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姓　　名： 张明

学　　校： 青岛农业大学

院（系）： 食品科学与工程学院

准考证号： [redacted]

身份证号： [redacted]

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Ultrasound-assisted extraction of phenolic compounds from macadamia (*Macadamia integrifolia*) green peel: Purification, identification and antioxidant activities

Ming Zhang [a,b], Ya Li [a,b], Xi-xiang Shuai [a,b,**], Jian Qiao [a,b], Chang-bin Wei [a], Fei-yue Ma [a,b], Yu-han Zhang [a,b], Li-qing Du [a,b,*]

[a] South Subtropical Crops Research Institute, China Academy of Tropical Agricultural Sciences, Zhanjiang, 524091, China
[b] Key Laboratory of Hainan Province for Postharvest Physiology and Technology of Tropical Horticultural Products, Zhanjiang, 524091, China

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ABSTRACT

China is one of the world's main producers of macadamia. The macadamia green peel (MGP), byproducts of industrial processing, are commonly discarded for use as fertilizer. In this study, the ultrasound-assisted extraction and purification process of phenolic compounds from MGP were optimized, and the identification and analysis of antioxidant activities of purified extracts were performed. Results indicated that the optimal extraction conditions were sonication power 140 W, solid-liquid ratio 1:45 g/mL, and extraction temperature 43 °C, and the total phenolic content (TPC) was 18.23 mg gallic acid equivalent (GAE)/g dry weight (DW). Among four purified fractions (PF1, PF2, PF3 and PF4) obtained by ADS17 resin, sixty phenolic compounds were identified and twenty-one phenolic compounds were quantified for the first time, of which PF2 showed the highest TPC (246.18 mg GAE/g DW), mainly including 3,4-dihydroxybenzaldehyde, vanillic acid, 4-hydroxybenzoic acid and gallocatechin. In addition, PF2 demonstrated excellent total antioxidant activity (ABTS, DPPH and FRAP assays were 2.16, 2.59, 1.96 mM Trolox equivalent/g DW, respectively) and cellular antioxidant activity (0.97 mM quercetin equivalent/g DW). The antioxidant activities showed significant positive correlated with the content of catechin and procyanidin B1. The results provide guidance for the industrial production and application of MGP.

1. Introduction

Macadamia (*Macadamia integrifolia*) is native to the rainforest regions of Australia's East Coast, well known as the "King of nuts" (Pan et al., 2022). It was introduced into China in the 1970s, and China became the largest macadamia cultivation country in the world, which cultivated area accounted for ~60% of the world's planted area at the end of 2022. In general, as the edible portion, the kernel only accounts for about 20% of the total weight of the nut and is commonly processed into snacks for consumption. The remaining 80% of the nut, which consists of green peel (42%) and husk (38%), is usually discarded as industrial processing by-products (Dailey & Vuong, 2015). As a result, it is very necessary to realize the sufficient utilization of these byproducts. Currently, there were lots of studies had attempted to the disposal of macadamia husk, such as modified to be functional adsorption materials and electrode materials (Chang et al., 2022; Wang, Al-Kurdhani, Ma, & Wang, 2023), and powered for animal feed filler and furniture panels (Cholake, Rajarao, Henderson, Rajagopal, & Sahajwalla, 2017). Nevertheless, there is limited details about the utilization of macadamia green peel (MGP).

According to the previous study, MGP is abundant in bioactive compounds, especially phenolic compounds (Chang, Alasalvar, Bolling, & Shahidi, 2016). Generally, the extraction yield and biology activity of phenolic compounds are directly affected by extraction methods. Therefore, it is important to explore a suitable extraction method for MGP. Ultrasound-assisted extraction (UAE) is an emerging extraction technology of phenolic compounds based on the cavitation effect and has been proved to be effective in improving extraction yield, reducing extraction time and solvent consumption (Brahmi et al., 2022; Kumar, Srivastav, & Sharanagat, 2021). Silva Júnior, Araújo, Santana, Silva, &

* Corresponding author. South Subtropical Crops Research Institute, China Academy of Tropical Agricultural Sciences, 1 Huxiu Road, Zhanjiang, China.
** Corresponding author. South Subtropical Crops Research Institute, China Academy of Tropical Agricultural Sciences, 1 Huxiu Road, Zhanjiang, China.
E-mail addresses: shuaixixiang1989@163.com (X.-x. Shuai), duliqing927618@163.com (L.-q. Du).

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Article

Macadamia (*Macadamia integrifolia*) Oil Prevents High-Fat Diet-Induced Lipid Accumulation and Oxidative Stress by Activating the AMPK/Nrf2 Pathway

Ming Zhang [1,2], Yuhan Zhang [2], Lingdong Li [1,2], Changbin Wei [1,2], Taotao Dai [3], Ya Li [1,2], Xixiang Shuai [1,2] and Liqing Du [1,2,*]

1 South Subtropical Crop Research Institute, China Academy of Tropical Agricultural Sciences, Zhanjiang 524091, China; zhangmingqau@163.com (M.Z.); lingdong0510@163.com (L.L.); zbwcb@163.com (C.W.); liya1995ncu@163.com (Y.L.); shuaixixiang1989@163.com (X.S.)
2 Key Laboratory of Tropical Fruit Biology, Ministry of Agriculture & Rural Affairs; Key Laboratory of Hainan Province for Postharvest Physiology and Technology of Tropical Horticultural Products, Zhanjiang 524091, China; nyszhangyh@163.com
3 State Key Laboratory of Food Science and Technology, Nanchang University, Nanchang 330047, China; ncubamboo@163.com
* Correspondence: dlq927618@catas.cn; Tel.: +86-0759-2859788

Abstract: Hyperlipidemia, characterized by an abnormal lipid metabolism, is related to multiple cardiovascular diseases that pose challenges to global public health. Macadamia oil (MO), rich in monounsaturated fatty acids (around 80%), is regarded as a functional oil used to regulate lipid accumulation. Nonetheless, the lipid-lowering mechanism of MO is still unknown. Therefore, the lipid-lowering effects of MO in high-fat diet (HFD)-induced hyperlipidemic mice were evaluated in this study. The results revealed that MO could effectively reduce body weight and the organ index and improve serum lipid levels by reducing total cholesterol, triglycerides, and low-density lipoprotein cholesterol levels and elevating high-density lipoprotein cholesterol levels. Additionally, MO supplementation could improve abnormal liver function caused by hyperlipemia, characterized by decreased liver enzyme levels, including alanine aminotransferase and aspartate aminotransferase. Meanwhile, MO also exhibited an inhibitory effect on oxidative stress and lipid accumulation caused by an HFD. Moreover, findings from qRT-PCR and Western blotting analyses suggest that MO supplementation markedly prevented hyperlipidemia by inhibiting the expression of AMPK pathway-related genes, SREBP-1c, FAS, ACC, and PPAR-γ, as well as upregulating the levels of Nrf2, HO-1, and γ-GCS. These results indicate that MO attenuates lipid accumulation in vivo via AMPK/Nrf2 pathway activation, suggesting that MO could serve as a dietary supplementation or medication for treating hyperlipidemia.

Keywords: macadamia oil; high-fat diet; oxidative stress; lipid lowering; AMPK/Nrf2 pathway

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1. Introduction

Hyperlipidemia is a primary risk factor for cardiovascular disease, which commonly manifests in abnormal lipid metabolism and liver function [1]. Meanwhile, hyperlipidemia has been demonstrated to relate to many common human diseases, such as stroke, hypertension, and coronary heart disease [2]. Notably, with the rapid development of the economy, high-fat and low-fiber diets have gradually become a favored dietary pattern, which has led to hyperlipidemia emerging as a serious global public health problem [3]. Currently, several drugs, including statins, fibrates, and niacin, have been verified to be effective in alleviating hyperlipidemia. Unfortunately, long-term exposure to these drugs may cause some side effects, such as liver injury, muscle pain, and dyspepsia [4]. There is no doubt that exploring new medications and dietary supplements is crucial for replacing chemicals to regulate lipid metabolism.

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EDITED BY
Runqiang Yang,
Nanjing Agricultural University, China

REVIEWED BY
Pedro Ferreira Santos,
University of Minho, Portugal
Er Sheng Gong,
Gannan Medical University, China

*CORRESPONDENCE
Chang-bin Wei
zbwcb@163.com
Jun-jun He
hbj46@163.com
Li-qing Du
duliqing927618@163.com

†These authors share first authorship

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Characterization, antioxidant and antitumor activities of phenolic compounds from *Amomum villosum* Lour.

Ming Zhang[1†], Xi-xiang Shuai[1,2†], Zhi Wei[2], Tao-tao Dai[2], Chang-bin Wei[1*], Ya Li[1], Jun-jun He[3*], Li-qing Du[1*]

[1]South Subtropical Crops Research Institute, China Academy of Tropical Agricultural Sciences, Key Laboratory of Hainan Province for Postharvest Physiology and Technology of Tropical Horticultural Products, Zhanjiang, China, [2]State Key Laboratory of Food Science and Resources, Nanchang University, Nanchang, China, [3]Zhanjiang Experimental Station, China Academy of Tropical Agricultural Sciences, Zhanjiang, China

Amomum villosum Lour. (*A. villosum*), known as Sharen in China, is widely used for culinary and medicinal purposes due to containing a diverse set of bioactive compounds. In this study, the optimum ethanol extraction process was optimized and the composition and biological activities (antioxidant and antitumor) of five different fractions (dichloromethane, petroleum ether, ethyl acetate, *n*-butanol and H_2O) extracted from the ethanol extract of *A. villosum* were investigated. The results showed that the optimal extraction conditions were extraction temperature 80°C, extraction time 120 min, ethanol concentration 40% and solid–liquid ratio 1:25 g/mL. Moreover, 35 bioactive compounds were successfully identified by UPLC-ESI-QTOF-MS/MS from five factions for the first time, including 12 phenolic acids and derivatives, 2 organic acids, 12 flavonoids and derivatives, 2 oxylipins and 7 proanthocyanidins. Among them, ethyl acetate fraction (Fr-EtOAc) exhibited the highest content of total phenolic (374.01 mg GAE/g DW) and flavonoid (93.11 mg RE/g DW), where vanillic acid, catechin, epicatechin and protocatechuic acid were the predominant phenolic compounds that accounting for 81.65% of the quantified bioactive compounds. In addition, Fr-EtOAc demonstrated excellent total antioxidant activity (IC_{50} of DPPH and ABTS assays were 0.23, 0.08 mg/mL, respectively, and FRAP assay was 322.91 mg VCE/100 g DW) and antitumor activity (1,000 μg/mL, 79.04% inhibition rate). The results could provide guidance for the industrial production and application of *A. villosum*.

KEYWORDS

***Amomum villosum* Lour., phenolic compounds, UPLC-ESI-QTOF-MS/MS, antioxidant, antitumor**

1 Introduction

Amomum villosum Lour. (*A. villosum*), usually called sharen in China, is a member of Zingiberaceae family and is mainly cultivated in Southern China and Southeast Asian countries. The fruit of *A. villosum* was used for medicine purposes could be traced back to the seventh century, and together with *Areca catechu* L., *Morinda officinalis* How. and *Alpinia oxyphylla* Miq. were called "four southern medicines" (1). Nowadays, the fruit of *A. villosum*

《澳洲坚果油加工技术》

编写人员

主　　编：杜丽清　戴涛涛　帅希祥　张　明
副 主 编：李钤东　李　娅　张宇晗　涂行浩
编写人员：杜丽清　戴涛涛　帅希祥　张　明
　　李钤东　李　娅　张宇晗　涂行浩
　　邓　旭　乔　健　陈　姝

作者单位

中国热带农业科学院南亚热带作物研究所
南昌大学
湛江市休闲农业工程技术研究中心

《神秘果栽培与利用》

编写人员

主　　编：张秀梅　马飞跃

副 主 编：张　明　袁晓丽　白　净

编写人员：张秀梅　马飞跃　张　明　袁晓丽

白　净　李　娅　徐行浩　陈荣豪

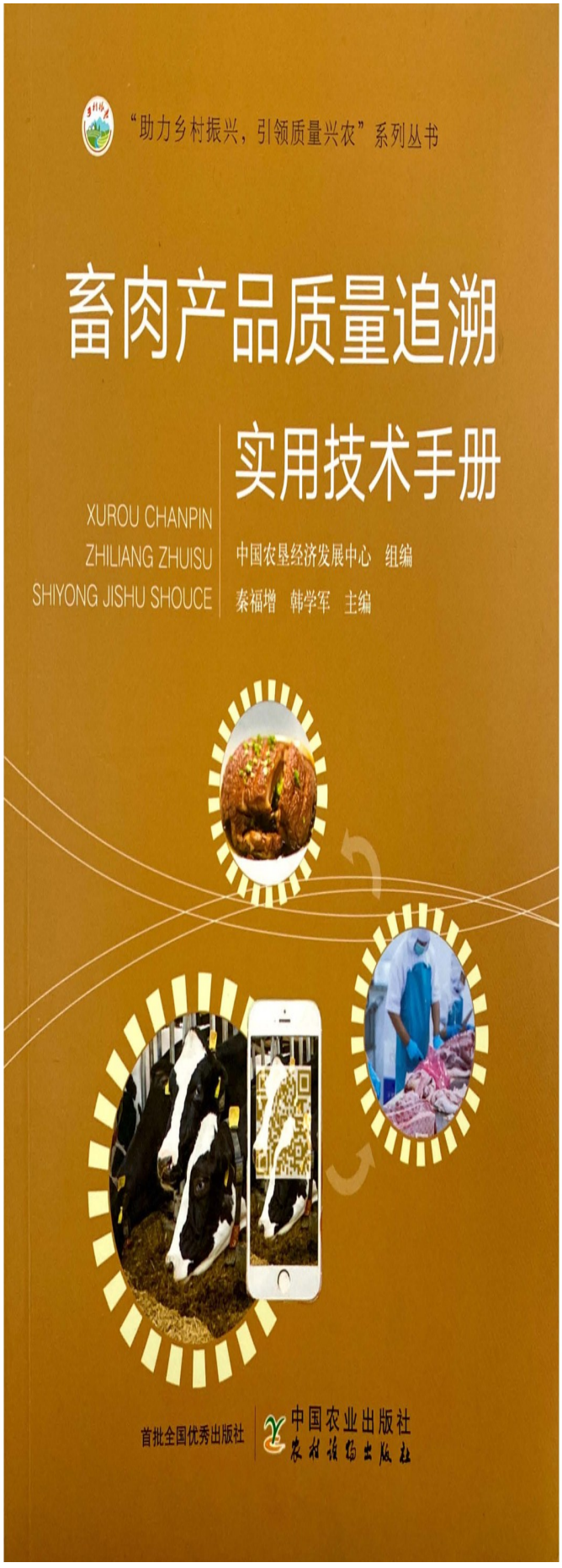
贺军军　陈　妹　乔　健　邓　旭

帅希祥　黄文佳　陈李雨嘉　陈　岚

作者单位

中国热带农业科学院南亚热带作物研究所

中国热带农业科学院科技信息研究所



本书编写人员名单

主　　编：秦福增　韩学军

副 主 编：张颖璐　张宗城　张　明

编写人员（按姓氏笔画排序）：

刘　阳　许冠堂　张　明　张宗城

张颖璐　陈　杨　陈　曙　秦福增

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本书编写人员名单

主　　编： 秦福增　韩学军

副 主 编： 张　明　段余君　张海珍

编写人员（按姓氏笔画排序）：

王亚宁　户江涛　刘　阳　许冠堂

孙明山　杨　宇　张　坤　张　明

张红涛　张海珍　陈　杨　陈　曙

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地　　址：524091 广东省湛江市霞山区社坛路5号

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第 1 页 (共 1 页)

海南省技术发明奖

证　书

为表彰海南省技术发明奖获奖者，特颁发此证书。

项目名称：神秘果产业化关键技术和装备创新与应用

奖励等级：二等奖

获 奖 者：张　明

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中国热带农业科学院
科学技术奖

证书

为表彰中国热带农业科学院科学技术奖获得者，特颁发此证书。

奖励类别：科技创新奖

成果名称：澳洲坚果综合加工关键技术创新与应用

奖励等级：二等奖

获 奖 者：张　明

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