UNIVERSITI PUTRA MALAYSIA

INFLUENCE OF OIL TYPE ON ACRYLAMIDE FORMATION IN INTERMITTENT FRIED BEEF NUGGETS AND IN ASPARAGINE-GLUCOSELIPID SYSTEM

SITI NUR SYAHIRAH BINTI AHMAD

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By

SITI NUR SYAHIRAH BINTI AHMAD

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

INFLUENCE OF OIL TYPE ON ACRYLAMIDE FORMATION IN INTERMITTENT FRIED BEEF NUGGETS AND IN ASPARAGINE-GLUCOSE-LIPID SYSTEM

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SITI NUR SYAHIRAH BINTI AHMAD

August 2021

Chairman : Maimunah Sanny, PhD
Faculty : Food Science and Technology

This study aims to investigate the effect of different vegetable oils and frying cycles on acrylamide formation during the intermittent frying of beef nuggets. Different vegetable oils, palm olein (PO), red palm super olein (RPSO), sunflower oil (SFO), and soybean oil (SBO), were used for a total of 80 frying cycles. Oil was collected at every 16th frying cycle and analysed for peroxide value (PV), *p*-anisidine value (*p*-AV), free fatty acid (FFA), total polar compound (TPC), polar compound fractions, and fatty acid composition (FAC). Total oxidation (TOTOX) value was calculated, and acrylamide content was quantified in the nuggets. Regardless of the oil type, PV, *p*-AV, and TOTOX initially increased but gradually decreased. However, FFA and TPC continued to develop across the 80 frying cycles. The C18:2/C16:0 remained almost unchanged in PO and RPSO but dropped progressively in SFO and SBO. The lowest acrylamide content in fried products was observed in the PO, while the highest content was observed in RPSO. The oil type but not the frying cycle significantly affected the acrylamide concentration in beef nuggets. PO is shown to be the most suitable vegetable oil to be used in lowering acrylamide formation during heat treatment. Next, the effect of different compositions of beta-carotene and vitamin E in RPSO blends on the kinetics parameters of acrylamide formation/elimination in an asparagine-glucose-lipid model system. Different blends of RPSO and canola oil (10, 20 and 30%) were applied and heated at series of temperature (120, 140, 160, 180, and 200°C) for 20 min. Linear equation for each oil blend was plotted in which the activation energy (*Ea*) was estimated and found that acrylamide formation obeyed the Arhenius Law. Higher level of RPSO incorporated in the blend led to a higher amount of beta carotene and tocols in the blend. Acrylamide content was determined using GCMS method and results indicated that the acrylamide formation obeyed the Arrhenius Law. Highest acrylamide content was revealed when 30% RPSO used at temperature 200°C whereas the lowest was noted when 20% RPSO was used at 120°C. Per contra for *Ea* which 20% RPSO revealed the highest and 30% RPSO the lowest revealing that higher energy was

required for the reaction to proceed then leading to lower acrylamide formation compared to others. The kinetics parameters of different oil blends of RPSO estimated in the present study may provide insight into the optimum RPSO blend to reduce acrylamide formation during heat treatment.

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

PENGARUH JENIS MINYAK PADA PEMBENTUKAN AKRILAMIDA DALAM NUGGET LEMBU PENGORENGAN SEKEJAP DAN DALAM SISTEM LIPID-GLUKOSA-ASPARAGIN

Oleh

SITI NUR SYAHIRAH BINTI AHMAD

Ogos 2021

Pengerusi : Maimunah Sanny, PhD
Fakulti : Sains dan Teknologi Makanan

Kajian ini bertujuan untuk mengkaji kesan penggunaan minyak sayuran dan penggorengan berbeza terhadap pembentukan akrilamida dalam nugget daging lembu. Minyak sayuran yang berbeza, olein sawit (OS), olein sawit merah (OSM), minyak bunga matahari (MBM), dan minyak kacang soya (MKS), digunakan selama 80 kali penggorengan. Minyak dikumpulkan pada setiap kitaran menggoreng ke-16 dan dianalisis untuk nilai peroksida (PV), nilai *p*-anisidin (*p*-AV), asid lemak bebas (ALB), jumlah komponen polar (JKP), pecahan sebatian polar, dan komposisi asid lemak (KAL). Nilai pengoksidaan total (PT) dikira, dan kandungan akrilamida dihitung dalam nugget. Kesemua minyak menunjukkan PV, *p*-AV, dan PT pada mulanya meningkat tetapi secara beransur-ansur menurun. Walaubagaimanapun, ALB dan JKP terus berkembang sepanjang 80 kitaran penggorengan. C18:2 / C16:0 kekal hampir tidak berubah di OS dan OSM tetapi turun secara berperingkat di MBM dan MKS. Kandungan akrilamida terendah dalam produk goreng diperhatikan dalam OS, sementara kandungan tertinggi diperhatikan dalam OSM. Analisis korelasi bivariate tidak menunjukkan hubungan yang signifikan ($p \leq 0.05$) antara atribut kualiti minyak dan kepekatan akrilamida. Jenis minyak tetapi bukan kitaran menggoreng mempengaruhi kepekatan akrilamida dalam nugget daging lembu. Minyak sayuran yang paling sesuai dalam mengurangkan pembentukan akrilamida semasa proses pemanasan adalah OS. Seterusnya, kesan komposisi beta-karoten dan vitamin E yang berlainan dalam OSM bergabung pada parameter kinetik pembentukan/penghapusan akrilamida dalam sistem model asparagine-glukosa-lipid. Campuran minyak OSM dan kanola yang berbeza (10, 20 dan 30%) digunakan dan dipanaskan pada suhu (120, 140, 160, 180, dan 200 °C) selama 20 minit. Persamaan linear untuk setiap campuran minyak digambarkan di mana tenaga pengaktifan (*Ea*) dianggarkan dan didapati bahawa pembentukan akrilamida mematuhi Hukum Arhenius. Tahap OSM yang lebih tinggi yang digabungkan dalam campuran menyebabkan jumlah beta

karoten dan tokol yang lebih tinggi dalam campuran. Kandungan akrilamida ditentukan menggunakan kaedah GCMS dan hasil menunjukkan bahawa pembentukan akrilamida mematuhi Hukum Arrhenius. Kandungan akrilamida tertinggi dinyatakan ketika 30% OSM digunakan pada suhu 200°C sedangkan yang terendah dicatat ketika 20% OSM digunakan pada suhu 120°C. Sebaliknya nilai *Ea* adalah apabila 20% OSM digunakan dan 30% OSM menunjukkan nilai *Ea* terendah, secara tidak langsung menunjukkan bahawa tenaga yang lebih tinggi diperlukan agar tindak balas dapat diteruskan sehingga menyebabkan pembentukan akrilamida lebih rendah berbanding yang lain. Parameter kinetik campuran minyak OSM yang berbeza yang dianggarkan dalam kajian ini dapat memberikan gambaran mengenai campuran OSM yang optimum untuk mengurangkan pembentukan akrilamida pada suhu yang tinggi.

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Maimunah Sanny, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Chairman)

Azmil Haizam Ahmad Tarmizi, PhD
Product Development and Advisory Services Division
Malaysia Palm Oil Board
(Member)

Rabiha binti Sulaiman, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

Jinap binti Selamat, PhD
Professor
Institute of Tropical Agriculture and Food Security
Universiti Putra Malaysia
(Member)

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

Date: 14 April 2022

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature : _____

Name of Chairman of
Supervisory Committee : Assoc. Prof. Dr. Maimunah Sanny

Signature : _____

Name of Member of
Supervisory Committee : Dr. Azmil Haizam Ahmad Tarmizi

Signature : _____

Name of Member of
Supervisory Committee : Assoc. Prof. Dr. Rabiha Sulaiman

Signature : _____

Name of Member of
Supervisory Committee : Prof. Dr. Jinap Selamat

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LIST OF ABBREVIATIONS

%	Percentage
°C	Degree celcius
µg	Microgram
µl	Microliter
µmol	Micromole
ANOVA	Analysis of variance
AOCS	American Oil Chemists' Society
APA	Aminopropionamide
b.w.	body weight
BHT	Butylated hydroxytoluene
C	Concentration of acrylamide
cm	Centimeter
CO	Canola oil
DAG	Diacylglycerols
DE	Diethyl ether
Ea	Activation energy
EFSA	European Food Safety Authority
EGCG	Epigallocatechin gallate
ELSD	Evaporative Light Scattering Detector
FAC	Fatty acid composition
FAME	Fatty acid methyl ester
FAQ	Food and Agricultural Organization
FDA	Food and Drug Administration
FFA	Free Fatty Acid

FFQ	Food Frequency Questionnaire
FID	Flame Ionization Detector
g	Gram
GC	Gas Chromatography
HLB	Hydrophilic-Lipophilic-Balanced
HPLC	High Performance Liquid Chromatography
IARC	International Agency for Research on Cancer
IUPAC	International Union of Pure and Applied Chemistry
J	Joule
K	Rate constant
K	Kelvin
kg	Kilogram
m	Meter
m/z	Mass to charge ratio
MAG	Monoacylglycerols
MCX	Mixed-mode Cation-eXchange
mg	Milligram
mL	Milliliter
mm	Millimeter
mmol	millimole
MUFA	Monounsaturated fatty acid
ng	Nanogram
OTAG	Oxidised triacylglycerol
OxTAG	oxidized triacylglycerols
p-AV	*p*-anisidine value
PE	Petroleum ether

PMC	2,2,5,7,8-Pentamethyl-6-chromanol
PO	Palm oil
PTAG	Polymerised triacylglycerol
PTAG	polymerized triacylglycerols
PUFA	Polyunsaturated acid
PV	Peroxide value
RCF	Relative centrifugal force
RR	Ranger Russet
RSPO	Red palm oil
SBO	Soybean oil
SFA	Saturated fatty acid
SFO	Sunflower oil
TAG	Triacylglycerol
TBHQ	Food and Drug Administration
THF	Tetrahydrofuran
TOTOX	Total oxidation value
TPC	Total polar compounds
TRF	Tocols rich fraction
VG	Van Gogh
VOO	Virgin olive oil
WHO	World Health Organisation

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Heat treatment is a common method applied in food production in order to improve the final quality of food. However, it was reported that heat treatment with the temperature slightly above 120°C, will cause the formation of acrylamide in the food (Mottram, Wedzicha, & Dodson, 2002; Tareke, Rydberg, Karlsson, Eriksson, & Törnqvist, 2002). Acrylamide has been classified under Group 2A; probably carcinogenic to human since 1994 by the International Agency for Research on Cancer (1994) which can lead to potential to cause toxic effects in animals and humans (Baskar & Aiswarya, 2018). In 2002, Swedish National Food Administration and the University of Stockholm announced the discovery of acrylamide in a variety of heated starch-rich foods at high temperatures (Tareke et al., 2002). Apparently, it has been found that widely consumed foods, such as potato products (potato chips and French fries), cereal-based products (biscuits, bakery foods, breakfast cereals and bread) and coffee, are highly risk with acrylamide (Zhang, Huang, Wang, & Cheng, 2016).

Frying is one of the widely applied methods in food processing in order to make the food more palatable and desirable (Pankaj & Keener, 2017) thus increasing high consumption of fried food such as nugget which is commonly found in food establishments (Barbut, 2013). However, frying has been associated with acrylamide formation in which it was reported that frying cycles (Gertz, 2004; Lim, Jinap, Sanny, & Tan, 2014) and type of oils influenced the acrylamide formation in fried food (Becalski, Lau, Lewis, & Seaman, 2003; Daniali, Jinap, Hajeb, & Sanny, 2016). Different oil types composed of different fat composition and chain length, for instance previous research works reported that higher acrylamide formation is more likely to take place in lipid with higher unsaturation level due to higher lipid oxidation rate (Capuano, Oliviero, Açar, Gökmen, & Fogliano, 2010). Apart from Maillard reaction, lipid oxidation has been acknowledged as a minor pathway for acrylamide formation in food (Gertz & Klostermann, 2002; Jin, Wu, & Zhang, 2013; Weisshaar, 2004) via its precursor, acrolein; the acrolein formed due to dehydration of glycerol which was further oxidised becoming acrylic acid which then generate acrylamide with presence of asparagine (Yasuhara, Tanaka, Hengel, & Shibamoto, 2003).

Consequently, various studies have been conducted to reduce the formation of acrylamide in food, including the application of antioxidants in the recipe formulation (Jing et al., 2019). Antioxidants has been reported to able to give discordant; both positive and negative effect on acrylamide formation in food and model systems (Jin et al., 2013). Reduction of acrylamide contents was reported in fried potato slices, cookies, and crackers when associated with rosemary herb, vitamin E and ascorbic acid and ascorbate respectively (Becalski et al., 2003; Li

et al., 2012). However, addition of BHT, sesamol, and vitamin E to meat before heating elevated the formation of acrylamide (Tareke, 2003). In a lipid oxidation system, antioxidants inhibit acrylamide formation via interrupting the lipid oxidation to take place, hence limiting the carbonyls accumulation (Jin et al., 2013). Additionally, vegetable oils contain fat-soluble antioxidants, mainly vitamin E (tocopherols and tocotrienols) and beta-carotene (Jin et al., 2013; Sundram, Sambanthamurthi, & Tan, 2003).

Food matrices are very complicated involving many chemical and physical interactions, hence model system is applied alternatively in to obtain a clearer understanding of the reactions occurred (Van Boekel, 2008). Kinetic expresses the rate of a reaction (De Vleeschouwer, Van der Plancken, Van Loey, & Hendrickx, 2009). Thus, kinetic model describes those reactions in term of mathematical relationship among the variables, consisting of kinetic parameters known as reaction orders, reaction rates and activation energies. Since acrylamide mitigation effort is highly associated with temperature and time combination, Arrhenius equation has been applied in kinetic models to obtain insight into how insight on how the reactions proceed (Ravi & Gurunathan, 2018).

1.2 Problem Statements

Since nugget is subjected to deep frying, it is a matter of concern to investigate the acrylamide formation in nugget. Furthermore, currently there are various types of nuggets can be obtained easily in the market. However, there is lack of studies on the formation of acrylamide in beef nugget during deep frying. Previous studies on chicken nuggets were focused on the oil quality instead of acrylamide formation (Bansal, Zhou, Barlow, Lo, & Neo, 2010; Enríquez-Fernández, Álvarez de la Cadena y Yañez, & Sosa-Morales, 2011; Park & Kim, 2016).

In addition, there are two types of antioxidants which are water soluble (e.g., ascorbic acid, phenolic compounds, and flavonoids) and lipid soluble (e.g., tocopherol, tocotrienol, and carotenoids) (Jin et al., 2013; Sundram, Sambanthamurthi, & Tan, 2003). However, previous acrylamide-antioxidants studies were mainly focused on the application of water-soluble antioxidants and lack of information on the application of fat-soluble antioxidants (Jin et al., 2013). Previously, it was suggested that the level of fat-soluble antioxidants present in the oils have been neglected in the studies that investigated the association of vegetable oils and acrylamide formation in food (Napolitano, Morales, Sacchi, & Fogliano, 2008).

Apart from that, various studies have been conducted to study the effect of lipid towards acrylamide formation/elimination in food and chemical model system such as dry fat-rich model systems (Capuano et al., 2010), oil-rich model systems (Nan et al., 2020), asparagine–lipid model system (Zamora & Hidalgo,

2008). Unfortunately, kinetics parameters of acrylamide formation in asparagine-glucose-lipid system have not been published.

1.3 Significance of Study

This study can give a better and clearer understanding on the role different vegetable oils and frying cycles on the acrylamide formation in beef nugget. Besides that, the gap of on kinetics parameters of acrylamide formation in asparagine-glucose-lipid system can be filled through this study. These will be beneficial to the researchers to help in developing methods dealing with acrylamide mitigation. Additionally, the findings in this study should be of interest to the food manufacturers, food processing industry, restaurateurs, and home-makers as it can be used as general precaution since deep-fat frying is widely applied in various food production.

1.4 Objectives of Study

Therefore, the objectives of this study were:

1. To investigate the effect of different vegetable oils and frying cycles on the acrylamide formation during the intermittent frying of beef nuggets.
2. To unravel the effect of different compositions of beta-carotene and vitamin E in red palm super olein (RPSO) blends on the kinetics parameters of acrylamide formation/elimination in an asparagine-glucose-lipid model system.

REFERENCES

Abdulkarim, S., Long, K., Lai, O., Muhammad, S., & Ghazali, H. (2007). Frying quality and stability of high-oleic *Moringa oleifera* seed oil in comparison with other vegetable oils. *Food Chemistry, 105*(4), 1382-1389. doi:10.1016/j.foodchem.2007.05.013

Abd Razak, R. A., Tarmizi, A. H. A., Kuntom, A., Sanny, M., & Ismail, I. S. (2021). Intermittent frying effect on French fries in palm olein, sunflower, soybean and canola oils on quality indices, 3-monochloropropane-1, 2-diol esters (3-MCPDE), glycidyl esters (GE) and acrylamide contents. *Food Control*, *124*, 107887.

Ahmad Tarmizi, A. H., Ahmad, K., Mat Sahri, M., & May, C. Y. (2016). Rancimat test for measuring the oxidative stability of cooking oils upon prolonged frying: short communication. *Journal of Oil Palm Research, 28*(4), 531-535. Retrieved from http://jopr.mpob.gov.my/wp-content/uploads/2016/12/JOPR-VOL.284-13.pdf

Ahmad Tarmizi, A., Abd Razak, R., Abdul Hammid, A., & Kuntom, A. (2019). Effect of anti-clouding agent on the fate of 3-monochloropropane-1,2-diol esters and glycidyl esters in palm olein during repeated frying. *Molecules, 24*(12), 2332. doi:10.3390/molecules24122332

Ahmad Tarmizi, A., Hishamuddin, E., & Abd Razak, R. (2019). Impartial assessment of oil degradation through partitioning of polar compounds in vegetable oils under simulated frying practice of fast food restaurants. *Food Control, 96*, 445-455. doi:10.1016/j.foodcont.2018.10.010

Ahmad Tarmizi, A., Ismail, R., & Kuntom, A. (2016). Effect of frying on the palm oil quality attributes – A review. *Journal of Oil Palm Research, 28*(2). Retrieved from https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.21894%2Fjopr.2016.2802.01

Ahmad, K. (2014). Availability of different types of palm olein and their performance during deep frying. *Journal of International Scientific Publications: Agriculture & Food, 2*, 511-520. Retrieved from https://www.scientific-publications.net/en/article/1000066/

Aladedunye, F., & Przybylski, R. (2009). Protecting oil during frying: A comparative study. *European Journal of Lipid Science and Technology, 111*(9), 893-901. doi:10.1002/ejlt.200900020

Aladedunye, F., & Przybylski, R. (2013). Performance of palm olein and modified rapeseed, sunflower, and soybean oils in intermittent deep-frying. *European Journal of Lipid Science and Technology, 116*(2), 144-152. doi:10.1002/ejlt.201300284

Ali, M., Daud, A., Latip, R., Othman, N. H., & Islam, M. (2014). Impact of chicken nugget presence on the degradation of canola oil during frying. *International Food Research Journal, 21*(3), 1083-1088. Retrieved from

https://www.researchgate.net/publication/287750387_Impact_of_chicken_nugget_presence_on_the_degradation_of_canola_oil_during_frying

Al-Khusaibi, M., Gordon, M., Lovegrove, J., & Niranjan, K. (2012). Frying of potato chips in a blend of canola oil and palm olein: Changes in levels of individual fatty acids and tocols. *International Journal of Food Science & Technology, 47*(8), 1701-1709. doi:10.1111/j.1365-2621.2012.03024.x

Aluyor, E., & Ori-Jesu, M. (2008). The use of antioxidants in vegetable oils–A review. *African Journal of Biotechnology, 7*(25), 4836-4842. Retrieved from https://www.researchgate.net/publication/228353606_The_use_of_antioxidants_in_vegetable_oils-A_review

Anese, M., Quarta, B., & Frias, J. (2011). Modelling the effect of asparaginase in reducing acrylamide formation in biscuits. *Food Chemistry, 126*(2), 435-440. doi:10.1016/j.foodchem.2010.11.007

AOCS. (2011). *Official Method Cd 18-90 p-Anisidine Value.* Urbana: The American Oil Chemists' Society.

AOCS. (2011). *Official Method Cd 8b-90. Peroxide value acetic acid–isooctane method.* Urbana: The American Oil Chemists' Society.

AOCS. (2012). *Official Methods and Recommended Practices of the AOCS (6th ed.)* (6 ed.). Urbana: The American Oil Chemists' Society.

AOCS. (2017). *AOCS Official Method Ce 8-89.* Urbana: The American Oil Chemists' Society.

Arrhenius, S. (1889). On the reaction rate of the inversion of nonrefined sugar at souring. *International Journal of Research in Physical Chemistry and Chemical Physics, 4*, 226.

Arribas-Lorenzo, G., Fogliano, V., & Morales, F. J. (2009). Acrylamide formation in a cookie system as influenced by the oil phenol profile and degree of oxidation. *European Food Research and Technology, 228*, 63-79. doi:10.1007/s00217-009-1026-z

Arslan, F., Şapçı, A., Duru, F., & Kara, H. (2017). A study on monitoring of frying performance and oxidative stability of cottonseed and palm oil blends in comparison with original oils. *International Journal of Food Properties, 20*(3), 704-717. doi:10.1080/10942912.2016.1177544

Awogbemi, O., Onuh, E. I., & Inambao, F. L. (2019). Comparative study of properties and fatty acid composition of some neat vegetable oils and waste cooking oils. *International Journal of Low-Carbon Technologies*, *14*(3), 417-425.

Babu, P., Aafrin, B. V., Archana, G., Sabina, K., Sudharsan, K., Sivarajan, M., & Sukumar, M. (2017). Effects of polyphenols from *Caralluma fimbriata* on acrylamide formation and lipid oxidation—An integrated approach of

nutritional quality and degradation of fried food. *International Journal of Food Properties, 20*(6), 1378-1390. doi:10.1080/10942912.2016.1210161

Bansal, G., Zhou, W., Barlow, P. J., Lo, H.-L., & Neo, F.-L. (2010). Performance of palm olein in repeated deep frying and controlled heating processes. *Food Chemistry, 121*(2), 338-347. doi:10.1016/j.foodchem.2009.12.034

Barbut, S. (2013). Frying — Effect of coating on crust microstructure, color, and texture of lean meat portions. *Meat Science, 93*(2), 269-274. doi:10.1016/j.meatsci.2012.09.006

Baskar, G., & Aiswarya, R. (2018). Overview on mitigation of acrylamide in starchy fried and baked goods. *Journal of the Science of Food and Agriculture, 98*(12). doi:10.1002/jsfa.9013

Bassama, J., Brat, P., Bohuon, P., Boulanger, R., & Günata, Z. (2010). Study of acrylamide mitigation in model system: Effect of pure phenolic compounds. *Food Chemistry, 123*(2), 558-562. doi:10.1016/j.foodchem.2010.04.071

Becalski, A., Lau, B. P.-Y., Lewis, D., & Seaman, S. W. (2003). Acrylamide in foods: occurrence, sources, and modeling. *Journal of Agricultural and Food Chemistry, 51*(3), 802-808. doi:10.1021/jf020889y

Bellaloui, N., Bruns, H., Gillen, A., Abbas, H., Zablotowicz, R., Mengistu, A., & Paris, R. (2010). Soybean seed protein, oil, fatty acids, and mineral composition as influenced by soybean-corn rotation. *Agricultural Sciences, 1*(3), 102-109. doi:10.4236/as.2010.13013

Berger, K. G. (2005). The use of palm oil in frying. *Malaysian Palm Oil Promotion Council.*

Bertuzzi, T., Martinelli, E., Mulazzi, A., & Rastelli, S. (2020). Acrylamide determination during an industrial roasting process of coffee and the influence of asparagine and low molecular weight sugars. *Food Chemistry, 303*. doi:10.1016/j.foodchem.2019.125372

Bouchon, P., Aguilera, J., & Pyle, D. (2003). Structure Oil-Absorption Relationships During Deep-Fat Frying. *Journal of Food Science, 68*(9), 2711-2716. doi:10.1111/j.1365-2621.2003.tb05793.x

Brannan, R. G., Mah, E., Schott, M., Yuan, S., Casher, K. L., Myers, A., & Herrick, C. (2013). Influence of ingredients that reduce oil absorption during immersion frying of battered and breaded foods. *European Journal of Lipid Science and Technology, 116*(3), 240-254. doi:10.1002/ejlt.201200308

Burley, V. J., Greenwood, D. C., Hepworth, S. J., Fraser, L. K., de Kok, T. M., van Breda, S. G., . . . Cade, J. E. (2010). Dietary acrylamide intake and risk of breast cancer in the UK women's cohort. *British Journal of Cancer, 103*, 1749-1754. doi:10.1038/sj.bjc.6605956

Butinar, B., Bučar-Miklavčič, M., Mariani, C., & Raspor, P. (2011). New vitamin E isomers (gamma-tocomonoenol and alpha-tocomonoenol) in seeds, roasted seeds and roasted seed oil from the Slovenian pumpkin variety '*Slovenska golica*'. Food chemistry, 128(2), 505-512.

Capuano, E., & Fogliano, V. (2011). Acrylamide and 5-hydroxymethylfurfural (HMF): A review on metabolism, toxicity, occurrence in food and mitigation strategies. *LWT - Food Science and Technology, 44*(4), 793-810. doi:https://doi.org/10.1016/j.lwt.2010.11.002

Capuano, E., Oliviero, T., Açar, Ö. Ç., Gökmen, V., & Fogliano, V. (2010). Lipid oxidation promotes acrylamide formation in fat-rich model systems. *Food Research International, 43*(4), 1021-1026. doi:https://doi.org/10.1016/j.foodres.2010.01.013

Carocho, M., & Ferreira, I. C. (2013). A review on antioxidants, prooxidants and related controversy: Natural and synthetic compounds, screening and analysis methodologies and future perspectives. *Food and Chemical Toxicology, 51*, 15-25. doi:https://doi.org/10.1016/j.fct.2012.09.021

Casal, S., Malheiro, R., Sendas, A., Oliveira, B., & Pereira, J. (2010). Olive oil stability under deep-frying conditions. *Food and Chemical Toxicology, 48*(10), 2972-2979. doi:10.1016/j.fct.2010.07.036

Cassiday, L. (February, 2017). Red palm oil. *INFORM Magazine*. Retrieved from https://ww.aocs.org/stay-informed/inform-magazine/featured-articles/red-palm-oil-february-2017?SSO=True

Castelo-Branco, V., Santana, I., Di-Sarli, V., Freitas, S., & Torres, A. (2016). Antioxidant capacity is a surrogate measure of the quality and stability of vegetable oils. *European Journal of Lipid Science and Technology, 118*(2), 224-235. doi:10.1002/ejlt.201400299

Cengiz, M. F., & Gündüz, C. (2013). Acrylamide exposure among Turkish toddlers from selected cereal-based baby food samples. *Food and Chemical Toxicology, 60*, 514-519. doi:10.1016/j.fct.2013.08.018

Cheng, J., Chen, X., Zhao, S., & Zhang, Y. (2015). Antioxidant-capacity-based models for the prediction of acrylamide reduction by flavonoids. *Food Chemistry, 168*, 90-99. doi:10.1016/j.foodchem.2014.07.008

Choe, E., & Min, D. (2007). Chemistry of deep-fat frying oils. *Journal of Food Science, 72*(5), 77-86. doi:10.1111/j.1750-3841.2007.00352.x

Claeys, W., De Vleeschouwer, K., & Hendrickx, M. (2005). Kinetics of acrylamide formation and elimination during heating of an asparagine−sugar model system. *Journal of Agricultural and Food Chemistry, 53*(26), 9999-1005. doi:10.1021/jf051197n

Constantinou, C., & Koutsidis, G. (2016). Investigations on the effect of antioxidant type and concentration and model system matrix on acrylamide formation in model Maillard reaction systems. *Food Chemistry, 197*, 769-775. doi:10.1016/j.foodchem.2015.11.037

Crozier, A., Jaganath, I. B., & Clifford, M. N. (2009). Dietary phenolics: Chemistry, bioavailability and effects on health. *Natural Product Reports, 26*(8), 1001-1043. doi:10.1039/b802662a

Dana, D., & Saguy, I. S. (2006). Review: Mechanism of oil uptake during deep-fat frying and the surfactant effect-theory and myth. *Advances in Colloid and Interface Science, 128-130*, 267-272. doi:10.1016/j.cis.2006.11.013

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

Daniali, G., Jinap, S., Sanny, M., & Tan, C. (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. doi:0.1016/j.foodchem.2017.10.070

Dauqan, E., Abdullah Sani, H., Abdullah, A., Muhamad, H., & Md. Top, A. (2011). Vitamin E and beta carotene composition in four different vegetable oils. *American Journal of Applied Sciences, 8*(5), 407-412. doi:10.3844/ajassp.2011.407.412

De Vleeschouwer, K., Van der Plancken, I., Van Loey, A., & Hendrickx, M. (2009). Modelling acrylamide changes in foods: From single-response empirical to multiresponse mechanistic approaches. *Trends in Food Science & Technology, 20*(3-4), 155-167. doi:https://doi.org/10.1016/j.tifs.2009.01.060

De Vleeschower, K., Van der Plancken, I., Van Loey, A., & Hendrix, M. (2008). The kinetics of acrylamide formation/elimination in asparagine–glucose systems at different initial reactant concentrations and ratios. *Food Chemistry, 111*(3), 719-729. doi:10.1016/j.foodchem.2008.04.045

Del Carmen Flores-Álvarez, M., Molina-Hernández, E., Hernández-Raya, J., & Sosa-Morales, M. (2012). The effect of food type (fish nuggets or French fries) on oil blend degradation during repeated frying. *Journal of Food Science, 77*(11), 1136-1143. doi:10.1111/j.1750-3841.2012.02930.x

Dobarganes, M., Velasco, J., & Dieffenbacher, A. (2000). Determination of polar compounds, polymerized and oxidized triacylglycerols, and diacylglycerols in oils and fats - Results of collaborative studies and the standardized method (Technical Report). *Pure and Applied Chemistry, 72*(8), 1563-1575. doi:10.1351/pac200072081563

Dorni, C., Sharma, P., Saikia, G., & Longvah, T. (2018). Fatty acid profile of edible oils and fats consumed in India. *Food Chemistry, 238*, 9-15. doi:10.1016/j.foodchem.2017.05.072

Edem, D. (2002). Palm oil: Biochemical, physiological, nutritional, hematological and toxicological aspects: A review. *Plant Foods for Human Nutrition, 57*(3-4), 319-341. doi:10.1023/a:1021828132707

EFSA CONTAM Panel. (2015). Scientific Opinion on acrylamide in food. *EFSA Journal, 13*(6), 4104. doi:10.2903/j.efsa.2015.4104

Ehling, S., Hengel, M., & Shibamoto, T. (2005). Formation of acrylamide from lipids. *Chemistry and Safety of Acrylamide in Food, 561*, 223-233. doi:10.1007/0-387-24980-X_17

El-Hadad, N., Abou-Gharbia, H., Abd El-Aal, M., & Mohamoud Youssef, M. (2009). Red palm olein: Characterization and utilization in formulating novel functional biscuits. *Journal of the American Oil Chemists' Society, 87*, 295-304. doi:10.1007/s11746-009-1497-x

Enríquez-Fernández, B. E., Álvarez de la Cadena y Yañez, L., & Sosa-Morales, M. E. (2011). Comparison of the stability of palm olein and a palm olein/canola oil blend during deep-fat frying of chicken nuggets and French fries. *International Journal of Food Science & Technology, 46*(6), 1231-1237. doi:10.1111/j.1365-2621.2011.02627.x

Falowo, A. B., Fayemi, P. O., & Muchenje, V. (2014). Natural antioxidants against lipid–protein oxidative deterioration in meat and meat products: A review. *Food Research International, 64*, 171-181. doi:https://doi.org/10.1016/j.foodres.2014.06.022

FDA. (October, 2006). *Survey Data on Acrylamide in Food: Total Diet Study Results*. Retrieved 21 January, 2018, from FDA: https://www.fda.gov/food/chemicals/survey-data-acrylamide-food-total-diet-study-results#table4

Feng, H.-X., Sam, R., Jiang, L.-Z., Li, Y., & Cao, W.-M. (2016). High-performance size-exclusion chromatography studies on the formation and distribution of polar compounds in camellia seed oil during heating. *Journal of Zheijang University SCIENCE B - Biomedicine & Biotechnology, 17*(11), 882-891. doi:10.1631/jzus.B1600173

Freisling, H., Moskal, A., Ferrari, P., Nicolas, G., Knaze, V., Clavel-Chapelon, F., . . . Slimani, N. (2013). Dietary acrylamide intake of adults in the European Prospective Investigation into Cancer and Nutrition differs greatly according to geographical region. *European Journal of Nutrition, 52*(4), 1369-1380. doi:https://doi.org/10.1007/s00394-012-0446-x

Friedman, M. (2003). Chemistry, biochemistry, and safety of acrylamide. A review. *Journal of Agricultural and Food Chemistry, 51*(16), 4504-4526. doi:https://doi.org/10.1021/jf030204+

Friedman, M. A., Dulak, L. H., & Stedham, M. A. (1995). A Lifetime Oncogenicity Study in Rats with Acrylamide. *Fundamental and Applied Toxicology, 27*(1), 95-105. doi:https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.1006%2Ffaat.1995.1112

Gertz, C. (2004). Optimising the baking and frying process using oil-improving agents. *European Journal of Lipid Science and Technology, 106*(11), 736-745. doi:https://doi.org/10.1002/ejlt.200401015

Gertz, C., & Klostermann, S. (2002). Analysis of acrylamide and mechanisms of its formation in deep-fried products. *European Journal of Lipid Science*

and Technology, 104(11), 762-771. doi:https://doi.org/10.1002/1438-9312(200211)104:11%3C762::AID-EJLT762%3E3.0.CO;2-R

Ghasemian, S., Rezaei, K., Abedini, R., Poorazarang, H., & Ghaziani, F. (2014). Investigation of different parameters on acrylamide production in the fried beef burger using Taguchi experimental design. *Journal of Food Science and Technology, 51*(3), 440-448. doi: 10.1007/s13197-011-0514-x

Ghazani, S., & Marangoni, A. (2013). Minor components in canola oil and effects of refining on these constituents: A review. *Journal of the American Oil Chemists' Society volume, 90*, 923-932. doi:10.1007/s11746-013-2254-8

Gholami, F., Rahman, A., & Mostaghim, T. (2017). Effects of rosemary and thyme extracts on acrylamide formation in fried beef. *International Journal of Scientific Research in Science and Technology, 3*(4), 352-360.

Gökmen, V. (2015). *Acrylamide in Food: Analysis, Content and Potential Health Effects.* Cambridge: Academic Press.

Gökmen, V., & Senyuva, H. (2006). A simplified approach for the kinetic characterization of acrylamide formation in fructose-asparagine model system. *Food Additives and Contaminants, 23*(4), 348-354. doi:10.1080/02652030500482355

Gökmen, V., Tolgahan, K., Neslihan, G., & Mogol, B. (2012). Model studies on the role of 5-hydroxymethyl-2-furfural in acrylamide formation from asparagine. *Food Chemistry, 132*(1), 168-174. doi:10.1016/j.foodchem.2011.10.048

Hedegaard, R. V., Granby, K., Frandsen, H., Thygesen, J., & Skibsted, L. (2008). Acrylamide in bread. Effect of prooxidants and antioxidants. *European Food Research and Technology, 227*(2), 519-525. doi:https://doi.org/10.1007/s00217-007-0750-5

Hekmat, S., & Haines, J. (2003). Comparison of the effects of Carotino and canola oils on the sensory properties of various foods. *Nutrition Research, 23*(9), 1211-1219. doi:https://doi.org/10.1016/S0271-5317(03)00129-5

Hogervost, J. G., Schouten, L. J., Konings, E. J., Goldbohm, R. A., & van den Brandt, P. A. (2007). A prospective study of dietary acrylamide intake and the risk of endometrial, ovarian, and breast cancer. *Cancer Epidemiology Biomarkers & Prevention, 16*(11), 2304-2313. doi:https://doi.org/10.1158/1055-9965.epi-07-0581

Hou, L., Xie, J., Zhao, J., Zhao, M., Fan, M., Xiao, Q., . . . Chen, F. (2017). Roles of different initial Maillard intermediates and pathways in meat flavor formation for cysteine-xylose-glycine model reaction systems. *Food Chemistry, 232*, 135-144. doi:https://doi.org/10.1016/j.foodchem.2017.03.133

Hsu, H.-T., Chen, M.-J., Tseng, T.-P., Cheng, L.-H., Huang, L.-J., & Yeh, T.-S. (2016). Kinetics for the distribution of acrylamide in French fries, fried oil and vapour during frying of potatoes. *Food Chemistry, 211*, 669-678. doi:10.1016/j.foodchem.2016.05.125

Huang, M., Wang, Q., Chen, X., & Zhang, Y. (2017). Unravelling effects of flavanols and their derivatives on acrylamide formation via support vector machine modelling. *Food Chemistry, 221*, 178-186. doi:10.1016/j.foodchem.2016.10.060

International Agency for Research on Cancer. (1994). *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans*. *60*. Retrieved from https://monographs.iarc.who.int/wp-content/uploads/2018/06/mono60.pdf

Isleroglu, H., Kemerli, T., Sakin-Yilmazer, M., Guven, G., Ozdestan, O., Uren, A., & Kaymak-Ertekin, F. (2012). Effect of steam baking on acrylamide formation and browning kinetics of cookies. *Journal of Food Science, 77*(10). doi:10.1111/j.1750-3841.2012.02912.x

Israilides, C., & Theodoros, V. (2015). Strategies to Reduce the Formation of Acrylamide in Potato Chips. A Market and Consumer's Prospective. *Current Research in Nutrition and Food Science Journal, 3*(1), 20-25. doi:http://dx.doi.org/10.12944/CRNFSJ.3.1.03

Jin, C., Wu, X., & Zhang, Y. (2013). Relationship between antioxidants and acrylamide formation: A review. *Food Research International, 51*(2), 611-620. doi:https://doi.org/10.1016/j.foodres.2012.12.047

Jing, Y., Li, X., Hu, X., Ma, Z., Liu, L., & Ma, X. (2019). Effect of buckwheat extracts on acrylamide formation and the quality of bread. *Journal of the Science of Food and Agriculture, 99*(14), 6482-6489. doi:https://doi.org/10.1002/jsfa.9927

Johnson, K. A., Gorzinski, S. J., Bodner, K. M., Campbell, R. A., Wolf, C. H., Friedman, M. A., & Mast, R. W. (1986). Chronic toxicity and oncogenicity study on acrylamide incorporated in the drinking water of Fischer 344 rats. *Toxicology and Applied Pharmacology, 85*(2), 154-168. doi:https://doi.org/10.1016/0041-008x(86)90109-2

Juárez, M. D., Osawa, C. C., Acuña, M. E., Sammán, N., & Gonçalve, L. (2011). Degradation in soybean oil, sunflower oil and partially hydrogenated fats after food frying, monitored by conventional and unconventional methods. *Food Control, 22*(12), 1920-1927. doi:https://doi.org/10.1016/j.foodcont.2011.05.004

Kahkeshani, N., Saeidnia, S., & Abdollahi, M. (2015). Role of antioxidants and phytochemicals on acrylamide mitigation from food and reducing its toxicity. *Journal of Food Science and Technology, 52*(6), 3169-3186. doi:https://dx.doi.org/10.1007%2Fs13197-014-1558-5

Kamal-Eldin, A. (2019). Antioxidative activity of vitamin E. *Vitamin E in Human Health*, 19-30. doi:10.1007/978-3-030-05315-4_3

Kamarudin, S. A., Jinap, S., Sukor, R., Foo, S. P., & Sanny, M. (2018). Effect of fat-soluble anti-oxidants in vegetable oils on acrylamide concentrations during deep-fat frying of French fries. *Malaysian Journal of Medical Sciences, 25*(5), 128-139. doi:https://dx.doi.org/10.21315%2Fmjms2018.25.5.12

Karimi, S., Wawire, M., & Mathooko, F. (2017). Impact of frying practices and frying conditions on the quality and safety of frying oils used by street vendors and restaurants in Nairobi, Kenya. *Journal of Food Composition and Analysis, 62*, 239-244. doi:10.1016/j.jfca.2017.07.004

Knol, J. J., Linssen, J. P., & van Boekel, M. A. (2010). Unravelling the kinetics of the formation of acrylamide in the Maillard reaction of fructose and asparagine by multiresponse modelling. *Food Chemistry, 120*(4), 1047-1057. doi:10.1016/j.foodchem.2009.11.049

Knol, J., van Loon, W., Linssen, J., Ruck, A.-L., van Boekel, M., & Voragen, A. (2005). Toward a kinetic model for acrylamide formation in a glucose−asparagine reaction system. *Journal of Agricultural and Food Chemistry, 53*(15), 6133-6139. doi:10.1021/jf050504m

Kotsiou, K., Tasioula-Margari, M., Capuano, E., & Fogliano, V. (2011). Effect of standard phenolic compounds and olive oil phenolic extracts on acrylamide formation in an emulsion system. *Food Chemistry, 124*(1), 242-247. doi:https://doi.org/10.1016/j.foodchem.2010.06.025

Kotsiou, K., Tasioula-Margari, M., Kukurová, K., & Ciesarová, Z. (2010). Impact of oregano and virgin olive oil phenolic compounds on acrylamide content in a model system and fresh potatoes. *Food Chemistry, 123*(4), 1149-1155. doi:10.1016/j.foodchem.2010.05.078

Krishnakumar, T., & Visvanathan, R. (2014). Acrylamide in food products: A review. *Journal of Food Processing and Technology, 5*(7). doi:10.4172/2157-7110.1000344

Kuek, S., Ahmad Tarmizi, A., Abd Razak, R., Jinap, S., Norliza, S., & Sanny, M. (2020). Contribution of lipid towards acrylamide formation during intermittent frying of French fries. *Food Control, 118*. doi:10.1016/j.foodcont.2020.107430

Lebold, K., & Traber, M. (2014). Interactions between alpha-tocopherol, polyunsaturated fatty acids, and lipoxygenases during embryogenesis. *Free Radical Biology and Medicine, 66*, 13-19. doi:https://doi.org/10.1016/j.freeradbiomed.2013.07.039

Lenz, M., & Lund, D. (1980). Experimental procedures for determining destruction kinetics of food components. *Food Technology (USA), 34*(2), 51-55.

Li, D., Chen, Y., Zhang, Y., Lu, B., Jin, C., Wu, X., & Zhang, Y. (2012). Study on mitigation of acrylamide formation in cookies by 5 antioxidants. *Journal of Food Science, 77*(11), 1144-1149. doi:https://doi.org/10.1111/j.1750-3841.2012.02949.x

Li, X., Li, J., Wang, Y., Cao, P., & Liu, Y. (2017). Effects of frying oils' fatty acids profile on the formation of polar lipids components and their retention in French fries over deep-frying process. *Food Chemistry, 237*, 98-105. doi:https://doi.org/10.1016/j.foodchem.2017.05.100

Lim, P. K., Jinap, S., Sanny, M., Tan, C. P., & Khatib, A. (2014). The influence of deep frying using various vegetable oils on acrylamide formation in sweet potato (*Ipomoea batatas* L. Lam) chips. *Journal of Food Science, 79*(1), 115-121. doi:10.1111/1750-3841.12250

Loganathan, R., Ahmad Tarmizi, A., Vethakhan, S., & Teng, K.-T. (2020). Retention of carotenes and vitamin E, and physico-chemical changes occurring upon heating red palm olein using deep-fat fryer, microwave oven and conventional oven. *Journal of Oleo Science, 69*(3), 167-183. doi:10.5650/jos.ess19209.

Mancini, A., Imperlini, E., Nigro, E., Montagnese, C., Daniele, A., Orrù, S., & Buono, P. (2015). Biological and nutritional properties of palm oil and palmitic acid: Effects on health. *Molecules, 20*(9), 17339-17361. doi:https://doi.org/10.3390/molecules200917339

Martins, S. I., Jongen, W. M., & van Boekel, M. A. (2000). A review of Maillard reaction in food and implications to kinetic modelling. *Trends in Food Science & Technology, 11*(9-10), 364-373. doi:10.1016/S0924-2244(01)00022-X

Martins, S., & van Boekel, M. (2005). A kinetic model for the glucose/glycine Maillard reaction pathways. *Food Chemistry, 90*(1-2), 527-269. doi:10.1016/j.foodchem.2004.04.006

Matthäus, B., Haase, N., & Vosmann, K. (2004). Factors affecting the concentration of acrylamide during deep-fat frying of potatoes. *European Journal of Lipid Science and Technology, 106*(11), 793-801. doi:https://doi.org/10.1002/ejlt.200400992

May, C. Y., & Nesaretnam, K. (2014). Research advancements in palm oil nutrition. *European Journal of Lipid Science and Technology, 116*(10), 1301-1315. doi:https://doi.org/10.1002/ejlt.201400076

Mba, O., Dumont, M.-J., & Ngadi, M. (2017). Thermostability and degradation kinetics of tocochromanols and carotenoids in palm oil, canola oil and their blends during deep-fat frying. *LWT - Food Science and Technology, 82*, 131-138. doi:10.1016/j.lwt.2017.04.027

Mestdagh, F., De Meulenaer, B., & Van Petegham, C. (2007). Influence of oil degradation on the amounts of acrylamide generated in a model system and in French fries. *Food Chemistry, 100*(3), 1153-1159. doi:10.1016/j.foodchem.2005.11.025

Mestdagh, F., 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*(15), 6170-6174. doi:10.1021/jf0506683

Mosjka, H., Gielecińska, I., Szponar, L., & Ołtarzewski, M. (2010). Estimation of the dietary acrylamide exposure of the Polish population. *Food and Chemical Toxicology, 48*(8-9), 2090-2096. doi:https://doi.org/10.1016/j.fct.2010.05.009

Mottram, D. S., Wedzicha, B. L., & Dodson, A. T. (2002). Acrylamide is formed in the Maillard reaction. *Nature*, 448-449.

Multari, S., Marsol-Vall, A., Heponiemi, P., Suomela, J. P., & Yang, B. (2019). Changes in the volatile profile, fatty acid composition and other markers of lipid oxidation of six different vegetable oils during short-term deep-frying. Food Research International, 122, 318-329.

Mulla, M., Annapure, U., Bharadwaj, V., & Singhal, R. (2016). A study on the kinetics of acrylamide formation in banana chips. *Journal of Food Processing and Preservation, 41*(1). doi:10.1111/jfpp.12739

Nan, X., Wu, Q., Nan, S., Zeng, X., Dai, Y., & Kang, L. (2020). Effect of oil oxidation on acrylamide formation in oil-rich model systems without the participation of reducing sugars. *Journal of Food Protection, 83*(2), 342-349. doi:https://doi.org/10.4315/0362-028X.JFP-19-353

Napolitano, A., Morales, F., Sacchi, R., & Fogliano, V. (2008). Relationship between virgin olive oil phenolic compounds and acrylamide formation in fried crisps. *Journal of Agricultural and Food Chemistry, 56*(6), 2034-2040. doi:https://doi.org/10.1021/jf0730082

Nayak, P. K., Dash, U., Rayaguru, K., & Krishnan, K. R. (2015). Physio-chemical changes during repeated frying of cooked oil: A review. *Journal of Food Biochemistry, 40*(3), 371-390. doi:https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.1111%2Fjfbc.12215

Naz, S., Sherazi, S., & Talpur, F. N. (2010). Changes of total tocopherol and tocopherol species during sunflower oil processing. *Journal of the American Oil Chemists' Society, 88*(1), 127-132. doi:https://doi.org/10.1007/s11746-010-1652-4

Nodeh, H., Wan Ibrahim, W., Kamboh, M., & Sanagi, M. (2018). Magnetic graphene sol-gel hybrid as clean-up adsorbent for acrylamide analysis in food samples prior to GC-MS. *Food Chemistry, 239*, 208-216. doi:10.1016/j.foodchem.2017.06.094

Obón-Santacana, M., Slimani, N., Lujan-Barroso, L., Travier, N., Hallmans, G., Freisling, H., . . . Duell, E. J. (2013). Dietary intake of acrylamide and pancreatic cancer risk in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohort. *Annals of Oncology, 24*(10), 2645-2651. doi:https://doi.org/10.1093/annonc/mdt255

Olesen, P. T., Olsen, A., Frandsen, H., Frederiksen, K., Overvad, K., & Tjønneland, A. (2008). Acrylamide exposure and incidence of breast cancer among postmenopausal women in the Danish diet, cancer and health study. *International Journal of Cancer, 122*(9), 2094-2100. doi:https://doi.org/10.1002/ijc.23359

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

Oroian, M., & Escriche, I. (2015). Antioxidants: Characterization, natural sources, extraction and analysis. *Food Research International, 74*, 10-36. doi:https://doi.org/10.1016/j.foodres.2015.04.018

Pal, U. S., Patra, R., Sahoo, N. R., Bakhara, C., & Panda, M. (2015). Effect of refining on quality and composition of sunflower oil. *Journal of Food Science and Technology, 52*(7), 4613-4618. doi:https://dx.doi.org/10.1007%2Fs13197-014-1461-0

Pankaj, S. K., & Keener, K. M. (2017). A review and research trends in alternate frying technologies. *Current Opinion in Food Science, 16*, 74-79. doi:https://doi.org/10.1016/j.cofs.2017.09.001

Parcell, J., Kojima, Y., Roach, A., & Cain, W. (2018). Global edible vegetable oil market trends. *Biomedical Journal of Scientific & Technical Research, 2*(1), 2282-2291. doi:10.26717/BJSTR.2018.02.000680

Park, J.-M., & Kim, J.-M. (2016). Monitoring of used frying oils and frying times for frying chicken nuggets using peroxide value and acid value. *Korean Journal for Food Science of Animal Resources, 36*(5), 612-616. doi:https://doi.org/10.5851/kosfa.2016.36.5.612

Patrick, L. (2000). Beta-carotene: The controversy continues. *Alternative Medicine Review, 5*(6), 530-545.

Pedreschi, F., Mariotti, M., & Granby, K. (2014). Current issues in dietary acrylamide: Formation, mitigation and risk assessment. *Journal of the Science of Food and Agriculture, 94*(1), 9-20. doi:https://doi.org/10.1002/jsfa.6349

Ravi, A., & Gurunathan, B. (2018). Acrylamide mitigation in fried kochchi kesel chips using free and immobilized fungal asparaginase. *Food Technology and Biotechnology, 56*(1), 51-57. doi:https://doi.org/10.17113/ftb.56.01.18.5422

Riboldi, B. P., Vinhas, Á. M., & Moreira, J. D. (2014). Risks of dietary acrylamide exposure: A systematic review. *Food Chemistry, 157*, 310-322. doi:https://doi.org/10.1016/j.foodchem.2014.02.046

Rietjens, I., Boersma, M., de Haan, L., Spenkelink, B., Awad, H., Cnubben, N., . . . Koeman, J. (2002). The pro-oxidant chemistry of the natural antioxidants vitamin C, vitamin E, carotenoids and flavonoids. *Environmental Toxicology and Pharmacology, 11*(3-4), 321-333. doi:10.1016/s1382-6689(02)00003-0

Rydberg, P., Eriksson, S., Tareke, E., Karlsson, P., Ehrenberg, L., & Törnqvist, M. (2003). Investigations of factors that influence the acrylamide content of heated foodstuffs. *Journal of Agricultural and Food Chemistry, 51*(24), 7012-7018. doi:https://doi.org/10.1021/jf034649+

Sampaio, K., Ayala, J., Silva, S., Ceriani, R., Verhé, R., & Meirelles, A. (2012). Thermal degradation kinetics of carotenoids in palm oil. *Journal of the American Oil Chemists' Society, 90*(2), 191-198. doi:10.1007/s11746-012-2156-1

Sanny, M., Jinap, S., Bakker, E., van Boekel, M., & Luning, P. (2012). Possible causes of variation in acrylamide concentration in French fries prepared in food service establishments: An observational study. *Food Chemistry, 132*(1), 134-143. doi:https://doi.org/10.1016/j.foodchem.2011.10.044

Sebastian, A., Ghazani, S., & Marangoni, A. (2014). Quality and safety of frying oils used in restaurants. *Food Research International, 64*, 420-423. doi:10.1016/j.foodres.2014.07.033

Seppanen, C., Song, Q., & Csallany, A. (2010). The antioxidant functions of tocopherol and tocotrienol homologues in oils, fats, and food systems. *Journal of the American Oil Chemists' Society volume, 87*, 469-481. doi:10.1007/s11746-009-1526-9

Serjouie, A., Tan, C., Mirhosseini, H., & Che Man, Y. (2010). Effect of vegetable-based oil blends on physicochemical properties of oils during deep-fat frying. *American Journal of Food Technology, 5*, 310-323. doi:10.3923/ajft.2010.310.323

Soncu, E., & Kolsarici, N. (2017). Microwave thawing and green tea extract efficiency for the formation of acrylamide throughout the production process of chicken burgers and chicken nuggets. *Journal of the Science of Food and Agriculture, 97*(6), 1790-1797. doi:10.1002/jsfa.7976

Soncu, E., Haskaraca, G., & Kolsarıcı, N. (2017). Presence of acrylamide and heterocyclic aromatic amines in breaded chicken meat products and dietary exposure of Turkish population from Ankara based on the food frequency questionnaire study. *European Food Research and Technology volume, 244*, 501-511. doi:10.1007/s00217-017-2976-1

Stadler, R. H. (2003). Editorial: Understanding the formation of acrylamide and other Maillard-derived vinylogous compounds in foods. *European Journal of Lipid Science and Technology, 105*(5), 199-200. doi:https://doi.org/10.1002/ejlt.200390051

Stadler, R. H., Blank, I., Varga, N., Robert, F., Hau, J., Guy, P. A., . . . Riediker, S. (2002). Acrylamide from Maillard reaction products. *Nature, 419*, 449-450. doi:https://doi.org/10.1038/419449a

Stadler, R. H., Robert, F., Riediker, S., Varga, N., Davidek, T., Devaud, S., . . . Blank, I. (2004). In-depth mechanistic study on the formation of acrylamide and other vinylogous compounds by the maillard reaction. *Journal of Agricultural and Food Chemistry, 52*(17), 5550-5558. doi:https://doi.org/10.1021/jf0495486

Stadler, R. H., Verzegnassi, L., Varga, N., Grigorov, M., Studer, A., Riediker, S., & Schilter, B. (2003). Formation of vinylogous compounds in model maillard reaction systems. *Chemical Research in Toxicology, 16*(10), 1242-1250. doi:https://doi.org/10.1021/tx034088g

Stahl, W., & Sies, H. (2003). Antioxidant activity of carotenoids. *Molecular Aspects of Medicine, 24*(6), 345-351. doi:https://doi.org/10.1016/S0098-2997(03)00030-X

Sundram, K., Sambanthamurthi, R., & Tan, Y.-A. (2003). Palm fruit chemistry and nutrition. *Asia Pacific Journal of Clinical Nutrition, 12*(3), 355-362.

Tareke, E. (2003). *Identification and Origin of Potential Background Carcinogens: Endogenous Isoprene and Oxiranes, Dietary Acrylamide.* Stockholm University, Department of Environmental Chemistry. Department of Environmental Chemistry.

Tareke, E., Rydberg, P., Karlsson, P., Eriksson, S., & Törnqvist, M. (2002). Analysis of acrylamide, a carcinogen formed in heated foodstuffs. *Journal of Agricultural and Food Chemistry*.

Tepe, T., & Kadakal, Ç. (2019). Temperature and slice size dependences of acrylamide in potato fries. *Journal of Food Processing and Preservation, 43*(12). doi:10.1111/jfpp.14270

Tran, N., Barraj, L. M., Murphy, M. M., & Bi, X. (2010). Dietary acrylamide exposure and hemoglobin adducts--National Health and Nutrition Examination Survey (2003-04). *Food and Chemical Toxicology, 48*(11), 3098-3108. doi:https://doi.org/10.1016/j.fct.2010.08.003

Tyagi, V., & Vasishta, A. (1996). Changes in the characteristics and composition of oils during deep-fat frying. *Journal of the American Oil Chemists' Society volume, 73*, 499-506. doi:10.1007/BF02523926

Van Boekel, M. A. (2008). Kinetic modeling of food quality: A critical review. *Comprehensive Reviews in Food Science and Food Safety, 7*(1), 144-158. doi:https://doi.org/10.1111/j.1541-4337.2007.00036.x

Vattem, D. A., & Shetty, K. (2003). Acrylamide in food: A model for mechanism of formation and its reduction. *Innovative Food Science & Emerging Technologies, 4*(3), 331-338. doi:https://doi.org/10.1016/S1466-8564(03)00033-X

Vieira, S., Zhang, G., & Decker, E. (2017). Biological implications of lipid oxidation products. *Journal of the American Oil Chemists' Society, 94*(3), 339-351. doi:10.1007/s11746-017-2958-2

Vinci, R. M., Mestdagh, F., & De Meulenaer, B. (2012). Acrylamide formation in fried potato products – Present and future, a critical review on mitigation strategies. *Food Chemistry, 133*(4), 1138-1154. doi:https://doi.org/10.1016/j.foodchem.2011.08.001

Weisshaar, R. (2004). Acrylamide in heated potato products - Analytics and formation routes. *European Journal of Lipid Science and Technology, 106*(11), 786-792. doi:https://doi.org/10.1002/ejlt.200400988

Weisshaar, R. (2014). Quality control of used deep-frying oils. *European Journal of Lipid Science and Technology, 116*(6), 716-722. doi:https://doi.org/10.1002/ejlt.201300269

Weisshaar, R., & Gutsche, B. (2002). Formation of acrylamide in heated potato products-model experiments pointing to asparagine as precursor. *Deutsche Lebensmittel-Rundschau: Zeitschrift für Lebensmittelkunde und Lebensmittelrecht, 98*(11), 397-400.

WHO Food Safety Programme. (2002). *WHO Global Strategy for Food Safety : Safer Food for Better Health.* World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/42559

Williams, J. (2005). Influence of variety and processing conditions on acrylamide levels in fried potato crisps. *Food Chemistry, 90*(4), 875-881. doi:10.1016/j.foodchem.2004.05.050

Wilson, K. M., Giovannucci, E., Stampfer, M. J., & Mucci, L. A. (2013). Dietary acrylamide and risk of prostate cancer. *International Journal of Cancer, 131*(2), 479-487. doi:https://dx.doi.org/10.1002%2Fijc.26383

World Health Organization, Food and Agriculture Organization of the United Nations & Joint FAO/WHO Expert Committee on Food Additives. (2011). *Evaluation of certain contaminants in food: seventy-second [72nd] report of the Joint FAO/WHO Expert Committee on Food Additives.* Rome: World Health Organization. Retrieved from https://apps.who.int/iris/handle/10665/44514

Wu, X., Wu, S., Ji, M., & Yoong, J. (2018). Influence of red palm oil on the physicochemical and sensory qualities of flavouring oil gravy for instant noodles. *RSC Advances, 8*(2), 1148-1158. doi:10.1039/C7RA12387F

Xu, F., Oruna-Concha, M.-J., & Elmore, S. (2016). The use of asparaginase to reduce acrylamide levels in cooked food. *Food Chemistry, 210*, 163-171. doi:https://doi.org/10.1016/j.foodchem.2016.04.105

Xu, X., & An, X. (2016). Author links open overlay panelXiaoXuXiaoningAn. *Food Research International, 84*, 9-17. doi:https://doi.org/10.1016/j.foodres.2016.03.020

Xu, Y., Cui, B., Ran, R., Chen, H., Kai, G., & Shi, J. (2014). Risk assessment, formation, and mitigation of dietary acrylamide: Current status and future prospects. *Food and Chemical Toxicology, 69*, 1-12. doi:https://doi.org/10.1016/j.fct.2014.03.037

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. doi:https://doi.org/10.1016/j.foodcont.2015.10.028

Yasuhara, A., Tanaka, Y., Hengel, M., & Shibamoto, T. (2003). Gas chromatographic investigation of acrylamide formation in browning model systems. *Journal of Agricultural and Food Chemistry, 51*(14), 3999-4003. doi:https://doi.org/10.1021/jf0300947

Yaylayan, V. A., Wnorowski, A., & Locas, C. P. (2003). Why asparagine needs carbohydrates to generate acrylamide. *Journal of Agricultural and Food Chemistry, 51*(6), 1753-1757. doi:https://doi.org/10.1021/jf0261506

Young, A., & Lowe, G. (2001). Antioxidant and prooxidant properties of carotenoids. *Archives of Biochemistry and Biophysics, 385*(1), 20-27. doi:Archives of Biochemistry and Biophysics

Zając , J., Bojar, I., Helbin, J., Kolarzyk, E., Potocki, A., Strzemecka, J., & Owoc, A. (2013). Dietary acrylamide exposure in chosen population of South Poland. *Annals of Agricultural and Environmental Medicine, 20*(2), 351-355.

Zamora, R., & Hidalgo, F. (2008). Contribution of lipid oxidation products to acrylamide formation in model systems. *Journal of Agricultural and Food Chemistry, 56*(15), 6075-6080. doi:https://doi.org/10.1021/jf073047d

Zhang, B., Deng, Z., Tang, Y., Chen, P., Liu, R., Ramdath, D., . . . Tsao, R. (2014). Fatty acid, carotenoid and tocopherol compositions of 20 Canadian lentil cultivars and synergistic contribution to antioxidant activities. *Food Chemistry, 161*, 296-304. doi:10.1016/j.foodchem.2014.04.014

Zhang, H., Zhang, H., Cheng, L., Wang, L., & Qian, H. (2015). Influence of deep-frying using various commercial oils on acrylamide formation in French fries. *Food Additives & Contaminants: Part A, 32*, 1083-1088. doi:10.1080/19440049.2015.1045559

Zhang, Y., & Zhang, Y. (2008). Effect of natural antioxidants on kinetic behavior of acrylamide formation and elimination in low-moisture asparagine–glucose model system. *Journal of Food Engineering, 85*(1), 105-115. doi:10.1016/j.jfoodeng.2007.07.013

Zhang, Y., Chen, J., Zhang, Xiaoling, Wu, X., & Zhang, Y. (2007). Addition of antioxidant of bamboo leaves (AOB) effectively reduces acrylamide formation in potato crisps and French fries. *Journal of Agricultural and Food Chemistry, 55*(2), 523-528. doi:10.1021/jf062568i

Zhang, Y., Huang, M., Wang, Q., & Cheng, J. (2016). Structure-guided unravelling: Phenolic hydroxyls contribute to reduction of acrylamide using multiplex quantitative structure-activity relationship modelling. *Food Chem, 199*, 492-501. doi:https://doi.org/10.1016/j.foodchem.2015.12.038

Zhang, N., Li, Y., Wen, S., Sun, Y., Chen, J., Gao, Y., ... & Yu, X. (2021). Analytical methods for determining the peroxide value of edible oils: A mini-review. Food Chemistry, 129834.

Zhu, Y., Wang, P., Wang, F., Zhao, M., Hu, X., & Chen, F. (2016). The kinetics of the inhibition of acrylamide by glycine in potato model systems. *Journal of the Science of Food and Agriculture, 96*(2), 548-554. doi:10.1002/jsfa.7122

Zuo, S., Zhang, T., Jiang, B., & Mu, W. (2015). Reduction of acrylamide level through blanching with treatment by an extremely thermostable L-asparaginase during French fries processing. *Extremophiles, 19*(4), 841-851. doi:https://doi.org/10.1007/s00792-015-0763-0

Zyzak, D. V., Sanders, R. A., Stojavonic, M., Tallmadge, D. H., Eberhart, B., Ewald, D. K., . . . Villagran, M. D. (2003). Acrylamide formation mechanism in heated foods. *Journal of Agricultural and Food Chemistry, 51*(16), 4782-4787. doi:https://doi.org/10.1021/jf034180i