UNIVERSITI PUTRA MALAYSIA

EFFECTS OF BATTER - COATED METHYLCELLULOSE ON POTATO SUBSTRATE DURING THE FRYING PROCESS

LUA HWEE YING

FK 2022 4

EFFECTS OF BATTER - COATED METHYLCELLULOSE ON POTATO SUBSTRATE DURING THE FRYING PROCESS

By

LUA HWEE YING

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree Master of Science

May 2021

© COPYRIGHT UPM

All material contained within the thesis, including without limitation text, logos, icons, photographs and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright © Universiti Putra Malaysia

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

EFFECTS OF BATTER - COATED METHYLCELLULOSE ON POTATO SUBSTRATE DURING THE FRYING PROCESS

By

LUA HWEE YING

May 2021

Chair : Associate Professor Mohd Nazli Naim, PhD
Faculty : Engineering

Food hydrocolloids, i.e., hydrolyzed methylcellulose, with thermal gelation properties, are widely used as batter mixtures to coat the fried food prior to the frying process. Properties of hydrocolloids able to satisfy population's food demand by introducing health-benefits food in conjunction with public health concerns worldwide such as obesity. To study the coating mechanism's advantages, the hydrolyzed Methylcellulose (MC) that, possessed with thermal-reversible properties, was coated onto a potato substrate and investigated along the frying process. Different MC concentration samples between 0.5-2.0 w/v% were subjected to ultrasound treatment (UT) at 20 W to improve the prepared batter mixtures' rheological behaviour and physiochemical properties of fried food. Application of UT to methylcellulose (UTMC) clearly showed a phase transition from fluid- to gel-like between 20 °C and 65 °C with the increase in the oscillation frequency and temperature ramp test. UTMC method also showed lower sol-gel transition occurrence than non-UTMC at 25 °C and 30 °C respectively, within the linear viscoelastic region. When the MC concentrations were varied, the most effective concentration for coating purposes was noticed to occur at 1.0 (w/v%) UTMC, whereby the water retention and oil uptake was reduced to 39.3% and 56.9 %, respectively, as compared to 1.0 w/v% non-UTMC formulation. The batter-coated fried food also showed a significant decrease in the acrylamide concentration. The amount of acrylamide in 1.0 w/v% MC was reduced from 156.40±7.44 ng/g to 64.8 ±5.05 ng/g in 1.0 w/v% UTMC. In conclusion, this work's findings provide further insights into the influence of hydrocolloids as an effective layer to improve the quality of the fried products.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SIASATAN KESAN RAWATAN SALUTAN METISELULOSA KE ATAS SUBSTRAK UBI KENTANG SEMASA PROSES PENGGORENGAN

Oleh

LUA HWEE YING

Mei 2021

Pengerusi : Profesor Madya Mohd Nazli Naim, PhD
Fakulti : Kejuruteraan

Hidrokoloid makanan seperti metilselulose yang dihydrolisiskan sentiasa digunakan sebagai adunan dalam makan goreng semasa proses menggoreng. Sifat hidrokoloid dapat memenuhi permintaan makanan semasa dengan memperkenalkan makanan yang berkhasiat bagi menjamin kesihatan bersama yang disebabkan masalah kegemukan di seluruh dunia makin serius. Metiselulose (MC) yang dihidrolisiskan mempunyai ciri-ciri termal terbalik diselidiki dan dicirikan apabila disalutkan pada permukaan ubi kentang semasa proses menggoreng dapat mengkaji kebaikan mekanisme salutan. Sampel-sampel kepekatan MC yang berbeza antara 0.5-2.0 w/v% yang tertakluk kepada rawatan ultrasonik (UT) pada 20 W dapat meningkatkan tingkah rheologi adunan yang disediakan dan sifat fisiokimia dalam makanan goreng. Penggunaan UT atas methylcellulose (UTMC) dengan jelas menunjukkan peralihan fasa dari cecair ke gel antara 20 ° C dan 65 ° C dengan peningkatan frekuensi pengayun dan ujian ramp suhu. Apabila kepekatan MC berubah, kepekatan yang paling berkesan sebagai salutan dapat diperhatikan pada 1.0 w/v% UTMC di mana jumlah pengekalan air dan pengambilan minyak mengurangkan kira-kira 39.3 % and 56.9 %, berbanding 1.0 w/v% formulasi MC yang tidak dirawatan dengan ultrasonik. Sampel ubi kentang goreng yang disalut menunjukkan penurunan yang ketara dalam jumlah akrilamida dan bertambah baik apabila rawatan ultrasonik dirawat pada salutan. Jumlah akrilamida dalam 1.0 w/v% MC yang tidak dirawat dengan ultrasonik mengurang dari 156.40 ± 7.44 ng g-1 ke 64.8 ± 5.05 ng g-1 dikesan dalam 1.0 (w / v%) UTMC. Secara konklusi, penemuan dalam kajian ini boleh digunakan untuk memberikan gambaran lanjut mengenai pengaruh hidrokoloid sebagai salutan sepanjang proses menggoreng dan membantu pemahaman yang lebih baik mengenai proses penyalut yang berkesan dan untuk meningkatkan kualiti makanan bergoreng.

© COPYRIGHT UPM

ACKNOWLEDGEMENTS

This research was part of al MSc program co-funded by Eramus+ 573957-EPP-2016-EPPKA2-CBHE-JP(2016-3771) Project. First and foremost, I would like to express sincere gratitude to my project supervisor, Assoc. Professor Ir. Dr. Mohd. Nazli Naim for the confidence he had in me regarding this project. His constructive guidance, advice, and constant reminders were fulfilling my inspiration and motivating me to bring out a successful project. I would also like to express my sincere gratitude to my co-supervisor for their help, sharing, and support throughout this project. Moreover, I would like the express greatest gratitude to Sime Darby Technology centre for the chance to make experiments. I especially want to thank Dr. Teh Huey Fang for giving me the opportunity to attend the centre for Acrylamide Extraction. I am grateful to respected faculty's staff and laboratory technicians from University Putra Malaysia, Malaysia and Kasetsart University, Thailand who assisted me during my lab work. Their technical help has been unique and is a stepping stone towards the successful completion of my project. Finally, I would like the express greatest gratitude for providing my family and my labmates for their valuable encouragement and support until the completion of this study. Last but not least, I would like to thank to those people who had helped and contributed for the succession of this study, whether directly and indirectly.

Sincerely,
Lua Hwee Ying

© COPYRIGHT UPM

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Mohd Nazli Naim, PhD, PEng
Associate Professor,Ir
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Afandi P. Mohammed, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Kanithaporn Vangnai, PhD
Assistant Professor
Faculty of Agro-Industry
Kasetsart University
(Member)

Fariza Hamidon,
Senior Lecturer
Faculty of Engineering
Universiti Teknologi MARA
(Member)

Teh Huey Fang, PhD
Chief Scientist
Industrial Chemistry Unit
Sime Darby Plantation Technology Centre
(Member)

____
ZALILAH MOHD SHARIFF,PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 20 January 2021

© COPYRIGHT UPM

Declaration by Members of the Supervisory Committee

This is to confirm that:

- the research and the writing of this thesis were done under our supervision;
- supervisory responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2015-2016) are adhered to.
-

Signature: ______________________________

Name of Chairman of Supervisory Committee: Mohd Nazli Naim, PhD, PEng

Signature: ______________________________

Name of Member of Supervisory Committee: Mohd Afandi P. Mohammed, PhD

Signature: ______________________________

Name of Member of Supervisory Committee: Kanithaporn Vangnai, PhD

Signature: ______________________________

Name of Member of Supervisory Committee: Fariza Hamidon

Signature: ______________________________

Name of Member of Supervisory Committee: Teh Huey Fang, PhD

© COPYRIGHT UPM

TABLE OF CONTENTS

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

LIST OF TABLES

© COPYRIGHT UPM

LIST OF FIGURES

© COPYRIGHT UPM

© COPYRIGHT UPM

© COPYRIGHT UPM

LIST OF ABBREVIATIONS

a*	Redness
b*	Yellowness
L*	Lightness
ΔE	total colour change

© COPYRIGHT UPM

CHAPTER 1

INTRODUCTION

1.1 Overview

Hydrocolloids are the most widely investigated biopolymer in the edible coating field to improve coating performance, especially in food and beverage products, i.e., sauces, gelled desserts, cakes, and soft drinks (Saha & Bhattacharya, 2010). Typically, they functioned as a thickening, gelling, emulsifying, and stabilization agent, i.e., for controlling ice and sugar crystal growth. The addition of food hydrocolloids as dry ingredients is a practical way of improving barrier properties, yield, and strength (Meyer et al., 2006).

Methylcellulose (MC), hydroxypropyl cellulose (HPC), and hydroxypropyl methylcellulose (HPMC) are types of cellulose derivative hydrocolloids that are commonly used in the food and beverage field. They are water-soluble polymer with good film-forming properties and coupled with the hydrophilic functional group. It is reported that the gel formation process of the hydrocolloids such as HPC, HPMC, and MC demonstrated the viscoelastic behavior as the elastic and viscous were combined and dependently on the temperature that caused the changes in the polymer deformation rate (Picout and Ross-Murphy, 2003).

In the deep-frying process, one of the main concern is high absorption of oil available in food which might affected the consumer’s health. For example, oil content of French fries increases from 0.2 to 14 % while oil content available in potato chip may reach up to 40 % (Garcia, 2004). Alternatively, researchers found that hydrocolloids was significantly reduce the oil uptake when used in the coating as batter mixtures. According to Daraei Garmakhany et al. (2014), different hydrocolloid properties behave differently in terms of the fried product's mass and heat transfer. During the frying process, heat and mass transfer occur simultaneously by two mechanisms where heat is initially transferred from the oil to the surface of the product through free convection and from the surface to the interior via conduction (Safari et al., 2018; van Koerten et al., 2017). There are numerous empirical and mathematical models in the literature related to the heat and mass transfer during the food frying process (B. E. Farkas et al., 1996; B.E. Farkas et al., 1996).

Thermal properties possess by some cellulose derivatives were found to be an effective surface coating for reducing oil uptake in fried products (Albert and Mittal, 2002). For instance, MC can increase the viscosity with temperature and formed weak viscoelastic gel when the temperature rises above 52 °C (Saha and Bhattacharya, 2010). An increasing number of works that related to the MC

© COPYRIGHT UPM

application were reported in the cereal product (Albert and Mittal, 2002), puri (Parimala and Sudha, 2012), akara (Hasheminya et al., 2019), and others.

Besides that, high amount of acrylamide (AA) available in fried potato which was considered a "potential" carcinogen in humans become attention for consumption. Many of the causes of acrylamide formation are presented by previous researchers.

Zhang et al. (2005) reviewed the acrylamide formation mechanisms to announce that the asparagine pathway was mainly responsible for acrylamide formation in cooked foods at high temperatures after condensated with reducing sugars or carbonyl source, the main intermediate product, and molecular rearrangement products. Recently, hydrocolloids have attracted increasing attention due to their potential to mitigate acrylamide and oil uptake in frying foods (Fang et al., 2016; Medeiros Vinci et al., 2012; Zeng et al., 2010). According to Kurek et al. (2017), hydrocolloid coating could interfere with the molecular interactions during acrylamide formation and subsequently reduce acrylamide content in deep fat frying products. Pectin, alginic acid, and xanthan gum inhibited up to 50% of the acrylamide model system (Achaerandio and Benedetti, 2017).

Applying ultrasound to hydrocolloid mixture seems desirable for the degradation of hydrocolloid dispersions when applied on food, a promising alternative to presently used degradation techniques (Tiwari et al., 2010). In general, the ultrasonic wave reduced the microcrystalline cellulose's degree of polymerization by disrupting the interchain-hydrogen bond between hydrogen and oxygen during the process (Li et al., 2018).

During the process, the hydrogen bond network is strongly disturbed at the interface; between the water and extended hydrophobic surface. The condition formed an interfacial region with depleted water density where the OH stretch range of water molecules organized at interfaces (Cheng et al., 2010; Simonsen et al., 2004). The ultrasound treatment (UT) to the hydrocolloid mixtures has become significant as the process enhances the rheology properties of hydrocolloid mixtures such as optimizing viscosity, enhancing the gel-structures, and improving structural stability (Tiwari et al., 2010). Although studies of gelation mechanisms provide enormous information that is very useful for applying hydrocolloids in food products, the study in this work is limited only to the application of batter-coating processing. It is relevant to improve the batter-coated fried product along the frying process.

This study emphasized the batter mixtures' properties correlated to the oil uptake minimization and acrylamide formation of potatoes substrate (French fries) along the deep-fat frying process.

© COPYRIGHT UPM

1.2 Problem Statement

Food is known as a pillar industry that is closely related to people's life. Along with the promotion of life quality and accelerated pace of life, food demands are going through transmission from quantity and nutrition to pleasure and health-benefits, and customized food products targeting specific populations with desired functionalities are becoming increasingly important. However, the worldwide prevalence of obesity has nearly doubled in the last two decades, and obesity is currently among the most significant public health concerns worldwide. Recently, the UK Food Standards Agency (FSA) has announced the risk of cancer associated with cooking potatoes and other starchy foods at high temperatures due to acrylamide formation, contributing to the nervous system and reproductive disease. One of the bold reformulation strategies proposed is to directly control the human digestion and absorption system of lipids by manipulating a food product's physiochemical and structural attributes for daily consumption. Interestingly, the application of hydrocolloids, i.e., MC, as food coating, was found to have advantages in terms of controllable heat transfer onto the food matrix along with the frying condition. Hydrophobic saccharides available in hydrocolloids created a potential layer for surface minimization, which will minimize acrylamide formation at high-temperature process food. Therefore, this study was important to determine the correlation between fried food and the hydrocolloids coating mechanism of a fried substrate.

1.3 Specific Objective

The objectives of this study were:

1. To characterize the rheology properties of ultrasonic treatment (UT) methylcellulose.
2. To investigate the effect of batter-coated methylcellulose potato substrate on oil uptake, with the ultrasonic treatment.
3. To study the effect of the ultrasonic treatment in minimizing the acrylamide formation of the fried potato substrate.

1.4 Scope of Study

In this study, the experiment was focus on two parts; the properties of Methylcellulose (MC) with ultrasound treatment (UT) and the effects of the UTMC on the potato substrate during and/or post frying process was demonstrated. The study was performed in depth by studying the rheology properties of UTMC. The methylcellulose solutions with and without ultrasound treatment was analysed in term of the thermal reversible gelation at varies temperature and frequency with different concentration. Application of methylcellulose with ultrasound treatment as coating on potatoes was performed. Potato strips were coated with ultrasonicated methylcellulose solutions and undergo deep-fat frying at 180˚C±5 °C. The physical properties (moisture content, oil content, acrylamide content,

© COPYRIGHT UPM

colour and texture) of coated fried potato was measured to study the effect of treatment in producing more healthier fried potato strips.

1.5 Framework of the thesis

The thesis is organized into five chapters in the following way. Chapter 1 introduces the thesis, and Chapter 2 contains the literature review of the work, including an overview of hydrocolloids, ultrasound treatment, deep fat frying process, and acrylamide formation. In Chapter 3, the methodology of this research is discussed. The experimental results and statistical analysis are shown and discussed in Chapter 4. This includes an investigation of MC solutions' rheology properties, an investigation of pre-treatments influence on fried potato's physical properties, and an evaluation influence of pre-treatment using mathematical modelling. Finally, the overall conclusion and recommendation of this study are given in Chapter 5.

© COPYRIGHT UPM

REFERENCES

Achaerandio, I., Benedetti, B.C., (2017). The influence of edible coatings , blanching and ultrasound treatments on quality attributes and shelf-life of vacuum packaged potato strips. LWT - Food Science and Technology 85, 449–455. https://doi.org/10.1016/j.lwt.2017.03.062

Ahmadi, E., Sareminezhad, S., Azizi, M.H., (2011). The effect of ultrasound treatment on some properties of methylcellulose films. Food Hydrocolloids 25, 1399–1401. https://doi.org/10.1016/j.foodhyd.2010.08.015

Albert, S., Mittal, G.S., (2002). Comparative evaluation of edible coatings to reduce fat uptake in a deep-fried cereal product. Food Research International 35, 445–458. https://doi.org/10.1016/S0963-9969(01)00139-9

Angor, M.M., (2016). Reducing Fat Content of Fried Potato Pellet Chips Using Carboxymethyl Cellulose and Soy Protein Isolate Solutions as Coating Films. Journal of Agricultural Science 8, 162. https://doi.org/10.5539/jas.v8n3p162

Antunes-Rohling, A., Ciudad-Hidalgo, S., Mir-Bel, J., Raso, J., Cebrián, G., Álvarez, I., (2018a). Ultrasound as a pretreatment to reduce acrylamide formation in fried potatoes. Innovative Food Science and Emerging Technologies 49, 158–169. https://doi.org/10.1016/j.ifset.2018.08.010

Antunes-Rohling, A., Ciudad-Hidalgo, S., Mir-Bel, J., Raso, J., Cebrián, G., Álvarez, I., (2018b). Ultrasound as a pretreatment to reduce acrylamide formation in fried potatoes. Innovative Food Science and Emerging Technologies 49, 158–169. https://doi.org/10.1016/j.ifset.2018.08.010

Aouada, F.A., Chiou, B., Orts, W.J., Mattoso, L.H.C., (2009). Physicochemical and Morphological Properties of Poly (acrylamide) and Methylcellulose Hydrogels : Effects of Monomer , Crosslinker and Polysaccharide Compositions 2–9. https://doi.org/10.1002/pen

Ashokkumar, M., (2015). Ultrasonics Sonochemistry Applications of ultrasound in food and bioprocessing. Ultrasonics - Sonochemistry 25, 17–23. https://doi.org/10.1016/j.ultsonch.2014.08.012

Barnes, H.A., (2004). Chapter 18 The rheology of emulsions, Interface Science and Technology. Elsevier Masson SAS. https://doi.org/10.1016/S1573-4285(04)80020-6

Barutcu, I., Sahin, S., Sumnu, G.,(2009). Acrylamide formation in different batter formulations during microwave frying. LWT - Food Science and Technology 42, 17–22. https://doi.org/10.1016/j.lwt.2008.07.004

© COPYRIGHT UPM

Baskar, G., Aiswarya, R., (2018a). Overview on mitigation of acrylamide in starchy fried and baked foods. Journal of the Science of Food and Agriculture 98, 4385–4394. https://doi.org/10.1002/jsfa.9013

Baskar, G., Aiswarya, R., (2018b). Overview on mitigation of acrylamide in starchy fried and baked foods. https://doi.org/10.1002/jsfa.9013

Belc, N., Papageorgiou, M., Duta, D., Lazaridou, A., Biliaderis, C.G., (2006). Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. Journal of Food Engineering 79, 1033–1047. https://doi.org/10.1016/j.jfoodeng.2006.03.032

Bodvik, R., Dedinaite, A., Karlson, L., Bergström, M., Bäverbäck, P., Pedersen, J.S., Edwards, K., Karlsson, G., Varga, I., Claesson, P.M., (2010). Aggregation and network formation of aqueous methylcellulose and hydroxypropylmethylcellulose solutions. Colloids and Surfaces A: Physicochemical and Engineering Aspects 354, 162–171. https://doi.org/10.1016/j.colsurfa.2009.09.040

Chatterjee, T., Nakatani, A.I., Adden, R., Brackhagen, M., Redwine, D., Shen, H., Li, Y., Wilson, T., Sammler, R.L., (2012). Structure and properties of aqueous methylcellulose gels by small-angle neutron scattering. Biomacromolecules 13, 3355–3369. https://doi.org/10.1021/bm301123a

Cheng, W., Chen, J., Liu, D., Ye, X., Ke, F., (2010). Impact of ultrasonic treatment on properties of starch film-forming dispersion and the resulting films. Carbohydrate Polymers 81, 707–711. https://doi.org/10.1016/j.carbpol.2010.03.043

Crum, L.A., (1995). Comments on the evolving field of sonochemistry by a cavitation physicist. Ultrasonics - Sonochemistry 2, 147–152. https://doi.org/10.1016/1350-4177(95)00018-2

Daniali, G., Jinap, S., Hajeb, P., Sanny, M., Tan, C.P., (2016). Acrylamide formation in vegetable oils and animal fats during heat treatment. Food Chemistry 212, 244–249. https://doi.org/10.1016/j.foodchem.2016.05.174

Daniali, G., Jinap, S., Sanny, M., Tan, C.P., (2018). Effect of amino acids and frequency of reuse frying oils at different temperature on acrylamide formation in palm olein and soy bean oils via modeling system. Food Chemistry 245, 1–6. https://doi.org/10.1016/j.foodchem.2017.10.070

Daraei Garmakhany, A., Mirzaei, H.O., Maghsudlo, Y., Kashaninejad, M., Jafari, S.M., (2014). Production of low fat french-fries with single and multi-layer hydrocolloid coatings. Journal of Food Science and Technology 51, 1334–1341. https://doi.org/10.1007/s13197-012-0660-9

© COPYRIGHT UPM

De Paola, E.L., Montevecchi, G., Masino, F., Garbini, D., Barbanera, M., Antonelli, A., (2017). Determination of acrylamide in dried fruits and edible seeds using QuEChERS extraction and LC separation with MS detection. Food Chemistry 217, 191–195. https://doi.org/10.1016/j.foodchem.2016.08.101

Desbrières, J., Hirrien, M., Rinaudo, M., (1998). A calorimetric study of methylcellulose gelation. Carbohydrate Polymers 37, 145–152. https://doi.org/10.1016/S0144-8617(98)00023-X

Desbrières, J., Hirrien, M., Ross-Murphy, S.B., (2000). Thermogelation of methylcellulose: Rheological considerations. Polymer 41, 2451–2461. https://doi.org/10.1016/S0032-3861(99)00413-9

Di Francesco, A., Mari, M., Ugolini, L., Parisi, B., Genovese, J., Lazzeri, L., Baraldi, E., (2019). Reduction of acrylamide formation in fried potato chips by Aureobasidum pullulans L1 strain. International Journal of Food Microbiology 289, 168–173. https://doi.org/10.1016/j.ijfoodmicro.2018.09.018

E., D., (2003). Hydrocolloids at interfaces and the influence on the properties of dispersed systems. Food Hydrocolloids 17, 25.

Ekiz, I., (2007). Reduction of acrylamide formation in French fries by microwave pre-cooking 137, 133–137. https://doi.org/10.1002/jsfa

Fang, Y., Cao, Y., Gao, Z., Nishinari, K., Liao, H., Phillips, G.O., (2016). Hydrocolloid-food component interactions. Food Hydrocolloids 68, 149–156. https://doi.org/10.1016/j.foodhyd.2016.08.042

Farahnaky, A., Askari, H., Majzoobi, M., Mesbahi, G., (2010). The impact of concentration, temperature and pH on dynamic rheology of psyllium gels. Journal of Food Engineering 100, 294–301. https://doi.org/10.1016/j.jfoodeng.2010.04.012

Farkas, B.E., Singh, R.P., Rumsey, T.R., (1996). Modeling heat and mass transfer in immersion frying. II, model solution and verification. Journal of Food Engineering 29, 227–248. https://doi.org/10.1016/0260-8774(95)00048-8

Farkas, B. E., Singh, R.P., Rumsey, T.R., (1996). Modeling heat and mass transfer in immersion frying. I, model development. Journal of Food Engineering 29, 211–226. https://doi.org/10.1016/0260-8774(95)00072-0

Fiszman, S.M., Salvador, A., (2003). Recent developments in coating batters. Trends in Food Science and Technology 14, 399–407. https://doi.org/10.1016/S0924-2244(03)00153-5

Friedman, M., (2003). Chemistry , Biochemistry , and Safety of Acrylamide . A Review 4504–4526.

© COPYRIGHT UPM

Funami, T., Kataoka, Y., Hiroe, M., Asai, I., Takahashi, R., Nishinari, K., (2007). Thermal aggregation of methylcellulose with different molecular weights. Food Hydrocolloids 21, 46–58. https://doi.org/10.1016/j.foodhyd.2006.01.008

García, M.A., Ferrero, C., Bértola, N., Martino, M., Zaritzky, N., (2002). Edible coatings from cellulose derivatives to reduce oil uptake in fried products. Innovative Food Science and Emerging Technologies 3, 391–397. https://doi.org/10.1016/S1466-8564(02)00050-4

García, M.A., Ferrero, C., Campana, A., Bértola, N., Martino, M., Zaritzky, N., (2004). Methylcellulose coatings applied to reduce oil uptake in fried products. Food Science and Technology International 10, 339–346. https://doi.org/10.1177/1082013204047564

Garmakhany, A.D., Mirzaei, H.O., Nejad, M.K., Maghsudlo, Y., (2008). Study of oil uptake and some quality attributes of potato chips affected by hydrocolloids. European Journal of Lipid Science and Technology 110, 1045–1049. https://doi.org/10.1002/ejlt.200700255

Gertz, C., Klostermann, S., Kochhar, S.P., (2003). Deep frying: The role of water from food being fried and acrylamide formation. OCL - Oleagineux Corps Gras Lipides 10, 297–303. https://doi.org/10.1051/ocl.2003.0297

González, M.M., Caja-munoz, B., Darder, M., Aranda, P., Vázquez, L., Ruiz-hitzky, E., (2020). Applied Clay Science Ultrasound-assisted preparation of nanocomposites based on fi brous clay minerals and nanocellulose from microcrystalline cellulose. Applied Clay Science 189, 105538. https://doi.org/10.1016/j.clay.2020.105538

Guerra-Hernández, E.J., (2015). Acrylamide in Battered Products, Acrylamide in Food: Analysis, Content and Potential Health Effects. Elsevier Inc. https://doi.org/10.1016/B978-0-12-802832-2.00013-9

Gustavo F. Gutiérrez-Lopez, Jorge Welti-Chanes, E.P.-A., (2008). Food Engineering: Integrated Approaches 476. https://doi.org/10.1007/978-0-387-75430-7

Haque, A., Richardson, R.K., Morris, E.R., Gidley, M.J., Caswell, D.C., (1993). Thermogelation of methylcellulose. Part II: effect of hydroxypropyl substituents. Carbohydrate Polymers 22, 175–186. https://doi.org/10.1016/0144-8617(93)90138-T

Hasheminya, S., Rezaei, R., Ghanbarzadeh, B., (2019). Development and characterization of biocomposite films made from kefiran , carboxymethyl cellulose and Satureja Khuzestanica essential oil. Food Chemistry 289, 443–452. https://doi.org/10.1016/j.foodchem.2019.03.076

Health, N., Engineering, F., (2015). Role of MC Compounds at Less of Oil Absorption of French Fries Potato 2, 2–4. https://doi.org/10.15406/jnhfe.2015.02.00075

© COPYRIGHT UPM

Hirrien, M., Chevillard, C., Desbrières, J., Axelos, M.A.V., Rinaudo, M., (1998). Thermogelation of methylcelluloses: New evidence for understanding the gelation mechanism. Polymer 39, 6251–6259. https://doi.org/10.1016/S0032-3861(98)00142-6

Huse, H.L., Mallikarjunan, P., Chinnan, M.S., Hung, Y.C., Phillips, R.D., (1998). Edible coatings for reducing oil uptake in production of akara (deep-fat frying of cowpea paste). Journal of Food Processing and Preservation 22, 155–165. https://doi.org/10.1111/j.1745-4549.1998.tb00811.x

Iida, Y., Tuziuti, T., Yasui, K., Towata, A., Kozuka, T., (2008). Control of viscosity in starch and polysaccharide solutions with ultrasound after gelatinization. Innovative Food Science and Emerging Technologies 9, 140–146. https://doi.org/10.1016/j.ifset.2007.03.029

JECFA, (2011). Evaluation of certain contaminants in food. In Seventy-second report of the joint FAO/WHO expert committee on food additives.

Jia, B., Fan, D., Li, J., Duan, Z., Fan, L., (2017). Effect of Guar Gum with Sorbitol Coating on the Properties and Oil Absorption of French Fries. https://doi.org/10.3390/ijms18122700

Ke, L., Zhang, P., Xiang, L., Wang, H., Rao, P., Wang, S., (2020). Interaction of acrylamide with micelles in French fry aqueous extracts. Food Control 110, 106974. https://doi.org/10.1016/j.foodcont.2019.106974

Keramat, J., LeBail, A., Prost, C., Soltanizadeh, N., (2011). Acrylamide in Foods: Chemistry and Analysis. A Review. Food and Bioprocess Technology 4, 340–363. https://doi.org/10.1007/s11947-010-0470-x

Kim, D.N., Lim, J., Bae, I.Y., Lee, H.G., Lee, S., (2011). Effect of hydrocolloid coatings on the heat transfer and oil uptake during frying of potato strips. Journal of Food Engineering 102, 317–320. https://doi.org/10.1016/j.jfoodeng.2010.09.005

Kurek, M., Ščetar, M., Galić, K., (2017). Edible coatings minimize fat uptake in deep fat fried products: A review. Food Hydrocolloids 71, 225–235. https://doi.org/10.1016/j.foodhyd.2017.05.006

Li, H., Zhang, K., Zhang, X., Cao, Q., Jin, L.,(2018). Contributions of ultrasonic wave, metal ions, and oxidation on the depolymerization of cellulose and its kinetics. Renewable Energy 126, 699–707. https://doi.org/10.1016/j.renene.2018.03.079

Li, J.M., Nie, S.P., (2016). The functional and nutritional aspects of hydrocolloids in foods. Food Hydrocolloids 53, 46–61. https://doi.org/10.1016/j.foodhyd.2015.01.035

© COPYRIGHT UPM

Li, W., Yue, J., Liu, S., (2012). Ultrasonics Sonochemistry Preparation of nanocrystalline cellulose via ultrasound and its reinforcement capability for poly (vinyl alcohol) composites. Ultrasonics - Sonochemistry 19, 479–485. https://doi.org/10.1016/j.ultsonch.2011.11.007

Liu, C., Grimi, N., Lebovka, N., Vorobiev, E., (2018). Effects of preliminary treatment by pulsed electric fields and convective air-drying on characteristics of fried potato. Innovative Food Science and Emerging Technologies 47, 454–460. https://doi.org/10.1016/j.ifset.2018.04.011

Liu, E.Z., Scanlon, M.G., (2007). Modeling the effect of blanching conditions on the texture of potato strips. Journal of Food Engineering 81, 292–297. https://doi.org/10.1016/j.jfoodeng.2006.08.002

Luo, J., Fang, Z., Smith, R.L., (2014). Ultrasound-enhanced conversion of biomass to biofuels. Progress in Energy and Combustion Science 41, 56–93. https://doi.org/10.1016/j.pecs.2013.11.001

Mahmood, K., Kamilah, H., Shang, P.L., Sulaiman, S., Ariffin, F., Alias, A.K., (2017). A review: Interaction of starch/non-starch hydrocolloid blending and the recent food applications. Food Bioscience 19, 110–120. https://doi.org/10.1016/j.fbio.2017.05.006

Mallikarjunan, P., Chinnan, M., Balasubramaniam, V., Phillips, R., (1997). Edible Coatings for Deep-fat Frying of Starchy Products1. Lebensmittel-Wissenschaft und-Technologie 30, 709–714. https://doi.org/10.1006/fstl.1997.0263

Matthäus, B., Haase, N.U., (2014). Review Article Acrylamide – Still a matter of concern for fried potato food ? Ã 675–687. https://doi.org/10.1002/ejlt.201300281

Mason, T. J. (2014). Introduction. http://www.sonochemistry.info/introdution.htm

Medeiros Vinci, R., Mestdagh, F., De Meulenaer, B.,(2012). Acrylamide formation in fried potato products - Present and future, a critical review on mitigation strategies. Food Chemistry 133, 1138–1154. https://doi.org/10.1016/j.foodchem.2011.08.001

Mellema, M., (2003). Mechanism and reduction of fat uptake in deep-fat fried foods. Trends in Food Science and Technology 14, 364–373. https://doi.org/10.1016/S0924-2244(03)00050-5

Mesias, M., Delgado-Andrade, C., Holgado, F., Morales, F.J., (2019). Acrylamide content in French fries prepared in food service establishments. Lwt 100, 83–91. https://doi.org/10.1016/j.lwt.2018.10.050

© COPYRIGHT UPM

Mestdagh, F.J., De Meulenaer, B., Van Poucke, C., Detavernier, C., Cromphout, C., Van Peteghem, C., (2005). Influence of oil type on the amounts of acrylamide generated in a model system and in french fries. Journal of Agricultural and Food Chemistry 53, 6170–6174. https://doi.org/10.1021/jf0506683

Mestdagh, F.R.;, Meulenaer;, B.D., Cucu;, T., Peteghem, C. VAN, (2006). Role of Water upon the Formation of Acrylamide in a Potato Model System 9092–9098.

Meyer, E.E., Rosenberg, K.J., Israelachvili, J., (2006). Recent progress in understanding hydrophobic interactions 103, 15739–15746.

Moreira, R., Chenlo, F., Silva, C., Torres, M.D., (2017). Rheological behaviour of aqueous methylcellulose systems: Effect of concentration, temperature and presence of tragacanth. LWT - Food Science and Technology 84, 764–770. https://doi.org/10.1016/j.lwt.2017.06.050

Moreno, M.C., Brown, C.A., Bouchon, P., (2010). Effect of food surface roughness on oil uptake by deep-fat fried products. Journal of Food Engineering 101, 179–186. https://doi.org/10.1016/j.jfoodeng.2010.06.024

Mousa, R., Mousa, A., (2018). Food Hydrocolloids Simultaneous inhibition of acrylamide and oil uptake in deep fat fried potato strips using gum Arabic-based coating incorporated with antioxidants extracted from spices. Food hydrocolloids 83, 265–274. https://doi.org/10.1016/j.foodhyd.2018.05.007

Murniece, I., Karklina, D., Galoburda, R., Sabovics, M., (2010). Reducing Sugar Content and Colour Intensity of Fried Latvian Potato Varieties Reducējošo cukuru saturs un krāsas intensitāte ceptos Latvijas šķirņu kartupeļos 24, 20–30.

Murata, H., (2012). Rheology – Theory and Application to Biomaterials. Polymerization 403–425.
http://doi.org/10.5772/48393

Muttucumaru, N., Powers, S.J., Elmore, J.S., Briddon, A., Mottram, D.S., Halford, N.G., (2014). Evidence for the complex relationship between free amino acid and sugar concentrations and acrylamide-forming potential in potato 164, 286–300. https://doi.org/10.1111/aab.12101

Nasatto, P.L., Pignon, F., Silveira, J.L.M., Duarte, M.E.R., Noseda, M.D., Rinaudo, M., (2015a). Influence of Molar Mass and Concentration on the Thermogelation of Methylcelluloses. International Journal of Polymer Analysis and Characterization 20, 110–118. https://doi.org/10.1080/1023666X.2015.973155

Nasatto, P.L., Pignon, F., Silveira, J.L.M., Duarte, M.E.R., Noseda, M.D., Rinaudo, M., (2015b). Methylcellulose, a cellulose derivative with original physical properties and extended applications. Polymers 7, 777–803. https://doi.org/10.3390/polym7050777

© COPYRIGHT UPM

Noguchi, S., Takaomi, K., (2020). Ultrasonics - Sonochemistry Ultrasound response of viscoelastic changes of cellulose hydrogels triggered with Sono-deviced rheometer. Ultrasonics - Sonochemistry 67, 105143. https://doi.org/10.1016/j.ultsonch.2020.105143

Onishi, Y., Prihanto, A.A., Yano, S., (2015). Effective treatment for suppression of acrylamide formation in fried potato chips using L-asparaginase from Bacillus subtilis. 3 Biotech 783–789. https://doi.org/10.1007/s13205-015-0278-5

Pahade, P.K., Sakhale, B.K., (2012). Effect of blanching and coating with hydrocolloids on reduction of oil uptake in french fries. International Food Research Journal 19, 697–699.

Parimala, K.R., Sudha, M.L., (2012). Food Hydrocolloids Effect of hydrocolloids on the rheological , microscopic , mass transfer characteristics during frying and quality characteristics of puri. Food hydrocolloids 27, 191–200. https://doi.org/10.1016/j.foodhyd.2011.07.005

Park, H., Kim, M.H., Yoon, Y. Il, Park, W.H., (2017). One-pot synthesis of injectable methylcellulose hydrogel containing calcium phosphate nanoparticles. Carbohydrate Polymers 157, 775–783. https://doi.org/10.1016/j.carbpol.2016.10.055

Patel, A.R., (2018). Functional and Engineered Colloids from Edible Materials for Emerging Applications in Designing the Food of the Future 1806809, 1–34. https://doi.org/10.1002/adfm.201806809

Paul, V., (2017). Acrylamide in processed potato products : progress made and present status Acrylamide in processed potato products : progress made and present status. https://doi.org/10.1007/s11738-016-2290-8

Pedreschi, F., Cocio, C., Moyano, P., Troncoso, E., (2008a). Oil distribution in potato slices during frying 87, 200–212. https://doi.org/10.1016/j.jfoodeng.2007.11.031

Pedreschi, F., Kaack, K., Granby, K., (2008b). The effect of asparaginase on acrylamide formation in French fries 109, 386–392. https://doi.org/10.1016/j.foodchem.2007.12.057

Phillips, G.O., (2004). Water-soluble polymer applications in foods. Food Hydrocolloids 18, 693. https://doi.org/10.1016/j.foodhyd.2003.09.002

Picout, D.R., Ross-Murphy, S.B., (2003). Rheology of biopolymer solutions and gels. TheScientificWorldJournal 3, 105–121. https://doi.org/10.1100/tsw.2003.15

Portenlänger, G., Heusinger, H., (1997). The influence of frequency on the mechanical and radical effects for the ultrasonic degradation of dextranes. Ultrasonics Sonochemistry 4, 127–130. https://doi.org/10.1016/S1350-4177(97)00018-7

© COPYRIGHT UPM

Primo-Martín, C.., Sanz, T.., Steringa, D.W.., Salvador, A.., Fiszman, S.M.., van Vliet, T., (2010). Performance of cellulose derivatives in deep-fried battered snacks: Oil barrier and crispy properties. Food Hydrocolloids 24, 702–708. https://doi.org/10.1016/j.foodhyd.2010.04.013

Razzera, R., Keven, E., El-bialy, T., Saldaña, M.D.A., (2020). Ultrasonics - Sonochemistry Clove essential oil emulsion-filled cellulose nanofiber hydrogel produced by high-intensity ultrasound technology for tissue engineering applications. Ultrasonics - Sonochemistry 64, 104845. https://doi.org/10.1016/j.ultsonch.2019.104845

Rimac-Brnčić, S., Lelas, V., Rade, D., Šimundić, B., (2004). Decreasing of oil absorption in potato strips during deep fat frying. Journal of Food Engineering 64, 237–241. https://doi.org/10.1016/j.jfoodeng.2003.10.006

Rommens, C.M., Yan, H., Swords, K., Richael, C., Ye, J., (2008). Low-acrylamide French fries and potato chips 843–853. https://doi.org/10.1111/j.1467-7652.2008.00363.x

Safari, A., Salamat, R., Baik, O.D., (2018). A review on heat and mass transfer coefficients during deep-fat frying: Determination methods and influencing factors. Journal of Food Engineering 230, 114–123. https://doi.org/10.1016/j.jfoodeng.2018.01.022

Saguy, I.S., Dana, D., (2003). Integrated approach to deep fat frying: Engineering, nutrition, health and consumer aspects. Journal of Food Engineering 56, 143–152. https://doi.org/10.1016/S0260-8774(02)00243-1

Saha, D., Bhattacharya, S., (2010). Hydrocolloids as thickening and gelling agents in food : a critical review 47, 587–597. https://doi.org/10.1007/s13197-010-0162-6

Salvador, A.., Sanz, T.., Fiszman, S.M., (2008). Performance of methyl cellulose in coating batters for fried products. Food Hydrocolloids 22, 1062–1067. https://doi.org/10.1016/j.foodhyd.2007.05.015

Sansano, M.., Juan-Borrás, M.., Escriche, I.., Andrés, A.., Heredia, A., (2015). Effect of pretreatments and air-frying, a novel technology, on acrylamide generation in fried potatoes. Journal of Food Science 80, T1120–T1128. https://doi.org/10.1111/1750-3841.12843

Sansano, M., (2015). Effect of Pretreatments and Air-Frying , a Novel Technology , on Acrylamide Generation in Fried Potatoes 80, 1120–1128. https://doi.org/10.1111/1750-3841.12843

Sanz, T.., Fernández, M.A.., Salvador, A.., Muñoz, J.., Fiszman, S.M., (2005a). Thermogelation properties of methylcellulose (MC) and their effect on a batter formula. Food Hydrocolloids 19, 141–147. https://doi.org/10.1016/j.foodhyd.2004.04.023

© COPYRIGHT UPM

Sanz, T.., Salvador, A.., Fiszman, S.M.., (2004a). Effect of concentration and temperature on properties of methylcellulose-added batters Application to battered, fried seafood. Food Hydrocolloids 18, 127–131. https://doi.org/10.1016/S0268-005X(03)00050-X

Sanz, T.., Salvador, A.., Fiszman, S.M., (2004b). Innovative method for preparing a frozen, battered food without a prefrying step. Food Hydrocolloids 18, 227–231. https://doi.org/10.1016/S0268-005X(03)00067-5

Sanz, T.., Salvador, A.., Vélez, G.., Muñoz, J.., Fiszman, S.M., (2005b). Influence of ingredients on the thermo-rheological behaviour of batters containing methylcellulose. Food Hydrocolloids 19, 869–877. https://doi.org/10.1016/j.foodhyd.2004.11.003

Sarkar, N., Walker, L.C., (1995). Hydration-dehydration properties of methylcellulose and hydroxypropylmethylcellulose. Carbohydrate Polymers 27, 177–185. https://doi.org/10.1016/0144-8617(95)00061-B

Sayyed, A.J., Mohite, L. V, Deshmukh, N.A., Pinjari, D. V, (2018). Ultrasonics - Sonochemistry E ff ect of ultrasound treatment on swelling behavior of cellulose in aqueous N-methyl-morpholine-N-oxide solution. Ultrasonics - Sonochemistry 49, 161–168. https://doi.org/10.1016/j.ultsonch.2018.07.042

Schierbaum, F., Reuther, F., Braudo, E.E., Plashchina, I.G., Tolstoguzov, V.B., (1990). T h e r m o d y n a m i c Parameters of the Junction Zones in Thermoreversible Maltodextrin Gels 12, 245–253.

Seshadri, R., Weiss, J., Hulbert, G.J., Mount, J., (2003). Ultrasonic processing influences rheological and optical properties of high-methoxyl pectin dispersions. Food Hydrocolloids 17, 191–197. https://doi.org/10.1016/S0268-005X(02)00051-6

Shojaee-aliabadi, S., Nikoopour, H., Kobarfard, F., Parsapour, M., Moslehishad, M., Hassanabadi, H., Jesus, M., (2013). Acrylamide reduction in potato chips by selection of potato variety grown in Iran and processing conditions. https://doi.org/10.1002/jsfa.6076

Simonsen, A.C., Hansen, P.L., Klösgen, B., (2004). Nanobubbles give evidence of incomplete wetting at a hydrophobic interface 273, 291–299. https://doi.org/10.1016/j.jcis.2003.12.035

Song, Y., Gao, L., Li, L., Zheng, Q., (2010). Influence of gliadins on rheology of methylcellulose in 70% (v/v) aqueous ethanol. Food Hydrocolloids 24, 98–104. https://doi.org/10.1016/j.foodhyd.2009.08.010

Stojanovska, S., Tomovska, J., (2002). Factors influence to formation of acrylamide in food.

© COPYRIGHT UPM

Sun, Y., Xie, G., Peng, Y., Xia, W., Sha, J., (2016). Colloids and Surfaces A : Physicochemical and Engineering Aspects Stability theories of nanobubbles at solid – liquid interface : A review. Colloids and Surfaces A: Physicochemical and Engineering Aspects 495, 176–186. https://doi.org/10.1016/j.colsurfa.2016.01.050

Superior, C., Cient, I., Ii, F., (2008). Mitigation Strategies to Reduce Acrylamide Formation in Fried Potato Products 100, 89–100. https://doi.org/10.1196/annals.1433.051

Takahashi, M., Shimazaki, M., (2001). Formation of Junction Zones in Thermoreversible 943–946.

Tanner, R.I., 2009. The changing face of rheology. Journal of Non-Newtonian Fluid Mechanics 157, 141–144. https://doi.org/10.1016/j.jnnfm.2008.11.007

Tanner, R.I., (2002). A suspension model for low shear rate polymer solidification. Journal of Non-Newtonian Fluid Mechanics 102, 397–408. https://doi.org/10.1016/S0377-0257(01)00189-6

Tareke, E., Rydberg, P., Karlsson, P.;, Eriksson, S., and Margareta Törnqvist, (2002). Analysis of Acrylamide, a Carcinogen Formed in Heated Foodstuffs. Journal of Agricultural and Food Chemistry 50, 4998–5006. https://doi.org/10.1021/jf020302f

Tavera-Quiroz, M.J., Urriza, M., Pinotti, A., Bertola, N., (2012). Plasticized methylcellulose coating for reducing oil uptake in potato chips. Journal of the Science of Food and Agriculture 92, 1346–1353. https://doi.org/10.1002/jsfa.4704

Thormann, E., Bodvik, R., Karlson, L., Claesson, P.M., (2014). Surface forces and friction between non-polar surfaces coated by temperature-responsive methylcellulose. Colloids and Surfaces A: Physicochemical and Engineering Aspects 441, 701–708. https://doi.org/10.1016/j.colsurfa.2013.10.038

Tiwari, B.K., Muthukumarappan, K., O'Donnell, C.P., Cullen, P.J., (2010). Rheological properties of sonicated guar, xanthan and pectin dispersions. International Journal of Food Properties 13, 223–233. https://doi.org/10.1080/10942910802317610

Toubal, M., Nongaillard, B., Radziszewski, E., Boulenguer, P., Langendorff, V., (2003). Ultrasonic monitoring of sol-gel transition of natural hydrocolloids. Journal of Food Engineering 58, 1–4. https://doi.org/10.1016/S0260-8774(02)00325-4

Tran, N.L., Barraj, L.M., Collinge, S., (2017). Reduction in Dietary Acrylamide Exposure — Impact of Potatoes with Low Acrylamide Potential 37, 1754–1767. https://doi.org/10.1111/risa.12709

© COPYRIGHT UPM

van Koerten, K.N., Somsen, D., Boom, R.M., Schutyser, M.A.I., (2017). Modelling water evaporation during frying with an evaporation dependent heat transfer coefficient. Journal of Food Engineering 197, 60–67. https://doi.org/10.1016/j.jfoodeng.2016.11.007

Varela, P.., Fiszman, S.M., 2011. Hydrocolloids in fried foods. A review. Food Hydrocolloids 25, 1801–1812. https://doi.org/10.1016/j.foodhyd.2011.01.016

Vinci, R.M., Mestdagh, F., Meulenaer, B. De, (2012). Acrylamide formation in fried potato products – Present and future , a critical review on mitigation strategies. Food Chemistry 133, 1138–1154. https://doi.org/10.1016/j.foodchem.2011.08.001

Voong, K.Y., Norton, A.B., Mills, T.B., Norton, I.T., (2018). Characterisation of deep-fried batter and breaded coatings. Food Structure 16, 43–49. https://doi.org/10.1016/j.foostr.2018.03.002

Wang, Q., Li, L., Liu, E., Xu, Y., Liu, J., (2006). Effects of SDS on the sol-gel transition of methylcellulose in water. Polymer 47, 1372–1378. https://doi.org/10.1016/j.polymer.2005.12.049

Williams, R., Mittal, G.S., (1999). Low-Fat Fried Foods with Edible Coatings : Modeling and Simulation. Journal of Food Science 64, 317–322.

Yang, Y., Achaerandio, I., (2016). Influence of the frying process and potato cultivar on acrylamide formation in French fries 62, 216–223. https://doi.org/10.1016/j.foodcont.2015.10.028

Yang, Y., Achaerandio, I., Pujolà, M., (2016). Influence of the frying process and potato cultivar on acrylamide formation in French fries. Food Control 62, 216–223. https://doi.org/10.1016/j.foodcont.2015.10.028

Yasui, K., (2010). Fundamentals of Acoustic Cavitation and Sonochemistry. In Theoretical and Experimental Sonochemistry Involving Inorganic Systems (pp. 1–29). Springer, Dordrecht. https://doi.org/10.1007/978-90-481-3887-6_1)

Yu, F., Zhang, H., Zhao, L., Sun, Z., Li, Y., Mo, Y., Chen, Y.,(2020). A fl exible Cellulose / Methylcellulose gel polymer electrolyte endowing superior Li + conducting property for lithium ion battery. Carbohydrate Polymers 246, 116622. https://doi.org/10.1016/j.carbpol.2020.116622

Yusoff, Martini Mohammad, Halim, M.R.A., Ismail, N.A., Abdullah, S.N., Shari, E.S., Yusoff, Masnira Mohammad, (2018). Growth and yield performance of five purple sweet potato (ipomoea batatas) accessions on colluvium soil. Pertanika Journal of Tropical Agricultural Science 41, 975–986.

© COPYRIGHT UPM

Zeng, X., Cheng, K., Du, Y., Kong, R., Lo, C., Chu, I.K., Chen, F., Wang, M., (2010). Activities of hydrocolloids as inhibitors of acrylamide formation in model systems and fried potato strips. Food Chemistry 121, 424–428. https://doi.org/10.1016/j.foodchem.2009.12.059

Zuidema, J.M., Rivet, C.J., Gilbert, R.J., Morrison, F.A., (2014). A protocol for rheological characterization of hydrogels for tissue engineering strategies. Journal of Biomedical Materials Research - Part B Applied Biomaterials 102, 1063–1073. https://doi.org/10.1002/jbm.b.33088

Zúñiga, R.N., Skurtys, O., Osorio, F., Aguilera, J.M., Pedreschi, F., (2012). Physical properties of emulsion-based hydroxypropyl methylcellulose films: Effect of their microstructure. Carbohydrate Polymers 90, 1147–1158. https://doi.org/10.1016/j.carbpol.2012.06.066

Zuo, J.Y., Knoerzer, K., Mawson, R., Kentish, S., Ashokkumar, M., (2009). The pasting properties of sonicated waxy rice starch suspensions. Ultrasonics Sonochemistry 16, 462–468. https://doi.org/10.1016/j.ultsonch.2009.01.002

© COPYRIGHT UPM