatty acids to promote health and to prevent disease, e.g., atopic dermatitis (Noli et al., 2007), gastric ulcer (Xing et al., 2002) and immune response (Wu et al., 1999).

There are two major extraction techniques used to obtain vegetable oil from coriander seeds, which are organic solvent extraction and supercritical fluid extraction (Mhemdi et al., 2011).

Recently, the application of continuous oil extraction process using extrusion technology gets some attentions from few researchers (Zheng et al., 2003).

The twin-screw extruders play an important role in transforming the material physically and chemically in a single step in the food industry. Actually, in several studies the extruder is considered also as a reactor to conduct a thermomechano-chemical action and a liquid/solid extraction, as in hemicelluloses extraction (N'Diaye and Rigal, 2000), in a continuous mode. Extrusion technology has many advantages, including its versatility, high productivity, low cost and the ability to produce unique product shapes and high product quality (Koksel et al., 2004).

Today, the products of extrusion are of major importance in the food and feed industries. Extruders can be used for a wide range of traditional (conventional) food products, as well as in the production of numerous new products (cereal baby food, confectionery, breakfast cereals, snack foods, bakery products, flavors, pastas, pet food and meat products) (Wiedemann and Strobel, 1987). During any extrusion process, the treatment of the material consists of mixing, mass kneading, heating and shearing, and finally extrusion through a die appropriately designed to form and dry the product under expansion and rapid fall in pressure (Akdogan, 1999). Nevertheless, no work has been undertaken concerning the extraction

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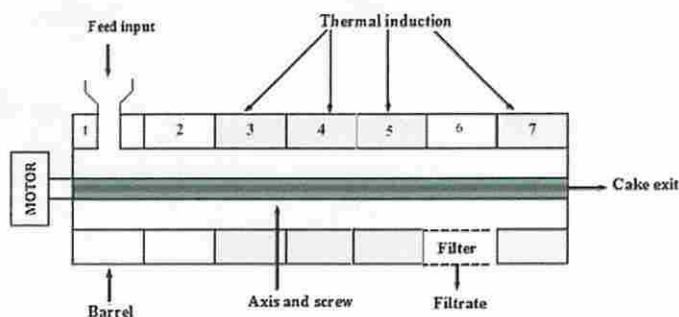


Fig. 1. Schematic modular barrel and global screw configuration of twin-screw extruder BC 21 used for direct extraction of oil from coriander fruit.

oil of coriander by twin-screw extruder. For the first time, the main objectives of this study is set out to evaluate the effects of screw configuration and operating parameters such as screw speed and flow rate on oil extraction from coriander fruits. The characterization of extraction performance was observed by determinations of oil extraction yield and oil quality.

2. Materials and methods

2.1. Materials

All trials were carried out using a single batch of coriander fruits (20 kg) obtained from Korba area (North East of Tunisia). The lipid content *C. sativum* fruit was 21.87% on the basis of their dry matter weight. The moisture content was 9.47%.

All solvents and chemicals were analytical grades that were obtained from Sigma-Aldrich, Fluka, Prolabo and ICS (France).

2.2. Dry matter, protein and mineral content

Dry matter was determined gravimetrically after drying at 105 °C for 24 h (NF V03-908).

Protein content was determined by Kjeldahl method according to the French Standard NF V18-100 consisting of mineralization of organic nitrogen content in the sample to mineral nitrogen. By convention, the protein content of the sample was then obtained by multiplying the total nitrogen content by a conversion factor empirically (6.25).

The mineral content was determined according to standard French NF V 03-322. The sample underwent calcination in an oven at 550 °C until constant weight. All experiments were done in triplicates.

2.3. Experimental

2.3.1. Twin-screw extruder

Experiments were conducted with a twin-screw extruder BC21 made by Clextral (Firminy, France), involving co-rotation screws. A BC21-type extruder was used to determine the optimal profile for the operation (Fig. 1). The machine was operated by the Terminal Operator Intouch version 1.00 software (Clextral) to determine the parameters controlling the twin-screw extruder function (input flow rate, torque) and the temperatures of the different barrel modules. The barrel consisted of 7 modules of 10 cm in length, and the input of whole seeds into the first module was controlled by a scale of LWF-D55 type (Ktron, Niederlenz, Switzerland). A filtration module was inserted at position 6, the filters consisting of four hemispherical dishes with perforations of 1 mm in diameter, with an open outlet on the seventh barrel module (no frontal plate). Modules 2, 3, 4, 5 and 7 were heat-regulated with heating and cooling systems.

2.3.2. Screw configuration study

Experiments were carried out to evaluate one screw profile (Fig. 2). The profile of the screw used in the BC21 twin-screw extruder consisted of trapezoidal double-thread screws to ensure efficient transport and bilobe paddle-screws (BB) which had a pronounced shearing effect. The presence of a reverse screw, or screw elements carrying the contents in the opposite direction, immediately beneath the filtration module guaranteed the formation of a so-called "dynamic plug".

The filtrate was centrifuged to separate the solid particle (foot) from the liquid oil. The response investigated in both types of tests was the oil extraction yield obtained after centrifugation to remove the solid particles carried over. Samples of the filtrate (oil containing the foot) and the remaining fatty cake were taken when the machine had been operating for approximately 10–15 min to ensure a stable flow rate and temperature. Six tests of different parameters configurations were used for the pressing of the coriander fruit (Table 1). The filtrate was centrifuged to separate the foot from the liquid oil. The moisture and residual oil contents of the cake meal were measured according to standards NF V03-903 and NF V03-908. The response investigated in the different tests was the oil extraction yield obtained after centrifugation to remove the solid particles carried over. This was calculated from the following relationship:

(1) Oil yield separated from the filtrate by centrifugation:

$$(R\%) = \left[\frac{Q_F \times T_F}{Q_S \times T_S} \right] \times 100$$

(2) Oil yield based on the residual oil content of the cake meal:

$$(R_0\%) = \left[\frac{Q_S \times T_S - Q_C \times T_C}{Q_S \times T_S} \right] \times 100$$

where Q_S is the inlet flow rate of the fruits (kg/h), Q_C is the outlet flow rate of the cake meal (kg/h), T_S and T_C are the oil contents of the seed (%) and the cake meal (%), respectively.

2.4. Oil extraction and fatty acid methylation

Fruits from coriander were extracted with BC21 twin-screw extruder. The filtrate was centrifuged at 8,000 g for 20 min in order to separate the foot from the liquid oil and the oil content was determined. Then, 20 mg of total extracted oil was solubilized in 1 mL *ter*-butyl-methyl ether (TBME). Before analysis by gas chromatography, fatty acids were transformed into their corresponding methyl esters according to the procedure reported by norm NF of ISO 5508 using 50 μ L trimethylsulfonium hydroxide (TMSH) in methanol (Müller et al., 1990). The sample was analyzed in triplicates.

2.5. Unaponifiable and sterol extraction

Five mg of dihydrocholesterol (internal standard) was added to 140 mg of oil. Then, 3 mL of 1 M KOH in ethanol was added and the mixture was maintained at 75 °C for 30 min. After cooling at the ambient temperature, 1 mL of distilled water and 6 mL of isohexane were added to the mixtures. The isohexane phase was allowed to isolate unaponifiable fraction which was analyzed by GC. Before GC analysis, samples were silylated by the addition of 1 mL *N*-methyl-*N*-trimethylethylsilyl-heptafluorobutyramide (MSHFBA) mixed with 50 μ L of 1-imidazol methyl and heated for 5 min at 103 °C. All experiments were done in triplicates.

1		2		3		4		5		6		7	
T2F 50	T2F 50	C2F 33	C2F 33	C2F 25	BB 10x10	C2F 33	C2F 33	C2F 25	C2F 25	C2F16	C2F16	C2F16	CP2C-25
												C2F25	C2F25

Fig. 2. Screw profile used for optimization of oil expression from coriander fruits in a BC21 twin-screw extruder. T2F: trapezoidal double thread screw; C2F: conveying double thread screw; BB: bilobe paddle screw. CF: reversed screw. The numbers following the type of the screw indicate the pitch of T2F C2F and CF screws and the length of the BB screw.

2.6. Gas chromatography

The fatty acid methyl esters were analyzed by GC, using a Varian 3900 gas chromatography (Grenoble, FR) flame ionization gas chromatograph, with a fused silica capillary column, CP Select CB (50 m, 0.25 mm i.d., 0.25 μ m film thickness; Grenoble, FR). The carrier gas was helium with a flow rate of 1.2 mL/min; split ratio was 1:100. The initial oven temperature was held at 185 °C for 40 min, increased at a rate of 15 °C/min to 250 °C and then held there for 10 min. The detector and injector temperatures were 250 °C. Analyses were done in triplicate.

Sterol samples were analyzed by GC using a FID-PerkinElmer gas chromatograph (Courtaboeuf, FR) equipped with a CP-SIL 8CB capillary column (30 m; 0.25 mm i.d., 0.52–1 μ m film thickness; Grenoble, FR). The carrier gas was hydrogen with a flow rate of 1 mL/min (split-splitless injection was used). Analyses were performed under the following temperature program: isotherm at 160 °C during 0.5 min, from 160 to 260 °C at a rate of 20 °C/min, from 260 to 300 °C at a rate of 2 °C/min and from 300 to 350 °C at a rate of 45 °C/min. Injector and detector temperatures were maintained respectively at 340 °C and 365 °C.

2.7. Statistical analyses

All extractions and determinations were conducted in triplicates and results were expressed on the basis of dry matter weight. Data are expressed as means \pm SD. The means were compared by using the one-way and multivariate analysis of variance (ANOVA) followed by Duncan's multiple range tests. The differences between individual means were deemed to be significant at $P < 0.05$. All analyses were performed by using the "Statistica v 5.1" software (Statsoft, 1998).

3. Results and discussion

3.1. Effect of screw configuration

The reduction in the screw rotation speed increased the oil extraction yields R (oil separated from the filtrate by centrifugation) and R_0 (oil extraction based on the residual oil content of the cake meal) (Fig. 3). The oil extraction yield increased when the input flow rate of the seeds increased (4.5 kg/h) with screw speed maintained stable (100 rpm) and reached 34 and 29%, respectively (R and R_0). Indeed, the oil extraction yield decreased significantly when the screw speed was increased to 100 rpm (flow rate of seed = 2.27 kg/h) and reached 29% and 25%, respectively (R and R_0). In this context, Amalia Kartika et al. (2005) showed that the reduction in the screw rotation speed increased the mean residence time of the matter through the twin-screw extruder and then increased the oil extraction yield. Different studies reported that an increase in feed flow rate at constant screw rotation speed caused a decrease in residence time (N'Diaye and Rigal, 2000; Barres et al., 1990), which decreased the level of material transformation. On the other hand, the oil extraction yield could be decreased if the screw rotation speed was increased and the input flow rate of the seeds

was remained constant (2.27 kg/h). Similar results were found by Amalia Kartika et al. (2005) with sunflower seeds.

The flow rate of filtrate and cake meal increased with the input flow rate of the seeds, followed by a decrease in foot content of filtrate and residual oil content of cake meal (Table 1).

3.2. Effect of operating conditions on oil quality

The extracted oil had an excellent quality for all the tests (Table 1). The modification of screw configuration did not change oil quality. The acid value remained stable at less than 1.54–2.21 mg of KOH/g of oil. The iodine value was at 35–44 g of iodine/100 g of oil.

The results of other extraction performance parameters showed that the screw configuration affected the flow rate and the foot content of filtrate, particularly. However, an increase in screw speed enhanced significantly the filtrate flow rate and the barrel temperature, although there was a moderate change in the cake meal flow rate (Table 1). In contrast with our result, Amalia Kartika et al. (2006) noted that the increased screw speed and barrel temperature did not improve the filtrate flow rate. On the other hand, these authors showed that the oil extraction yield increased slightly with an increase of the barrel temperature to 100 °C, but further increase did not improve the oil extraction yield. According to Karleskind (1996), the high barrel temperature has few favorable effects because it induces an increase in the oil fluidity, breaking of the walls of additional fatty cells and coagulation of the protein fraction of seed; lipid droplets release easily through the fibrous matrix toward the surface of the matter. In all these reports and according to Lacaze-Dufaure et al. (1999) and Amalia Kartika et al. (2005, 2006), the decrease of the rotation speed of lived in constant flow of seeds, which increases the rate of filling and the residence time in the pressing zone, and favors the return of expression and separation of the oil.

3.3. Fatty acid composition

The chemical compositions of the fatty acids in the oils are presented in the Table 2.

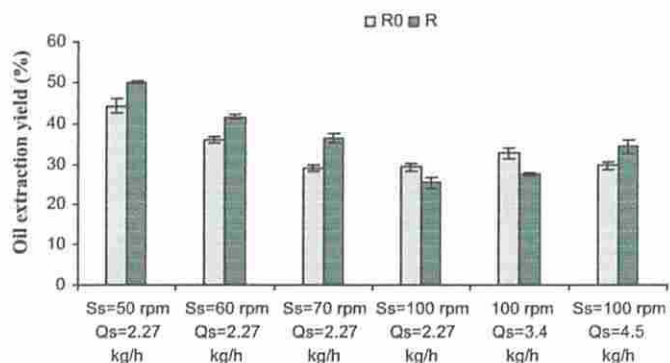


Fig. 3. Variation of oil extraction yield on different screw configuration. Data are expressed of three replicates. Q_s , flow rate, S_s screw speed.

Table 1
Performance of extraction parameters on different screw configurations.

Operating conditions		Filtrate			Cake meal						
S _s (rpm)	T (°C)	Q _s (kg/h)	Flow rate (Kg/h)	Foot content (%)	Acid value (mg KOH/g)	Iodine value (g iodine for 100 g oil)	Flow rate (Kg/h)	Residual oil content (%)	Moisture content (%)	Minerals (%)	Protein (%)
50	65	2.27	0.47	47.48	1.56 ± 0.09	44.16 ± 0.12	1.84	16.55 ± 0.29	9.14 ± 0.02	7.99 ± 0.08	16.14 ± 0.58
60	65	2.27	0.41	49.85	1.54 ± 0.03	43.84 ± 0.34	1.89	18.57 ± 0.44	8.78 ± 0.01	7.50 ± 0.43	16.31 ± 0.70
70	66	2.27	0.40	54.96	1.64 ± 0.05	42.69 ± 0.54	1.90	20.46 ± 1.27	8.86 ± 0.00	7.68 ± 0.04	16.11 ± 0.45
100	66	2.27	0.37	65.96	2.08 ± 0.10	35.19 ± 0.32	1.92	20.14 ± 0.48	8.72 ± 0.04	7.60 ± 0.07	16.17 ± 0.60
100	70	3.40	0.57	64.25	2.21 ± 0.04	40.61 ± 0.65	2.83	19.49 ± 0.91	8.53 ± 0.05	7.44 ± 0.34	15.75 ± 0.33
100	73	4.54	0.79	56.95	2.12 ± 0.06	40.38 ± 0.43	3.76	20.47 ± 0.81	7.91 ± 0.03	7.64 ± 0.01	16.22 ± 0.11

S_s: screw speed, Q_s: flow rate of the seed, T: temperature. Data are expressed as mean ± SD of three replicates.

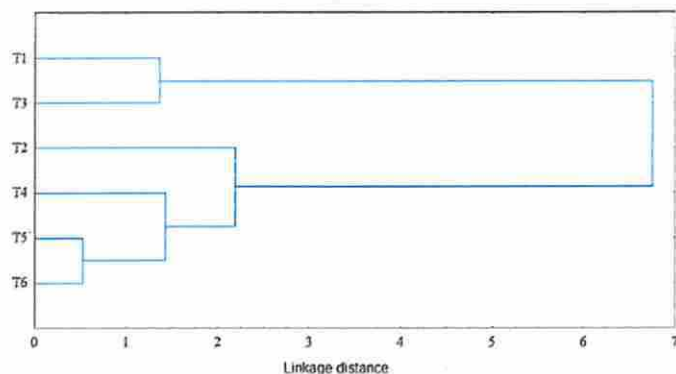


Fig. 4. Two-dimensional dendrogram obtained from the cluster analysis of the fatty acids of the different trial of *C. sativum* fruits based on the data (Table 2): horizontal, samples analyzed; vertical, differentiation level between samples. T: tests, Q_s flow rate, S_s screw speed. T1: Q_s = 2.27 kg/h, S_s = 50 rpm. T2: Q_s = 2.27 kg/h, S_s = 60 rpm. T3: Q_s = 2.27 kg/h, S_s = 70 rpm. T4: Q_s = 2.27 kg/h, S_s = 100 rpm. T5: Q_s = 3.40 kg/h, S_s = 100 rpm. T6: Q_s = 4.54 kg/h, S_s = 100 rpm.

Significant changes ($P < 0.05$) were observed among the studied tests for oil content during pressing conditions of coriander fruit. A total of 10 different fatty acids were identified in percentages of the TFA of the fruit oil. Petroselinic acid was the major fatty acid for all the tests. Its proportion remained stable under the increase in flow rate of the fruits (2.27, 3.4 and 4.4 kg/h) and reached 73%. The most important variation was noted for the increase of the screw speed from 50 to 70 rpm for which the levels of petroselinic acid increased drastically from 65% to 75%. For these screw speed configurations (50 and 70 rpm) we noted in contrast of petroselinic acid, that the proportion of oleic and linoleic acids decreased significantly with the increase of the screw speed. However, these two acids remained stable under the flow rate variations of the fruits and represented 6 and 14%, respectively (oleic/linoleic). Other representative fatty acids were palmitic (4.10–5.16%) and stearic (0.84–1.03%) acids. In addition, palmitoleic, α -linolenic, arachidic, gadoleic and myristic acids were minor fatty acids constituting 0.26–0.36%; 0.15–0.21%; 0.10–0.14% and 0.12–0.16%, respectively.

So, the extracted oil was rich in petroselinic acid and had a large spectrum of applications in industry due to their high amounts in this acid which is an isomer of oleic acid.

To the best of our knowledge, the effect of screw configuration on fatty acid composition is investigated for the first time in coriander fruits. For this reason, it is difficult to compare results of this study with other works. The result obtained showed that the vegetable oil of coriander is very rich in unsaturated fatty acids: about 94% in mass are unsaturated, splitted in 75–80% monounsaturated (mainly petroselinic acid and oleic acid) and 15–19% polyunsaturated (mainly linoleic acid and linolenic acid). The major fatty acid is petroselinic acid (above 70%). These values are similar to the works for which vegetable oil extraction is obtained by organic solvent (Msaada et al., 2009) and by supercritical CO₂ (Mhemdi et al., 2011).

On the other hand, cluster analysis (CA) was carried out in order to determine the relationship between the different conditions of pressing on the basis of their fatty acids composition (Fig. 4). Obtained results showed the existence of two well-defined groups. The first one was represented by the tests affected by a flow rate of 2.27, 3.40 and 4.54 kg/h. The second group was formed by the tests with speed screw of 50 and 70 rpm suggesting similar composition. It is noteworthy that operating conditions (screw speed and flow rate) have no major effect on the fatty acid composition of coriander vegetable oil.

Table 2
Variation of fatty acid composition (%) on different screw configurations.

Fatty acids	Q _s = 2.27 kg/h S _s = 50 rpm	Q _s = 2.27 kg/h S _s = 60 rpm	Q _s = 2.27 kg/h S _s = 70 rpm	Q _s = 2.27 kg/h S _s = 100 rpm	Q _s = 3.4 kg/h S _s = 100 rpm	Q _s = 4.54 kg/h S _s = 100 rpm
Myristic acid (14:0)	0.15 ± 0.03 ^a	0.14 ± 0.01 ^a	0.16 ± 0.01 ^a	0.14 ± 0.02 ^a	0.14 ± 0.00 ^a	0.12 ± 0.01 ^b
Palmitic acid (16:0)	4.89 ± 0.67 ^a	4.10 ± 0.28 ^{cb}	5.16 ± 0.13 ^a	4.60 ± 0.14 ^b	4.18 ± 0.05 ^c	4.15 ± 0.11 ^c
Palmitoleic acid (16:1)	0.35 ± 0.05 ^a	0.26 ± 0.02 ^c	0.36 ± 0.01 ^a	0.31 ± 0.01 ^b	0.27 ± 0.01 ^c	0.27 ± 0.01 ^c
Stearic acid (18:0)	0.84 ± 0.03 ^b	0.91 ± 0.08 ^{ab}	0.91 ± 0.05 ^{ab}	1.03 ± 0.16 ^a	0.92 ± 0.01 ^{ab}	0.85 ± 0.04 ^b
Petroselinic acid (18:1)	66.87 ± 1.45 ^b	75.17 ± 1.76 ^a	65.68 ± 0.55 ^b	72.40 ± 1.23 ^a	73.23 ± 0.39 ^a	73.37 ± 1.02 ^a
Oleic acid (18:1)	7.46 ± 0.89 ^a	5.30 ± 0.50 ^b	7.71 ± 0.26 ^a	5.55 ± 0.87 ^b	6.37 ± 0.20 ^b	6.03 ± 0.58 ^b
Linoleic acid (18:2)	18.95 ± 0.65 ^a	13.79 ± 1.22 ^c	19.52 ± 0.09 ^a	15.61 ± 0.68 ^b	14.43 ± 0.19 ^{cb}	14.81 ± 0.26 ^b
Arachidic acid (20:0)	0.11 ± 0.06 ^b	0.10 ± 0.05 ^b	0.10 ± 0.00 ^b	0.10 ± 0.00 ^b	0.14 ± 0.04 ^a	0.11 ± 0.01 ^b
α-Linolenic acid (18:3)	0.20 ± 0.02 ^a	0.15 ± 0.02 ^b	0.21 ± 0.00 ^a	0.16 ± 0.01 ^b	0.16 ± 0.00 ^b	0.16 ± 0.00 ^b
Gadoleic acid (20:1)	0.17 ± 0.02 ^b	0.09 ± 0.01 ^d	0.19 ± 0.00 ^a	0.11 ± 0.01 ^c	0.16 ± 0.01 ^b	0.13 ± 0.02 ^b
Saturated fatty acids (SFA)	5.99 ± 0.76 ^a	5.24 ± 0.12 ^b	6.33 ± 0.19 ^a	5.85 ± 0.32 ^a	5.39 ± 0.01 ^b	5.23 ± 0.16 ^b
Monounsaturated fatty acids (MUFA)	74.86 ± 0.98 ^b	80.82 ± 1.03 ^a	73.94 ± 0.28 ^b	78.36 ± 0.31 ^a	80.03 ± 0.19 ^a	79.80 ± 0.42 ^a
Polyunsaturated fatty acids (PUFA)	19.16 ± 0.55 ^a	13.94 ± 0.45 ^c	19.73 ± 0.09 ^a	15.77 ± 0.68 ^b	14.59 ± 0.19 ^c	14.96 ± 0.27 ^b

Reported values are average of three analyses. S_s: screw speed, Q_s: flow rate of the seed. Fatty acids percentages in the same line with different superscripts (a–c) are significantly different at $P < 0.05$.

Table 3
Variation of sterol composition (%) on different screw configurations.

	Q _s = 2.27 kg/h S _s = 50 rpm	Q _s = 2.27 kg/h S _s = 60 rpm	Q _s = 2.27 kg/h S _s = 70 rpm	Q _s = 2.27 kg/h S _s = 100 rpm	Q _s = 3.4 kg/h S _s = 100 rpm	Q _s = 4.54 kg/h S _s = 100 rpm
β-Sitosterol	31.02 ± 0.21 ^b	31.65 ± 0.14 ^b	31.41 ± 0.07 ^b	32.21 ± 0.04 ^a	31.81 ± 0.29 ^b	31.56 ± 0.15 ^b
Stigmasterol	24.52 ± 0.02 ^a	24.69 ± 0.03 ^a	24.60 ± 0.15 ^a	24.25 ± 0.01 ^a	23.33 ± 0.38 ^b	24.26 ± 0.25 ^a
Δ ⁷ -Stigmasterol	16.52 ± 0.11 ^a	16.98 ± 0.16 ^a	16.93 ± 0.04 ^a	16.95 ± 0.18 ^a	16.84 ± 0.03 ^a	16.85 ± 0.09 ^a
Δ ^{5,24} -Stigmastadienol	12.27 ± 0.34 ^a	10.55 ± 0.42 ^c	10.58 ± 0.60 ^c	10.72 ± 0.35 ^c	11.52 ± 0.09 ^b	11.29 ± 0.28 ^b
Campesterol	8.43 ± 0.05 ^a	7.89 ± 0.06 ^{ab}	8.04 ± 0.30 ^a	7.81 ± 0.01 ^{ab}	7.45 ± 0.12 ^c	7.72 ± 0.04 ^b
Δ ⁷ -Avenasterol	4.66 ± 0.06 ^a	4.90 ± 0.01 ^a	4.99 ± 0.00 ^a	4.76 ± 0.04 ^a	4.92 ± 0.00 ^a	4.92 ± 0.04 ^a
Δ ⁵ -Avenasterol	2.58 ± 0.03 ^c	3.35 ± 0.02 ^b	3.45 ± 0.05 ^b	3.32 ± 0.08 ^b	4.13 ± 0.85 ^a	3.38 ± 0.02 ^b

S_s: screw speed, Q_s: flow rate of the seed. Values given are the means of three replicates ± standard deviation. RT: retention time. Sterols percentages in the same line with different superscripts (a–h) are significantly different at $P < 0.05$.

3.4. Sterol composition

Sterols constitute the major fraction of the unsaponifiable matter in many oils. They are of interest due to their antioxidant activity and beneficial impact on human health (Dutta et al., 1994; Richardson, 1996). Moreover, analysis of sterols provides a powerful tool for oil authenticity and quality control otherwise not recognized by the fatty acids profile. Thus, the sterol profile constitutes a perfect fingerprint of vegetable oils.

The compositions of sterol in coriander oils obtained by twin-screw extrusion are presented in Table 3. No significant differences were observed between the total unsaponifiable content of all trials, where β-sitosterol, stigmasterol, Δ⁷-stigmasterol, Δ^{5,24}-stigmastadienol and campesterol were the major compounds.

β-Sitosterol (31% of TS) represents the main component followed by stigmasterol (24% of TS). These compounds remained stable under the operating conditions (screw speed and flow rate). Similar results were recorded for Δ⁷-stigmasterol (16% of TS) and Δ⁷-avenasterol. The next major component was Δ^{5,24}-stigmastadienol, the highest proportion (12.27% of TS) was obtained under screw speed and flow rate of 50 rpm and 2.27 kg/h, respectively. However, the levels of this compound decreased drastically under an increase of the screw speed from 50 to 100 rpm and reached 10%. The most important variation was noted for an increase of the screw speed from 50 to 100 rpm and of the fruits flow rate from 2.27 to 3.4 kg/h for which the levels of Δ⁵-avenasterol increased drastically from 2.58% to 4.13%. Campesterol was present at a level of 7% of TS. The results obtained by twin-screw extrusion showed the same sterol composition of coriander fruit compared with the literature (Ramadan and Mörseel, 2002). These authors showed that the coriander fruits grown in Germany characterize by the abundance of β-sitosterol and stigmasterol, which represented 24% and 29%, respectively. In general, most vegetable seeds such as *Ornithopus sativus* (Schmidt et al., 1993), millet, sunflower (Lognay

et al., 1988) and fenugreek (Artaud et al., 1988) were characterized by the predominance of β-sitosterol. The latter is the sterol marker in extra virgin olive oil and ranges from 75% to 87% of total sterols (Cercaci et al., 2003). Indeed, this compound had been most intensively investigated with respect to its beneficial and physiological effects on health (Yang et al., 2001).

We concluded that the screw configuration and the operating conditions had an important influence on the oil extraction yield and the quality of oil extracted during the extrusion of coriander fruits. Higher oil extraction yield was reached at a screw speed of 50 rpm and with a flow rate of 2.27 kg/h. Our results show that a twin-screw extruder can be configured to produce good quality oil.

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Publication information: *Industrial Crops and Product* (ISSN 0926-6690). For 2012, volumes 36-43 (8 issues) are scheduled for publication by Elsevier (Radarweg 29, 1043 NX Amsterdam, the Netherlands). Further information on this journal is available from the Publisher or from the Elsevier Customer Service Department nearest you or from this journal's website (<http://www.elsevier.com/locate/indcrop>). Information on other Elsevier products is available through Elsevier's website (<http://www.elsevier.com>). Periodicals Postage Paid at Rahway, NJ, and at additional mailing offices.

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