UNIVERSITI PUTRA MALAYSIA

EFFECTS OF GERMINATION ON NUTRITIONAL PROPERTIES AND ANTI-NUTRIENTS IN SELECTED LEGUMES

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EFFECTS OF GERMINATION ON NUTRITIONAL PROPERTIES AND ANTI-NUTRIENTS IN SELECTED LEGUMES

By

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

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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

EFFECTS OF GERMINATION ON NUTRITIONAL PROPERTIES AND ANTI-NUTRIENTS IN SELECTED LEGUMES

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April 2015

Chair: Assoc. Prof. Azrina binti Azlan, PhD

Faculty: Medicine and Health Sciences

Legume is a plant in the family of *Fabaceae* (or *Leguminosae*) that is cultivated and consumed throughout the world. Legume's role in human health appears to be limited because of several limiting factors such as low protein and starch digestibility, poor mineral bioavailability and high anti-nutritional factors. Germination is defined as a process that occurs during seed growth that starts with uptake of water until the emergence of radicle through the surrounding structure. It has been suggested that germination is a cheaper and more effective technology that can improve the quality of legumes by increasing their nutritional value. This study is conducted to compare changes in proximate content, anti-nutrients, anti-oxidants, dietary fibre, total sugar and fatty acid composition after germination process in kidney, mung, soy beans and peanuts. Germination was done by soaking the legume samples followed by leaving the samples on wet muslin cloth until the emergence of radicle. Germination caused a significant increase ($p<0.05$) of moisture content while ash, carbohydrate, protein and fat contents were significantly decreased. Total dietary fibre (both soluble and insoluble) was found to be significantly increased ($p<0.05$) in all germinated legume samples. Tannin content in germinated mung beans and peanut was decreased while phytic acid of germinated mung and soy beans was significantly decreased ($p<0.05$). Total cyanide content was significantly decreased ($p<0.05$) in all germinated legumes. All germinated legumes had significantly lower ($p<0.05$) total phenolic content while ferric reducting ability of plasma (FRAP) level was increased in all except germinated peanuts. Diphenyl-1-picrylhydrazyl (DPPH) activity of germinated mung beans was improved while in other germinated legumes, it was reduced. For fatty acid composition, saturated fatty acids was decreased in germinated soy beans and peanuts while polyunsaturated fatty acids was increased in germinated peanuts. For total sugar content, germination increased the level in all legume samples. Overall, germination has been proven to improve nutritional properties of legumes but the changes are influenced by the type of legumes.

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

KESAN PERCAMBAHAN KEPADA SIFAT PEMAKANAN DAN ANTI-NUTRIEN DI DALAM KEKACANG

Oleh

MEGAT RUSYDI BIN MEGAT RADZI

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Pengerusi: Prof. Madya Azrina binti Azlan, PhD

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Kekacang adalah tumbuhan di dalam keluarga *Fabaceae* (atau *Leguminosae*) yang ditanam dan dimakan di serata dunia. Peranan kekacang di dalam kesihatan manusia adalah terbatas kerana beberapa faktor seperti penghadaman protein dan kanji yang rendah, kehadiran mineral yang rendah dan tinggi faktor anti-nutrien. Pencambahan ditakrifkan sebagai proses yang berlaku semasa pertumbuhan biji benih yang bermula dari pengambilan air sehingga kemunculan radikal merentasi struktur persekitaran. Proses ini adalah efektif dan lebih murah untuk menambah baik kualiti kekacang dari segi nilai pemakanan. Kajian ini dijalankan untuk membandingkan perubahan di dalam kandungan proksimat, anti-nutrien, anti-oksidan, serat, jumlah gula dan komposisi asid lemak selepas proses pencambahan di dalam kacang merah, hijau, soya dan tanah. Proses pencambahan sampel kekacang dimulakan dengan merendam sampel di dalam air sebelum dibiarkan di atas kain muslin lembap. Pencambahan menyebabkan kenaikan signifikan ($p<0.05$) kandungan air, manakala kandungan abu, karbohidrat, protein dan lemak menurun secara signifikan. Jumlah kandungan serat (larut dan tidak larut) didapati bertambah secara signifikan ($p<0.05$) di dalam semua sampel kekacang cambah. Kandungan tannin di dalam kacang hijau dan kacang tanah cambah berkurang manakala asid fitik di dalam kacang hijau dan soya berkurang secara signifikan ($p<0.05$). Kandungan sianida berkurang secara signifikan ($p<0.05$) di dalam semua kekacang cambah. Kandungan fenolik mengalami penurunan signifikan ($p<0.05$) di dalam semua kekacang cambah manakala paras FRAP meningkat di dalam semua kekacang cambah kecuali kacang tanah. Aktiviti DPPH kacang hijau cambah meningkat manakala di dalam kekacang cambah lain, ia berkurang. Untuk kandungan asid lemak, asid lemak tepu berkurang di dalam kacang soya dan tanah cambah manakala asid lemak poli-tak-tepu meningkat di dalam kacang tanah. Untuk kandungan gula, pencambahan telah meningkatkan kandungan gula di dalam semua sampel kekacang. Secara keseluruhan, pencambahan telah meningkatkan kandungan zat pemakanan kekacang tetapi perubahannya dipengaruhi oleh jenis kekacang.

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'There is a tide, in the affairs of men, which taken at the flood leads onto fortune. Omitted, all the voyage of your life is bound up in sorrows and in miseries. On such a full sea we now float, and we must take the current when we serve or lose our ventures.'

William Shakespeare

I certify that a Thesis Examination Committee has met on 21 April 2015 to conduct the final examination of Megat Rusydi Bin Megat Radzi on his thesis entitled "Effects of Germination on Nutritional Properties and Anti-Nutrients in Selected Legumes" 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 Master of Science.

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d.w.:	dry weight
DPPH:	diphenyl-1-picrylhydrazyl
FRAP:	ferric reducing ability of plasma
G:	germinated
GAE:	gallic acid equivalent
IDF:	insoluble dietary fibre
MUFA:	monounsaturated fatty acid
NG:	non-germinated
PUFA:	polyunsaturated fatty acid
SDF:	soluble dietary fibre
SFA:	saturated fatty acid
TDF:	total dietary fibre
TPC:	total phenolic content

CHAPTER 1

INTRODUCTION

1.1 Study Background

Legume is a plant in the family of *Fabaceae* (or *Leguminosae*), or a fruit of these specific plants. Legume family can be characterized by "edible seeds, borne in pods that often open along two seams, by pea-shaped flowers, and by compound stipulate leaves" (Mazur, Duke, Wähälä, Rasku & Adlercreutz, 1998). Legumes have been recognized as important sources of proteins, carbohydrates, dietary fibre, and in some cases of oil. Generally, they contain 18-25% proteins and contribute to important part of low-income people's diet especially in developing countries. There are approximately 20 leguminous species being used for human consumption such as pea (*Pisum sativum* L.) in Asian countries, common bean (*Phaseolus vulgaris* L.) in Latin American and African countries, chickpea (*Cicer arietinum* L.) in India and lentil (*Lens culinaris* Med.) in countries of the Middle East (Morrow, 1991, de Almeida Costa, da Silva Queiroz-Monici, Reis, & de Oliveira, 2006).

Germination is defined as a process that occurs during seed growth that starts with uptake of water until the emergence of radicle through the surrounding structure (Nonogaki, Bassel, & Bewley, 2010). It generally preceded by soaking the legume seeds in water. During this period, reserve materials stored in cotyledon of the seeds, were degraded and used for respiration and synthesis of new cells prior to the developing of embryo thus causing significant changes in the biochemical characteristics. The source of energy during this process is mainly from fats and carbohydrates in the seeds (Vidal-Valverde et al., 2002).

In recent times, the numbers of studies on the effect of germination on legume seeds are increasing due to the positive nutritional effects reported. Moisture, total ash, total protein and total dietary fibre contents have reportedly increased with increased germination time while antinutritional factors, such as phytic acid, tannin and hemaglutinin activity were decreased (El-Adawy et al., 2003; Sangronis, Rodriguez, Cava, & Torres, 2006; Ghavidel & Prakash, 2006; Khandelwal, Udipi & Ghugre, 2010). Levels of free amino acids and the functionality of the seeds due to the subsequent increase in the bioactive compounds were found to be increased after germination (Frías, Miranda, Doblado, & Vidal-Valverde, 2005; López-Amorós, Hernandez & Estrella, 2006, Vernaza, Dia, Gonzalez de Mejia, & Chang, 2012). Vitamins and anti-oxidant capacity were found to be increased after germination due to the enhancement of vitamin C, E and tocopherols' content (Vidal-Valverde et al., 2002; Frias et al., 2005; Fernandez-Orozco et al., 2008).

It has been suggested that germination is a cheaper and more effective technology that can improve the quality of legumes by increasing their nutritional value (Frias et al., 2005). In addition, germinated soy beans are served as vegetables and used in salads, soups, and side dishes in Asia countries such as China, Korea and India (Vidal-Valverde et al., 2002; Sangronis et al., 2006; Choi & Bajpai, 2010). However, the effects of germination on the chemical composition and biochemical constituents of seeds vary differently among plant species, seed varieties or cultivars and the germination

conditions such as temperature, light, moisture and the time of germination (Sattar, Durrani, Mahmood, Ahmad, & Khan, 1989; Bau, Villaume, Nicolas, & Mejean, 1997; Kuo, Rozan, Lambein, Frias, & Vidal-Valverde, 2004; Paucar-Menacho, Berhow, Mandarino, de Mejia, & Chang, 2010, Vernaza et al., 2012).

It was estimated that 345.7 million tonnes of legumes were produced in 2010, increased from 224.59 million tonnes in 2007 (FAO, 2007; FAO, 2010). Out of this value, soy beans were the largest type of legumes produced (264 million tonnes) followed by peanut (37.95 million tonnes). Across the globe, United States of America (USA) was the largest producer of soy beans with 90.6 million tonnes produced, followed by Brazil (68.75 million tonnes) and Argentina (52.67 million tonnes). For peanut, the largest producer was China with 15.7 million tonnes, followed by India (5.64 million tonnes), and Nigeria (2.64 million tonnes). Other types of legumes were mass produced in India (4.87 million tonnes), Brazil (3.16 million tonnes) and Myanmar (3.03 million tonnes). According to a report by Akibode and Maredia (2011), the average per capita consumption of all legumes in developing countries was around 8 kg/year, while in the developed countries and the rest of the world, the consumption was around 4 kg/year. Although the data for specific legumes are not available, it was reported that the worldwide consumption of common beans (*Phaseolus* spp.) was around 3.03 kg/year.

Peanut (*Arachis hypogea* L.) is known by several names throughout the world, such as groundnut and earth nut, because the seeds develop under the ground. Peanuts shelf live are not long; hence, utilization of peanuts into different product has to be made (Pattee, 2005). Most peanuts grown in U.S. are used for oil production, peanut butter, confections, and snack products (Yu, Ahmedna, Goktepe & Dai, 2006). A. hypogea, of the pea family, that develops in an underground pod and a pod containing two seeds with thin brownish skin. It is also widely cultivated in warm climates, and has short lived yellow flowers. Average peanut contains 25.5% protein, 41.8% fat, 6.1% fibre and 16.30% carbohydrates (Tee, Noor, Azudin, & Idris, 1997).

Soy bean (*Glycine Max*) is a species of legume native to East Asia and one of the most important crops in China (Liu, Guo, Zhu & Liu, 2007) although in recent years, the amount of production of soy bean was led by U.S.A (FAO, 2010). The value of soy bean is based on their protein and fat content. Protein in soy bean is quite high, 33.8%, while other nutrients such as fat and carbohydrate are 18.9% and 25.5%, respectively (Tee et al., 1997). Soy bean oil, usually high in linoleic, oleic, and linolenic acid, is beneficial to human health and related to reduce risk of cardiovascular disease, prevention of certain cancer and improved glucose tolerance in diabetes patients (Redondo-Cuenca, Villanueva-Suarez, Rodriguez-Sevilla, & Mateos-Aparicio, 2006).

Kidney beans (*Phaseolus vulgaris*) can be found mainly in arid and semi-arid areas of Pakistan (Yasmin, Zeb, Khalil, Paracha, & Khattak, 2008). It is also the most widely produced and consumed legume in Africa, India, Latin America and Mexico (FAO, 2002). In India, kidney beans are commonly known as *Rajmah* which represent a rich and cheap source of protein and carbohydrates among the population (Wani, Sogi, Wani, Gill, & Shivhare, 2010). Dry kidney beans contains 27.1% protein, 1.89% fat and 57.7% carbohydrate (Kaur & Singh, 2007; Yasmin et al., 2008). Kidney beans can be consumed either raw or cooked alone or along with cereals and other food groups (Yasmin et al., 2008). It is reported that kidney beans have numerous health benefits such as reduce heart and renal disease risks, lower glycaemic index for persons with diabetes, increase satiation, and cancer prevention (Shimelis & Rakshit, 2007).

Mung bean (*Vigna Radiata*), also known as green bean, is mainly cultivated in China, Thailand, India, and also in hot and dry regions of South Europe and Southern USA. In Egypt, it was introduced as summer legume crop by the Ministry of Agriculture (El-Adawy, Rahma, El-Bedawey, & El-Beltagy, 2003). It contains 16.10% protein, 0.8% fat, 64.2% carbohydrate and 3.7% fibre (Tee et al., 2004).

In this study, kidney, mung, soy beans and peanuts were selected as study samples because these four legumes are the most consumed by Malaysians (APO, 2003). Peanuts are mainly used in local dishes, as well as being processed and produced as oil, peanut butter and margarine. Soy beans are often being used as beverages while the by-products such fermented soy bean cake, soy bean curd and sauce, are consumed as side dishes. Mung beans can either be cooked or sprouted while the dried beans are prepared as soup or snacks as well as kidney beans.

1.2 Problem Statements

Numerous studies have shown that intake of legumes have many health effects in controlling and preventing various metabolic diseases such as diabetes mellitus and coronary heart diseases (Anderson, Smith, & Washnock, 1999; Liu et al., 1999). A prospective cohort study among diabetic population from European countries found that intake of 20 g legumes per day was inversely related to the risk for cardiovascular mortality significantly (Nothlings et al., 2008). Phytochemicals found in soy beans can reduce lipid peroxidation and increase resistance of low-density lipoprotein (LDL) to oxidation (Anderson & Major, 2002; Winham, Hutchins, & Johnston, 2007). Intake of whole grain and legume powder combined can reduce fasting levels of glucose and insulin among coronary artery disease patients without diabetes mellitus (Jang, Lee, Kim, Park, & Lee, 2001).

Although legumes have important part in the diet of many developing countries, their role appears to be limited due to several limiting factors such as poor mineral bioavailability (Rao & Prabhavathi, 1982; Kamchan, Puwastien, Sirichakwal, & Kongkachuichai, 2004) and high antinutritional factors (Das, Chaturvedi, & Nagar, 1999; Ramulu & Udayasekhara, 1997; Savelkoul, Vanderpoel & Tamminga, 1999). Poor digestibility of proteins and inhibitory effects for absorption and utilization of calcium, iron, and zinc have been attributed to the presence of protease inhibitors (trypsin), α-amylase inhibitors, lectins, polyphenolic compounds, tannins and phytic acid (Liener, 2003; Yasmin et al., 2008).

Many studies have been done to study the effect of germination on proximate content and antinutritients in legumes such as kidney beans (Yasmin et al., 2008), soy beans (Bau et al., 1997) and cowpea (El-Adawy et al., 2004; Ghavidel & Prakash, 2006). There are also studies on the effect of germination on carbohydrate composition of the dietary fiber of peas (Martin-Cabrejas et al., 2003), anti-oxidant content and anti-oxidant capacity of lupin seeds (Frias et al., 2005) and fatty acid composition (Bau et al., 1996; Dhaliwal & Aggarwal, 1999). However, there are no thorough studies on nutritional properties of germinated legumes that compare between different types of legumes.

1.3 Significance of Study

The significance of this study is to share the knowledge of how germination process affects the nutritional composition of legumes and how human can benefit from it. This study also aimed to provide data on nutritional contents of germinated legumes as well as the non-germinated legumes. These data may be useful for further research in the future as well as developing new and improved food products for the market.

Based on previous studies, nutrients such as amino acids, carbohydrates and dietary fibre were found to be increased in germinated legumes compared to non-germinated legumes. Study by Urbano et al. (2005) found that germination caused a notable decrease in α-galactoside content and significant increase in sucrose, glucose and fructose. Similar result was found by Vidal-Valverde et al (2002) as they found that the amount of soluble sugar content increased after two days of germination. Theoretically, this finding may result in sweeter legumes after germination compared to raw legumes, hence, improved the taste and acceptance of the legumes themselves.

Ghavidel & Prakash (2006) found that *in vitro* starch digestibility was increased in legumes after germination compared to non-germinated legumes, as well as *in vitro* protein digestibility. This finding shows that germinated seeds are more easily digested by human, especially for elderly and babies. Besides that, germinated legumes were found to be low in anti-nutrients such as tannin and phytic acid. Study by Yasmin et al. (2008) found that total tannin, phenols, cyanide and phytic acid were decreased significantly after 96 hours of germination. This finding was further supported by Khandelwal et al. (2010) as they found that polyphenols and tannins were decreased after germination in Indian pulses such as Bengal gram and lentil. Anti-nutrients contribute to poor digestibility of protein and inhibitory effects for absorption and utilization of calcium, iron and zinc. Hence, reduction in anti-nutrients will allow protein to be digested more easily and absorption of nutrients could take place.

Study by Torres, Frias, Granito, & Vidal-Valverde (2005) found that germinated pigeon peas seeds could be good ingredients in pasta products. In the study, germinated seeds were made into powder and used as ingredients to produce pasta products in different proportion. The end product had shorter cooking time, similar acceptance to control pasta in sensory evaluation and higher protein, fat, dietary fibre and mineral contents.

1.4 Objective

1.4.1 General Objective

To compare changes in proximate content, anti-nutrients, anti-oxidants, dietary fibre, total sugar and fatty acid composition of germinated and non-germinated soy, mung, kidney bean and peanut.

1.4.2 Specific Objectives

1.4.2.1 To compare the nutrients (carbohydrate, protein, fat, fibre, ash and moisture), anti-oxidant content (Total phenolic content, DPPH activity and FRAP activity), anti-nutrient (total cyanide, tannin, and phytic acid content) total sugar available, dietary fibre fractions and fatty acid composition (FAC) of germinated and non-germinated soy, mung, kidney bean and peanut

1.4.2.2 To correlate the nutritional contents of germinated and non-germinated soy, mung, kidney bean and peanut.

REFERENCES

Abd El-Hady, E. A., & Habiba, R. A. (2003). Effect of soaking and extrusion conditions on anti-nutrients and protein digestibility of legume seeds. *LWT-Food Science and Technology*, 36(3), 285-293.

Aguilera, Y., Martín-Cabrejas, M. A., Benítez, V., Mollá, E., López-Andréu, F. J., & Esteban, R. M. (2009). Changes in carbohydrate fraction during dehydration process of common legumes. *Journal of Food Composition and Analysis*. 22(7), 678-683.

Akibode, S., & Maredia, M. (2011). Global and regional trends in production, trade and consumption of food legume crops. *Department of Agricultural, Food and Resource Economics, Michigan State University*, 87.pat

Alabaster, O., Tang, Z., & Shivapurkar, N. (1997). Inhibition by wheat bran cereals of the development of aberrant crypt foci and colon tumours. *Food and chemical toxicology*. 35(5), 517-522.

Alajaji, S.A. & El-Adawy, T. (2006). Nutritional composition of chickpea (*Cicer arietinum* L.) as affected by microwave cooking and other traditional cooking methods. *Journal of Food Composition and Analysis.* 19(8), 806-812

Anderson, J. W., Smith, B. M., & Washnock, C. S. (1999). Cardiovascular and renal benefits of dry bean and soybean intake. *The American Journal of Clinical Nutrition*. *70*(3), 464-474.

Anderson, J. W., & Major, A. W. (2002). Pulses and lipaemia, short-and long-term effect: potential in the prevention of cardiovascular disease. *British Journal of Nutrition*. 88(S3), 263-271.

AOAC. (2000). Official Methods of Analysis, 14th ed. Washington DC: Association of Official Agricultural Chemists.

Apata, D. F. (2008). Effect of cooking methods on available and unavailable carbohydrates of some tropical grain legumes. *African Journal of Biotechnology*. 7(16).

APO. (2003) Report of the APO seminar on Processing and Utilization of Legumes. Japan

Aune, D., De Stefani, E., Ronco, A., Boffetta, P., … & Mendilaharsu, M. (2009). Legume intake and the risk of cancer: a multisite case-control study in Uruguay. *Cancer Causes Control*. 20:1605-1615.

Azeke, M. A., Elsanhoty, R. M., Egielewa, S. J., & Eigbogbo, M. U. (2010). The effect of germination on the phytase activity, phytate and total phosphorus contents of some Nigerian-grown grain legumes. *Journal of the Science of Food and Agriculture*. *91*(1), 75-79.

Banerjee, S., Li, Y., Wang, Z., & Sarkar, F. H. (2008). Multi-targeted therapy of cancer by genistein. *Cancer letters*. 269(2), 226-242.

Bau, H. M., Villaume, C., Nicolas, J. P., & Mejean, L. (1997). Effect of germination on chemical composition, biochemical constituents and antinutritional factors of soya bean (Glycine max) seeds. *Journal of the Science of Food and Agriculture*, *73*(1), 1-9.

Beninger, C. W., & Hosfield, G. L. (2003). Anti-oxidant activity of extracts, condensed tannin fractions, and pure flavonoids from Phaseolus vulgaris L. seed coat color genotypes. *Journal of Agricultural and Food Chemistry*. 51(27), 7879-7883.

Benitez, V., Cantera, S., Aguilera, Y., Molla, E., Esteban, R.M., Diaz, M.F. & Martin-Cabrejas, M.A. (2013). Impact of germination on starch, dietary fiber and physicochemical properties in non-conventional legumes. *Food Research International.* 50(1), 64-69

Benzie, I. F., & Strain, J. J. (1996). The ferric reducing ability of plasma (FRAP) as a measure of "anti-oxidant power": the FRAP assay. *Analytical biochemistry*. 239(1), 70-76.

Bewley, J.D., Bradford, K., Hilhorst, H, & Nonogaki, H. (2013) Seeds: Physiology of Development, Germination and Dormancy, 3rd Edition. *Springer New York.*

Blomhoff, R., Carlsen, M. H., Andersen, L. F., & Jacobs, D. R. (2006). Health benefits of nuts: Potential role of anti-oxidants. *British Journal of Nutrition*. 96 (2), 52–60.

Brune, M., Rossander, L., & Hallberg, L. (1989). Iron absorption and phenolic compounds: importance of different phenolic structures. *European Journal of Clinical Nutrition*. 43(8), 547-557.

Bucher, H. C., Hengstler, P., Schindler, C., & Meier, G. (2002). N-3 polyunsaturated fatty acids in coronary heart disease: a meta-analysis of randomized controlled trials. *The American Journal of Medicine*. 112(4), 298-304.

Carbonaro, M. (2011). Role of pulses in nutraceuticals. *Pulse foods: processing, quality and nutraceutical applications. Oxford (UK): Academic Press*. p, 385-418.

Cardador-Martínez, A., Loarca-Piña, G., & Oomah, B. D. (2002). Anti-oxidant Activity in Common Beans (Phaseolus vulgaris L.) §. *Journal of Agricultural and Food Chemistry*, 50(24), 6975-6980.

Cevallos-Casals, B.A. & Cisneros-Zevallos, L (2010). Impact of germination on phenolic content and anti-oxidant activity of 13 edible seed species. *Food Chemistry*. 119, 1485-1490.

Chevance, F.F.V., Farmer, L.J., Desmond, E.M., Novelli, E., Troy, D.J., & Chizzolini, R. (2000). Effect of some fat replacers on the release of volatile aroma compound from low-fat meat products. *Journal of Agricultural and Food Chemistry*. 48(8), 3476–3484.

Chiou, Robin Y.-Y., Ku, K.-L., & Chen, W.-L. (1997). Compositional characterization of peanut kernels after subjection to various germination times. *Journal of Agricultural and Food Chemistry*. 45(8), 3060-3064.

Choi, U. K., & Bajpai, V. K. (2010). Comparative study of quality characteristics of meju a Korean soybean fermentation starter, made by soybeans germinated under dark and light conditions. *Food and chemical toxicology*. 48(1), 356-362.

Clegg, K. M. (1956). The application of the anthrone reagent to the estimation of starch in cereals. *Journal of the Science of Food and Agriculture.* 7(1), 40-44.

Connor, W. E. (2000). Importance of n− 3 fatty acids in health and disease. *The American Journal of Clinical Nutrition*, 71(1), 171S-175S.

Das, J., Chaturvedi, Y., & Nagar, R. (1999). Effect of germination on inorganic, labile and phytate phosphorous of some legumes. *Journal of Food Science and Technology*, 36(6), 532–534

Davis, J.P., Dean, L.L., Price, K.M., & Sanders, T.H. (2010). Roast effects on the hydrophilic and lipophilic anti-oxidant capacities of peanut flours, blanched peanut seed and peanut skins. *Food Chemistry*, 119, 539-547.

de Almeida Costa, G. E., da Silva Queiroz-Monici, K., Reis, S. M. P. M., & de Oliveira, A. C. (2006). Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes. *Food Chemistry*. *94*(3), 327-330.

de Cortes Sánchez-Mata, M., Cámara-Hurtado, M., & Díez-Marqués, C. (2002). Identification and quantification of soluble sugars in green beans by HPLC. *European Food Research and Technology*, 214(3), 254-258.

Dhakal, K.H., Jung, K.H., Chae, J.H., Shannon, J.G. & Lee, J.D. (2014). Variation of unsaturated fatty acids in soybean sprout of high oleic acid accessions. *Food Chemistry.* 164, 70-73.

Dhaliwal, Y. S., & Aggarwal, R. A. K. (1999). Composition of fat in soybeans as affected by duration of germination and drying temperature. *Journal of Food Science and Technology*, 36(3), 266-267.

Dhingra, D., Michael, M., Rajput, H. & Patil (2012). Dietary fibre in foods: a review. *Journal of Food Science & Technology.* 49(3), 255-266

Diaz, A.M., Caldas, G.V. & Blair, M.W. (2010). Concentrations of condensed tannins and anthocyanins in common bean seed coats. *Food Research International.* 43(2), 595-601.

Dongowski, G. & Ehwald, R. (1998). Properties of dietary preparations of the cellan-type. In *Proceeding of the PROFIBRE Symposium, Functional properties of non-digestible carbohydrates. Imprimerie Parentheses, Nantes*. (pp 52–54)

Drizikova, B., Dongowski, G., Gebhardt, E., & Habel, A. (2005). The composition of dietary fibre-riche extrudates from oat affects from oat affects bile acid binding and fermentation in vitro. *Food Chemistry.* 90(1), 181-192.

Duenas, M., Hernandez, T., Estrella, I., & Fernandez, D. (2009). Germination as a process to increase the polyphenol content and anti-oxidant activity of lupin seeds (*Lupinus angustifolius* L.). *Food Chemistry*. *117*(4), 599-607.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., & Attia, H. (2011). Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. *Food Chemistry*, 124(2), 411-421.

El-Adawy, T. A. (2002). Nutritional composition and antinutritional factors of chickpeas (*Cicerarietinum* L.) undergoing different cooking methods and germination. *Plant Foods for Human Nutrition* 57:83–97

El-Adawy, T. A., Rahma, E. H., El-Bedawey, A. A., & El-Beltagy, A. E. (2003). Nutritional potential and functional properties of germinated mung bean, pea and lentil seeds. *Plant Foods for Human Nutrition*, *58*(3), 1-13.

Embaby, H. E. S. (2010). Effect of soaking, dehulling, and cooking methods on certain anti-nutrients and in vitro protein digestibility of bitter and sweet lupin seeds. *Food Science and Biotechnology*, 19(4), 1055-1062.

Ertas, N. (2014). Technological and chemical characteristics of breads made with lupin sprouts. *Quality Assurance and Safety of Crops & Foods.* 1-7

Fang, Y-Z., Yang, S. & Wu. (2002). Free radicals, anti-oxidants, and nutrition. *Nutrition*. 18:872-879

FAO (2007) FAOSTAT Online Statistical Service. United Nations Food and Agriculture Organization (FAO), Rome.

FAO. (2010). FAOSTAT statistical database of the United Nations Food and Agriculture Organization (FAO). Italy: Rome.

Fenn, D., Lukow, O.M., Humphreys, G., Fields, P.G., & Boye, J.I. (2010). Wheat-legume composite flour quality. *International Journal of Food Properties.* 13(2). 381-393.

Fernandez-Orozco, R., Frias, J., Zielinski, H., Piskula, M. K., Kozlowska, H., & Vidal-Valverde, C. (2008). Kinetic study of the anti-oxidant compounds and anti-oxidant capacity during germination of *Vigna radiate* cv. *emmerald*, *Glycine max* cv jutro and *Glycine max* cv. *merit*. *Food Chemistry*, *111*(3), 622-630

Fordoński, G., Łapiński, M., Pszczółkowska, A., Kulik, T., Olszewski, J., & Płodzień, K. (2001). Identifying *Fusarium avenaceum* and *Fusarium culmorum* in selected legumes and cereals with the PCR method. *Electronic Journal of Polish Agricultural Universities*, 4(2).

Frank, D., Pat, S., & Philip, L.W. (2006). Improving the analysis of fatty acids, ethyl esters using retention time locked methods and retention time databases. *Agilent Technologies*, 1-5.

Frias, J., Miranda, M. L., Doblado, R., & Vidal-Valverde, C. (2005). Effect of germination and fermentation on the anti-oxidant vitamin content and anti-oxidant capacity of *Lupinus albus* L. var. Multolupa. *Food Chemistry*, *92*(2), 211-220.

Fuentes-Zaragoza, E., Riquelme-Navarrete, M. J., Sánchez-Zapata, E., & Pérez-Álvarez, J. A. (2010). Resistant starch as functional ingredient: A review. *Food Research International*, 43(4), 931-942.

Gardarin, A., Dürr, C., & Colbach, N. (2011). Prediction of germination rates of weed species: relationships between germination speed parameters and species traits. *Ecological Modelling*, 222(3), 626-636.

Gawlik-Dziki, U., & Świeca, M. (2011). Sprouts of selected plants as a source of bioavailable anti-oxidants and lipoxygenase inhibitors. *Annales Universitatis Mariae Curie-Skłodowska, Sectio,* 1500(23), 3.

Gebrelibanos, M., Tesfaye, Raghavendra, Y. & Sintayeyu, B. (2013). Nutritional and health implications of legumes. *International Journal of Pharmaceutical Sciences and Research.* 4(4), 1269-1279.

Ghanem, K. Z., & Hussein, L. (1999). Calcium bioavailability of selected Egyptian foods with emphasis on the impact of fermentation and germination. *International journal of food sciences and nutrition*, 50(5), 351-356.

Ghavidel, R. A., & Prakash, J. (2006). Effect of germination and dehulling on functional properties of legume flours. *Journal of the Science of Food and Agriculture*, *86*(8), 1189-1195.

Ghavidel, R.A. & Prakash, J. (2007) The impact of germination and dehulling on nutrients, anti-nutrients, in vitro iron and calcium bioavailability and in vitro starch and protein digestibility of some legume seeds. *LWT* 40 (7), 1292-1299.

Glasgow, R.E., Fisher, E.B., Anderson, B.J., LaGreca, A., Marrero, D., Johnson, S.B., Rubin, R.R. & Cox, D.J. (1999). Behavioral science in diabetes. Contributions and opportunities. *Diabetes care.* 22(5), 832-843.

Goldstein, W.S., & Spencer, K.C. (1985). Inhibition of cyanogenesis by tannins. *Journal of Chemical Ecology,* 11, 847-858.

Gomez, M., Oliete, B., Rosell, C.M., Pando, V., & Fernandez, E. (2008). Studies on cake quality made of wheat-chickpea flour blends. *LWT – Food Science and Technology.* 41(9), 1701-1709.

Goyoaga, C., Burbano, C., Cuadrado, C, Romero, C., Guillamon, E., Varela, A., Pedrosa, M.M., & Muzquiz, M. (2011). Content and distribution of protein, sugars and inositol phosphates during the germination and seedling growth of two cultivars of *Vicia faba*. *Journal of Food Composition and Analysis.* 24(3), 391-397

Guajardo-Flores, D., Serna-Saldívar, S. O., & Gutiérrez-Uribe, J. A. (2013). Evaluation of the anti-oxidant and antiproliferative activities of extracted saponins and flavonols from germinated black beans (*Phaseolus vulgaris* L.). *Food chemistry*, 141(2), 1497-1503.

Guillon, F., Auffret, A., Robertson, J.A., Thibault, J.F., & Barry, J.L. (1998) Relationships between physical characteristics of sugar beet fibre and its fermentability by human fecal flora. *Carbohydrate Polymers*. 37(2), 185–197

Guimarães, V. M., de Rezende, S. T., Moreira, M. A., de Barros, E. G., & Felix, C. R. (2001). Characterization of α-galactosidases from germinating soybean seed and their use for hydrolysis of oligosaccharides. *Phytochemistry*,58(1), 67-73.

Gupta, R.K., Gangoliya, S.S. & Singh, N.K. (2013). Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. *Journal of Food Science & Technology.* 1-9

Ha, D.M., Park, Y.K., Kang, J.H., & Kim, M.H. (2012). Dough properties and quality characteristics of breads added with barley flour. *Korean Journal of Food Preservation.* 19(3), 344-353.

Hahm, T.-S., Park, S.-J, and Martin Lo, Y. (2009) Effects of germination on chemical composition and functional properties of sesame (*Sesamum indicum* L.) *Bioresource Technology.* 100(4), 1647-1647

Halvorsen, B. L., Holte, K., Myhrstad, M. C., Barikmo, I., Hvattum, E., Remberg, S. F., ... & Blomhoff, R. (2002). A systematic screening of total anti-oxidants in dietary plants. *The Journal of Nutrition*, 132(3), 461-471.

Haque, M. R., & Bradbury, J. H. (2002). Total cyanide determination of plants and foods using the picrate and acid hydrolysis methods. *Food Chemistry*. 77(1), 107-114.

Hu, F. B., Stampfer, M. J., Haffner, S. M., Solomon, C. G., Willett, W. C., & Manson, J. E. (2002). Elevated risk of cardiovascular disease prior to clinical diagnosis of type 2 diabetes. *Diabetes Care*. 25(7), 1129-1134.

Huang, D., Ou, B., & Prior, R. L. (2005). The chemistry behind anti-oxidant capacity assays. *Journal of Agricultural and Food Chemistry*. 53(6), 1841-1856.

Ichihara, K. I., & Fukubayashi, Y. (2010). Preparation of fatty acid methyl esters for gas-liquid chromatography. *Journal of Lipid Research*. 51(3), 635-640.

Institute of Medicine (US). Panel on Micronutrients, Institute of Medicine (US). Food, & Nutrition Board. (2001). *DRI, Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc: A Report of the Panel on Micronutrients...[et Al.], Food and Nutrition Board, Institute of Medicine*. National Academies Press.

Isanga, J., & Zhang, G. N. (2007). Biologically active components and nutraceuticals in peanuts and related products: Review. *Food Reviews International*. 23, 123–140.

Jackman, K. A., Woodman, O. L., & Sobey, C. G. (2007). Isoflavones, equol and cardiovascular disease: pharmacological and therapeutic insights. *Current Medicinal Chemistry*. 14(26), 2824-2830.

Jang, Y., Lee, J. H., Kim, O. Y., Park, H. Y., & Lee, S. Y. (2001). Consumption of whole grain and legume powder reduces insulin demand, lipid peroxidation, and plasma homocysteine concentrations in patients with coronary artery disease randomized controlled clinical trial. *Arteriosclerosis, Thrombosis, and Vascular Biology*. 21(12), 2065-2071.

Jood, S., Chauhan, B.M., & Kapoor, A.C. (1988) Contents and digestibility of carbohydrates of chickpea and black gram as affected by domestic processing and cooking. *Food Chemistry.* 30(2), 113–127.

Kalpanadevi, V. & Mohan, V.R. (2013). Effect of processing on anti-nutrients and in vitro protein digestibility of the underutilized legume, *Vigna unguiculata* (L.) Walp subsp. *Unguiculata*. *LWT-Food Science and Technology*. 51(2), 455-461.

Kamchan, A., Puwastien, P., Sirichakwal, P. P., & Kongkachuichai, R. (2004). In vitro calcium bioavailability of vegetables, legumes and seeds. Journal of food composition and analysis, 17(3), 311-320.

Kaur, M., & Singh, N. (2007). A comparison between the properties of seed, starch, flour and protein separated from chemically hardened and normal kidney beans. *Journal of the Science of Food and Agriculture*, 87(4), 729-737.

Kaushik, G., Satya, S., & Naik, S. N. (2010). Effect of domestic processing techniques on the nutritional quality of the soybean. *Mediterranean Journal of Nutrition and Metabolism*, *3*(1), 39-46.

Kaushik, A., Jijta, C., Kaushik, J. J., Zeray, R., Ambesajir, A., & Beyene, L. (2012). FRAP (Ferric reducing ability of plasma) assay and effect of Diplazium esculentum (Retz) Sw.(a green vegetable of North India) on central nervous system. *Indian Journal of Natural Products and Resources*, 3(2), 228-231.

Khandelwal, S., Udipi, S. A., & Ghugre, P. 2010. Polyphenols and tannins in Indian pulses: Effect of soaking, germination and pressure cooking. *Food Research International*, 43(2), 526-530.

Khattak, A. B., Zeb, A., Bibi, N., Khalil, S. A., & Khattak, M. S. (2007). Influence of germination techniques on phytic acid and polyphenols content of chickpea (*Cicer arietinum* L.) sprouts. *Food Chemistry*, 104(3), 1074-1079.

Khattak, A. B., Zeb, A., Khan, M., Bibi, N., & Khattak, M. S. (2007). Influence of germination techniques on sprout yield, biosynthesis of ascorbic acid and cooking ability, in chickpea (*Cicer arietinum* L.). *Food chemistry*, 103(1), 115-120.

Kim, E.H., Kim, S.H., Chung, J.I., Chi, H.Y., Kim, J.A., & Chung, I.M. (2006). Analysis of phenolic compounds and isoflavones in soybean seeds (*Glycine max* (L.) *Merill*) and sprouts grown under different condition. *European Food Research and Technology*. 222(1-2), 201-208

Kim, H. Y., Hwang, I. G., Kim, T. M., Woo, K. S., Park, D. S., Kim, J. H., ... & Jeong, H. S. (2012). Chemical and functional components in different parts of rough rice (*Oryza sativa* L.) before and after germination. *Food chemistry*, *134*(1), 288-293

Kim, S. H., Jung, W. S., Ahn, J. K., & Chung, I. M. (2005). Analysis of isoflavone concentration and composition in soybean [Glycine max (L.)] seeds between the cropping year and storage for 3 years. *European Food Research and Technology*, 220(2), 207-214.

Kosson, R. (1991). [Determination of raffinose type sugars in seeds of leguminous plants by high pressure liquid chromatography (HPLC)]. *Roczniki Panstwowego Zakladu Higieny*, 43(2), 179-185.

Kuo, Y. H., Rozan, P., Lambein, F., Frias, J., & Vidal-Valverde, C. (2004). Effects of different germination conditions on the contents of free protein and non-protein amino acids of commercial legumes. *Food Chemistry*, 86(4), 537-545.

Lehrfeld, J. & Morris, E.R. (1992). Overestimation of phytic acid in foods by the AOAC anion-exchange method. *Journal of Agricultural and Food Chemistry*, 40(11), 2208-2210.

Lecerf, J. M. (2009). Fatty acids and cardiovascular disease. *Nutrition Reviews*. 67(5), 273-283.

Lewis, G. P., Schrire, B., & Lock, M. (Eds.). (2005). *Legumes of the World* (Vol. 577). Richmond, UK: Royal Botanic Gardens, Kew.

Liener, I.E. (2003). *Plant Antinutritional Factors/ Detoxification*. 4587-4593; Elsevier Science Ltd.; University of Minnesota, St. Paul, MN, USA

Lin, P. Y., & Lai, H. M. (2006). Bioactive compounds in legumes and their germinated products. *Journal of Agricultural and Food Chemistry*, *54*(11), 3807-3814.

Lipkin, M., Reddy, B., Newmark, H., & Lamprecht, S.A. (1999) Dietary factors in human colorectal cancer. *Annual Review of Nutrition*. 19(1), 545–586

Liu, S., Stampfer, M. J., Hu, F. B., Giovannucci, E., Rimm, E., Manson, J. E., Hennekens, C.H. & Willett, W. C. (1999). Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. *The American Journal of Clinical Nutrition*. 70(3), 412-419.

Liu, B., Guo, X., Zhu, K., & Liu, Y. (2011). Nutritional evaluation and anti-oxidant activity of sesame sprouts. *Food Chemistry*, 129(3), 799-803.

Liu, X., He, H., Wang, Y., & Zhu, S. (2007). Transesterification of soybean oil to biodiesel using SrO as a solid base catalyst. *Catalysis Communications*. *8*(7), 1107-1111.

López-Amorós, M. L., Hernandez, T., & Estrella, I. (2006). Effect of germination on legume phenolic compounds and their anti-oxidant activity. *Journal of Food Composition and Analysis*. 19(4), 277-283.

Lunn, J., & Buttriss, J. L. (2007). Carbohydrates and dietary fibre. *Nutrition Bulletin*. 32(1), 21-64.

Luthria, D. L., & Pastor-Corrales, M. A. (2006). Phenolic acids content of fifteen dry edible bean (*Phaseolus vulgaris* L.) varieties. *Journal of Food Composition and Analysis*. 19(2), 205-211.

Ma, G., Jin, Y., Piao, J., Kok, F., Guusje, B., & Jacobsen, E. (2005). Phytate, calcium, iron, and zinc contents and their molar ratios in foods commonly consumed in China. *Journal Of Agricultural And Food Chemistry*. 53(26), 10285-10290.

Makkar, H. P., Blümmel, M., Borowy, N. K., & Becker, K. (1993). Gravimetric determination of tannins and their correlations with chemical and protein precipitation methods. *Journal of the Science of Food and Agriculture.* 61(2), 161-165.

Mann, J. I., & Cummings, J. H. (2009). Possible implications for health of the different definitions of dietary fibre. *Nutrition, Metabolism and Cardiovascular Diseases*. 19(3), 226-229.

Martin-Cabrejas, M.A., Ariza, N., Esteban, R., Molla, E., Waldron, K., & Lopez-Andreu, F.J. (2003). Effect of germination on the carbohydrate composition of the dietary fiber of peas (*Pisum sativum* L.). *Journal of Agricultural and Food Chemistry.* 51, 1254-1259

Martin-Cabrejas, M.A., Diaz, M.F., Aguilera, Y., Benitez, V., Molla, E. and Esteban, R.M. (2008). Influence of germination on the soluble carbohydrates and dietary fibre fractions in non-conventional legumes. *Food Chemistry.* 107, 1045-1052

Martín-Cabrejas, M. A., Aguilera, Y., Pedrosa, M. M., Cuadrado, C., Hernández, T., Díaz, S., & Esteban, R. M. (2009). The impact of dehydration process on anti-nutrients and protein digestibility of some legume flours. *Food Chemistry*. 114(3), 1063-1068.

Mazur, W. M., Duke, J. A., Wähälä, K., Rasku, S., & Adlercreutz, H. (1998). Isoflavonoids and lignans in legumes: nutritional and health aspects in humans.*The Journal of Nutritional Biochemistry*. *9*(4), 193-200.

Megat Rusydi, M.R., Noraliza, C.W., Azrina, A., and Zulkhairi A. (2011) Nutritional changes in germinated legumes and rice varieties. *International Food Research Journal.* 18, 688-696

Menotti, A., Kromhout, D., Blackburn, H., Fidanza, F., Buzina, R., & Nissinen, A. (1999). Food intake patterns and 25-year mortality from coronary heart disease: cross-cultural correlations in the Seven Countries Study. *European journal of epidemiology*, 15(6), 507-515.

Mermelstein, N. H. (2009). Laboratory: analyzing for resistant starch. *Food Technology* (Chicago), 63(4).

Mesa Garcia, M. D., Aguilera Garcia, C. M., & Gil Hernandez, A. (2006). Importance of lipids in the nutritional treatment of inflammatory diseases. *Nutrición Hospitalaria*, 21, 28–41.

Mohammed, I., Ahmed, A.R., & Senge, B. (2012). Dough rheology and bread quality of wheat-chickpea flour blends. *Industrial Crops and Products.* 36, 196-202

Molyneux, P. (2004). The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating anti-oxidant activity. *Songklanakarin Journal of Science and Technology*, 26(2), 211-219.

Morrow, B. (1991). The rebirth of legumes. *Food Technology*, *45*(9).

Nagabhushana Rao, G. and Shrivastava, S.K. (2011). Toxic and Antinutritional Factors of New Varieties of Pea Seeds. *Research Journal of Pharmaceutical, Biological and Chemical Sciences.* 2(2), 512-523

Nassar, A.G., Abd El-Hamied, A.A., El-Naggar, E.A. (2008) Effect of citrus by-products flour incorporation on chemical, rheological and organoleptic characteristics of biscuits. *World Journal of Agricultural Sciences*. *4*(5), 612-616.

Nergiz, C., & Gökgöz, E. (2007). Effects of traditional cooking methods on some anti-nutrients and in vitro protein digestibility of dry bean varieties (Phaseolus vulgaris L.) grown in Turkey. *International Journal of Food Science & Technology*. 42(7), 868-873.

Nestares, T., Barrionuevo, M., Urbano, G., & Lopez-Frias, M. (1999). Effect of processing methods on the calcium, phosphorus, and phytic acid contents and nutritive utilization of chickpea (Cicer arietinum L.). *Journal of Agricultural and Food Chemistry*. 47(7), 2807–2812.

Nonogaki, H., Bassel, G. W., & Bewley, J. D. (2010). Germination—still a mystery. *Plant Science*. *179*(6), 574-581.

Nöthlings, U., Schulze, M. B., Weikert, C., Boeing, H., van der Schouw, Y. T., Bamia, C., ... & Trichopoulo, A. (2008). Intake of vegetables, legumes, and fruit, and risk for all-cause, cardiovascular, and cancer mortality in a European diabetic population. *The Journal of Nutrition*. 138(4), 775-781.

Oke, O. L. (1969). The role of hydrocyanic acid in nutrition. *World Review of Nutrition and Dietetics*, 11, 118-147.

Oomah, B. D., Tiger, N., Olson, M., & Balasubramanian, P. (2006). Phenolics and antioxidative activities in narrow-leafed lupins (*Lupinus angustifolius* L.). *Plant Foods for Human Nutrition*. 61(2), 86-92.

Parmar, H. S., & Kar, A. (2007). Antidiabetic potential of Citrus sinensis and Punica granatum peel extracts in alloxan treated male mice. *Biofactors*. 31(1), 17-24.

Pastor-Cavada, E., Juan, R., Pastor, J. E., Alaiz, M., & Vioque, J. (2009). Fatty acid distribution in the seed flour of wild Vicia species from Southern Spain. *Journal of the American Oil Chemists' Society*. 86(10), 977-983.

Pattee, H. E. (2005). Peanut oil. *Bailey's industrial oil and fat products*.

Paucar-Menacho, L. M., Berhow, M. A., Mandarino, J. M. G., de Mejia, E. G., & Chang, Y. K. (2010). Optimisation of germination time and temperature on the concentration of bioactive compounds in Brazilian soybean cultivar BRS 133 using response surface methodology. *Food Chemistry*. 119(2), 636-642.

Petry, N., Egli, I., Zeder, C., Walczyk, T., & Hurrell, R. (2010). Polyphenols and phytic acid contribute to the low iron bioavailability from common beans in young women. *The Journal of Nutrition*. 140(11), 1977-1982.

Pirman, T., & Stibilj, V. (2003). An influence of cooking on fatty acid composition in three varieties of common beans and in lentil. *European Food Research and Technology*. 217(6), 498-503.

Prosky, L., Asp, N.G., Schweizer, T.F., DeVries, J.W. and Eurda, J. (1988). Determination of insoluble, soluble and total dietary fiber in foods and food products: Collaboration study. *Journal -Association Official Analytical Chemist* 71(5): 1017-1023.

Qiu, J., Chen, L., Zhu, Q., Wang, D., Wang, W., Sun, X., Liu, X., & Du, F. (2012). Screening natural anti-oxidants in peanut shell using DPPH-HPLC-DAD-TOF/MS methods. *Food Chemistry.* 135, 2366-2371.

Raghavendra, S. N., Ramachandra Swamy, S. R., Rastogi, N. K., Raghavarao, K. S. M. S., Kumar, S., & Tharanathan, R. N. (2006). Grinding characteristics and hydration properties of coconut residue: A source of dietary fiber. *Journal of Food Engineering*, 72(3), 281-286.

Rajjou, L., Duval, M., Gallardo, K., Catusse, J., Bally, J., Job, C., & Job, D. (2012). Seed germination and vigor. *Annual Review of Plant Biology*. 63, 507-533.

Ramulu, P., & Udayasekhara, P. R. (1997). Effect of processing on dietary fiber content of cereals and pulses. *Plant Foods for Human Nutrition*. 50, 249–257.

Ranilla, L. G., Kwon, Y. I., Apostolidis, E., & Shetty, K. (2010). Phenolic compounds, anti-oxidant activity and *in vitro* inhibitory potential against key enzymes relevant for hyperglycemia and hypertension of commonly used medicinal plants, herbs and spices in Latin America. *Bioresource Technology*. 101(12), 4676-4689.

Rao, B. S., & Prabhavathi, T. (1982). Tannin content of foods commonly consumed in India and its influence on ionisable iron. *Journal of the Science of Food and Agriculture*. 33(1), 89-96.

Rasane, P., Jha, A., Kumar, A., & Sharma, N. (2014). Reduction of phytic acid content and enhancement of anti-oxidant properties of nutricereals by processing for developing a fermented baby food. *Journal of Food Science & Technology*. 1-16.

Recommended Nutrient Intakes for Malaysia, National Coordinating Committee on Food and Nutrition, Ministry of Health Malaysia, Putrajaya: NCCFN; 2005. ISBN 983-42438-0-4.

Redondo-Cuenca, A., Villanueva-Suarez, M. J., Rodriguez-Sevilla, M. D., & Mateos-Aparicio, I. (2006): Comercial composition and dietary fibre of yellow and green commercial soybeans (Glycine max) *Food Chemistry.* 101, 1216-1222.

Rehinan, Z., Rashid, M., & Shah, W.H. (2004). Insoluble dietary fibre components of food legumes as affected by soaking and cooking processes. *Food Chemistry.* 85:245-249

Rehman, Z.U. (2007). Domestic processing effects on available carbohydrate content and starch digestibility of black grams (Vigna mungo) and chick peas (Cicer arietium). *Food Chemistry*. 100(2), 764-767.

Rehman, Z.U., & Shah, W.H. (2005). Thermal heat processing effects on anti-nutrients, protein and starch digestibility of food legumes. *Food Chemistry*. 91(2), 327-331.

Rehman, Z. U., Salariya, A. M., & Zafar, S. I. (2001). Effect of processing on available carbohydrate content and starch digestibility of kidney beans (*Phaseolus vulgaris* L.). *Food Chemistry*, 73(3), 351-355.

Rodrigues, R. C., & Ayub, M. A. Z. (2011). Effects of the combined use of *Thermomyces lanuginosus* and *Rhizomucor miehei* lipases for the transesterification and hydrolysis of soybean oil. *Process Biochemistry.* 46(3), 682-688.

Rodriguez, C., Frias, J., Vidal-Valverde, C., & Hernandez, A. (2008). Correlations between some nitrogen fractions, lysine, histidine, tyrosine, and ornithine contents during the germination of peas, beans, and lentils. *Food Chemistry*. 108 (1), 245-252.

Ryan, E., Galvin, K., O'Connor, T.P., Maguire, A.R., & O'Brien, N.M. (2007). Phytosterol, squalene, tocopherol content and fatty acid profile of selected seeds, grains, and legumes. *Plant Foods For Human Nutrition.* 62(3). 85-91.

Sánchez-Mata, M. C., Peñuela-Teruel, M. J., Cámara-Hurtado, M., Díez-Marqués, C., & Torija-Isasa, M. E. (1998). Determination of mono-, di-, and oligosaccharides in legumes by high-performance liquid chromatography using an amino-bonded silica column. *Journal of Agricultural and Food Chemistry*. 46(9), 3648-3652.

Sangronis, E., & Machado, C. J. (2007). Influence of germination on the nutritional quality of *Phaseolus vulgaris* and *Cajanus cajan*. *LWT-Food Science and Technology*. 40(1), 116-120.

Sangronis, E., Rodríguez, M., Cava, R., & Torres, A. (2006). Protein quality of germinated Phaseolus vulgaris. *European Food Research and Technology*. 222(1-2), 144-148.

Sattar, A., Durrani, S. K., Mahmood, F., Ahmad, A., & Khan, I. (1989). Effect of soaking and germination temperatures on selected nutrients and anti-nutrients of mungbean. *Food Chemistry*. 34(2), 111-120.

Satya, S., Kaushik, G. & Naik, S.N. (2010). Processing of food legumes: a boon to human nutrition. *Mediterranean Journal of Nutrition and Metabolism.* 3(3), 183-195

Savelkoul, F. H. M. G., Vanderpoel, A. F. B., & Tamminga, S. (1992). The presence and inactivation of trypsin inhibitors, tannins, lectins and amylase inhibitors in legume seeds during germination: A review. *Plant Foods for Human Nutrition*. 42, 71–85.

Scalbert, A., & Williamson, G. (2000). Dietary intake and bioavailability of polyphenols. *The Journal of Nutrition*. 130(8), 2073-2085.

Scalbert, A., Johnson, I. T., & Saltmarsh, M. (2005). Polyphenols: anti-oxidants and beyond. *The American Journal of Clinical Nutrition*. 81(1), 215-217.

Sendra, E., Fayos, P., Lario, Y., Fernandez-Lopez, J.A., Sayas-Barbera, E., & Perez-Alvarez, J.A. (2008) Incorporation of citrus fibres in fermented milk containing probiotic bacteria. *Food Microbiology,* 25(1). 13–21

Seppänen-Laakso, T., Laakso, I., & Hiltunen, R. (2002). Analysis of fatty acids by gas chromatography, and its relevance to research on health and nutrition. *Analytica Chimica Acta*, 465(1), 39-62.

Sharma, S., Goyal, R., & Barwal, S. (2013). Domestic processing effects on physicochemical, nutritional and anti-nutritional attributes in soybean (Glycine max L. Merill). *International Food Research Journal*. 20(6), 3203-3209.

Shimelis, E.A. & Rakshit, S.K. (2007). Effect of processing on anti-nutrients and in vitro protein digestibility of kidney bean (*Phaseolus vulgaris* L.) varieties grown in East Africa. *Food Chemistry*. 103(1), 161-172

Shivashankara, K. S., & Acharya, S. N. (2010). Bioavailability of dietary polyphenols and the cardiovascular diseases. *Open Nutraceuticals Journal*. 3, 227-241.

Sreerama, Y. N., Sashikala, V. B., & Pratape, V. M. (2009). Effect of enzyme pre-dehulling treatments on dehulling and cooking properties of legumes. *Journal of Food Engineering*. 92(4), 389-395.

Stanner, S. (Ed.). (2008). *Cardiovascular Disease: Diet, Nutrition and Emerging Risk Factors (The Report of the British Nutrition Foundation Task Force)*. John Wiley & Sons.

Sturtzel, B., Dietrich, A., Wagner, K. H., Gisinger, C., & Elmadfa, I. (2010). The status of vitamins B6, B12, folate, and of homocysteine in geriatric home residents receiving laxatives or dietary fiber. *The Journal of Nutrition, Health & Aging*. 14(3), 219-223.

Sudha, M.L., Baskaran, V., Leelavathi, K. (2007) Apple pomace as a source of dietary fibre and polyphenols and its effect on the rheological characteristics and cake making. *Food Chemistry.* 104(2), 686-692.

Świeca, M., Gawlik-Dziki, U., Kowalczyk, D., & Złotek, U. (2012). Impact of germination time and type of illumination on the anti-oxidant compounds and anti-oxidant capacity of *Lens culinaris* sprouts. *Scientia Horticulturae*. 140, 87-95.

Takahashi, R., Ohmori, R., Kiyose, C., Momiyama, Y., Ohsuzu, F., & Kondo, K. (2005). Anti-oxidant activities of black and yellow soybeans against low density lipoprotein oxidation. *Journal of Agricultural and Food Chemistry*. 53(11), 4578-4582.

Taylor, C. K., Levy, R. M., Elliott, J. C., & Burnett, B. P. (2009). The effect of genistein aglycone on cancer and cancer risk: a review of in vitro, preclinical, and clinical studies. *Nutrition Reviews*. 67(7), 398-415.

Tee, E.S., Noor, M.I., Azudin, M.N., Idris, K., 1997. *Nutrient Composition of Malaysian Foods 4th edition*. Institute of Medical Research, Kuala Lumpur.

Teres, S. G., Barcelo-Coblijn, M., Benet, R., Alvarez, R., Bressani, R., Halver, J. E., et al. (2008). Oleic acid concentration is responsible for the reduction in blood pressure induced by olive oil. *Proceeding of the National Academy of Sciences of the United States of America*. 105(37), 13811–13816.

Tharanathan, R. N., & Mahadevamma, S. (2003). Grain legumes—a boon to human nutrition. *Trends in Food Science & Technology*. 14(12), 507-518.

Torres, A., Frias, J., Granito, M., & Vidal-Valverde, C. (2007). Germinated Cajanus cajan seeds as ingredients in pasta products: Chemical, biological and sensory evaluation. *Food Chemistry*. 101(1), 202-211.

Trinidad, T. P., Mallillin, A. C., Loyola, A. S., Sagum, R. S., & Encabo, R. R. (2010). The potential health benefits of legumes as a good source of dietary fibre. *British Journal of Nutrition*. 103(04), 569-574.

Tudoric, C.M., Kuri, V., & Brennan, C.S. (2002) Nutritional and physicochemical characteristics of dietary fibre enriched pasta. *Journal of Agricutural and Food Chemistry*, 50(2), 347–356

Uppal, V. and Bains, K. (2012) Effect of germination periods and hydrothermal treatments on in vitro protein and starch digestibility of germinated legumes. *Journal of Food Science and Technology*. 49(2): 184-191

Urbano, G., Lopez-Jurado, M., Frejnagel, S., Gomez-Villalva, E., Porres, J.M., Frias, J., Vidal-Valverde, C. and Aranda, P. 2005. Nutritional assesment of raw and germinated pea (*Pisum Sativum* L.) protein and carbohydrate by in vitro and in vivo techniques. *Nutrition* 21 (2): 230-239.

Van Loo, J., Coussement, P., De Leenheer, L., Hoebregs, H., & Smits, G. (1995). On the presence of inulin and oligofructose as natural ingredients in the western diet. *Critical Reviews in Food Science & Nutrition*, 35(6), 525-552.

Vasishtha, H., & Srivastava, R. P. (2013). Effect of soaking and cooking on dietary fibre components of different type of chickpea genotypes. *Journal of food science and technology*, *50*(3), 579-584.

Vernaza, M. G., Dia, V. P., Gonzalez de Mejia, E., & Chang, Y. K. (2012). Anti-oxidant and antiinflammatory properties of germinated and hydrolysed Brazilian soybean flours. *Food chemistry*, *134*(4), 2217-2225.

Vidal-Valverde, C., Frias, J., & Esteban, R. (1992). Dietary fiber in processed lentils. *Journal of food science*, 57(5), 1161-1163.

Vidal-Valverde, C., Frias, J., Sierra, I., Blazquez, I., Lambein, F., & Kuo, Y. H. (2002). New functional legume foods by germination: effect on the nutritive value of beans, lentils and peas. *European Food Research and Technology*,*215*(6), 472-477.

Villares, A., Rostagno, M. A., García-Lafuente, A., Guillamón, E., & Martínez, J. A. (2011). Content and profile of isoflavones in soy-based foods as a function of the production process. *Food and Bioprocess Technology*, 4(1), 27-38.

Vita, J. A. (2005). Polyphenols and cardiovascular disease: effects on endothelial and platelet function. *The American journal of clinical nutrition*, 81(1), 292S-297S.

Wang, S., Melnyk, J.P., Tsao, R., & Marcone, M.F. (2011). How natural dietary anti-oxidants in fruits, vegetables and legumes promote vascular health. *Food Research International*. 44, 14-22.

Wani, I. A., Sogi, D. S., Wani, A. A., Gill, B. S., & Shivhare, U. S. (2010). Physico-chemical properties of starches from Indian kidney bean (Phaseolus vulgaris) cultivars. *International journal of food science & technology*, *45*(10), 2176-2185.

Winham, D. M., Hutchins, A. M., & Johnston, C. S. (2007). Pinto bean consumption reduces biomarkers for heart disease risk. Journal of the American College of Nutrition, 26(3), 243-249.

Wise, A. (1995). Phytate and zinc bioavailability. *International Journal of Food Sciences and Nutrition.* 46(1), 53-63.

Wisker, E., Daniel, M., & Feldheim, W. (1994). Effects of a fiber concentrate from citrus fruits in humains. *Nutrition Research. 14*, 361-372.

Wootton-Beard, P. C., & Ryan, L. (2011). Improving public health?: The role of anti-oxidant-rich fruit and vegetable beverages. *Food Research International*. 44(10), 3135-3148.

Wu, P., Tian, J.C., Walker, C.E., & Wang, F.C. (2009) Determination of phytic acid in cereals—a brief review. *International Journal of Food and Science Technology*. 44(9), 1671–1676

Xu, B. J., & Chang, S. K. C. (2007). A comparative study on phenolic profiles and anti-oxidant activities of legumes as affected by extraction solvents. *Journal of Food Science*. 72(2), S159-S166.

Xu, B., & Chang, S. K. (2008). Effect of soaking, boiling, and steaming on total phenolic contentand anti-oxidant activities of cool season food legumes. *Food Chemistry*. 110(1), 1-13.

Yamaki, T., Nagamine, I., Fukumoto, K., Yano, T., Miyahara, M., & Sakurai, H. (2005). High oleic peanut oil modulates promotion stage in lung tumergenesis of mice treated with methyl nitrosourea. *Food Science and Technology Research*. 11, 231–235.

Yasmin, A., Zeb, A., Khalil, A.W., Paracha, G.M. & Khattak, A.B. (2008) Effect of processing on anti-nutritional factors of red kidney bean *(Phaseolus vulgaris)* grains. *Food and Bioprocess Technology*. 1(4), 415-419

Yen, W.J., Chang, L.W., & Duh, P.D. (2005). Anti-oxidant activity of peanut seed testa and its antioxidative component, ethyl protocatechuate. *LWT-Food Science and Technology.* 38(3), 193-200.

Yoshida, H., Hirakawa, Y., Tomiyama, Y., Nagamizu, T., & Mizushina, Y. (2005). Fatty acid distributions of triacylglycerols and phospholipids in peanut seeds (*Arachis hypogaea* L.) following microwave treatment. *Journal of Food Composition and Analysis.* 18(1), 3-14.

Yoshida, Y., Niki, E., & Noguchi, N. (2003). Comparative study on the action of tocopherols and tocotrienols as anti-oxidant: chemical and physical effects. *Chemistry and Physics of Lipids.* 123(1), 63-75.

Yu, J., Ahmedna, M., & Goktepe, I. (2005). Effects of processing methods and extraction solvents on concentration and anti-oxidant activity of peanut skin phenolics. *Food Chemistry*. 90(1), 199-206.

Yu, J., Ahmedna, M., Goktepe, I., & Dai, J. (2006). Peanut skin procyanidins: Composition and anti-oxidant activities as affected by processing. *Journal of Food Composition and Analysis*. *19*(4), 364-371.

Zanarini, M.C., Frankenburg, F.R. (2003) Omega-3 fatty acid treatment of women with borderline personality disorder: a doubleblind, placebo-controlled pilot study. *American Journal of Psychiatry*, 160:167-169

Zhang, Z., Lanza, E., Kris-Etherton, P. M., Colburn, N. H., Bagshaw, D., Rovine, M. J., ... & Hartman, T. J. (2010). A high legume low glycemic index diet improves serum lipid profiles in men. *Lipids*, 45(9), 765-775.

Zhang, G., Xu, Z., Gao, Y., Huang, X., Zou, Y., & Yang, T. (2015). Effects of Germination on the Nutritional Properties, Phenolic Profiles, and Anti-oxidant Activities of Buckwheat. *Journal of Food Science*, 80(5), H1111-H1119.

Zieliński, H., Frias, J., Piskuła, M. K., Kozłowska, H., & Vidal-Valverde, C. (2005). Vitamin B1 and B2, dietary fiber and minerals content of Cruciferae sprouts. *European Food Research and Technology*, 221(1-2), 78-83.