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Processing of groundnut and soybean to enhance their value

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At present, for medical reasons, significant amount of consumers opt for plant based milk substitutes for various medical reasons or as a lifestyle choice. Medical reasons include lactose intolerance as well as milk protein allergies. Plant milk substitutes also serve as a more affordable option. Technologically, plant milk substitutes are suspensions of dissolved and disintegrated plant material in water, resembling cow's milk in appearance. They are manufactured by extracting the plant material in water, separating the liquid and formulating the final product. Homogenisation and thermal treatments are necessary to improve the suspension and microbial stabilities of commercial products that can be consumed as such or be further processed into fermented dairy type products. Groundnut and soybean are two major raw materials used for preparation of plant based milk. The nutritional properties depend on the plant source, processing and fortification.

Key Words : Processing, Value addition, Medicinal value, Product quality

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INTRODUCTION

Plant milk substitutes are water extracts of legumes, oil seeds, cereals or pseudocereals that resemble cow's milk in appearance. There is a wide variety of traditional plant based beverages around the world, for example "tigernut milk" in Spain; Sikhye, a beverage made of cooked rice, malt extract and sugar in Korea; Boza, a fermented drink made of wheat, rye, millet and maize consumed in Bulgaria, Albania, Turkey and Romania; Bushera, a fermented sorghum or millet malt based beverage from Uganda, and traditional soy milk originating from China. The most widely consumed plant milk substitute is soy milk. The first commercially successful product was launched in Hong Kong in 1940 and the market grew rapidly during the seventies and early eighties in Asia after the development of technologies for large scale production of mild flavoured soy milk (Chen, 1989). The demand for soy milk in the Western world was initiated by consumers intolerant to cow's milk (Patisaul and Jefferson, 2010). Soy products are still dominating the market in the Western world, but the emerging of alternative products from other plant sources such as coconut, oat, peanut and almond have decreased its share. Overall, the dairy alternative market is still growing. According to an estimate, 15% of European consumers avoid dairy products for a variety of reasons, including medical reasons such as lactose intolerance (LI), cow's milk allergy (CMA), cholesterol issues and phenylketonuria, as well as lifestyle choices like a vegetarian/vegan diet or concerns about growth hormone or antibiotic residues in cow's milk (Jago, 2011).

The main treatment for LI is the avoidance of lactose containing foods and replacing milk and dairy products with lactose free dairy or dairy free alternatives.

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Functional food market is dominated by dairy based probiotic products mainly yoghurt. There is need to develop dairy alternatives due to allergenic milk proteins, lactose and high cholesterol content (Bansal *et al.,* 2016a and b) Total world production of groundnut in 2012-13 is about 37.2 mt. It is major oilseed crop in India accounting for 45% of oilseed area and 55% of oilseed production. India is rated as the second largest producer of groundnut in the world with annual production of over 5-6 mt. China, India, Nigeria, USA and Myanmar are the major groundnut growing countries. Groundnut contains on an average 40-45 per cent oil and 23-25 per cent protein and is a rich source of calcium, iron and vitamin B complex like thiamine, riboflavin, niacin and vitamin A. In developing countries, it is mainly used for oil extraction and its by product is utilized for animal feed purposes. Animal milk, in India at any rate, has a venerated place as a food for both children and adults. A milk-like beverage, or a re-constitutable powder from which to generate it by adding water, represents an acceptable way of furnishing proteins and other nutrients to all age groups, often at reasonable cost. Plant milks may serve as a boon for the countries where the supply of milk is inadequate. Groundnut and soybean are two major raw materials used for preparation of milk like products.

Process :

Plant milk substitutes are colloidal suspensions or emulsions consisting of dissolved and disintegrated plant material. They are prepared traditionally by grinding the raw material into a slurry and straining it to remove coarse particles. Although countless variations of the process exist, the general outline of a modern industrial scale process is essentially the same: the plant material is soaked and wet milled to extract the milk constituents, or alternatively the raw material is dry milled and the flour is extracted in water. The grinding waste is separated by filtering or decanting. Depending on the product, standardisation and/or addition of other ingredients such as sugar, oil, flavourings and stabilisers may take place, followed by homogenisation and pasteurisation/UHT treatment to improve suspension and microbial stabilities. These extracts can also be spray dried to produce powders (Diarra *et al.,* 2005).

Pre-treatments :

Raw material pre-treatments include dehulling, soaking and blanching (Debruyne, 2006). Blanching is required to inactivate trypsin inhibitors and lipoxygenase that would produce off flavours in soy milk and peanut milk (Yadav *et al.,* 2010 and Giri and Mangaraj, 2012). Roasting of the raw material enhances the aroma and flavour of the final product, but heating decreases the protein solubility and extraction yield (Hinds *et al.*, 1997 and Chauhn *et al.,* 2003).

Extraction :

The extraction step has a profound effect on the composition of the resulting product. To increase the yield of the process, the efficiency of this step may be improved by increasing the pH with bicarbonate or NaOH, elevated temperatures or the use of enzymes. Alkaline pH during extraction increases the protein extractability. A higher extraction temperature increases the extractability of fat, but the denaturation of proteins decreases their solubility and yield. Papain and enzymes extracted from *Pestulotiopsis westerdijkii* increased the protein yield of peanut and soy milks (Rustom *et al.*, 1996). In addition to proteolytic enzymes, a mixture of amyloglucosidase and a cellulase cocktail has been shown to increase the carbohydrate recovery of peanut milk (Rustom *et al.*, 1996). Eriksen (1983) used a variety of enzymes in soy milk extraction, and found out that the highest protein and total solids yield was attained using a neutral or alkaline proteinases at their optimum pH. In addition to increasing the extraction yield, proteolytic enzymes improve the suspension stability (Rustom *et al.,* 1991). Also a cellulase treatment after homogenisation has been reported to decrease the particle size and yield a more stable suspension (Rosenthal *et al.,* 2003).

Separation :

After the extraction step coarse particles are removed from the slurry by filtration, decanting or centrifugation. When using raw materials high in fat, such as peanuts, the excess fat can be removed using a separator as in dairy processing.

Product formulation :

Other ingredients can be added to the product base after the removal of coarse plant material. These include vitamins and minerals used for fortification as well as sweeteners, flavourings, salt, oils and stabilizers. As suspension stability is an issue in plant milk substitutes, hydrocolloids are often used to increase the viscosity of the continuous phase, and also emulsifiers have been proven to be beneficial in some beverages. Mono- and diglycerides, glyceryl monostearate, guar gum and carrageenan can be effectively used for stabilizing peanut and soymilk. The addition of nutrients in food substitutes may be necessary to ensure the nutritional quality of the product. The nutrients used must be bioavailable and sufficiently stable, and not cause excessive changes in product quality. The challenge in mineral enrichment is the reactivity of metal ions with other food components, and the use of sequestrants such as citric acid may thus be necessary (Zhang *et al.*, 2007a). Some mineral sources used in plant milk substitutes include ferric ammonium citrate and ferric pyrophosphate as iron sources and tricalcium phosphate and calcium carbonate as calcium sources (Zhang *et al.*, 2007b; Zhao *et al.*, 2005).

Stability :

Plant milk substitutes contain insoluble particles, such as protein, starch, fibre and other cellular material. These particles, being denser than water can sediment, making the product unstable. The suspension stability can be increased by decreasing the particle size, improving their solubility or by using hydrocolloids and emulsifiers (Durand *et al.*, 2003). Many plant milk substitutes coagulate when heating. When proteins unfold as a result of heating, the nonpolar amino acid residues are exposed to water increasing the surface hydrophobicity. This enhances protein-protein interactions that can result in aggregation and sedimentation or gelling (Phillips *et al.*, 1994). The heat stability of proteins depends on the pH, ionic strength and the presence of other compounds such as minerals and carbohydrates (McSweeney *et al.*, 2004). Homogenisation improves the stability of plant milk substitutes by disrupting aggregates and lipid droplets and thus decreasing the particle size distribution (Malaki Nik *et al.*, 2008). Homogenisation in the conventional dairy processing pressure range (20 MPa) increases the suspension stability sufficiently of soy and peanut milk. Ultra high pressure homogenisation (UHPH) of soy milk at 200-300 MPa reduces the particle sizes intensely and improves the stability compared to conventionally processed products. A higher homogenisation temperature has been reported to increase the stability of peanut milk (Hinds *et al.*, 1997a). In soy milk, heat denaturation of proteins is required for suspension stability.

Shelf life :

Commercial plant milk substitutes are pasteurised or UHT treated to extend the shelf life. Pasteurisation is carried out at temperatures below 100° C, and it destroys enough micro-organisms to enable a shelf-life. Rustom *et al.* (1996) treated a peanut beverage for 4 and 20 s at 137°C. The longer treatment time decreased the suspension stability slightly, but led to higher taste and acceptability scores. Both treatments were effective in increasing the microbial shelf life. In commercial products, pulsed electric fields have been suggested to extend the microbial shelf life (Cortés *et al.,* 2005). Also other non-thermal processes such as ultraviolet sterilisation, high pressure throttling, high pressure processing and ultra-high pressure homogenisation (UHPH) have been explored as methods of soy milk preservation (Bandla *et al.,* 2011; Cruz *et al.,* 2007; Smith *et al.*, 2009 and Sharma *et al.*, 2009).

Fermented products :

Fermentation with lactic acid bacteria improves the sensory and nutritional properties, and microbial shelf life of foods. Plant milk substitutes can be fermented to produce dairy free yoghurt type products while rendering the raw material into a more palatable form (Bansal *et al.,* 2016a and b). The levels of hexanal responsible for the undesired nutty flavour in peanut milk can be efficiently reduced with fermentation (Yadav *et al.,* 2010). Fermentation of soy milk reduced the amount of flatulence inducing oligosaccharides. Some authors have used additives such as carboxymethyl cellulose, coagulants (calcium citrate), milk powder and gelatin to enhance the texture and reduce syneresis in the final product (Cheng *et al.*, 2006; Yadav *et al.,* 2010).

Nutritional quality :

Plant milk substitutes are often perceived as healthy. In reality the nutritional properties vary greatly, as they depend strongly on the raw material, processing, fortification and the presence of other ingredients such as sweeteners and oil. Also milks produced of legumes other than soy, such as peanut and cowpea can have protein content as high as 4% (Tano-Debrah *et al.*, 2005). Although plant milk substitutes are low in saturated fats and most products have caloric counts comparable to skim milk, some products contain as much energy as full milk, originating mostly from sugars and other carbohydrates. Plant proteins are generally of a lower nutritional quality compared to animal derived proteins due to limiting amino acids (lysine in cereals, methionine in legumes) and poor digestibility. The nutritional value of proteins depends mainly on the amino acid composition and their physiological utilisation, and absorption that is in turn affected by processing. In addition to containing high value protein, milk and other dairy products provide 30–40% of dietary calcium, iodine, vitamin B12 and riboflavin, and population groups with low milk intakes often have a poor status for these nutrients. To combat these shortcomings, some plant milk substitutes are fortified with calcium and vitamins, mainly B12, B2, D and E. However, consumer awareness is important as many of these products are not fortified.

Acceptability :

Although the demand for plant milk substitutes is increasing, the unwillingness of the mainstream consumer to try unfamiliar foods that are perceived as unappealing may be a limiting factor. Many modern day soy and peanut milks and related products may have an improved sensory quality, but the product group carries a stigma because of early less appealing products on the market. Legume milks tend to possess "beany" and "painty" off-flavours originating from lipoxygenase activity (Chauhan *et al.*, 2003). The presence and intensity of the "beany" flavour depends on processing and storage conditions of soy milks and varieties with less lipoxygenase have less "beany" character (Chambers *et al.*, 2006). Another problem is a chalky mouthfeel some products have due to large insoluble particles (Durand *et al.*, 2003). The acceptance of peanut milk has been shown to depend on the colour, mouthfeel, the absence of peanut flavour and similarity to cow's milk (Diarra *et al.*, 2005) Information can increase the willingness to try novel foods. Taste is the most important purchase criteria of foods, and the information about a good and/or familiar taste increase the willingness to try an unfamiliar food most efficiently. Possible health benefits are also an important criteria and health information may increase both the willingness to try and the perceived liking of a food.

Future prospects :

Plant based milk substitutes have a reputation of "health foods" but the products on the market vary remarkably in their nutritional profiles, some having very low protein and mineral contents. If these products are to be portrayed as substitutes for cow's milk, protein content and quality as well as fortification has to be considered by manufacturers. Attention should be brought to the possible ways of improving the nutritional properties by processing means e.g. the use of enzymes and the selection of raw materials based on their protein quality. Also a reconstitution approach may allow a more efficient extraction of protein from the material and the formulation of higher protein products. This would however increase the costs and also the environmental impact of the products. More knowledge is required to overcome the mineral fortification related stability issues.

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