UNIVERSITI PUTRA MALAYSIA

CHARACTERIZATION OF NATURAL PEANUT BUTTER PRODUCED BY ONE-STAGE FINE GRINDING METHOD USING ULTRA-HIGH SPEED GRINDER

NORAZATUL HANIM BINTI MOHD ROZALLI

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By

NORAZATUL HANIM BINTI MOHD ROZALLI

Thesis Submitted to the school of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

May 2015

To my beloved husband Muzaidi

and my wonderful kids Muaz & Mus'ab....

Thank you for your loving support.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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May 2015

Chairman : Assoc. Prof. Ir. Chin Nyuk Ling, PhD
Faculty : Engineering

Peanut butter is a major product of peanuts (*Arachis hypogaea* L.) consumed worldwide. The concerns with additives in food products attract the demands for alternative natural peanut butter in market. It is common in peanut butter production that two stages of size reduction are required to transform the peanuts into paste form. Little attempts had been made to minimize the grinding stage and producing natural peanut butter as well. This study focuses on producing natural peanut butter by single 1-stage fine grinding method using ultra-high speed grinder. An extensive study on interrelation of particle size and natural peanut butter properties were conducted. Comparisons were made with commercial peanut butter in quality aspects. The qualities of roasted peanuts were optimized in roasting process. The effect of hot-air roasting temperatures and time on quality attributes of two different types of peanuts (Virginia and Spanish variety) were investigated using response surface methodology (RSM). The optimum roasting parameters for the Virginia and Spanish peanuts was 152°C-60 minutes and 158°C-45 minutes, respectively. Roasted peanuts were ground in a commercial ultra-high speed grinder operated at 20000 rpm for 2.0-5.0 minutes for natural peanut butter production. Grinding characteristics of both peanuts were evaluated in terms of specific energy consumption, E_{sc} with respect to its grinding time and mean particle size. The specific energy consumption modeled to the size reduction ratio of Virgina and Spanish peanuts was predicted more accurately using a linear and exponential model respectively compared to the classical models by Bond, Rittinger and Kick. Bond's working index, W_i, the ultra-high speed grinder is said to be more energy efficient than other comminutors in terms of its capability to produce finer particle size in shorter time than the rest. The peanut butter was successfully produced by 1-stage fine grinding method using the ultra-high speed grinder. Particle size analysis of natural peanut butter exhibited statistically significant difference between the analyzed parameters ($d_{0.1}$, $d_{0.5}$, $d_{0.9}$). Multimodal particle size distribution (PSD) was observed for all the samples. Particle size distribution is an inverse function of grinding time. All peanut butter samples exhibited elastic properties, adequately fitted to the Casson model and behaved as non-Newtonian shear-thinning food suspension with apparent yield stress. The storage modulus (G′) is a decreasing

function of grinding time and temperature. Grinding time and temperature show significant effect on all the responses ($p \leq 0.05$) while peanut origins only had impact on the particle size distribution. Identical trend was observed on all tests between natural peanut butter of Virginia and Spanish peanuts. The storage stability of natural peanut butter was evaluated for changes in physicochemical quality, microbiological properties, oxidative stability and textural quality. For storage study conducted over 16 weeks at 10, 25 and 35°C, products stored at 10°C exhibited similar textural quality with commercial product without appreciable loss in oxidative stability until the 12th whereas it was within 4 weeks for 25°C and 35°C storage. Storage temperature and time have more significant impact than other factors on quality changes of natural peanut butter during storage.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENCIRIAN MENTEGA KACANG SEMULAJADI DIHASILKAN OLEH SATU PERINGKAT KAEDAH PENGISARAN HALUS MENGGUNAKAN PENGISAR BERKELAJUAN ULTRA TINGGI

Oleh

NORAZATUL HANIM BINTI MOHD ROZALLI

May 2015

Pengerusi : Professor Madya Ir. Chin Nyuk Ling, PhD
Fakulti : Kejuruteraan

Mentega kacang adalah produk utama kacang tanah (*Arachis hypogaea* L.) yang digunakan di seluruh dunia. Kebimbangan dengan bahan tambahan dalam produk makanan menarik permintaan untuk alternatif mentega kacang semulajadi di pasaran. Ia adalah perkara biasa dalam pengeluaran mentega kacang dimana dua peringkat pengurangan saiz diperlukan untuk mengubah kacang ke dalam bentuk pes. Sedikit sahaja percubaan telah dibuat untuk mengurangkan peringkat pengisaran dan penghasilan mentega kacang semula jadi. Kajian ini memberi tumpuan kepada menghasilkan mentega kacang semula jadi melalui satu peringkat kaedah pengisaran halus menggunakan pengisar berkelajuan ultra tinggi. Kajian menyeluruh tentang hubungkait saiz zarah dan sifat mentega kacang semula jadi telah dijalankan. Perbandingan telah dibuat dengan mentega kacang komersil dalam setiap aspek kajian. Kualiti kacang panggang telah dioptimumkan dalam proses pemanggangan. Kesan suhu dan masa pemanggangan ke atas sifat kualiti dua jenis kacang tanah dari varieti Virginia dan Spanish telah disiasat menggunakan kaedah gerak balas permukaan (RSM). Parameter pemanggangan optimum untuk kacang tanah dari varieti Virginia dan Spanish masing-masing adalah 152°C-60 minit dan 158°C-45 minit. Kacang panggang telah dikisar dalam pengisar komersil kelajuan ultra-tinggi beroperasi pada 20000 rpm untuk 2.0-5.0 minit bagi pengeluaran mentega kacang semula jadi. Ciri-ciri peangisaran kedua-dua kacang tanah telah dinilai dari segi penggunaan tenaga tertentu (*Esc*) terhadap masa pengisaran dan saiz pertengahan zarah. Penggunaan tenaga tertentu dimodelkan dengan nisbah pengurangan saiz kacang tanah Virginia dan Spanish masing-masing dapat diramalkan dengan lebih tepat menggunakan model linear dan eksponen, berbanding dengan model klasik oleh Bond, Rittinger dan Kick. Indeks kerja Bond, Wi, bagi pengisar kelajuan ultra-tinggi dikatakan lebih cekap tenaga daripada pengisar lain dari segi keupayaan untuk menghasilkan saiz zarah yang lebih halus dalam masa yang lebih singkat daripada yang lain. Mentega kacang semulajadi juga telah berjaya dihasilkan dengan menggunakan kaedah satu peringkat pengisaran halus menggunakan pengisar berkelajuan ultra tinggi. Analisis saiz zarah mentega kacang semulajadi menunjukkan perbezaan statistik yang nyata antara parameter yang dianalisis ($d_{0.1}$, $d_{0.5}$, $d_{0.9}$). Taburan saiz zarah multimodal (PSD) telah diperhatikan untuk semua

sampel. Taburan saiz zarah adalah fungsi songsang masa pengisaran. Semua sampel mentega kacang mempamerkan sifat-sifat elastik, sesuai untuk model Casson dan berkelakuan sebagai bukan Newtonian ricih-penipisan penggantungan makanan dengan tegasan alah jelas. Modulus penyimpanan (G') adalah pengurangan fungsi masa dan suhu pengisaran. Masa dan suhu pengisaran menunjukkan kesan yang besar ke atas semua respons ($p<0.05$) manakala asal kacang mentah hanya mempunyai kesan ke atas taburan saiz zarah. Corak yang serupa telah diperhatikan pada semua ujian antara mentega kacang semula jadi dari kacang tanah varieti Virginia dan Spanish. Kestabilan mentega kacang semula jadi dalam tempoh penyimpanan telah dinilai untuk perubahan dalam kualiti fizikokimia, mikrobiologi, kestabilan oksidatif dan kualiti tekstur. Kajian ini dijalankan selama 16 minggu pada suhu 10, 25 dan 35°C. Produk yang disimpan pada suhu 10°C menunjukkan kualiti tekstur sama dengan produk komersial tanpa perbezaan ketara dalam kestabilan oksidatif sehingga minggu 12. Ketidakstabilan oksidatif mentega kacang semula jadi yang disimpan pada 25°C dan 35°C telah ditunjukkan pada minggu keempat. Suhu dan masa penyimpanan mempunyai kesan lebih jelas daripada faktor-faktor lain pada perubahan kualiti mentega kacang semulajadi semasa penyimpanan.

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Thanks to other individuals whom I have not mentioned but have helped me in various possible ways.

I certify that a Thesis Examination Committee has met on 29 May 2015 to conduct the final examination of Norazatul Hanim binti Mohd Rozalli on her thesis entitled "Characterization of Natural Peanut Butter Produced by One-Stage Fine Grinding Method using Ultra-High Speed Grinder" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Desa bin Ahmad, PhD
Professor Ir.
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Johari bin Endan, PhD
Associate Professor Ir.
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Shamsul bin Anuar, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Keshavan Niranjan, PhD
Professor
University of Reading Whiteknights
United Kingdom
(External Examiner)

ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 17 June 2015

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

Chin Nyuk Ling, PhD
Associate Professor. Ir.
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Yus Aniza Yusof, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Nor AinyMahyudin, PhD
Associate Professor
Faculty of Food Science and Technology
Universiti Putra Malaysia
(Member)

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This is to confirm that:

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
AOAC	Association of Analytical Chemists
CCD	Central composite design
d.b.	Dry basis
DSC	Differential scanning colorimeter
FDA	Food and Drug Administration
HVO	Hydrogenated vegetable oil
LVR	Linear viscoelastic region
MC	Moisture content
MSE	Mean squared error
N	Newton
Pa	Pascal
PCA	Plate count agar
PV	Peroxide value
PSD	Particle size distribution
pf	Power factor
RSM	Response surface methodology
SAOS	Small amplitude oscillatory stress
Sdn. Bhd.	Sendirian Berhad
SEM	Scanning electron microscope
TFA	Trans fatty acid
TSA	Tryptic soy agar
USDA	United States Department of Agricultural

NOMENCLATURE

A	Current (ampere)
a_w	Water activity
d_1	Initial particle size diameter (mm)
d_2	Final particle size diameter (mm)
$d_{0.1}$	Particle size at which 10% of the particle size distribution fall below
$d_{0.5}$	Particle size at which 50% of the particle size distribution fall below
$d_{0.9}$	Particle size at which 90% of the particle size distribution fall below
E	Energy (kJ)
E_{sc}	Specific energy consumption (kJ/kg)
G'	Storage modulus (Pa)
G''	Loss modulus (Pa)
K_K	Kick's law constant (kJ/kg)
K_B	Bond's law constant (kJ/kg)
K_R	Rittinger's law constant (kJ/kg.m)
M_{H_20}	Weight of sample loss after drying (g)
M_{solids}	Weight of sample before drying (g)
P	Power (k Watt)
R^2	Correlation coefficient
t	Grinding time (second)
V	Voltage
W_i	Bond's working index (kJ/kg)

CHAPTER 1

INTRODUCTION

1.1 Introduction

Peanut butter is one of the most important products prepared from peanuts (*Arachis hypogaea* L.) where in the U.S. alone as example over 50% of the peanuts produced are processed into peanut butter (Suchoszek-Łukaniuk et al., 2011). Its high protein (27-30%) and polyunsaturated fatty acid content (45-50%) makes it an excellent source of energy (581 kCal/kg) (Woodroof, 1983). Peanut butter is a household staple and is usually consumed as spread on bread or cracker. It is also widely used in the food industry for flavour variety especially in confectionery and dessert products. The principal quality parameters for consumer acceptance of peanut butter are the appearance, flavour and aroma, as well as the spreadability and texture, which are dependent on the processing conditions during the production of peanut butter.

The production of peanut butter is relatively simple, consisting of roasting, blanching the peanuts followed by fine grinding. It is during the grinding stage that differentiates the textural quality among type of peanut butters. In commercial peanut butter manufacturing, peanuts have to undergo two steps of grinding in order to obtain the finest particle size of peanut butter. The initial milling reduces the peanuts into coarse or medium grind. It is then followed by second grinding in a high speed grinder operating at ~3000 rpm, to produce ultrafine particle size reaching to 2-P DQG KRPRJHQLVDWLRQ (Anyang General International Co., 2010). The peanuts have to be ground in two different grinders since the required clearance between plates of the grinder is different at each stage. The use of ultrasonification to substitute fine grinding in the second stage with do not give peanut paste particle sizes much smaller than conventional sizes (Dzurik *et al*., 1971). It is interesting to investigate if these two steps procedure can possibly done using single size reduction apparatus by applying the ultra high speed grinding. The implementation of single stage step grinding process in peanut butter production would be beneficial in terms of time and cost reduction. Besides it could ensure proper hygiene due to reduce chance of handling the product from one machine to another.

In commercial peanut butter production, various stabilizer and additives are added to serves various purposes. The use of hydrogenated vegetable oil (HVO) as stabilizer in peanut butter has arisen many health concern issues as it contains trans fatty acid (TFA) which associate with cardiovascular disease. Most peanut butter brands in Malaysia fell within a range of 0.020-0.67 g TFA kg^{-1} and are LGHQWLILHG DV ORZ 7)$ but a range of 1.66-6.7 g TFA kg^{-1} was reported LQ PDQ\ FRXQWULHV DV KLJK 7)$ (Karupaiah et al., 2014). It is suggested that TFA in peanut butter is varied between manufacturers (Karupaiah et al., 2014). Although this issue has been constantly overcame by reducing the HVO content to less than 1% or with better stabilizer and modification of hydrogenation process, it could not evade the demand for natural peanut butter. The increasing demands and consciousness among consumers suggest that fewer natural additives or no additives added in food are

preferable. 59% of the respondents in a study of peanut butter preference favour the ROG IDVKLRQHG SHDQXW EXWWHU GH WR LWV IODYRX DURPD WHXWXH DQG DEVHQ additives (How et al., 1985). The addition of HVO in peanut butter succeed to prevent oil separation but the resulting peanut butter has the disadvantage where it is difficult to spread and tends to cling to the palate when eaten (Gills et al., 2000b). Various attempts had been made to find the suitable stabilizer which satisfies all quality attributes of peanut butter such as by replacing HVO with palm oil (Gills and Resurreccion, 2000b; Hinds et al., 1994). However, the oxidative stability of palm oil-stabilised peanut butter is less susceptible than HVO-stabilised peanut butter. Sensory analysis showed that the natural peanut butter is more preferable than the palm oil-stabilised peanut butter in texture, oiliness, spreadability and overall liking (Gills et al., 2000a).

Oil separation is the major problems in natural peanut butter production. It leads to peroxidation of oil which results in rancidity of the product. To regain the terms of natural peanut butter, it is a challenge that no stabilizer should be added. By means, the capability of ultrahigh speed grinding to improve the fine particle size would provide some useful research area in mechanically controlling the oil separation thus improve the other quality attributes. Controlling particle size distribution (PSD) was proved to be the most prominent factor to obtain a desirable product (Lima et al., 2000).

1.2 Problem statements

In conventional peanut butter processing, two steps of grinding are required to achieve the finest possible particle size to ensure a smooth spread is achievable. Therefore, it is the main focus of this research to reduce the 2-steps to a 1-step grinding process in peanut butter production. The difference between conventional and new peanut butter processing are illustrated in Figure 1.1 and 1.2, respectively. In conventional peanut butter production, stabilizers such as hydrogenated vegetable oil (HVO) and additives are added to prevent oil separation. Due to various health concerns on the usage of HVO, it is the interest of this research to produce natural peanut butter as an alternative to the current range of peanut butter. The information and literature on natural food product particularly peanut butter is scarce. Therefore, the characterization and storage study on natural peanut butter would provide knowledge in structure-rheological interrelationship particularly in plant-based food suspension and also in stability evaluation of preservative-free food products.

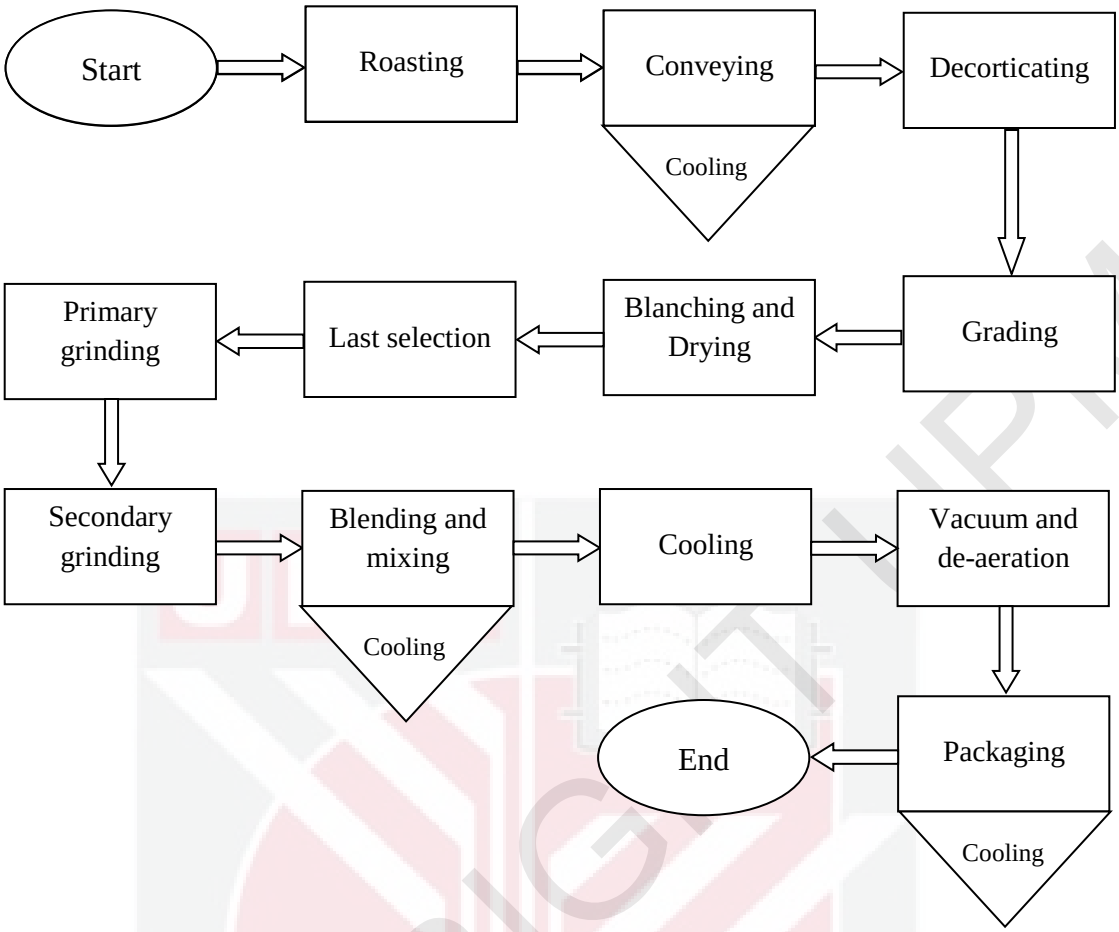

Figure 1.1. Flow diagram of conventional peanut butter processing

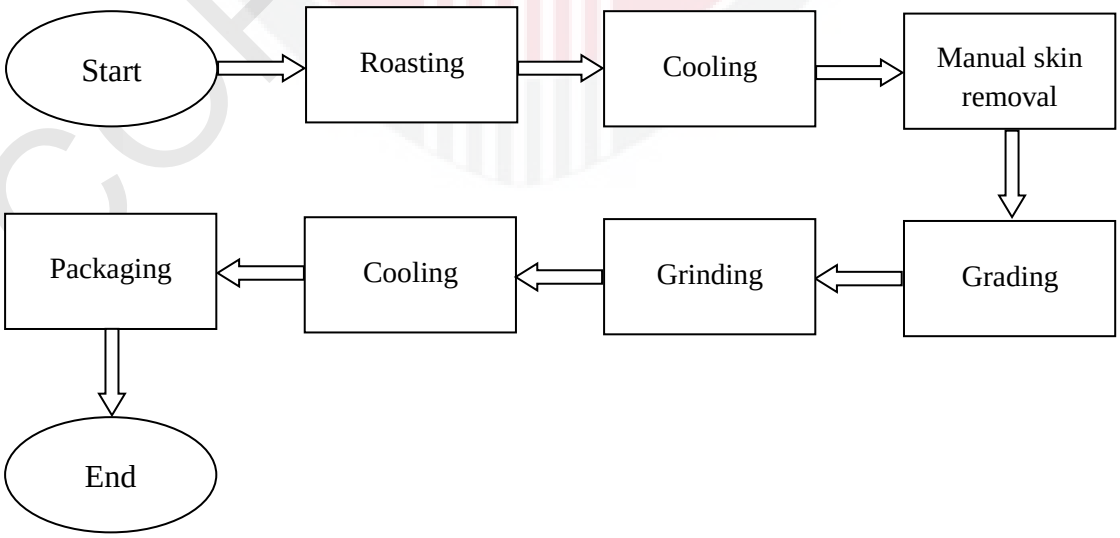

Figure 1.2. Flow diagram of new peanut butter processing

1.3 Objectives of the study

The main objective of this study is to evaluate the performance and capability of ultra high speed grinding in producing a reasonably stable natural peanut butter shelf life without stabilizer. Since the stability and quality of the product depends on the organoleptics, textural and microstructure properties, it is important to achieve desire characteristics to support the main objective. The study was carried out in comparison with commercial peanut butter in order to compare the quality between commercialand natural product. The specific objectives of the research were therefore:

1. To assess the influence of roasting parameters on the textural and organoleptic attributes of roasted peanuts. It is during roasting that determine the aroma, flavour and colour of final products. The determination of roasting parameters on quality parameters of roasted peanuts are reported in **Paper I**.

2. To evaluate the performance of ultra high speed grinder in terms of specific energy consumption. It is described in **Paper II**.

3. To study the influence of grinding on the textural, rheological and physicochemical properties of natural peanut butter. It is reported in **Paper III and IV**.

4. To study the behaviour and oxidative stability of peanut butter during storage at different temperatures. It is reported in **Paper V**.

1.4 Scope of work and thesis outlines

The work conducted in this research focused on production of natural peanut butter using ultra-high speed grinder. Quantitative characterization and evaluation were conducted on the production which are roasting and grinding as well as on the product which is natural peanut butter. Chapter 2 begins by introducing the classification of peanut butter and process flowchart of peanut butter production with detail description on roasting and grinding stage. Elaborate discussions were also presented on quality responses of peanut butter and other nut butters as well. The applications of instrumental analyses for quantitative measurements in previous studies are extensively discussed. The storage stability of peanut butter and other nut butter are also presented in terms of oxidative stability and microbial contamination.

The materials and methods, equipment used and procedures for analyses conducted in the experiments are described in Chapter 3. The works started with preparation of the peanuts for roasting process, followed by grinding process, and characterization of peanut butter, and storage study. The experimental design of roasting process is presented with aims to evaluate the effect of roasting time and temperature on four quality responses for roasted peanuts which are colour, moisture content, hardness and fracturability. This chapter also describes the experimental design of grinding process at five levels of grinding time and two levels of peanut origin where grinding

characteristics including particle size distribution, energy consumption and temperature generated were evaluated. The characterizations of natural peanut butter properties were also presented which includes physicochemical, rheological and textural properties. The properties of natural peanut butter were also compared with commercial peanut butter as benchmark of its characteristics. The effect of grinding time and storage temperature on oxidative stability, microbial count and changes in physicochemical, rheological and textural properties of natural peanut butter in comparison with commercial peanut butterare also described in this chapter.

Chapter 4 is a published paper of work on optimization of roasting process. It details the experimental design of roasting process and the application of response surface methodology (RSM) for simultaneous multiple responses modelling and optimization of peanuts roasting process in this study. The optimization was obtained by defining the goals and boundaries of each measured responses and later combined them into a single measure. The correlations between the responses are also reported.

Chapter 5 is a published paper of work on grinding process of roasted peanuts using ultra-high speed grinder. It discusses the grinding characteristics of roasted peanuts for natural peanut butter production. It covers the energy consumption and heat generated during grinding and particle size distribution obtained after grinding. The energy consumption and particle size were fitted to the three classical grinding laws ¶ KLFK DUH .LF¶V 5LWWLQJHU¶V DQG %RQG¶V WR DVVHVV WKH SHUIRUPDQFH RI XWUD speed grinder used in this study.

In Chapter 6, the preliminary study of rheological properties of natural peanut butter is presented. This chapter compared the dynamic rheological properties of natural peanut butter with commercial peanut butter at 25°C. The stress sweep test was performed in the work of this chapter. Comparisons were made between natural peanut butter produced at different grinding time and also with commercial peanut butter by comparing the linear viscoleastic region (LVR) of the products.

Chapter 7 discusses the effect of grinding time and temperature on rheological, textural,
colour and density of natural peanut butter in comparison with commercial peanut butter. Dynamic rheological properties are extensively discussed which includes results from oscillatory strain sweep test, time sweep test and frequency sweep test. The flow behaviours of peanut butters are also presented in this chapter. The SEM and particle size analysis were also assessed to understand particle size and structure influence on the peanut butter properties.

Chapter 8 elaborates the storage related changes in quality changes on natural peanut butter. It reports the effects of storage temperature and time, peanut variety and grinding time on storage stability of natural peanut butter. The quality attributes monitored were moisture content, water activity, microbial count, peroxide value, oil separation and spreadability. Subsequently, comparisons of quality changes during storage were compared with those of commercial peanut butter.

Finally, Chapter 9 concludes the overall findings and contributions of the works. Recommendations are listed for further research.

REFERENCES

Afolabi, C.G., Ezekiel, C.N., Kehinde, I.A., Olalu, A.W., Ogunsanya, O.M. (2015). Contamination of groundnut in South-Western Nigeria by aflatoxigenic fungi and aflatoxins in relation to processing. *Journal of Phytopathology*. 163(4): 279-286.

Ahmed, J., Al-Foudari, M., Al-Salman, F. and Almusallam, A.S. (2014). Effect of particle size and temperature on rheological, thermal, and structural properties of pumpkin flour dispersion. *Journal of Food Engineering*. 124: 43-53.

Akinoso, R. and Raji, A.O. (2011): Optimisation of oil extraction from locust bean using response surface methodology. *European Journal of Lipid Science and Technology*. *113*: 245-252.

Amemiya, J.I. and Menjivar, J.A. (1992). Comparison of small and large deformation measurements to characterize the rheology of wheat flour doughs. *Journal of Food Engineering*. 16: 91-108.

AnnaKate, W.R.A.H. (2008). Peanut butter. *Food Bites*. Springer New York. 1-3.

Anyang General International Co., Ltd. (2010). Peanut butter machine. http://agicl4430.en.china.cn/. Access: 2015/6/11.

AOAC (1996). Official Methods of Analysis. Washington, D.C: Association of Official Analytical Chemists.

Aryana, K.J., Resurrecion, A.V.A., Chinnan, M.S. and Beuchat, L.R. (2000). Microstructure of peanut butter stabilized with palm oil. *Journal of Food Processing and Preservation*. 24: 229-241.

Asal, A., Oye, G. and Sjoblom, J. (2009). Influence of pH, high salinity and particle concentration on stability and rheological properties of aqueous suspensions of fumed silica. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. 349: 43-54.

Balaz, P. (2008). High-Energy Milling. In: *Mechanochemistry in Nanoscience and Minerals Engineering*, pp. 103-132, Springer-Verlag, Berlin.

Demir, A.D. and Cronin, K. (2005). Modelling the kinetics of textural changes in hazelnuts during roasting. *Simulation Modelling Practice and Theory*, *13*: 97-107.

Bayod, E., Willers, E.P. and Tornberg, E. (2008). Rheological and structural characterization of tomato paste and its influence on the quality of ketchup. *LWT - Food Science and Technology*. 41(2008): 1289-1300.

Berkey, C.S., Willett, W.C., Tamimi, R.M., Rosner, B., Frazier, A.L. and Colditz, G.A. (2013). Vegetable protein and vegetable fat intakes in pre-adolescent and adolescent

girls, and risk for benign breast disease in young women. *Breast Cancer Research and Treatment*. 141: 299-306.

Birch, J., Yap., K., Silcock, P. (2010). Compositional analysis and roasting behaviour of gevuina and macadamia nuts. International *Journal of Food Science and Technology*. 45(1): 81-86.

Brannan, G.L., Koehler, P.E., Ware, G.O. (1999). Physico-chemical and sensory characteristics of defatted roasted peanuts during storage. *Peanut Science*. 26:44-53.

Brighenti, M., Govindasamy-Lucey, S., Lim, K., Nelson, K. and Lucey, J. A. (2008). Characterization of the rheological, textural, and sensory properties of samples of commercial US cream cheese with different fat contents. *Journal of Dairy Science*. 91(12): 4501-4517.

Brownell, K.D. and Pomeranz, J.L. (2014). The Trans-Fat Ban -Food Regulation and Long-Term Health. *New England Journal of Medicine*. 370: 1773-1775.

Burnett, S. L., Gehm, E. R., Weissinger , W. R., Beuchat , L. R. (2000). Survival of *Salmonella* in peanut butter and peanut butter spread. *Journal of Applied Microbiology*. 89: 472-477.

Carocho, M., Barreiro, M. F., Morales, P., Ferreira, I. C. F. R. (2014). Adding molecules to food, pros and cons: A review on synthetic and natural food additives. *Comprehensive Reviews in Food Science and Food Safety*. 13(4): 377-399.

Chang, A.S., Sreedharan, A., Schneider, K.R. (2013). Peanut and peanut products: A food safety perspective. *Food Control*. 32(1): 296-303.

Chung, C.S. (1988). Measuring density and porosity of grain kernels using a gas pycnometer. *Cereal Chemistry*. 65: 13-15.

Citerne, P.G., Carreau, P.J. and Moan, M. (2001). Rheological properties of peanut butter. *Rheol. Acta*. 40(1): 86-96.

De Conto, L.C., Oliveira, R.S.P., Martin, L.G.P., Chang, Y.K, Steel, C.J. (2012). Effects of the addition of microencapsulated omega-3 and rosemary extract on the technological and sensory quality of white pan bread. *LWT-Food Science and Technology*. *45* (2012): 103-109.

De Graef, V., Depypere, F., Minnaert, M., Dewettinck, K. (2011). Chocolate yield stress as measured by oscillatory rheology. *Food Research International*. 44(9): 2660-2665.

Deniz, Ç., Kahyaoglu, T., Kapucu, S., Kaya, S. (2008). Colloidal stability and rheological properties of sesame paste. *Journal of Food Engineering*. 87: 428-435.

Garg, S.K., Lohani, U.C., Pandey, J.P. (2010). Studies on continuous grinding process for dried water chestnut kernel. *Journal of Engineering Science and Technology*. 5: 140-150.

Genovese, D.B., Lozano, J.E., Rao, M. , Anandha. (2007) The rheology of colloidal and noncolloidal dispersions. *Journal of Food Science*. 72(2): R11-R20.

Ghorbani, Z., Masoumi, A.A., Hemmat, A. (2010). Specific energy consumption for reducing the size of alfafa chops using a hammer mill. *Biosystems Engineering*. 105: 34-40.

Gills, L. A. and Resurreccion, A. V. A. (2000a). Overall acceptability and sensory profiles of unstabilized peanut butter and peanut butter stabilized with palm oil. *Journal of Food Processing and Preservation*. 24(2000): 495-516.

Gills, L. A. and Resurreccion, A. V. A. (2000b). Sensory and physical properties of peanut butter treated with palm oil and hydrogenated vegetable oil to prevent oil separation. *Journal of Food Science*. 65(1): 173-180.

Glicerina, V., Balestra, F., Dalla Rosa, M., Romani, S. (2014a). Effect of manufacturing process on the microstructural and rheological properties of milk chocolate. *Journal of Food Engineering*. 145: 45-50.

Glicerina, V., Balestra, F., Rosa, M.D., Romani, S. (2014b). Rheological, textural and calorimetric modifications of dark chocolate during process. *Journal of Food Engineering*. 119: 173-179.

Granato, D., Masson, M.L. (2010). Instrumental color and sensory acceptance of soy-based emulsions: a response surface approach. *Ciênc. Tecnol. Aliment.* 30 (4): 1090-1096.

He, Y., Guo, D., Yang, J., Tortorello, M. L., Zhang, W. (2011). Survival and heat resistance of *Salmonella enterica* and *Escherichia coli* O157:H7 in peanut butter. *Applied and Environmental Microbiology*. 77(23): 8434-8438.

Hlavacek, R.G., and Freeman, W.G. (1968). Low-heat, 200 mesh milling provides smooth, uniform product. *Food Processing Marketing*. 29(4): 44-45.

Honfo, F., Hell, K., Akissoé, N., Coulibaly, O., Fandohan, P. and Hounhouigan, J. (2011). Effect of storage conditions on microbiological and physicochemical quality of shea butter. *Journal of Food Science and Technology*. 48(3): 274-279.

Hojjati, M., Calín-Sánchez, A., Razavi, S.H., Carbonell-Barrachina, A.A., (2013). Effect of roasting on colour and volatile composition of pistachios (*Pistacia vera* L.). *International Journal of Food Science and Technology*. 48(2): 437-443.

How, J. L., Young, C. (1985). Factors affecting peanut butter preference. *Journal of the American Oil Chemists' Society*. 62(3): 538-540.

Humphrey, J. H. (2008). Underweight malnutrition in infants in developing countries: An intractable problem. *Archives of Pediatrics and Adolescent Medicine*. 162(7): 692-694.

Hung, Y.C. (2000). Predicting the effect of drying conditions on the textural properties of roasted peanuts. *TRANSACTIONS of the ASAE*. *32*: 968-972.

Hung, Y.C. and Chinnan, M.S. (1989). Mechanical texture measurement of whole and chopped peanuts. *Peanut Science*. 16: 32-37.

Hvizdzak, A. L., Beamer, S., Jaczynski, J., Matak, K. E. (2010). Use of electron beam radiation for the reduction of *Salmonella enterica Serovars Typhimurium* and *Tennessee* in peanut butter. Journal of Food Protection. 73(2): 353-357.

IEEE. (2000). IEEE 100 The Authoritative Dictionary of IEEE Standards Terms
Indira, T.N., Bhattacharya, S. 2006. Grinding characteristics of some legumes. *Journal of Food Engineering*. 76: 113-118.

International Nut and Dried Fruit (INC). 2012. Global statistical review 2007-2012. www.nutfruit.org. Access 2014/07/14.

Israëls, T., Borgstein, E., Jamali, M., De Kraker, J., Caron, H. N. and Molyneux, E. M. (2009). *Acute malnutrition is common in Malawian patients with a Wilms tumour: A role for peanut butter*. Pediatric Blood and Cancer. 53(7): 1221-1226.

Jha, S.N., Sharma, R. (2010). Physical, gravimetric and functional characterization of various milling fractions of popped gorgon nut (*Euryale ferox*). *J Food Sci Technol*. 47: 564-570.

Johnsen, P.B., Civille, G.V., Vercellotti, J.R., Sanders, T.H. and Dus, C.A. (1988). Development of a lexicon for the description of peanut flavour. *Journal of Sensory Studies*. *3*: 9-17.

Kahyaoglu, T. (2008).Optimisation of the pistachio nut roasting process using response surface methodology and gene expression programming. *LWT-Food Science and Technology*. *41*: 26-33.

Kahyaoglu, T. and Kaya, S. (2006). Determination of optimum processing conditions for hot-air roasting of hulled sesame seeds using response surface methodology. *Journal of the Science of Food and Agriculture*. *86*: 1452-1459.

Kapur, P.C., Gutsche, O., Fuerstenau, D.W. (1993). Comminution of single particles in a rigidly-mounted roll mill part 3: particle interaction and energy dissipation. *Powder Technology*. 76: 271-276.

Khounvilay, K., and Sittikijyothin, W. (2012). Rheological behaviour of tamarind seed gum in aqueous solutions. *Food Hydrocolloids*. 26(2): 334-338.

Kirk, R. S. and Sawyer, R. (1991). Pearson's composition and analysis of foods. *Harlow, Longman Scientific and Technical*: 609-617.

Lawless, H.T., Heymann, H. *Sensory evaluation of food: Principles and practices*. 2nd ed. 2010, New York: Springer.

Li, H., Fan, Y.W., Li, J., Tang, L., Hu, J.N. and Deng, Z.Y. (2013). Evaluating and predicting the oxidative stability of vegetable oils with different fatty acid compositions. *Journal of Food Science*. 78(4): H633-H641.

Lima, L.M., Guraya, H.S. and Champagne, E.T. (2000). Improved peanut flour for a reduced-fat peanut butter product. *Journal of Food Science*. 65(5): 865-861.

Lopez-Sanchez, P. and Farr, R. (2012). Power Laws in the Elasticity and Yielding of Plant Particle Suspensions. *Food Biophysics*. 7: 15-27.

Ma, L., Zhang, G., Gerner-Smidt, P., Mantripragada, V., Ezeoke, I., Doyle, M. P. (2009). Thermal inactivation of Salmonella in peanut butter. *Journal of Food Protection*. 72: 1596–1601.

Mallia, S., Piccinali, P, Rehberger, B., Badertscher, R., Escher F. and Schlichtherle-Cerny, H. (2008). Determination of storage stability of butter enriched with unsaturated fatty acids/conjugated linoleic acids (UFA/CLA) using instrumental and sensory methods. *International Dairy Journal*. 18(10–11): 983-993.

Mani, S., Tabil, L.G. and Sokhansanj, S. (2004). Grinding performance and physical properties of wheat and barley straws, corn stover and switchgrass. *Biomass and Bioenergy*. 27: 339-352.

Mckiernan, F., Lokko, P., Kuevi, A., Sales, R.L., Costa, N.M.B., Bressan, J., Alfenas, R.C.G. and Mattes, R.D. (2010). Effects of peanut processing on body weight and fasting plasma lipids. *British Journal of Nutrition*. *104*: 418-426.

Megahed, M.G. (2001). Microwave roasting of peanuts: Effects on oil characteristics and composition. *Nahrung-Foo*., *45*: 255-257.

Mendes, L.C., De Menezes, H.C., Aparecida, M. and Da Silva, A.P. (2001). Optimisation of the roasting of robusta coffee (C. *Canephora conillon*) using acceptability tests and RSM. *Food Quality and Preference*. *12*:153-162.

Mexis, S.F., Badeka, A.V., Riganakos, K.A., Kontominas, M.G. (2010). Effect of active and modified atmosphere packaging on quality retention of dark chocolate with hazelnuts. *Innovative Food Science and Emerging Technologies*. 11(1):177-186.

Mohd Rozalli, N.H., Chin, N.L. and Yusof, Y.A. (2014). Simultaneous multiple responses modelling, optimisation and correlation of Asian type peanuts (*Arachis hypogaea* L.) roasting using response surface methodology. *Acta Alimentaria*. 43(1): 142-157.

Mohd Rozalli, N.H., Chin, N.L., Yusof, Y. A. (2015). Grinding characteristics of Asian originated peanuts (*Arachis hypogaea* L.) and specific energy consumption during ultra-high speed grinding for natural peanut butter production. *Journal of Food Engineering*. 152 (2015): 1-7.

Muttagi, G., Joshi, N., Shadakshari, Y. G., Chandru, R. (2014). Storage stability of value added products from sunflower kernels. *Journal of Food Science and Technology*. 51(9): 1806-1816.

Muresan, V., Danthine, S., Racolta, E., Muste, S., Blecker, C. (2014). The influence of particle size distribution on sunflower tahini rheology and structure. *Journal of Food Process Engineering*. 37: 411-426.

Ng, S., Lasekan, O., Kharidah, M., Rabiha, S., Norhayati, H. (2014). Effect of roasting conditions on color development and Fourier transform infrared spectroscopy (FTIR-ATR) analysis of Malaysian-grown tropical almond nuts (*Terminalia catappa* L.). *Chemistry Central Journal*. 8: 55

Ngamnikom, P., Songsermpong, S. (2011). The effects of freeze, dry, and wet grinding processes on rice flour properties and their energy consumption. *Journal of Food Engineering*. 104**,** 632-638.

Nikzadeh, V., Sedaghat, N. (2008). Physical and sensory changes in pistachio nuts as affected by roasting temperature and storage. *American-Eurasian J. Agric. & Environ. Sci.*. *4*(4): 478-483.

O'Keefe, S. F., Wiley, V.A., Knauft, D.A. (1993). Comparison of oxidative stability of high and normal oleic peanut oils. *Journal of American Oil Chemists' Society*. 70(5): 489-492.

Onemli, F. (2012). Impact of climate change on oil fatty acid composition of peanut (*Arachis hypogaea* L.) in three market classes. *Chilean Journal of Agricultural Research*. 72(4): 483-488.0

Opazo-Navarrete, M., Tabilo-Munizaga, G., Vega-Gálvez, A., Miranda, M. and Pérez-Won, M. (2012). Effects of high hydrostatic pressure (HHP) on the rheological

properties of Aloe vera suspensions (Aloe barbadensis Miller). *Innovative Food Science and Emerging Technologies*. 16: 243-250.

Ortolá, M.D., Gutiérrez, C.L., Chiralt, A., Fito, P. (1998). Kinetic study of lipid oxidation in roasted coffee. *Food Science and Technology International*. 4(1): 67-73.

Özcan, M. and Seven, S. (2003). Physical and chemical analysis and fatty acid composition of peanut, peanut oil and peanut butter from ÇOM and NC-7 cultivars. *Grasas y Aceites*. *54*, Fasc. 1(2003): 12-18.

Özdemir, M. and Devres, O. (2000). Kinetics of colour changes of hazelnuts during roasting. *Journal of Food Engineering*. *44*: 31-38.

Ouattara, S., Frances, C. (2014). Grinding of calcite suspensions in a stirred media mill: Effect of operational parameters on the product quality and the specific energy. *Powder Technology*. 255**,** 89-97.

Pathare, P.B., Opara, U.L, Al-Said, F.A. (2013). Colour measurement and analysis in fresh and processed foods: A review. *Food Bioprocess Technology*. 6:36-60

Rahalkar, R.R. (1992). Viscoelastic properties of oil-water emulsions. In: *Viscoelastic Properties of Food*, (M.A. Rao, J. Steffe, eds.) pp. 317-354, Elsevier Science Publishers Ltd, Essex, England.

Rao, M.A., Measurement of viscoelastic properties of fluid and semisolid fluid, in *Viscoelastic Properties of Food*, M.A. Rao and J.F. Steffe, Editors. 1992, Elsevier Science Publishers Ltd.: Essex, England. 207-232.

Radočaj, O., Dimić, E., Vujasinović, V. (2012). Development of a hull-less pumpkin (*Cucurbita pepo* L.) seed oil press-cake spread. *Journal of Food Science*. 77(9):C1011-C1017.

Reed, K.A., Sims, C.A., Gorbet, D.W., O' Keefe, S.F. (2002). Storage water activity affects flavor fade in high and normal oleic peanuts. *Food Res. Intl*. 35:769-774.

Rhodes, M. (1997). Model predicting energy requirement and particle size distribution. In: *Introduction to Particle Technology*, (M. Rhodes, ed.) pp. 121-131, John Wiley & Sons, Ltd, New York.

Riveros, C. G., Mestrallet, M. G., Gayol, M. F., Quiroga, P. R., Nepote, V. and Grosso N. R. (2010). Effect of storage on chemical and sensory profiles of peanut pastes prepared with high-oleic and normal peanuts. *Journal of Food Science and Agriculture. 90*: 2694-2699.

Rodrigues, A.C., Ströher, G.L., Freitas, J.V., Visentainer, C.C. and Oliveira, N.E.D.S. (2011). The effect of genotype and roasting on the fatty acid composition of peanuts. *Food Research International*. *44*:187-192.

Sanders III, C. T., DeMasie, C. L., Kerr, W. L., Hargrove, J. L., Pegg, R. B. and Swanson, R. B. (2014). Peanut skins-fortified peanut butters: Effects on consumer acceptability and quality characteristics. *LWT - Food Science and Technology*. 59(1): 222-228.

Saklar, S., Ungan, S. and Katnas, S. (1999). Instrumental crispness and crunchiness of roasted hazelnuts and correlations with sensory assessment. *Journal of Food Science*. 64 (6): 1015-1019.

Saklar, S., Ungan, S. and Katnas, S. (2003). Microstructural changes in hazelnut during roasting. *Food Research International*. *36* (2003): 19–23

Saravacos, G.D., Kostaropoulos, A.E. (2002). Handbook of Food Processing Equipment. In: *Food Engineering Series*. (G.V. Barbosa-Canovas, ed.) pp. 133-135, 147-167, 188-194, Kluwer Academic/Plenum Publishers, New York.

Sato, A.C.K., and Cunha, Rosiane L., (2009). Effect of particle size on rheological properties of jaboticaba pulp. *Journal of Food Engineering*. 91(4): 566-570.

Schorno, A. L., Manthey, F. A. and Hall III, C. A. (2009). Effect of particle size and sample size on lipid stability of milled flaxseed (*Linum usitatissimum L.*). *Journal of Food Processing and Preservation*. 34(2010): 167-169.

Servais, C., Jones, R., Roberts, I. (2002). The influence of particle size distribution on the processing of food. *Journal of Food Engineering*. 51(2002): 201-208.

Severini, C., Gomes, T., De Pilli, T., Romani, S., Massini, R. (2000). Autoxidation of packed almonds as affected by Maillard reaction volatile compounds derived from roasting. *Journal of Agricultural and Food Chemistry*. 48(10): 4635-4640.

Shakerardekani, A., Karim, R., Mohd Ghazali, H. and Chin, N.L. (2011). Effect of roasting conditions on hardness, moisture content and colour of pistachio kernels. *International Food Research Journal*. *18*: 704-710.

Shakerardekani, A., Karim, R., Mohd Ghazali, H., Chin, N.L. (2013a). Textural, rheological and sensory properties and oxidative stability of nut spreads - a review. *International Journal of Molecular Sciences*. 14: 4223-4241.

Shakerardekani, A., Karim, R., Ghazali, H.M. and Chin, N.L. (2013b). Development of Pistachio (Pistacia vera L.) Spread. *Journal of Food Science*. 78**:** S484-S489.

Shakerardekani, A., Karim, R., Ghazali, H. and Chin, N.L. (2013c). The effect of monoglyceride addition on the rheological properties of pistachio spread. *Journal of the American Oil Chemists' Society*. 90(10): 1517-1521.

Shashidhar, M.G., Murthy, T.P.K., Girish, K.G., Manohar, B. (2013). Grinding of coriander seeds: Modeling of particle size distribution and energy studies. *Particulate Science and Technology*. 31: 449-457.

Shewfelt, A.L., Young, C.T. (1977). Storage stability of peanut-based foods: A review. *Journal of Food Science*. 42(5): 1148-1152.

Sihsobhon, C., Chompreeda, P., Suwonsichon, T., Haruthaithanasant, V. and Resurrreccion, A. (2008). American consumer acceptance of satay sauce as affected by different peanut grinding methods , the multi-step and one-step processes , and processing times. *Kasetsart J. (Nat. Sci.)*. 42: 117-128.

Singh, S.K., Castell-Perez, M.E. and Moreira, R.G. (2000). Viscosity and textural attributes of reduced-fat peanut pastes. *Journal of Food Science*. 65: 849-853.

Slade, L. and Levine, H. (2006). Optimisation of roasting process and product quality of peanuts. *Journal of Thermal Analysis and Colourimetry*. *83*: 163-166.

Smith, A.L., Perry, J.J., Marshall, J.A., Yousef, A.E., Barringer, S.A. (2014). Oven, microwave, and combination roasting of peanuts: Comparison of inactivation of *Salmonella* surrogate *Enterococcus faecium*, colour, volatiles, flavour, and lipid oxidation. *Journal of Food Science*. 79(8): S1584-S1594.

Smyth, D.A., Macku, C., Holloway, O.E., Deming, D.M., Slade, L. and Levine, H. (1998). Evaluation of analytical methods for optimizing peanut roasting for snack foods. *Peanut Science*. *25*: 70-76.

St. Angelo, A.J., Ory, R.L., Brown, L.E. (1972). A comparison of minor constituents in peanut butter as possible source of fatty acid oxidation. *J. Amer. Peanut Res. Educ. Assoc*. 4:186-194.

St. Angelo, A.J., Ory, R.L. (1975). Effects of lipid peroxidation during storage on raw and roasted peanut proteins. *Peanut Science*. 2:41.

Steffe, J.F. *Rheological methods in food process engineering*. 2nd. ed. 1996, Michigan: Freeman Press.

Subramaniam, R., and Gunasekaran, S. (1997). Small amplitude oscillatory shear studies on mozzarella cheese - part I. region of linear viscoelasticity. *Journal of Texture Studies*. 28(1997): 633-642.

Suchoszek-Łukaniuk, K., Jaromin, A., Korycińska, M. and Kozubek, A. (2011). Chapter 103 - Health Benefits of Peanut (*Arachis hypogaea* L.) Seeds and Peanut Oil Consumption. In Preedy, V.R., Watsons, R.R. and Patel, V. B. *Nuts and Seeds in Health and Disease Prevention* (pp. 873-880). San Diego: Academic Press.

Tabilo-Munizaga, G., and Barbosa-Canovas, G. V. (2005). Rheology for the food industry. *Journal of Food Engineering*. 67(1-2): 147-156.

Tan, M.C., Chin, N.L. and Yusof, Y.A. (2012). A Box-Behnken design for determining the optimum experimental condition of cake batter mixing. *Food Bioprocess Technology: An International Journal. 5* (3): 972-982.

Tomlins, K., Rukuni, T., Mutungamiri, A., Mandeya, S. and Swetman, A. (2007). Effect of roasting time and storage time on sensory attributes and consumer acceptability of peanut butters in southern Africa. *Trop. Sci. 47* (4): 165-182.

Tromans, D. (2008). Mineral comminution: Energy efficiency considerations. *Minerals Engineering*. 21**,** 613-620.

USDA. (2011): Oilseeds: World Markets and Trade Monthly Circular. Unites States Department of Agriculture: Foreign Agricultural Service. http://www.fas.usda.gov/oilseeds/Current/default.asp. Access: 2011/7/14.

Tunick, M.H. (2011). Small-Strain Dynamic Rheology of Food Protein Networks. *Journal of Agricultural and Food Chemistry*. 59(5): 1481-1486.

United States Department of Agriculture. *Commodity requirements PP12 peanut products for use in domestic programs*. Farm Service Agency (FSA). Washibgton, DC. 2010.

United States Department of Agriculture. *Grading manual for peanut butter*.USDA. Washington, DC. 2011.

Valencia, C., Sanchez, M.C., Ciruelos, A. and Gallegos, C. (2004). Influence of tomato paste processing on the linear viscoelasticity of tomato ketchup. *Food Sci Tech Int.* 10: 95-100.

Velu, V., Nagender, A., Prabhakara Rao, P.G., Rao, D.G. (2006). Dry milling characteristics of microwave dried maize grains (Zea mays L.). *Journal of Food Engineering*. 74**,** 30-36.

Vishwanathan, K.H., Subramanian, R. (2014). Particle size characteristics of ground soy and red gram. *International Journal of Food Properties*. 17**,** 1469-1481.

Walde, S.G., Balaswamy, K., Shivaswamy, R., Chakkaravarthi, A., Rao, D.G. (1997). Microwave drying and grinding characteristics of gum karaya (Sterculia urens). *Journal of Food Engineering*. 31**,** 305-313.

Walde, S.G., Balaswamy, K., Velu, V., Rao, D.G. (2002). Microwave drying and grinding characteristics of wheat (Triticum aestivum). *Journal of Food Engineering*. 55**,** 271-276.

Wilkin, J.D., Ashton, I.P., Fielding, L.M., Tatham, A.S. (2014). Storage stability of whole and nibbed, conventional and high oleic peanuts (*Arachis hypogeae* L.). *Food Bioprocess Technology*. 7:105-113.

Woodroof, J.G. (1983). Peanut butter. In *Peanuts Production, Processing, Products, (3rd eds.)* pp. 181-225, The AVI Publishing Company, Connecticut.

Wu, Y., Ding, W., Jia, L., He, Q. (2015). The rheological properties of tara gum (*Caesalpinia spinosa*). *Food Chemistry*. 168: 366-371.

Yang, J., Pan, Z., Takeoka, G., Mackey, B., Bingol, G., Brandl, M. T., Garcin, K., McHugh, T. H. and Wang, H. (2013). Shelf-life of infrared dry-roasted almonds. *Food Chemistry*. 138(1): 671-678.

Yazdanpanah, H., Mohammadi, T., Abouhossain, G., Cheraghali, A.M. (2005). Effect of roasting on degradation of Aflatoxins in contaminated pistachio nuts. *Food and Chemical Toxicology*. 43(7): 1135-1139

Youn, K.S. and Chung, H.S. (2011). Optimisation of the roasting temperature and time for preparation of coffee-like maize beverage using the response surface methodology. *LWT-Food Science and Technology*. *46*: 305-310.

Zhao, X., Yang, Z., Gai, G. and Yang, Y. (2009). Effect of superfine grinding on properties of ginger powder. *Journal of Food Engineering*. 91:217-222.