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Module on

Processing of Legumes

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Introduction

Legumes are ripe seeds of the plant family *Leguminosae/ Fabaceae*. The term "pulses" are limited to crops harvested for dry product only, excluding therefore crops harvested green for forage, used for grazing, or as green manure, and also crops harvested green for food (green beans, green peas, etc.). They also exclude those used mainly for extraction of oil (soybeans and groundnuts) and crops whose seeds are used exclusively for sowing purposes, such as alfalfa and clover. Pulses constitute an important source of dietary protein for large segments of the world's population particularly in those countries in which the consumption of animal protein is limited by non-availability or is self-imposed because of religious or cultural habits. Pulses provide energy, dietary fibre, protein, minerals and vitamins required for human health. Recent research studies suggest that consumption of pulses may have potential health benefits including reduced risk of cardiovascular disease, cancer, diabetes, osteoporosis, hypertension, gastrointestinal disorders, adrenal disease and reduction of LDL cholesterol. However, legumes contain several antinutritional factors in the raw seeds that need to be reduced by processing so as to enhance the digestibility and nutritive value.

Processing of Legumes

The processing of food commodities generally implies the transformation of the perishable raw commodity to value added product that has greater shelf life and is closer to being table ready. The common methods for processing of legumes include soaking, cooking, germination, fermentation, parching. Besides, canning, milling (dehulling), flour making, extrusion and fractionation. These are discussed as under:

Soaking: Soaking of legume seeds in water is used to moisten and soften the seeds to reduce cooking time, aid in seed coat removal and an aid in germination. Soaking reduces the toxin content and surface contamination. Soaking time varies with variety and species and with length and conditions of storage. High temperature soaking accelerates hydration. Cracking or scouring seeds with tough seed coats before soaking assists moisture uptake. The degree and rate of hydration of the starch-protein matrix influences the cooking rate and final texture of cooked beans. The content of total soluble sugars and soluble minerals in legume decreases during soaking because of leaching losses.

Germination/Sprouting: The germination process involves initially soaking the whole unhusked grains for 12 -24 hours, and then spreading them on a damp cloth for up to 48 hours. Under tropical conditions, sprouts up to a length of 1.0 cm appear. Sprouted grains are eaten raw with salt, or further seasoned and fried or boiled. The direct effect of sprouting on both the physical and chemical changes and the nutritive value of legumes is of great interest. Chemical changes occurring in sprouted legumes primarily involve the carbohydrate of the grain, namely the conversion of some starch to lower molecular disaccharides (maltose) and dextrins by the action of amylases. Increases in proteases also occur during germination, causing the degradation of high molecular proteins to lower molecular ones. It has been reported that protein content of raw beans slightly decreases from 28.1 - 26.7% in the germinated beans, the decrease being a result of protein breakdown by the proteolytic action of enzymes (proteases). Germination causes noticeable increase in the concentration of amino acids as a result of proteins being broken down into simpler units. Germinated beans had increased amounts of these essential amino acids: lysine (24%), threonine (19%), alanine (29%), and phenylalanine (7%). Ascorbic acid content has been reported to increase from a trace amount to 10-12 mg/100 g in legumes germinated for 48 hours. Increases in thiamine, riboflavin, niacin, pyridoxine, biotin, tocopherol, choline, and available iron have also been reported during germination of various pulses, including chickpeas, pigeon peas (Cajanus cajan), lentils, and mung beans.

Cooking: It is probably the oldest domestic method of processing for making legumes edible. Usually it includes a prior soaking of the seeds and subsequent cooking in boiling water until they become tender. Cooking of legumes can be done under ambient conditions, under pressure/autoclaving or by the use of microwaves.

Ordinary cooking:

Generally the pulses are added tap water and are cooked on a hot plate or cooking stove for 15–120 min or more until tenderness of the legumes is achieved. This is the most common form of cooking prevalent in rural habitats.

Pressure Cooking

Pulses are often cooked in a pressure cooker for faster cooking in order to save time. It involves both high temperature and pressure treatment for a short duration and enhances the digestibility and palatability of legumes considerably. Pre-soaked legumes are subjected to pressure cooking for reducing the processing time and also for obtaining a tender product.

Microwave wave cooking

It is a popular means of cooking in the urban areas for saving both energy and time. This form of cooking is even faster than pressure cooking but it is limited to the higher strata of the society in the developing countries due to high cost of the microwave oven and requirement of electricity for its working. Presoaked pulses are added water and then cooked in a microwave oven for 4-10 min or more until tenderness of the legume is achieved.

Generally the cooking treatments cause significant decreases in fat, total ash, carbohydrate fractions (decrease in reducing sugars, sucrose, raffinose and stachyose, while verbascose is completely eliminated after cooking treatments), antinutritional factors (trypsin inhibitor, tannins, saponins and phytic acid), minerals and B vitamins. Cooking treatments decrease the concentrations of lysine, tryptophan, total aromatic and sulphur containing amino acids. The losses in B vitamins and minerals in seeds cooked by microwave are smaller than those cooked by boiling and pressure-cooking. In vitro protein digestibility, protein efficiency ratio and essential amino acid index were found to be improved by all cooking treatments.

Fermentation: Fermentation is probably one of the oldest methods for processing food grain legumes. Fermentation of food legumes is common in Asia and Africa. During fermentation breaks down of carbohydrate (starch) into acid as the final end product by the action of microorganisms (bacteria, moulds, and yeast) takes place. In the household practice, such microorganisms in the atmosphere are the fermenting organisms. However, controlled fermentation, using specific moulds and bacteria, is followed in large-scale commercial operations. Examples of processed legumes using fermentation are *idli, dosa, temph, natto*, soya sauce etc.

The main effect of fermentation is to make more of the grain nutrients available for assimilation in the body, as the digestibility of the legume protein is increased. Digestive enzymes produced by microorganisms during fermentation are able to break down protein into amino acids and other water-soluble products of protein decomposition. In addition, it has been reported that the fermentation process inactivates unfavourable substances including trypsin inhibitors, haemagglutinins, and saponins that are associated with edible legumes. This relates to the heating process involved in the preparation of fermented foods. The natural formation of antioxidants during the fermentation process has also been reported. In addition, fermented products have an increased storage life at room temperature, since organic acids and the amino acids produced during the process can prevent contamination by pathogenic bacteria and microorganisms. Increases in choline and folic acid have also been observed in fermented preparations.

Roasting /Parching: Roasting also known as toasting or parching is a form of preparing legumes. It is practiced mainly in India and Africa. Roasting refers to the method in which usually whole, husked, or unhusked grains are exposed to dry heat. This is performed either directly by placing the whole grains and beans directly upon fire, or more commonly in hot common salt or sand that are in contact with the fire. Use of powdered common salt as heating medium is nowadays more common than using sand. Roasted legumes are generally consumed as snacks. The traditional Indian household practice for roasting or parching pulses (chickpea, etc.) involves initially sprinkling the grains with a little water, which may or may not contain added common salt. The pulse is then mixed with four times its own volume of preheated sand/salt. The pulse/sand or salt mixture is contained in a frying pan kept on an open fire, the sand reaching a temperature of about 200 – 250 °C. The pulse is subsequently roasted by rapid mixing in the frying pan using a ladle. During this process, the pulse has increased in temperature from an approximate initial 26 °C to 132 °C in a period of 2-3 minutes. The roasted material is separated from the salt/sand by sieving.

Roasting improves the flavour, texture, and nutritive value of the grain as the biological value of legume proteins increased. It also can serve as a preliminary step in facilitating husk removal during wet or dry grinding.

Puffing Puffed grain legumes are prepared in the Indian household in a manner similar to that used for roasting. It is nowadays commonly used at industrial level. Puffing brings about a light and porous texture. Whole unhusked grains are more commonly used for this process. For puffing, grains are soaked in water and mixed with sand, which has been heated to 250°C and then toasted for a short time, approximately 15-25 seconds. After the sand is sieved off, the grains are dehusked between a hot plate and rough roller. The more common legumes prepared in this manner are chickpeas and peas. Other dried legumes may be suitable for this process. These products are traditionally eaten either with parched cereals or as a snack. An exploratory study with chickpeas indicated that moisture conditioning either by soaking or by the addition of water to the grains prior to heating is responsible for good puffing.

Frying: This method of processing can be applied either at domestic or industrial level. Frying is mainly used on previously processed legumes, which are in the form of soaked grains, flour, paste, batter or dough. Frying takes place in an open kettle that contains hot oil. The food form that is subsequently fried may be either precooked or raw. In Brazil, bean puree from decorticated beans is fried to make a cake. Ground legume flours are commonly made into a stiff paste and fried to make a popular Nigerian, ready-to-eat snack. In India, chickpea, black gram (*Phaseolus mungo*), and peas (*Pisum sativum*) are often prepared into doughs or paste, which are deep fried into crispy products, for example *pakora* from *besan* (chick pea flour). In addition, mung bean or dhal is also fried in a little fat and eaten as a snack.

Canning: Canning is the preservation of food in hermetically sealed containers (usually tin cans) and subsequently heat processing of the cans. Since, the food is placed in air tight cans and heat processed for destruction of microbes, the contents of can remain preserved as further microbial entry into the can does not occur. Canning represents the most common method of processing legumes for human consumption, especially in the developed countries. It is done on a commercial basis since the process itself involves considerable time and the need for cooking kettles (pressure cookers) and can-sealing equipment. Industrial canning overcomes the long time and high fuel costs involved in home preparation of legumes. Generally common beans (*Phaseolus vulgaris* L.), lima beans (*Phaseolus lunatus*), green or garden pea and black eyed pea (*Vigna unguculata*) are canned.

Canning operation involves use of dried whole legumes seeds which are then washed in cold water. After draining, the seeds are allowed to soak overnight in water, during which time the moisture content of the dried seeds increases from an initial 10-

12% to approximately 20%. This facilitates cooking of the whole seeds, since there is a softening of the seeds. After a weighed amount of beans are put in each can, a liquid is added to the can, this being either a thin sauce (tomato) in the case of navy beans, or water, in the case of peas. The cans are then sealed on a double seamer (sealing machine) and subsequently placed in a retort for cooking. The heat-processing step proceeds for a time that is dependent upon the temperature and pressure used. Since the retort is essentially a large pressure cooker, a shorter cooking time for processing the seeds can be used than is possible during cooking at atmospheric pressure. Usually, a 90-minute process is used at a temperature of 135°C. After retorting, the cans are cooled in cold water for approximately 15 minutes prior to prevent overcooking of the canned product.

Anti-nutritional factors are destroyed during canning. Considerable losses of water soluble vitamins during soaking of legumes prior to canning have been reported. Protein efficiency ratio (PER) of canned beans have been reported to decreases to approximately 40% as a result of the canning process.

Milling of Pulses: Milling of pulses is done at industrial level. Dry whole seeds of pulses have a fibrous seed coat (husk, hull, or skin). The seed coat is often indigestible; therefore, pulses are mainly consumed after dehusking to improve their palatability, taste and cooking properties. In most parts of the world, pulses are traditionally consumed either in the whole or in the form of dehusked split pulse. Dehulling, therefore, is an important primary processing activity. Milling of pulses involves removal of outer husk and splitting the grain into two equal halves. Generally, the husk is much more tightly held by the kernel of some pulses than most cereals, causing dehusking of pulses a problem. Conventional milling of pulsed involves following steps:

Cleaning and grading of pulses: Cleaning of pulses involves removal of foreign material like chaff, sand, stones, mud, ferromagnetic materials etc. from pulse grains. This is accomplished by exploiting differences between size, shape, density and ferromagnetic properties of impurities and pulse grains. Grading is generally done on the basis of size using sieves of specific perforations, but it can also be done on the basis of colour and presence/absence of visible damage.

Pitting: Pitting involves cracking and scratching of clean pulses by passing through emery coated rollers. The clearance between the emery roller and cage (housing) gradually narrows from inlet to outlet. Cracking and scratching of husk take place mainly by friction between pulses and emery as the material is passed through the narrowing clearance. Some of the pulses are dehusked and split during this operation, which are then separated by sieving.

Pretreatment with oil: Scratched or pitted material is treated with some edible oil such as linseed oil at the rate of 1.5–2.5 kg/tonne of pulses. This is done by passing it through a screw conveyor which helps in mixing of oil with pitted material. Then they are placed on floors for about 12 h to diffuse the oil.

Conditioning: This is done by alternate wetting and drying. About (3–5% water) is added to the pulses after sun drying for a certain period and then tempering is done for about 8 hours. The grain is dried in the sun again. By allowing water to drop from an overhead tank on the pulses, which are passed through a screw conveyor, an addition of moisture to the pulses is achieved. The screw is slowly rotated (50–70 rpm) to achieve proper mixing of oil–water with the grain. The length and width of the conveyors range between 150–250 cm and 20–30 cm, respectively. Until all pulses are sufficiently conditioned the whole process of alternate wetting and drying is continued for 2–4 days. Pulses are finally dried to about 10%–12% moisture content in sun or by mechanical hot-air-drying.

Dehusking and Splitting: Dehusking is a process that removes seed coat/ husk from the whole pulse seeds. It improves appearance, texture, cooking quality, palatability, and digestibility of grains. In India, carborundum emery rollers are used for dehusking.

Dehusked pulses are split into two parts. The split pulses are then separated by sieving and the husk is aspirated off. Unsplit dehusked pulses and tail pulses are again dehusked and milled in a similar way. Until the remaining pulses are dehusked and split, the whole process is repeated two or three times.

Polishing: Polishing is done to provide luster and improve the consumer appeal, and usually a screw conveyor is used for this operation. Depending on the consumer need, different polishing materials such as water, oil, or soapstone powder are applied to the split surface. Products can then be packaged for consumption.

Pulse Flour Milling

Cleaned whole or dehulled seed or dehulled split seeds are ground into flour using a hammer, pin, and roller mill. Consumers usually prefer dehulled pulse flour as the bitter flavor, typical of pulses, is minimized. The flour is then packaged and sold to either the retail or ingredient supply market. Chickpea flour commonly known as *besan* is used in the production *pakora* in India. Pulse flours have been increasdly used as functional ingredients in bakery and meat products.

Extrusion Extrusion technology has been used recently for processing of legumes at industrial level. The extruded products are generally blends of cereal and legume flours. It involves the application of both pressure and heat. Products can be extruded at high temperature (140 - 200 ºC), high pressure (60 - 80 bars) with moisture content less than 20 %. The cooking of the products is accomplished in a short time (30 – 60 sec), forced out of the extruder though a variety of dies and dried quickly as it has lower moisture content than conventionally processed products. Besides products produced by extrusion have a light porous texture with high rehydration capacity.

Fractionation of pulses

Recently pulses have been fractionated into starch and proteins by either wet or dry milling. Milling of whole seed or dehulled seed followed by fractionation of starch- and protein-rich fractions will improve utilization of legumes. This method generates products that can be sold as ingredients to food processors and other industrial user's .With respect to legume utilization, milling of legumes and fractionation of protein and starch have increased in recent years.

Dry milling: In dry milling, pulses are subjected to pin milling twice for obtaining fine grade flour. The pin-milled flour is air classified in a spiral air stream and fractioned into light and heavy particles. The fine and light particles contain protein, whereas the coarse and heavier particles mostly contain starch granule. The starch granules remain intact during pin milling and the process must avoid damage to the starch granules. Although dry processing (air classification) does not result in as pure protein fractions as wet processing, it is an effluent-free process and separated fractions are suitable as food, food ingredient, and other uses. Since some protein bodies still adhere to the starch granules at the end of pin milling, it is necessary to reprocess the coarse fraction by pin milling and air classification for increased protein yield. Washing of the air classified starch has also been suggested to remove adhered protein.

Wet milling: In wet milling whole or decorticates seeds are soaked for 10 - 12 hours in water. The soaked seeds are decorticated and milled along with water to produce loose slurry. The slurry is adjusted to a pH from 8.5- 12 for one hour to remove protein from starch. The slurry is then sieved through sieve of specific mesh size depending on size of starch granules in legume. Sediment on the sieve which is chiefly dietary fiber is discarded. The liquid portion passing through the sieve is subjected to centrifugation at 3000 x *g* for 10 -15 min. The supernatant obtained is used for recovery of proteins while as the sediment obtained is washed 2-3 times with distilled water and dried at 40-45 ºC to recover starch. For recovery of proteins the supernatant is adjusted to a pH of 4.5 and then centrifuged at 8000 -10000 x *g* for 10 -15 min. The sediment obtained is collected, adjusted to pH 7 and dried as protein.