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REVIEW ARTICLE

# Processing technologies of Uttarakhand for lesser known crops: An overview

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## Abstract

An appropriate processing technology can enhance the agricultural production and lead to value addition maintaining the quality of the product. Adequate processing technologies may also be helpful in creating job opportunities (self-employment) and thus, play an important role in the rural development of the developing countries like India. The nutritive value of underutilized crops is comparable to other staple cereals like wheat and rice. They form an important component of diet of people in India especially in rural and remote areas. Several studies have been conducted on processing of minor millets, legumes and cereals indicating its importance and future potential including health benefits in modern diets. This review is intended to cover the information about processing technologies of lesser known crops so that its applications to available crops in Uttarakhand may enhance its utilization and nutritional importance.

**Keywords:** Processing technology, rural development, minor millets, legumes, cereals, lesser known crops.

## Introduction

Millets, legumes and cereals constitute an important part of the diet of a large section of the population in the world, as they are good source of proteins, minerals and vitamins. But these crops are being neglected even though it's high nutritive value and beneficial use. In developing countries like India, millets and legumes are consumed by people of low economic groups. The production of this lesser crops include, barnyard millet, finger millet and other lesser known crops like black soybean, horse gram, buck wheat etc. In Uttarakhand, these underutilized crops like, finger millet, barnyard millet, black soybean, horse gram etc. are cultivated in a wide range of soils and under diverse climatic conditions. The production of these underutilized crops (Table 1) is around 821076 Mt from approximately 522486 ha area reported during 20010-11(Directorate of Agriculture, UK).

The processing and utilization of these crops are largely confined to the home scales that render many of these valuable nutrients unavailable to human beings. In India, cereals and legumes are consumed in traditional ways and various products like porridge, chapathi, laddu, soup, machula, dubkee, churkani (traditional products of Uttarakhand prepared from millets/gahat/bhatt in combination with rice) etc. are prepared using these lesser known crops. But due to the lack of processing knowledge, widespread consumption of these crops is limited. Most of them produced are consumed locally in the form of traditional foods and majority of the nutrients remain unavailable to consumers because of presence of anti-nutrients. Legumes like black soybean and horse gram are not eaten in the raw state because of presence of anti-nutritional factors (Mbithi-Mwikya *et al.,* 2000). Different procedures have been proposed to eliminate or reduce anti-nutritional factors in legumes.

Home practices such as soaking, dehulling and cooking can effectively improve the nutritional value of grains. This review paper is aimed to explore the inherent technological opportunities for better utilization of undervalued crops in designing novel and functional value added lesser known crops based food products.

### Traditional processing technologies

In rural areas of Uttarakhand, traditional methods of millets/cereals/legume processing are being followed for utilization of these crops as small farmers depend upon these crops. The methods followed by the ladies are very crude and not standardized. The techniques/processes followed by them are laborious and time consuming and invariably the quality of the products require substantial improvements. Apart from that nutritional importance, crops are also neglected while preparing the products as the processes involved are not based on sound scientific principles. Keeping in view, the limitations of theses traditional technologies, an up gradation of these technologies is needed. This can be done by developing and introducing the farmers' friendly equipment and optimizing the processes parameters involved. Since women are largely involved in traditional processing, reducing the drudgery associated with traditional food processing operations, through the introduction of simple machines which would make life a lot easier for women with attendant benefits for the well-being of the family and society at large.

Different procedures as mentioned in Table 2 have been proposed to eliminate the anti-nutritional factors in different cereals/legumes. Home practices such as soaking, dehulling and cooking can effectively improve the nutritional value of grains.

Table 1. Production of underutilized crops in Uttarakhand.

| Crop | Local names | Area (ha) | Production (Mt) | Productivity (q/ha) |
|---|---|---|---|---|
| Finger millet | Maduva | 128070 | 170484 | 13.312 |
| Horse gram | Gahat | 12782 | 10449 | 8.175 |
| Black soybean | Bhatt | 5548 | 4981 | 8.978 |
| Amaranthus | Ramdana | 6072 | 2939 | 4.840 |
| Barn yard | Sava | 68056 | 88056 | 12.939 |
| Kidney bean | Rajama | 4377 | 4493 | 10.265 |

Development of simple technological inputs geared to promote processing and utilization at home, villages and commercial levels can have a great impact on utilization of undervalued crops. Various studies have been conducted in the past on different grain with different processing methods. Review of literatures related to the theme has been compiled and presented here.

*Soaking:* Kakade and Evans (1966) studied the effect of soaking on the nutritive value of navy beans. The studies were carried by using whole grains soaked in water, salt solution and sodium bicarbonate solution. The inactivation of trypsin-inhibitor was obtained about 28% when grains were soaked for 4 d.

Kadam and Salunkhe (1989) studied the improvement in cooking quality of horse gram (*Dolichos biflorus*) by pre-soaking treatment with salt solution, 1.5% $NaHCO_3$ and 0.75% citric acid for 12 h. The effective reduction in cooking time and polyphenol compound obtained from 145 to 27 min, 35% than that of untreated cooked samples respectively. The treatment also resulted in improvement protein digestibility of cooked horse gram from 69 to 78%.

Zia-ur-Rehman (2007) studied the effect of soaking on available carbohydrate contents and starch digestibility of black gram. The studies were carried out before cooking under pressure by using tap water and alkaline solution of sodium bicarbonate for soaking at 30 and 100°C for 1 to 2 h. The reduction of 4.46% of total soluble sugars, 3.84% of reducing sugars and 6.86% of starch contents was obtained when black grams were soaked in tap water at 30°C for 1 h temperature and time combination.

*Decortication:* Ghavidel and Prakash (2007) determined the content of anti-nutritional components (phytic acid and tannin) in control, germinated and dehulled green gram, cowpea, lentil and chickpea. The reduction was obtained in phytic acid and tannin content by 18-21% and 20-38%, respectively on germination and more reduction was observed in dehulled over germinated samples. Egounlety and Aworh (2003) reported that decortication significantly reduces anti-nutrients of all legumes. The tannins located mainly in seed coat were removed as a result of dehulling. Dharmaraj and Malleshi (2011) reported that dehusking and splitting of pulses into cotyledons reduces the cooking time considerably.

Decortication even though lowered the overall nutrients may increase the bioavailability of the nutrients including the calcium due to decreased dietary fibre, polyphenol and phytic acid contents. Decortication further increased the carbohydrate digestibility by 5% and that of protein by 8%. The combined effect of soaking, dehulling, washing and cooking almost eliminated the most of the anti-nutrients in soybean; cowpea and ground bean (Table 3).

*Cooking:* Egounlety and Aworh (2003) studied the effect of cooking on present anti-nutrients of all legumes. The studies were carried with raw soybean and it was observed that the highest amount of trypsin inhibitor (23.73 mg/100 g) can be effectively reduced up to 82.2%, when cooked for 30 min. They also studied the combined effect of soaking, dehulling, washing and cooking for soybean and reported that, level of oligosaccharide reduces to a greater extent. However, prolong cooking results in decrease in protein quality and loss of nutrients such as vitamins and minerals. Xu and Chang (2011) studied the effects of cooking (boiling and steaming) on the phyto-chemicals of two types of soybeans (yellow and black). They reported that the cooking caused significant decrease in total phenolic content and phytic acid content in all bean types as compared to those of the raw beans. They suggested that thermal processing is the best method for reducing phyto-chemicals in case of soybeans. Meera *et al.* (2003) studied the effect of heat processing for development of free fatty acids in millets. The studies were carried by using two varieties of pearl millet subjected to heat treatment (98°C) for 5, 15 and 25 min and then ground after decortication. The effective arresting to development of free fatty acid content (<10%) obtained up to four months of storage in whole and decorticated flour of both the varieties. Thus, they found out that heat processing technique is most suitable to enhance the shelf life of millets.

*Roasting:* Siegel and Fawcett (1976) reported the effects of roasting of legumes for varying periods of time, either pre-soaked moistened legumes or those to which no additional water are used. When this method applied to moistened grains, the cotyledons have a tendency to shrink more than the husk, resulting in the husk being loosened from the cotyledon. They also reported that in addition to facilitating husk removal, heating effectively destroys most of toxic factors present in legumes.

Table 2. Features of traditional processing methods used for utilization of undervalue crops.

| Technique | Purpose | Method | Limitations |
|---|---|---|---|
| Threshing | To detach kernel | By hand (beating with sticks) | Labour intensive, time consuming, low efficiency |
| Winnowing | To separate the chaff | By air | Inefficient, depend on weather conditions, low capacity |
| Dehulling | To separate husk | By pounding | Time consuming and labour intensive |
| Soaking | To increase softness of grains | By pounding in water | Depend on weather conditions, chances of contamination, low capacity |
| Germination | To improve the taste by increasing softness of grains | By using wet muslin cloth | low capacity and efficiency |
| Blanching | To kill pathogenic microorganisms | By using hot water | Inefficient blanching caused browning of grains, low efficiency |
| Roasting | To improve flavour and taste | Open pan (Kadhai). | Burning chances of grains, low efficiency |
| Popping | To improve softness flavour and taste of grains | Open pan (Kadhai). | Inefficient popping caused browning of grains, chances of contamination, low efficiency |

Sharma *et al.* (2011) conducted the extensive study on physico-chemical, thermal and pasting properties of different hulled barley grains when subjected to roasting in hot sand at about 280°C. The roasted barley flour obtained significantly higher water absorption and water solubility index, also roasting significantly affected the pasting and thermal properties of the flours. Griffith and Castell-Perez (1993) studied the effects of roasting on selected cereals and legumes. The studies were carried out using forced air oven in which pearl millet, cowpea and peanut are subjected to 160°C, temperature monitored with a microprocessor thermometer. They observed that a pleasant roasted flavour was developed when seeds approached 140°C, which established experimental roasting times. They also reported that the higher seed temperatures produced undesirable flavours and darkened colours due to heat-enhanced chemical reactions.

*Frying:* Frying is mainly doing in an open kettle that contains hot oil and it is used mostly on previously processed legumes, which are in the form of a flour, paste, or dough. The ground legumes flour are commonly made into a stiff paste and fried to make a popular ready-to-eat snack. The main effect of frying is to improve flavour and taste. Kurien *et al.* (1972) reported that in an India chickpea, black gram (*Phaseolus mungo*) and peas (*Pisum sativum*) are often prepared into dough's or paste, which are deep fried into crispy products. In addition, mung bean or dhal is also fried in a little fat and eaten as a snack (Kachroo, 1970).

*Puffing:* Sreerama *et al.* (2008) conducted an extensive study on the functional, expansion and anti-nutritional properties of popped legumes. The studies were carried with horse gram and subjected to popping/expansion after soaking in distilled water for 4-5 h to attain saturation. They were popped grains with hot sand (1:6) at temperature ranging from 230 to 250°C for a short time (20-30 sec). They improved the functional and expansion properties significantly by reducing the level of anti-nutritional components like phytic acid, tannins and trypsin inhibitor up to 60%, when horse gram expands for same temperature and time combination. Therefore, they suggested to use popping as a thermal treatment in case of horse gram to achieve desired properties. Siegel and Fawcett (1976) observed that in India, Puffing of grains like maize, horse gram etc. is mainly done in household in a manner similar to that used for roasting process. Since the process of puffing legumes needs to be developed, a hand operated home-scale system to a large-scale system in which mechanized puffing machines are used; investigation into standardizing the optimal processing conditions for producing the best puffed products is needed.

*Germination:* Magala-Nyago *et al.* (2005) studied the effects of germination in finger millet and soybean. They observed that the β-carotene significantly increased during germination, in case of finger millet, the increase in β-carotene was highest (126.9%) at 30°C for 48 h and (1102.7-8316.9%) 25°C for 72 h for soybean. Mbithi-Mwikya *et al.* (2000) studied the effects of germination on nutritional, anti-nutritional factors and viscosity of millets flour. Seeds were germinated for 48 h at 30°C. Most of the important changes, namely increasing nutritional parameters, lowering of viscosity and anti-nutritional factors were observed significantly when grains were subjected for 48 h germination. They also reported that germinating the millet seeds for longer than 48 h, increase in further dry matter loss without much improvement in nutritional quality was observed. Therefore, they suggested this time and temperature combination is optimum for finger millet effective germination. Ghavidel and Prakash (2007) analyzed the content of nutrients and anti-nutritional components in control, germinated and dehulled green gram, cowpea, lentil and chickpea.

Table 3. Suggested processing technologies for undervalued crops.

| Grain processing methods | Process description | Advantages of process | Equipment/technology available |
|---|---|---|---|
| Decortication | Decortication is a process of removal of the husk or skin from whole grain. | Significantly reduces anti-nutritional factors. | Pounding or grinding. |
| Soaking | Whole grains are soaked in water, salt solution and sodium bicarbonate solution. | Soften the grains and achieve easy removal of husk. Phytic acid level reduced in case of legumes | Done in an open container |
| Cooking | Cooking is a process in which whole legumes (husked or dehusked) is boiled with water, until becomes soft and then mashed, mixed with water and re-boiled to give a consistency of a soup or gruel. | Reduce microbial load, Impart desirable sensory qualities. | Open vessel and pressure cooker. |
| Frying | Frying takes place in an open kettle that contains hot oil. | Improve flavour and taste. | Open kettle that contains hot oil. |
| Roasting | Roasting is process in which grains are subjected to heat for varying periods of time. Initially, either pre-soaked moistened legumes or those to which no additional water has been added are used. | Impart desirable sensory qualities and reduce anti-nutritional factors. | Open pan (Kadhai) |
| Puffing | Puffing is the process in which whole unhusked grains are soaked in water and mixed with sand, which has been heated to 250°C, approximately 15-60 sec. | Improve taste and flavour by reducing anti-nutrients. Also improve storage quality of by inactivation of destructive bacteria's. | In salt using open hot pan (Kadhai). |
| Germination | Soaking the whole unhusked grains for 2-24 h, and then spreading them on a damp cloth for up to 24-48 h. | Increases digestibility by softening the grains and anti-nutrients. | Not particular set up available for germination. |
| Fermentation | Fermentation is the process whereby the raw material becomes the medium for the growth of micro-organisms. The growing microorganisms then produce their own by product such as acids or antibiotics by breaking down starches. | Impart desirable sensory qualities by improving nutritional value and digestibility and inhibit spoilage and pathogenic micro-organisms. | Natural fermentation with microbial flora selection by means of substrate composition. |
| Malting | Malting is a combined process of steeping, germination, drying, toasting, grinding, sieving. | Achieve better digestibility of starch. | No particular set up available for malting process. |

They observed that germination caused significant increase in protein, thiamine, iron and calcium bioavailability and starch and protein digestibility contents of all the legume samples. Also the reduction in phytic acid and tannin was obtained by 18-21% and 20-38%, respectively on effect of germination. Khalil and Mansour (1995) evaluated the nutritive value of raw, cooked, autoclaved and germinated faba bean. Heat processing and germination, resulted in significant reduction in stachyose, tannins, phytic acid, trypsin inhibitor activity. Heat processing was more effective in reducing the tannins, trypsin inhibitor. Heat processing and germination did not affect the total essential amino acids. The *in vitro* protein digestibility and PER value of faba bean were improved by heat processing and germination. There was a slight change in the mineral content by the heat processing with the exception of K and Ca. Germinated faba bean showed noticeable decreases in the contents of Na, K, Cu, Mn and Mg and increases in Zn and Fe.

*Malting:* Griffith and Castell-Perez (1993) studied the physicochemical properties of pearl millet, cowpea and peanut resulting from roasting and malting. The most significant changes in physicochemical properties in case of legumes were observed during malting. They also find out that the malted seeds produce flour with reduced viscosity and significant increase of WSI.

Gernah *et al*. (2011) studied the effect of malting and lactic fermentation on some chemical ad functional properties of maize. The studies were carried out with germination of white maize kernels over a period of 96 h and flour of 72 h fermented using back sloping. The germination and fermentation of white maize caused significant increase in quantity of protein, reduced bulk density and viscosity as well as reduction of toxins and anti-nutritional factors. They also reported the significant reduction of tannin content (2.62-0.42 g/100 g), phytates (2.3-0.84 g/100 g).

*Fermentation:* Murali and Kapoor (2003) studied the effects of artificial fermentation of finger millet. The studies were carried out for 24 h at 37°C using *Lactobacillus fermentum* and *Saccharomyces cerevisiae.* The significant reduction in phytic acid content and marked increase in the availability of Zinc was obtained when grains were fermented using same organisms for 24 h time period. Adebowale and Maliki (2011) analyzed the changes in the chemical composition and functional properties of fermented grains. The studied were carried out with pigeon pea (*Cajanus cajan* L.) for 1, 2, 3, 4 and 5 d. The significant increase in moisture, protein and ash contents of the seeds was observed while, the crude fat, crude fibre and carbohydrate contents were noted to be decreased. They also reported that significant reduction in water/oil absorption index, bulk density, swelling capacity, foam capacity, viscosity power was obtained after fermentation of pigeon peas.

Palanisamy *et al*. (2011) studied the enhancement of nutritional value of finger millet based food (Indian dosa) by co-fermentation. The studies were carried by fermentation of finger millet with horse gram flour blend in different proportions (2:1, 3:1, 4:1 and 5:1) performed for 24 h. The Dosa prepared from fermented flour, showed increase in lysine content from 5.87 to 6.73 g of amino acid/100 g of total amino acid and better sensory attributes when both were co-fermented in 4:1 ratio.

Ghavidel and Prakash (2007) reported that the fermentation is found to be most effective treatment for grains. The quantity as well as quality of the food proteins, vitamins and digestibility of starch in Bengal gram, cowpea and green gram was increased by fermentation, also the most of anti-nutritional factors found to be declined during fermentation process. They also reported that the combined effect of cooking and fermentation also improved the nutrient quality of sorghum seeds and reduced the content of anti-nutritional factors to a safe level in comparison with other methods of processing.

## Conclusion

From the presented reviews, it could be concluded that, the millets offer wide range of opportunities for utilization in the form of diversified products along with better nutritional qualities. The various processing methods such as soaking, dehulling, cooking, puffing, germination and fermentation effectively improve the nutritional value of grains. The problems of unavailability of many essential amino acids and valuable nutrients are of millet food that can be overcome when, our primary concern should be the presence of factors that interfere with nutrients, their identification, and the development of processing methods that inactivate or destroy them. This will contribute to increased development of nutritious food supplies and an improved nutritional status for the large number of malnourished people in our country.

## References


1. Adebowale, O.J. and Maliki, K. 2011. Effect of fermentation period on the chemical composition and functional properties of Pigeon pea (*Cajanus cajan*) seed flour. *Int. Food Res. J.* 18(4): 1329-1333.
2. Dharmaraj, U. and Malleshi, N.G. 2011. Changes in carbohydrates, proteins and lipids of finger millet after hydrothermal processing. *Food Sci. Technol*. 44(7): 1636-1642.
3. Directorate of Agriculture, Uttarakhand. Agricultural Statistics, 2011.
4. Egounlety, M. and Aworh, O.C. 2003. Effect of soaking, dehulling, cooking and fermentation with *Rhizopus oligosporus* on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean, cowpea and ground bean. *J. Food Engg.* 56: 249–254.
5. Gernah, D.I., Ariahu, C.C. and Inghian, E.K. 2011. Effect of malting and lactic fermentation on some chemical ad functional properties of maize (*Zea mays*). *Amer. J. Food Technol.* 6(5): 404-412.
6. 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*. 40(7): 1292-1299.
7. Griffith, L.D. and Castell-Perez, M.E. 1993. Effects of roasting and malting on physicochemical properties of select cereals and legumes. *J. Cereal Chem.* 75: 780-784.
8. Kachroo, P. 1970. Pulse crops in India. New Delhi, Indian Council of Agricultural Research.
9. Kadam, S.S. and Salunkhe, D.K. 1989. Nutritional composition, processing and utilization of horse gram and mouth bean. *Critical Rev. Food Sci. Nutrition.* 22(1): 1-26.
10. Kakade, M.L. and Evans, R.J. 1966. Effect of soaking and germinating on the nutritive value of navy beans. *J. Food Sci.* 31: 781.
11. Kakade, M.L., Rackis, J.J., Mcghee, J.E. and Puski, G. 1974. Determination of trypsin inhibitor activity of soy products: A collaborative analysis of an improved procedure. *J. Cereal Chem.* 51: 377-382.
12. Khalil, H. and Mansour, E.H. 1995. The effect of cooking, autoclaving and germination on the nutritional quality of faba beans. *J. Food Chem.* 54: 177-182.
13. Kurien, P.P., Desikachar, H.R. and Parpia, H.B.1972. Processing and utilization of legumes. Proceedings of a symposium on Tropical agriculture research grain legumes in India. Indian food legumes. Tokyo, Japan, Series No. 6: 225.
14. Magala-Nyago, C.M., Kikafunda, J. K., Mwasaru, M.A. and Connelly, R.K. 2005. Evaluation of nutritional value of malted and extruded finger millet based complementary foods. African crop science conference proceedings. 7: 677-686.
15. Mbithi-Mwikya, S., Yiru, J.V., Camp, Y. and Huyghebaert, A. 2000. Nutrient and antinutrients changes in finger millet (*Eleusine coracan*) during sprouting. *Lebensm. Wiss. U. Technol.* 33: 9-14.

16. Meera, M.S., Bhashyam, M.K. and Ali, S.Z. 2003. Effect of heat processing of pearl millet grains on shelf life and functional properties of flour and quality of final products. Paper presented at the 5th International Food Convention, Mysore, 5-8 Dec. p.124.
17. Murali, A. and Kapoor, R. 2003. Effect of natural and pure culture fermentation of finger millet on zinc availability as predicted from HCI extractability and molar ratios. *J. Food Sci. Technol.* 40(1): 112-11.
18. Palanisamy, B.D., Rajendran, V. and Sathyaseelan, S. 2011. Health benefits of finger millet (*Eleusine coracana* L.) polyphenol and dietary fiber: A review. *J. Food Sci. Technol.* pp.1-20.
19. Sharma, P., Singh, H., Cristina, G. and Rosell, M. 2011. Effects of roasting on barley β-glucan, thermal, textural and pasting properties. *J. Cereal Sci.* 53: 25-30.
20. Siegel, A. and Fawcett, B. 1976. Food legume processing and utilization (with special emphasis on application in developing countries) International development research centre, Ottawa Canada, Vol. 4.
21. Sreerama, Y., Sasikala, N. and Pratape, V.M. 2008. Nutritional implications and flour functionality of popped/expanded horse gram. *Food Chem.* 108: 891-899.
22. Xu, B. and Chang, K.C. 2011. Reduction of anti-proliferative capacities, cell-based antioxidant capacities and phytochemicals contents of common beans and soybeans upon thermal processing. *J. Food Chem.* 129: 974–981.
23. Zia-ur-Rehman. 2007. Domestic processing effects on available carbohydrate content and starch digestibility of black grams (*Vigna mungo*) and chick peas (*Cicer arietium*). *J. Food Chem.* (100): 764-767.