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Effect of germination on total dietary fibre and total sugar in selected legumes

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Abstract

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 antinutritional 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 was conducted to compare changes in dietary fibre and total sugar compositions after germination process in kidney, mung, soy beans and peanuts. Total dietary fibre was found to be significantly increased ($p<0.05$) in all germinated samples, with significant increased ($p<0.05$) of soluble and insoluble dietary fibres. For total sugar content, germination increased the level of total sugars. Glucose was the highest available sugar in samples that increased after germination while arabinose was second available sugar that increased in germinated legumes except kidney beans. Overall, germination has improved nutritional properties of legumes in terms of dietary fibre and total sugar content but the changes are influenced by the type of legumes.

Introduction

Legume is one of important source of protein, carbohydrates, dietary fibre and oil (Tharanathan and Mahadevamma, 2003). Several studies have shown that consumption of legumes was linked to reduce risk of cardiovascular disease, coronary heart disease and diabetes, as well as lowering the cholesterol levels (Jang *et al*., 2001; Khattak *et al*., 2007; Nöthlings *et al*., 2008; Carbonaro, 2011). However, there are several limiting factors such as low protein and starch digestibility, poor mineral bioavailability and high antinutritional factors (Ghavidel and Prakash, 2007; Khattak *et al*., 2007; Fernandez-Orozco *et al*., 2008). These limiting factors can be reduced by several preparation techniques such as cooking, soaking, dehulling and germination.

Germination is a process occurred during growth period that starts with the uptake of water by the dry seed and finished with the emergence of radical (Vidal-Valverde *et al*., 2002). During this period, storage components in seeds are degraded, use for respiration and production of new cells to develop new embryo (Hussein and Ghanem, 1999). Studies show that germination can increase protein and dietary fiber, reduce tannin and phytic acid contents and increase mineral bioavailability (Hussein and Ghanem, 1999; Ghavidel and Prakash, 2007; Khandelwal *et al*., 2010). Germination also was reported to be associated with increase of vitamin concentrations and bioavailability of trace elements and minerals (El-Adawy *et al*., 2004; Khattak *et al*., 2007; Kaushik *et al*., 2010).

This study uses kidney, mung, soy bean and peanut as samples as these 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 other 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 similar as the kidney beans.

The aim of this study was to compare the effect of germination on fibre and sugar compositions of legumes. It is hope that this study will provide

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additional data on nutritional contents of germinated and non-germinated legumes for further research in future as well as developing new and improved food functional ingredient in the market.

Materials and Methods

Samples

Dried kidney, mung, soy bean and peanut were purchased from hypermarkets in Seri Kembangan, Selangor, Malaysia. Legumes were stored in refrigerator at 4°C before germination.

Germination

Legume samples were washed with 70% ethanol for 2.5 min before further washed with sodium hypochlorite for 15 minutes at room temperature. Then, the samples were rinsed thoroughly until the pH becomes neutral before being soaked in distilled water for 6 hours. Later, the water was drained and samples were left to germinate on wet muslin cloth until the emergence of radical at maximum 5 mm. After germination, legume samples were dried in oven at 105°C and ground prior to analyses.

Total sugar analysis

Sample was vacuum evaporated to dryness and concentrated sugars were redissolved in deionised water and sonicated before filtered using Whatman 41 paper. Aliquot of 2 ml of filtrate was mixed with acetonitrile and filtered through a 0.54 µm Millex membrane prior to injection. Soluble carbohydrates were determined by HPLC using amino bonded column (250 mm x 4.6 mm x 5 µm), isocratic pump and refractive index detector. A mixture of acetonitrile:water (75:25; v/v) was used as a mobile phase with a flow rate of 1 ml/min. A mixture of carbohydrate standards at a concentration ranging from 2 to 10 mg/ml containing erythrose, rhamnose, mannose, arabinose, xylose, fructose, glucose, and galactose was used for monosaccharide identification and quantification (Yang *et al*., 2008).

Total dietary fibre analysis

Legume samples (1.0 ± 0.1 g) were digested with α-amylase (0.1 ml), protease (0.1 ml) and amyloglucosidase (0.3 ml) in a beaker. Heated (60°C) 95% ethanol was added and the solution was left precipitated at room temperature overnight. Digested samples were filtrated using Fibertec machine. Crucibles containing residues from filtration was dried and weighed. The procedure was repeated to obtain insoluble dietary fibre percentage and hence, soluble dietary fibre percentage (Prosky *et al*., 1988).

Statistical analysis

Every measurement of samples was in triplicate to obtain higher precision of data. Data was analyzed using SPSS software version 16.0. Paired T-test was used to compare between non-germinated and germinated legumes. Data was considered as significant when p value < 0.05.

Results and Discussion

Total sugar content

Total sugar was found to increase in all germinated legume samples. In germinated kidney beans, total sugar increased from 118.46 to 134.75 g/kg d.w. while in germinated mung beans, it was increased from 122.07 g/kg d.w. to 157.4 g/kg d.w. For soy beans, germination caused total sugar to increase from 157.53 g/kg d.w. to 194.86 g/kg d.w. and for peanuts, germination increased total sugar from 118.61 g/kg d.w. to 160.42 g/kg d.w. Comparison of all legume samples, the most dominant available carbohydrate was glucose and arabinose. After germination, glucose was increased in most samples except mung beans (decreased) while for arabinose, germination caused this sugar to reduce in the samples.

Urbano *et al.* (2005) suggested that germination process caused the metabolic changes in legume seeds in which carbohydrate storage in the form of starch and oligosaccharides were hydrolysed and caused the increase of sugar levels. Furthermore, Martin-Cabrejas *et al.* (2008) also suggested that during germination, α-galactosidase activity was increased, causing the break of α-1,6-galatosidic linkages and thus, increase the amount of total sugar.

Total dietary fibre content

Total dietary fibre (TDF) was significantly increased ($p < 0.05$) in all legumes after germination. In germinated kidney beans, TDF increased significantly ($p < 0.05$) from 36.6% to 59.9% while in germinated mung beans, the TDF increased significantly from 28.5% to 32.0%. TDF in soy beans increased significantly from 32.0% to 72.5% after germination, while in peanuts; germination significantly increased TDF percentage from 21.6% to 39.9%. Among the samples, germination significantly increased ($p < 0.05$) soluble dietary fibre (SDF) content. In kidney beans, SDF was significantly increased from 3.9% to 6.7% after germination while in mung beans; the SDF was significantly increased from 3.7% to 5.8%. In soy beans, germination significantly increased SDF from 8.2% to 17.4% while in peanuts, SDF was significantly increased from 5.5% to 9.1%. Similarly, germination caused insoluble dietary fibre (IDF) to

Table 1. Sugar profiles of germinated and non-germinated legume samples

Legume	Carbohydrates (%)						Total sugar
	Glucose	Galactose	Rhaminose	Arabinose	Mannose	Xylose	
Kidney beans							
NG	53.66 (1.02)	2.56 (0.16)*	1.94 (0.56)	20.37 (0.38)*	2.81 (1.28)	18.32 (0.77)*	118.46 (1.86)
G	54.58 (2.74)	3.24 (0.27)*	2.07 (1.35)	15.45 (0.32)*	3.13 (0.08)	21.58 (1.42)*	134.75 (3.92)
Mung beans							
NG	55.02 (2.47)	2.71 (1.69)	1.69 (0.32)	21.11 (1.11)	2.59 (0.15)*	16.88 (1.91)	122.07 (0.66)
G	53.18 (1.69)	2.84 (0.16)	1.87 (0.17)	19.84 (0.59)	2.84 (0.09)*	19.36 (0.86)	157.40 (0.88)
Soy beans							
NG	45.34 (1.02)	1.5 (0.24)	2.75 (0.09)	19.53 (1.35)	3.34 (0.18)*	27.53 (0.69)	157.53 (1.62)
G	47.13 (1.89)	1.74 (0.08)	2.72 (0.25)	19.48 (0.91)	1.86 (0.12)*	26.86 (3.61)	194.86 (5.81)
Peanuts							
NG	45.14 (2.52)	1.94 (0.11)	2.67 (0.33)	20.01 (1.12)	3.60 (0.32)*	26.64 (0.49)	118.61 (2.53)
G	45.49 (3.16)	1.97 (0.11)	2.62 (0.13)	19.1 (1.21)	1.64 (0.08)*	29.18 (2.51)	160.42 (3.44)

[1] All values are expressed as mean (standard deviation). Total sugar is presented as g/kg dry weight.

[2] (*) indicates significant change at ($p < 0.05$).

[3] NG: non-germinated; G: germinated.

Table 2. Dietary fibre content of germinated and non-germinated legume samples

	SDF (%)	IDF (%)	TDF (%)
Kidney Beans			
NG	3.91 (0.21)*	32.66 (0.45)*	36.57 (0.26)*
G	6.67 (0.59)*	53.27 (1.43)*	59.94 (1.59)*
Mung Beans			
NG	3.67 (0.46)*	24.81 (0.28)	28.49 (0.74)*
G	5.80 (0.06)*	26.24 (0.42)	32.04 (0.46)*
Soy Beans			
NG	8.19 (0.21)*	23.81 (0.29)*	32.01 (0.32)*
G	17.37 (1.21)*	55.11 (1.09)*	72.49 (2.15)*
Peanut			
NG	5.54 (0.29)*	16.05 (0.45)*	21.59 (0.41)*
G	9.09 (0.68)*	30.84 (0.60)*	39.93 (1.24)*

[1] All values are expressed as mean (standard deviation). Total sugar is presented as g/kg dry weight.

[2] (*) indicates significant changes at ($p < 0.05$).

[3] NG: non-germinated; G: germinated; SDF: soluble dietary fibre; IDF: insoluble dietary fibre; TDF: total dietary fibre.

increase in the studied samples. In kidney beans, IDF was significantly increased ($p < 0.05$) from 32.7% to 53.3% while in mung beans; the value was increased from 24.8% to 26.2%. Significant IDF increment was found in soy beans from 23.8% to 55.1% while in germinated peanuts, IDF was significantly increased from 16.0% to 30.8%.

Martin-Cabrejas *et al*. (2003) found that total dietary fibre content was increased after germination in daylight and without daylight. They also found that IDF and SDF fibres were also increased after germination. The result was similar to the current study where it was found that TDF increased after germination, alongside insoluble and SDF.

Dietary fibre was regarded as one of the most important ingredient in human diet (Dhingra *et al*., 2012). The characteristics of dietary fibre such as particle size, bulk volume, surface area characteristics, hydration, and adsorption as well as binding of ions and organic molecules are highly influential in human digestive system (Guillon *et al*., 1998; Raghavendra *et al*., 2006; Nassar *et al*., 2008; Dhingra *et al*., 2012). It was observed that addition of dietary fibre components in foods such as pasta, bakeries and biscuits improved the overall qualities such as biochemical composition, cooking properties and textural characteristics as well as the taste (Tudoric *et al*., 2002; Sudha *et al*., 2007; Nassar *et al*., 2008). Apart from that, dietary fibre can also be used to improve texture of meat products (Chevance *et al*., 2000) as well as functional ingredients in milk products (Sendra *et al*., 2008).

Martin-Cabrejas *et al.* (2003) found that TDF in germinated peas was increased because of the improved SDF and IDF levels. A different finding was found by Martin-Cabrejas *et al*. (2008) in which TDF was reduced after germination in cowpea, jack and mucuna beans. Similarly, in germinated dolichos and soy beans, total dietary fibre was reduced. They suggested that germination influenced TDF content differently according to types of legumes and light conditions of the germination process. Benitez *et al.* (2013) also suggested that the increased of TDF was due to synthesis of new polysaccharides during germination.

Conclusion

Total dietary fibre was found to be significantly increased in all germinated legume samples, with significant increase of soluble and insoluble dietary fibres found in all germinated legume samples as well. For total sugar content, germination caused it to be increased in all samples. Glucose was found to be the highest available sugar in all samples and the value was increased after germination. Arabinose was the second highest available sugar found in all legume samples and it was increased in mung, soy beans and peanuts after germination while in kidney beans, the value was decreased.

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References

Asian Productivity Organization. 2003. Processing and utilization of legumes. Report of the APO Seminar on Processing and Utilization of Legumes. Tokyo: Asian Productivity Organization.

Benitez, V., Cantera, S., Aguilera, Y., Molla, E., Esteban, R. M., Diaz, M. F. and 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.

Carbonaro, M. 2011. Role of pulses in nutraceuticals. Pulse foods: processing, quality and nutraceutical applications, Oxford: Academic Press.

Chevance, F. F. V., Farmer, L. J., Desmond, E. M., Novelli, E., Troy, D. J. and 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.

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

El-Adawy, T. A., Rahma, E. H., El-Bedawey, A. A. and El-Beltagy, A. E. 2004. Nutritional potential and functional properties of germinated mung bean, pea and lentil seeds. Plant Foods for Human Nutrition 58(3): 1-13.

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

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

Guillon, F., Auffret, A., Robertson, J. A., Thibault, J. F. and 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.

Hussein, L. and Ghanem, K. Z. 1999. Calcium bioavailability from selected Egyptian foods with emphasis on the impact of germination and fermentation. International Journal of Food Sciences and Nutrition 50(5): 351-356.

Jang, Y., Lee, J. H., Kim, O. Y., Park, H. Y. and 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: randomize controlled clinical trial. Arteriosclerosis, Thrombosis and Vascular Biology 21(12): 2065-2071.

Kaushik, G., Satya, S. and 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.

Khandelwal, S., Udipi, S. A. and 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. and 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.

Martin-Cabrejas, M. A., Ariza, N., Esteban, R., Molla, E., Waldron, K. and 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(5): 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(3): 1045-1052.

Nassar, A. G., AbdEl-Hamied, A. A. and 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.

Nöthlings, U., Schulze, M. B., Weikert, C., Boeing, H., van der Schouw, Y. T., Bamia, C., Benetou, V., Lagiou, P., Krogh, V., Beulens, J. W. J., Peeters, P. H. M., Halkjær, J., Tjønneland, A., Tumino, R., Panico, S., Masala, G., Clavel-Chapelon, F., de Lauzon, B., Boutron-Ruault, M., Vercambre, M., Kaaks, R., Linseisen, J., Overvad, K., Arriola, L., Ardanaz, E., Gonzalez, C. A., Tormo, M., Bingham, S., Khaw, K., Key, T. J. A., Vineis, P., Riboli, E., Ferrari, P., Boffetta, P., Bueno-de-Mesquita, H. B., van der A, D. L., Berglund, G., Wirfält, E., Hallmans, G., Johansson, I., Lund, E. and Trichopoulo, A. 2008. Intake of vegetables, legumes, and fruit, and risk for all-cause, cardiovascular, and cancer mortality in a European diabetic population. Journal of Nutrition 138(4): 775-781.

Raghavendra, S. N., Ramachandra Swamy, S. R., Rastogi, N. K., Raghavarao, K. S. M. S., Kumar, S. and 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.

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

Tharanathan, R. N. and Mahadevamma, S. 2003. Grain legumes-a boon to human nutrition. Trends in Food Science and Technology 14(12): 501-518.

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

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.

Vidal-Valverde, C., Frias, J., Sierra, I., Blazquez, I., Lambein, F. and Kuo, Y. 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.