ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 09, pp.38510-38516, September, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EFFECTS OF PROCESSING METHODS ON SOME NUTRITIONAL AND ANTI-NUTRITIONAL PROPERTIES OF SELECTED PULSES

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ARTICLE INFO

Article History:
Received 27th June, 2016
Received in revised form
18th July, 2016
Accepted 10th August, 2016
Published online 30th September, 2016

Key words:
Pulses,
Carbohydrate,
Protein,
Total Phenol,
Tannin,
Phytic acid.

ABSTRACT

Pulses are important source of macronutrients, containing almost twice the amount of protein compared to cereal grains. In addition to being a source of macronutrients and minerals, pulses also contain plant secondary metabolites that are increasingly being recognized for their potential benefits for human health. Pulses, whose history of cultivation dates back to earlier times, are essential for human and animal nutrition as well as crop rotation. It has been established that pulses contain various substances, some varieties of which can be toxic (though rare) or may cause indigestion. However, it has been observed that the effects of these factors disappear or decrease when legumes are properly prepared. The present study was based on the comparison of effects of processing on some of the nutritional and anti- nutritional properties of five selected pulses (Mung bean, Chickpea, Soya bean, Horse gram and Green peas) during various stages of processing (soaking, sprouting and cooking). In all the cases, it was observed that the pulses were affected by the processing methods. The carbohydrate content was increased as a result of cooking in all the pulses, while other factors decreased. The highest value of carbohydrate was found to be in cooked Horse gram (68730 mg/ml) and the lowest in sprouted Green peas (7460 mg/ml). Sprouted Soybean gave highest protein content (3562.5776 mg/ml) and the lowest by cooked Horse gram (102.6416 mg/ml). Soaked Chick pea showed maximum value for Total Phenol (2.615 mg/ml) and cooked Horse gram, the minimum value (0.089 mg/ml). In case of Tannin, soaked Soybean gave the highest value (2077.1422 mg/ml) and the lowest by cooked Horse gram (61.4284 mg/ml). Soaked Soybean was found to give maximum Phytic acid (16.2375 mg/ml) and the minimum by cooked Green peas (4.217 mg/ml). The sprouting led to the increase in the protein content in all the pulses, while carbohydrate, tannin, phenol and phytic acid contents were decreased. The decreased concentration in Total phenol, Tannin and Phytic acid content was due to enzymatic changes during germination period in seeds. The reduction of anti-nutrients may improve the nutritional quality of legumes. Thus it can be said that through proper processing methods, the nutritional factors can be improved and negative impacts due to anti-nutritional factors can be minimized**.**

Citation: Chinchitha Lawrence and Rajani, V., 2016. "Effects of processing methods on some nutritional and anti-nutritional properties of selected pulses" *International Journal of Current Research*, 8, (09), 38510-38516.

INTRODUCTION

Pulses are important source of macronutrients, containing almost twice the amount of protein compared to cereal grains. In addition to being a source of macronutrients and minerals, pulses also contain plant secondary metabolites that are increasingly being recognized for their potential benefits for human health. The present study was based on the comparison of effects of processing on nutritional and anti- nutritional properties of five selected pulses (Mung bean, Chickpea, Soya bean, Horse gram and Green peas) during various stages of processing (soaking, sprouting and cooking). Soaking pulses is an efficient process to reduce heat-stable anti-nutritional compounds such as tannins, phytic acid, raffinose, stachyose and verbascose. Therefore, soaking increases the nutritional benefits of pulses. It involves soaking and draining the pulses every 4 to 8 hours and this process usually takes 1 to 5 days. Sprouting pulses is vital to render them edible in a raw state and make them more easily digestible. Interestingly, sprouted pulses can significantly diminish polyphenols and tannins, and the protein, carbohydrates and fats begin to break down into a predigested form, leading to an easier and better digestion and making for better overall digestion.

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Thermal processes such as canning, pressure cooking, microwave cooking, traditional or stove-top cooking, roasting, and others are used in cooking or processing pulses. Lectins and enzymes inhibitors are proteins which could undergo denaturation by thermal processing prior to consumption. Protease inhibitors show different degrees of susceptibility to various processing treatments. Thus processing technique and conditions used to denature protease inhibitors could vary from one pulse type to another.

MATERIALS AND METHODS

The present study was based on the comparison of effects of processing on some of the nutritional and anti- nutritional properties of five selected pulses (Mung beans, Chick pea, Soyabean, Horse gram and Green peas) during various stages of processing (soaking, sprouting, and cooking). The following biochemical methods were used for the study.

Estimation of Total Carbohydrate

The Total Carbohydrate was estimated by the method of Hedge, J E and Hofreiter *et al*., 1962

Estimation of Protein

The protein content was estimated by Lowry's method (Lowry *et al*., 1951).

Estimation of Total phenol

The total phenol was estimated using the method by Malick *et al*., (1980)

Estimation of Tannin

Estimation of Tannin was done according to the method by Robert E B (1971)

Estimation of Phytic acid

The Phytic acid content was estimated for all the selected pulses (Wheeler and Feerel *et al.,* 1971).

RESULTS AND DISCUSSION

Diet is an important contributor to health, and to disease. Most countries face nutritional problems, from under nutrition and micronutrient deficiencies to obesity and diet-related diseases (such as type II diabetes and certain types of cancer), or a mix of these. Pulses such as lentils, dried beans, peas and chickpeas have been staple foods for many civilizations. Yet today, their nutritional benefits are often greatly underestimated. In some cultures pulses have a stigma of being a 'poor man's food' and are replaced by meat once people can afford meat. Many pulses are soaked in water from 4 to 8 hours – a practice that will dramatically reduce their phytate content and cooking time and their propensity to cause flatulence. Soaking ensures that pulses can be more easily digested and their nutrients better absorbed by the body. In fact, soaking dried pulses for several hours brings them back to life, activating their enzymes. Sprouting as a simple technological method that is used to germinate seeds has been reported to improve the nutritive value of seeds (Amal *et al*., 2007). At the same time there are indications that sprouting is effective in reducing phytic acid and flatulence causing oligosaccharides (namely stachyose and raffinose), thereby increasing protein digestibility and improving sensory properties (Lintschinger *et al.,* 1997). The presence of anti-nutritional factors such as trypsin and chymotrypsin inhibitors, oligosaccharides, lectins and tannins (Lyimo *et al*., 1992) limits the availability of nutrients present in the leguminous crops. Removal of these factors is achieved by soaking and cooking of dry grains of legumes. For the present study, the pulses were subjected to various processing methods (soaking, sprouting and cooking) and were used to study the effects of these processing methods on some of their nutritional and anti- nutritional properties.

Estimation of Total Carbohydrate

The concentration of many important nutrients found in pulses can be greatly affected by soaking and cooking. The results of the estimation of carbohydrate were given in the Figure 1. The highest value of carbohydrate was given by cooked Horse gram (68730mg/ml) and lowest concentration was found in sprouted Green peas (7460 mg/ml). In soaked Mung bean, the concentration of carbohydrate was found to be 61060 mg/ml, in sprouted 38380 mg/ml and in cooked, 66630 mg/ml. In soaked Chickpea, concentration of carbohydrate was found to be 52730 mg/ml, in sprouted 36250 mg/ml and in cooked 64960 mg/ml. In soaked Soybean, concentration of carbohydrate was found to be 28300 mg/ml, in sprouted, the concentration was 22910 mg/ml and in cooked, concentration was 38880 mg/ml. In soaked Horse gram, the concentration of carbohydrate was 53530 mg/ml, in sprouted 33790 mg/ml and in cooked, 68730mg/ml. In soaked Green peas, concentration of carbohydrate was 13800 mg/ml, sprouted was 7460 mg/ml and cooked 18380mg/ml. The result of the study revealed that the carbohydrate content was increased in all pulses as a result of the cooking, at the same time the sprouting led to the lowering of the carbohydrate content.

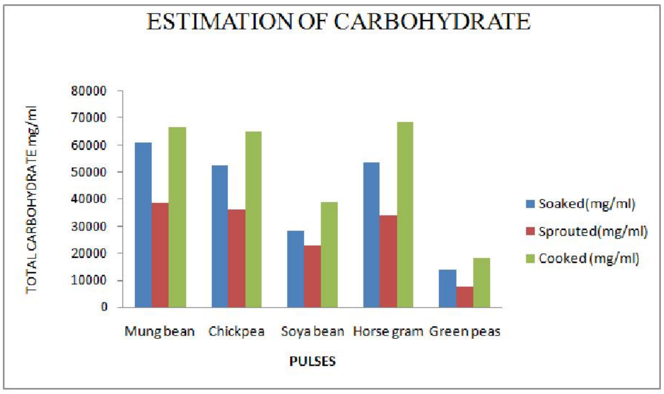

Figure 1. Estimation of Total Carbohydrate

The carbohydrates were significantly ($p<0.05$) increased in all the selected pulses by boiling treatments probably due to the heat involved which reduced the other components as a result of denaturation and leaching, leading to an increase in carbohydrate contents.

This result was in agreement with the findings of Finney *et al*., 1982 which showed that sprouting resulted to a reduction in the carbohydrate content of Mung bean. This could be due to increased starch digestibility promoted by improved hydrolytic activities of the enzymes during sprouting. Akinjayeju and Francis 2007 reported the conversion of carbohydrate by alpha amylases to simple and more soluble sugars needed by the growing seeds. The decrease in carbohydrate due to germination might also be due to the use of carbohydrate for metabolism by the young seedling (Obizoba and Atu, 1993). So from the study, it can be concluded that the various processing methods can affect the carbohydrate content of the selected pulses.

Estimation of Protein

Proteins are required for maintenance (replacement of wear and tear of tissues) in adults for the growth of infants and children, for fetal development in pregnancy and secretion of milk during lactation. The requirement of proteins for the later groups is higher than the adults (Rao *et al*., 1989). Legume seeds are valuable source of protein, oil, carbohydrates, minerals and vitamins. They are playing an important role in human nutrition mainly in developing countries (Yanez *et al*., 1995). Protein content was significantly ($p < 0.01$) influenced by sprouting treatments. Heat processing increased the protein digestibility most likely by destroying heat labile protease inhibitors and by denaturing other protein globulins highly resistant to proteases in the native state (Rani *et al*., 1996). High mean values for protein content was noted in sprouted mung bean (26.82%) as compared to chickpea (20.83%) over different sprouting intervals (Masood *et al.,* 2014). The increasing trend in protein content with progress in sprouting was almost similar to the results of the current study. The results of the estimation of protein were given in the Figure 2.
In the present study of protein estimation, the highest concentration of protein was in sprouted Soybean (3562.5776 mg/ml) and lowest concentration was found in cooked Horse gram (102.6416 mg/ml). Akinyele, 1989 reported that traditional cooking had a negative impact on protein content and maximum decrease was observed in Mung bean (58% over control) in cooked samples.

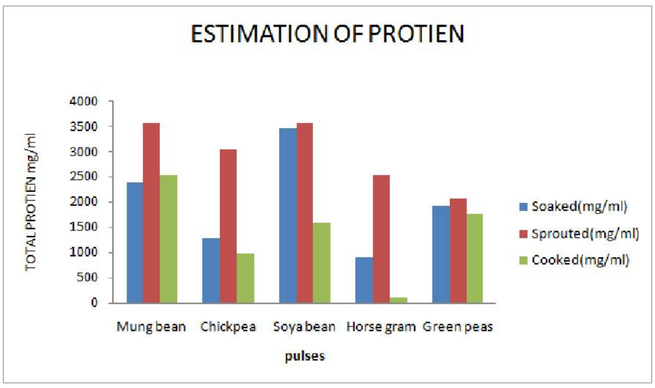

Figure 2. Estimation of Protein

In soaked Mung bean, concentration of protein was found to be 2378.6072 mg/ml, in sprouted, the concentration was 3561.458 mg/ml and in cooked, concentration was 2522.6036 mg/ml. in soaked Chickpea, concentration of protein was 1282.6346 mg/ml; in sprouted, concentration was 3039.924 mg/ml and in cooked, 973.309 mg/ml. In soaked Soyabean, concentration of protein was 3461.2468 mg/ml, in sprouted 3562.5776 mg/ml and in cooked, 1578.6272 mg/ml. The soaked Horse gram gave 894.964 mg/ml of protein, in sprouted, concentration was 2522.6036 mg/ml and in cooked, concentration was 102.6416 mg/ml. In soaked Green peas, the concentration of protein was 1919.952 mg/ml, in sprouted concentration was 2063.9484 mg/ml and in cooked concentration was 1762.6226 mg/ml. 48 hour sprouting brought maximum improvement in nutritional quality of Mung bean and chickpea with minimum loss of dry matter, which can be used as seeds in making different dishes. (Masood *et al*, 2014).

Many researchers reported increase in percent protein in germinated grains (Dogra *et al*., 2001; Sood *et al*. 2002; Urbano *et al.,* 2005; Khatoon and Prakash, 2006; Kaushik *et al*., 2010). The difference in results for protein content of sprouts not only depends on cultivar but also on germination conditions (Dagnia *et al.,* 1992; Urbano *et al*., 2005). The present study indicated maximum protein content in germinated pulses. The increase in the protein content may be mainly due to the use of seed components during the germination process (Mubarak, 2005), breakdown of complex proteins into simpler form and breakdown of nutritionally undesirable constituents (Chavan and Kadam, 1989). The metabolic activities of resting seeds increase as soon as they are hydrated during soaking. The complex biochemical changes that occur during hydration and sprouting lead the protein constituents being broken down by enzymes into simple compounds that are used to make new compounds. The increased hydrolytic activities of the enzymes caused by sprouting resulted in improvements in the contents of the total protein due to the disappearance of starch (Anonymous, 2008). According to Morgan *et al*., 1992, the absorption of nitrate facilitates the metabolism of the nitrogenous compounds from carbohydrate reserves; thus increasing crude protein level.

Estimation of Phenol

Phenolic compounds inhibit the activity of digestive as well as hydrolytic enzymes such as amylase, trypsin, chymotrypsin and lipase (Salunkhe *et al.,* 1992) and decrease the digestibility of proteins, carbohydrates and availability of vitamins and minerals (Rao and Deosthale, 1982). However, recent researchers report that the phenolic compounds are the main human dietary antioxidant and have a decreased incidence of chronic diseases. A number of polyphenolic compounds are present, which contribute towards the defense mechanism of plants. Although these are considered earlier as anti-nutritional compounds, under the present nomenclature, phenols fall under the category of nutraceuticals, offering many nutritional advantages to man (Shanthakumari *et al.,* 2008). The results of the estimation of phenol were given in the Figure 3. The present study showed that the highest concentration of Phenol was in soaked Chick pea (2.615 mg/ml) and lowest concentration was found in cooked Horse gram (0.089 mg/ml).In soaked Mung bean concentration was 0.536 mg/ml, in sprouted concentration was 0.364 mg/ml and cooked

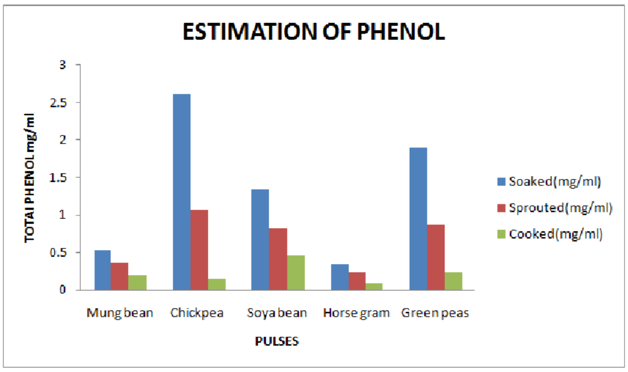

Figure 3. Estimation of phenol

concentration was 0.195 mg/ml. Randhir *et al.,*2004 reported that germination causes a decrease of total phenolic content in Green mung. Barroga *et al*., 1985 reported similar total phenolic content values for raw and 24 h germinated Mung bean. In soaked Chick pea, the concentration of Phenol was 2.615 mg/ml, sprouted concentration was 1.070 mg/ml and in cooked, the concentration was 0.145mg/ml. In Soya bean after soaking, concentration of Phenol was 0.449 mg/ml, sprouted concentration was 0.815 mg/ml and cooked concentration was 2.749 mg/ml. Horse gram when soaked gave the concentration of Phenol as 0.344 mg/ml, sprouted concentration was 0.230 mg/ml and cooked concentration was 0.089 mg/ml. In case of Green peas, after soaking, the concentration of Phenol was 1.895mg/ml, sprouted concentration was 0.865 mg/ml and cooked concentration was 0.228 mg/ml. Thus the results explain that for all the selected pulses, the total phenol content was lowered as a result of sprouting and cooking. Bressani and Elias 1980 observed that about 40% of phenolics could be removed from common beans (*P. vulgaris*) by cooking and discarding the cooking water. Xu and Chang, 2008 found that most total phenol in black soybean is lost during cooking. Regular cooking caused greater total phenol losses than steaming treatments, which could be attributed to water-soluble phenolics leaching into the soaking and cooking water (Xu and Chang, 2008). Randhir *et al*.,2004 reported that germination causes a decrease of total phenolic content in Green mung. Barroga *et al*., 1985 reported similar total phenolic content values for raw and 24 h germinated Mung bean. It is observed that the concentrations of the total phenolics, of the sprouted seeds decreases as the ratio of water and temperature of sprouting are increased. (Khandelwal *et al*., 2010) reported that the total phenolic was reduced significantly in germinated green gram compared to Bengal gram, red gram and lentil. In germinated kidney bean, the loss of total phenolic content can be as high as 96% as shown by (Shimelis and Rakshit, 2007).

Estimation of Tannin

Tannins are mainly located in seed coat of pulses, hence physical removal of seed coat by either dehulling or milling and separating hulls decreases the tannin content of pulses and improves their nutritional quality. Dehulling eliminates about 68 to 99% of tannins in seed. Soaking of seeds before cooking is a common household practice and, used to soften the texture and hasten the process of cooking. Leaching of tannins increases with the time of soaking in distilled water. Raising the period of soaking from 6 to 12 and 18 hrs further reduces tannin content of seed (Jood *et al.,* 1988). Cooking and discarding the cooking water results in about 37.5 to 77% decrease in tannin content of seeds (Reddy *et al*., 1985). Overnight soaking in water and subsequent germination for 48 hrs removes more than 50% of the tannins in pigeon pea, chickpea and mung bean (Jood *et al.,* 1987). As a result of the present study (Figure 4), it can be observed that the highest concentration of Tannin was observed in soaked Soya bean (2077.1422 mg/ml) and lowest concentration was found in cooked Horse gram (61.4284 mg/ml).

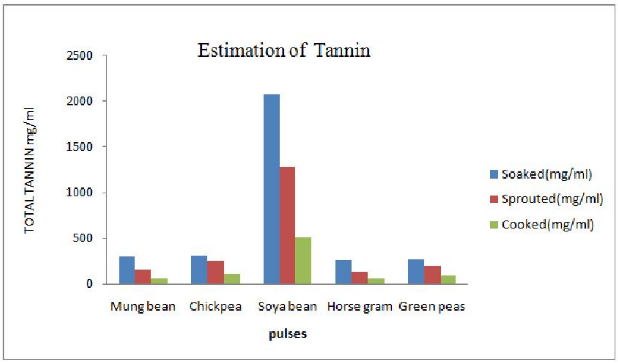

Figure 4. Estimation of Tannin

In soaked Mung bean, concentration of the tannin was found to be 301.4284 mg/ml, in sprouted 161.4285 mg/ml and cooked value was found to be 65.7141 mg/ml. In soaked Chickpea, concentration of Tannin was 315.7141 mg/ml, in sprouted was 254.2856 mg/ml and cooked 104.4284 mg/ml. In soaked Soya bean, the value of Tannin was found to be 2077.1422 mg/ml, in sprouted 1278.5713 mg/ml and cooked 508.5706 mg/ml. In soaked Horse gram, concentration of Tannin was found to be 264.2856 mg/ml, in sprouted 132.8570 mg/ml and cooked 61.4284 mg/ml. In the soaked Green peas, concentration of Tannin was found to be 265.7142 mg/ml mg/ml, sprouted 199.9999 mg/ml and cooked 95.7141 mg/ml. The present study revealed that, in case of tannin also, the sprouting and cooking processes lowers the concentration. The observed reduction in tannin content after germination may be a result of formation of hydrophobic association of tannins with seed proteins and enzymes. In addition, loss of tannins during germination also may be due to the leaching of tannins into the water (Shimelis and Rakshit, 2007) as well as washing during germination and binding of polyphenols with other organic substances such as carbohydrate or protein (Saharan *et al*., 2002). Apart from that, during the period of soaking prior to germination, the enzyme polyphenol oxidase may be activated, resulting in degradation and consequent losses of polyphenols (Saxena *et al*., 2003; Khandelwal *et al*., 2010). The decrease might also be due to break down of protein tannin complex and release of free tannins into soaking water during sprouting (Megat and Azrina, 2012).

Estimation of Phytic acid

Fiber rich foods, including both cereals and legumes, contain high levels of phytate or phytic acid.

The decreased of phytic acid contents of germinated legumes has been frequently reported (Ibrahim *et al.,* 2002). The reduction could be due to increase in endogenous phytase activity (Shimelis and Rakshit, 2007; Khattak *et al*., 2007) depending on different types of legume. It could also be due to diffusion into the soaking medium also known as leeching out. Soaking of legumes in distilled water was an effective way of removing phytic acid from legumes (Liang *et al.,* 2009).The cooking processes inecrease both water- and acid-extractable phytate phosphorus in 1egumes. Poor extractability of phytate phosphorus with water and HCl in cooked legumes was noticed by Kumar *et al.,* 1978 and it was attributed to the formation of insoluble complexes between phytate phosphorus and other components in legumes during cooking, which subsequently could not be extracted with water or HCl. In the present study (Figure 5), the highest concentration of phytic acid was in soaked Soyabean (16.2375 mg/ml) and lowest concentration was found in cooked green peas (4.217 mg/ml). In soaked Mung bean concentration was 13.6395 mg/ml, sprouted concentration was 11.423 mg/ml and cooked concentration was 9.3715 mg/ml. In soaked Chickpea, concentration of phytic acid was 13.2065 mg/ml; sprouted concentration was 9.5365 mg/ml and cooked concentration was 5.218 mg/ml.

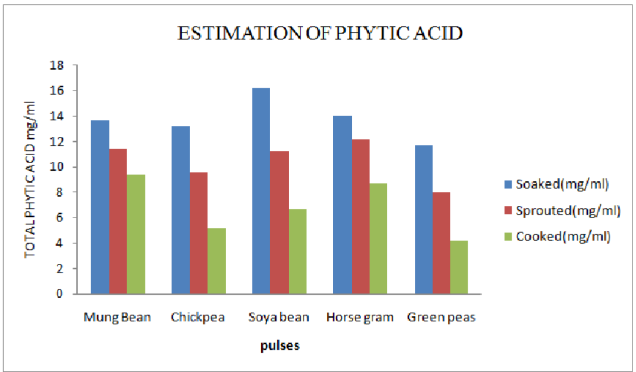

Figure 5. Estimation of Phytic acid

In case of soaked Soya bean, the concentration was 16.2375 mg/ml, sprouted concentration was 11.237 mg/ml and cooked concentration was 6.6705 mg/ml. The concentration in soaked Horse gram was 14.0725 mg/ml, sprouted concentration was in 12.1725 mg/ml and cooked concentration was 8.722 mg/ml. Green peas gave maximum value in soaked form (11.691 mg/ml) and minimum in cooked form (4.217 mg/ml). So it can be concluded that the phytate content of the study materials are being lowered as a result of the sprouting and germination. A significant improvement in availability of Fe was also observed on cooking treatments compared to the unprocessed treatment, which may be due to leaching out of anti-nutrients (Kakker, 1992). Phytate, the major phosphorus-bearing compound in cereals and pulses, chelates divalent and trivalent cations, like Ca, Fe and Zn, forming insoluble complexes and thereby decreasing the availability of minerals in humans (Vohra *et al*.,1965). The decrease in phytic acid content, possibly through its destruction by heat treatments, may result in the divalent and trivalent cations being freed from the phytate mineral complexes thus accounting for the improved availability of minerals in processed seeds. Reduction in Fe availability by the presence of phytate has also been reported in red gram, Bengal gram and green gram (Murthy *et al*., 1985; Hazel1 and Johnson 1987 and Khalil *et al.,* 2007).

Summary and Conclusion

Pulse grains are high in protein, carbohydrates, and dietary fibre and are a rich source of other nutritional components. Legumes contain a number of bioactive substances including enzyme inhibitors, lectins, phytates, oligosaccharides, and phenolic compounds that play metabolic roles in humans or animals that frequently consume these foods. These effects may be regarded as positive, negative, or both (Champ, 2002). Some of these substances have been considered as anti-nutritional factors due to their effect on diet quality. The present study was based on the comparison of effects of processing on nutritional and anti- nutritional properties of five selected pulses (Mung bean, Chickpea, Soya bean, Horse gram and Green peas) during various stages of processing (soaking, sprouting, cooking) and their effects on some nutritional and anti- nutritional factors were also analyzed. In all the cases, it was observed that the pulses were affected by the processing methods. The carbohydrate content was enhanced as a result of cooking in all the pulses, while other factors decreased. The highest value of carbohydrate was shown by cooked Horse gram and the lowest by sprouted Green peas. Soaked Chick pea showed maximum value for Total Phenol and cooked Horse gram, the minimum value. In case of Tannin, soaked Soybean gave the highest value and the lowest by cooked Horse gram. Soaked Soybean had given maximum value for Phytic acid and the minimum by cooked green peas. The sprouting led to the increase in the protein content in all the pulses, while carbohydrate, tannin, phenol and phytic acid contents were decreased. The decreased in total phenolic, tannin and phytic acid content was due to enzymatic changes during germination period in seeds. The reduction of anti-nutrients may improve the nutritional quality of legumes. Pulses are an important source of macronutrients, containing almost twice the amount of protein compared to cereal grains. In addition to being a source of macronutrients and minerals, pulses also contain plant secondary metabolites that are increasingly being recognized for their potential benefits for human health. So it can be concluded that germinated pulses are rich in protein content and the cooking process helps to increase the carbohydrate content in pulses. The cooking process also helps to lower the anti- nutritional factors in pulses. Future studies can be carried out with more nutritional and anti- nutritional factors.

REFERENCES

Akinyele, I.O. 1989. Effects of traditional methods of processing on the nutrient content and some anti-nutritional factors in cowpeas (Vignuunguiculata). *Food Chem*., 33: 291-299.

Akinjayeju, O. and O.C. Francis, 2007. Effects of sprouting on the proximate composition of Bambara nut flours. Proceedings of the annual conference/general meeting of NIFST. Oct. 22-25, Abuja, pp: 158-159.

Amal, B.K., Aurang, Z., Nizakat, B., Shahid. A.K., Mohammad. S.K. 2007. Influence of germination techniques on phytic acid and polyphenols content of chickpea (Cicerarietinum L.) sprouts. *Food Chem*., 104: 1074-1079

Barroga, C.F., Laurena, A.C,.Mendoza., M.T. 1985. Polyphenols in mung bean (Vignaradiata L, Wilczek): determination and removal. *J Agric Food Chem*., 33: 1006-1009.

Bressani and L. G. Elias., 1980."The Nutritional Role of Polyphenols in Beans," In: J. H. Hulse Ed., Polyphenols in Cereal and Legumes, International Development Research Center, Ottawa, Canada, pp 61-68.

Champ, M. M. 2002. Non-nutrient bioactive substances of pulses. *British Journal of Nutrition*, 88(Suppl. 3), S307–S319.

Chavan, J. and S.S. Kadam, 1989. Nutritional Importance of cereals by sprouting. *Crit. Rev. Food Sci. Nutr*., 28: 401-437.

Dagnia, S.G., D.S. Petterson, R.R. Bell and F.V. Flanagan 1992. Germination alters the nutritional value of lupin seed. *J. Sci. Food Agri*., 60: 419-423.

Dogra, J., Y.S. Dhaliwal and M. Kalia. 2001. Effect of soaking, germination, heating and roasting on the chemical composition and nutritional quality of Soybean and Its Utilization in Various Indian leavened products. *J. Food Sci. Technol.,* 38 (5): 453-456.

Finney, P.L., D. Beguin and J.D. Hubbard, 1982. Effects of germination on Bread-baking properties of Mungbean (*Phaseolusaureus*) and Garbanzo bean (*Cicerarietinum*). *Cereal Chem*., 59: 520-524

Hazell, T. and I.T. Johnson. 1987. *In vitro* estimation of iron availability from a range of plant foods: influence of phytate, ascorbate and citrate. *Brit. J. Nut*., 57: 223-233

Hedge, J. E. and Hofreiter, B. T. 1962 In: Carbohydrate Chemistry 17 (EdsWhisteler R L and Be Miller, JN)Academic Press Newyork.

IIbrahim, S. S., Habiba, R. A., Shatta, A. A. and Embaby, H. E. 2002. Effect of soaking, germination, cooking and fermentation on antinutritional factors in cowpeas. Nahrung 46: 92–95.

Jood, S., B.M. Chauhan and A.C. Kapoor. 1987. Polyphenols of chickpea and blackgram as affected by domestic processing and cooking methods. *J. Sci. Food Agric*., 39:145-149.

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

Kakker, S. 1992. Bioavailability of minerals: Effect of domestic processing and level of the anti-nutrients. Ph. D Dissert. HaryanaAgric. Univ. Hisar, India.

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: 39-46.

Khandelwal S, Udipi SA, Ghugre P. 2010. Polyphenols and tannins in Indian pulses: Effect of soaking, germination and pressure cooking. *Food Res. Int*., 4: 526-530.

Khalil, A.W., A. Zeb, F. Mahmood, S. Tariq, A.B. Khattak and H.U. Shah. 2007. Comparison of sprout quality characteristics of desi and kabuli type chickpea cultivars (Cicerarietinum L.). LWT 40: 937-945.

Khattak AB, Zeb A, Bibi N. 2007. Impact of germination time and type of illumination on carotenoid content, protein solubility and in vitro protein digestibility of chickpea (Cicerarietinum L.) sprouts. *Food Chemistry* 104: 1074-1079.

Khatoon, N. and Prakash, J. 2006. Nutrient retention in microwave cooked germinated legumes. *Food Chemistry,* 97 (1): 115-121.

Kumar, K. G., Venkataraman, L. V., Jaya, T. V., & Krishnamurthy, K. S. 1978. Cooking characteristics of some germinated legumes: changes in phytins, Ca^{++}, Mg^{++}, and pectins. *Journal of Food Science*, 43, 85–88.

Liang, J., B.Z. Han, M.J.R. Nout and R.J. Hamer, 2008. Effects of soaking, germination and fermentation on phytic acid, total and *in vitro*soluble zinc in brown rice. *Food Chem.*, 110: 821-828.

Lintschinger J, Fuchs N, Moser H, Jager R, Hlebeina T, Markolin G, Gossler W. 1997. Uptake of various trace elements during germination of wheat, buckwheat and quinoa. *Plant Foods Hum. Nutri*., 50: 223-237.

D.H. Lowry, N.J. Rosebrough, A.L. Tarr, R.J. Randall. 1951. Protein measurement with the folin-Phenol reagent. *J. Biol. Chem.,* 193: 265- 276

Lyimo M, Mugula J, Elias T. 1992. Nutritive composition of broth from selected bean varieties cooked for various periods. *J Sci Food Agric*., 58:535–539.

Malick CP, Singh MB. 1980. Estimation of polyphenols, In: CP. Malik,MB. Singh, (eds). In : Int. J. Adv. Res. Biol.Sci. 2(2): (2015): 185–189 189 Plant enzymology and histoenzymology., Kalyani publishers, New Delhi, p. 286.

Masood, H. U. Shah and A. Zeb.2014.The Journal of Animal & Plant Sciences, 24(3):, Page: 850-859 ISSN: 1018-7081

MegatRusydi MR, Azrina A. 2012. Effect of germination on total phenolic, tannin and phytic acid contents in soy bean and peanut. *Int. Food Res. J.,* 19(2): 673-676

Morgan, J., R.R. Hunter and R. O'Hare, 1992. Limiting factors in hydroponic barley grass production. 8th Int'l Conference on Sioless culture. Hunters' rest, South Africa.

Mubarak, A.E. 2005. Nutritional composition and antinutritional factors of mungbean seeds (*Phaseolusaureus*) as affected by some home traditional processes. *J. Food Chem.,* 89: 489-495

Murthy, N.K., S. Annapurani, P. Premjyothi, J. Rajah and K. Shubha. 1985. Bioavailability of iron by *in vitro* method from selected foods and effects of fortification promoters and inhibitors. *Indian J. Nut. Diet*. 22: 68-72.

Obizoba, I.C. and L.N. Atu, 1993. Production and chemical evaluation of some food condiments of Nigeria. *Plant Food Hum. Nutr.,* 44: 249-254.

Randhir R, Lin Y, Shetty K. 2004. Stimulation of phenolics, antioxidant and antimicrobial activities in dark germinated mung bean sprouts in response to peptide and phytochemical elicitors. *Process Biochemistry* 39: 637-46.

Rani, S., S. Jood and S .Sehgal. 1996. Cultivar differences and effect of pigeonpea seeds boiling on Trypsin lnhibitor activity and in vicro digestibility of protein and starch. Die Nahrung. 40: 145-146.

Rao, P.U., Deosthale, Y.G. 1982. Tannin content of pulses varietals differences and effects of germination and cooking. *Journal of Science Food and Agriculture*, 33: 1013 – 1016.

Rao, B.S.N., Deosthale, Y.G., Pant, K.C. 1989. Nutritive value of Indian goods. Pp 47-91. Hyderabad, India. *National Institute of Nutrition. Indian Council of Medical Research*.

Reddy, N.R., Pierson, M.D., Sathe, S.K., & Salunkhe, D.K., 1985. Chemical, nutritional and physiological aspects of dry bean carbohydrates - A review. *Food Chem*. 13, 25-68.

E.B. Robert. 1971. Method for estimation of tannin in grain sorghum. *Agro. J.,* 63: 511-512

Saharan, K., Khetarpaul, N., Bishnoi, S. 2002..Antinutrients and protein digestibility of Faba bean and Rice bean as affected by soaking, dehulling and germination*. J. Food Sci. Technol*., 39: 418-422.

Salunkhe, D.K. 1982. Legumes in human nutrition: current status and future research needs. *Current Science*, 57: 387-394

Saxena AK, Chadha M, Sharma S. 2003. Nutrients and antinutrients in chickpea (Cicerarietinum L.) cultivars after soaking and pressure cooking. *J. Food Sci. Technol*., 40: 93-497.

Shanthakumari, S., Mohan, V.R. Britto J. De. 2008. Nutritional evaluation and elimination of toxic principles in wild yam (Dioscorea spp.). Tropical and Subtropical Agroecosystems, 8: 313-319.

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

Sood. 2002. Effect of processing and cooking on proximate composition of chickpea varieties. *J. Food Sci. Technol*. 39: 69–71.

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

Vohra, P., G.A. Gray and F.H. Kratzer. 1965. Phytic acid metal complexes. Proc. SOC. Exp. *Biol. Med*. 120*:*447.

Wheeler, E. L. and Ferrel, R. E. 1971. A method for phytic acid determination in wheat and wheat fractions. *Cereal Chem.,* 48, 312 – 20

Xu, M. J., J. D. Dong and M. Y. Zhu. 2005. Effects of germination conditions on ascorbic acid leveland yield of soybean sprouts. *J. Sci. Food Agric*., 85(6): 943-947.

Yanez, E., Zacarias, I., Aguayo, M. Vasquez, M., Guzman, E. 1995. Nutritive value evaluated on rats of new cultivars of common beans (Phaseolus vulgaris) released on Chile. *Plant Foods for Human Nutrition*, 47: 301-307.

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