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Peanut Processing and It's Potential Food Applications

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Abstract: ***Peanut is one of the most important oil and protein producing crops in the world. Most peanuts grown in the world are used for oil production, peanut butter, confectionaries, roasted peanuts and snack products, extenders in meat product formulations, soups and desserts. Being a source of good fat namely poly and monounsaturated fatty acids; they are also used in weight management diets as they provide satiety. The substantial amounts of by-products are generated in the process of peanut harvest and peanut oil extraction. A large portion of peanut meals, skins, hulls, and vines is regarded as the agriculture wastes. With respect to it's high nutritive value especially being an excellent source of protein it can also be incorporated in many food preparations as supplementary food and emergency foods which can be supplied to populations suffering from hunger and malnutrition especially in the developing and underdeveloped countries. Earlier, many researchers focused on the investigation of producing and utilising edible oil and kernel. Since very little attention was given to the other by-products of peanut processing, at present, researches are carried out to improve the utilisation of other by-products other than oil and raw kernel as are proved to be having important nutritional and health benefits. This paper briefly describes various peanut by-products produced. Materials, processing, and potential applications in food manufacture of emerging materials, as are also briefly discussed.***

Keywords: Peanut, Peanut by-products, Utilization, Nutritional and Health benefits

1. Introduction

Peanuts known as the 'Poor man's nut' are the edible seeds of legume *Arachis hypogaea Linn*. The botanical name *Arachis hypogaea Linn* is derived from two Greek words, *Arachis* means 'a legume' and *hypogaea* means 'below ground' referring to the formation of pods in the soil. The world peanut production totals approximately 29 million metric tonnes per year, with the China being the world's largest producer, followed by India with a production of 7 million tonnes in 2012. The major groundnut producing countries in the world are China, India, Nigeria, USA, Indonesia, Argentina, Sudan, Senegal and Myanmar which accounts for nearly 70 per cent of the total world peanut production [8]. The U.S. is one of the world's leading peanut exporters, with average annual exports of between 200,000 and 250,000 metric tons. Argentina and China are other significant exporters [8].

Among all the nuts, peanuts have an excellent nutritional profile due to which it is widely used in the diets for weight management and meeting appropriate protein levels in the body. Peanut is a rich source of protein ranging from 21 per cent to 36.4 percent, 18 per cent of carbohydrates and 36-54 per cent fat [24]. Peanuts have a desirable fatty acid profile for which it is used for weight management diets and is rich in vitamins, minerals and several bioactive compounds. They contain several known heart healthy nutrients including MUFA and PUFA, potassium, magnesium, copper, niacin, arginine, fiber, alpha-tocopherol, folates, phytosterols and flavanoids [24]. Important bioactive compounds like catechins and procyanidins are found in peanut skin which are known for anti-inflammatory effect on pro-inflammatory enzymes and nitrous oxide levels [17]. Peanuts along with other legumes are considered a part of meat and meat alternative group in the Food Guide Pyramid. Groundnut consists of mainly of two globulins namely arachin (93% of defatted seed protein) and co-arachin.

Groundnut protein can be incorporated into a variety of food products without serious problem in terms of colour and flavor. The pleasant aroma, nutty flavor and smooth texture of roasted groundnut have found great acceptance. In India, edible groundnut flour is used in developing a variety of cost effective food formulations such as multipurpose food, fortified flour, paustic atta, malted food, chewy candies and high protein biscuits [5, 18, 20].

Malnutrition is the consequence of much food insecurity, which stems from poor food quality and quantity, severe repeated infections or combinations of all three [27]. Being a cheap source of good quality protein, peanuts can be utilized in the form of flour, protein isolates, and meal in low cost mixed products. Though it is deficient in some amino acids, its digestibility is comparable with that of animal protein [23]. The vast food preparation incorporating groundnut to improve the protein level has helped in reducing malnutrition in developing countries. Groundnut protein is increasingly becoming important as food source in developing countries where protein from animal source is not within the means of the majority of populace.

2. Processing of Peanuts

Peanut processing starts with harvesting. Small scale producers follow the traditional method of harvesting which involves plowing and manually stacking the plant for field curing. Harvesting begins with mowing of mature peanut plants. These are then inverted by specialized machines with peanut pods on top into windrows for field curing or open-air drying. Mature peanuts are picked up from the windrows

and using thrashing operators peanut pods are separated from the plant and accumulated in hoppers [1].

Harvesting is then followed by mechanical drying. Moisture of the peanuts is usually kept below 12 per cent, to prevent aflatoxin production [18]. On-farm dryers are also used which usually consists of storage trailers with air channels along with the storage bins with air vents. Peanuts are dried to a moisture level of 7 to 10 per cent. These peanuts are then further cleaned, stored and processed for various uses.

Achaya [2] reported that processing of peanuts have been done for in-shell consumption and shelling peanuts for other uses. In-shell processing begins precleaning which involves separation of foreign materials from peanut pods using a series of screens and blowers. The pods are then washed in wet, coarse sand that removes stains and discolouration. The sand is then screened from the peanuts for reuse. The nuts are then dried and powered with talc or kaolin to whiten the shells.

Processing of shelled peanut starts with the precleaning technique to separate foreign materials. The cleaned peanuts are then sized so that the pods can be crushed without damaging the kernels. The shells are then crushed by passing between rollers. The peanut is then crushed, pushing the shells and peanuts through the perforations. Shells are aspirated. The crushed shells and peanut kernels are then separated with oscillating shaker screens and aspirators. Peanut kernels are then sized using screens, bagged and shipped [2].

Roasting imparts the typical flavor to peanuts which can be achieved by dry roasting or oil roasting. During roasting, amino acids and carbohydrates react to produce tetrahydrofuran derivatives [3].

3. Processing of Peanuts to Different Byproducts

Raw or roasted peanuts are usually used as a snack and as an additive. They are used as such as an ingredient in confectionary products like candies, Breakfast cereals, Bakery products like doughnut, extruded products, milk, cheese, yoghurt etc. Most important byproduct of peanut processing most widely used is the peanut oil. The peanut cake or meal obtained after oil extraction which can be full fatted, partially defatted or defatted is later used as flour, isolates and concentrates [6].

Oil extraction from the peanut kernel is a well-established industrial since the early 1950s. They have thus supported in setting up of factories for this purpose, which, are large-scale plants situated in or near urban areas. Commercially oil is extracted from groundnut by three methods including hydraulic pressing, screw pressing and solvent extraction.

The ghani mill originated from India where these indigenous oil crushers have been improved over the time [1]. The original animal-powered ghani consists of a wooden mortar and a pestle. The mortar is fixed to the ground while the pestle attached to one or a pair of bullocks (or buffaloes or camel) is rotated in the mortar where the kernels are crushed. The oil runs through a hole at the bottom of the mortar. An animal-powered ghani can process 5 to 15 kg of kernels at a time. An improved version of the ghani has been developed in India, known as the Wardha Ghani. It was larger as well as more efficient than the traditional ghani. An engine-powered ghani is now replacing, to a large extent.

Problems of hygiene in ghani oil are unlikely because vegetable oils are naturally sterile. Ghani cake is known to be exceptionally hard and is not prone to mould infestation unless wetted. However, the ghani has its disadvantages, which are mainly economic such as high running costs. Animals need to be trained. Artisan training is also essential [2].

Peanut oil extraction using expellers has been well explained by Nautiyal [18]. Oil extraction by pressing can be achieved by single, duo or duplex expeller which is driven by an electrical motor or a v-belt from a separate diesel engine. When using a single expeller, the decision on whether to pass the seed once or twice should be based on economic considerations. A second pressing raises the oil extraction rate and therefore, yields additional quantities, but also increases processing costs. Thus, a second pressing is justified only when the increase in revenues is at least equal to the increase in cost.

It has been found that even the most perfect expeller leaves at least 6 percent of the oil in the expeller cake. It is possible to recover these losses using a solvent extraction plant and can reduce the residual oil in cake to less than 1 percent. Technologists have also observed a major drawback of expeller process, especially in view of the bias of the memorandum towards small-scale production, is that it is by nature suited to large scale extraction. Other drawbacks include high investment costs, the need for highly skilled labour, low employment generation and danger of explosion if the plant is not kept in perfect conditions [2]. However, this requires a good cake collection system and a sufficient supply of oil seeds in order to maintain the solvent extraction plant running at sufficiently high capacity utilization rate.

4. Food Applications of Peanut byproducts

George Washington Carver was a well known educator, farmer and a food scientist who developed peanut products that revolutionized the agricultural economy. His research developed 300 products and 105 ways of preparing peanuts for human consumption. According to a study in University of Georgia, peanuts were used to make products like Peanut butter, Variety Breads including - White and whole peanut bread, cookies, cakes and brownies, doughnuts and yeast products, pies & desserts, peanut milk, and cheese -type products, Non-milk beverages, soups, peanuts with meats, RTE cereals, peanut paste and noodles/fermented peanut pastes, coated nuts and RUTF – Read-to-use therapeutic foods [6].

Peanut Oil - Groundnut oil is used primarily as a cooking and salad oil. Groundnut oil is excellent fat for pan-frying or deep fat frying. Pastries shortening, oleomargarine, mayonnaise, salad dressing and other food products can be

easily made with this bland vegetable oil [7]. For use in mayonnaise, it should retain its natural yellow colour, but for oleomargarine, it should be colourless, for shortening and other plastic fats, it should contain an antioxidant. Peanut oil has also been experimented in weaning foods as a source of fat along with other ingredients [6]. Groundnut is used extensively for massaging polio patients It is also used as a carrier of adrenaline in the treatment of asthma [9].

Composite flours - Groundnut cake flour is used to improve protein content and quality of several cereal- based food products in India, Kenya, Malawi, Nigeria, Senegal and Zimbabwe [7, 10]. In India alone, there have been several agriculture-products with groundnut as the protein-enriching medium. The partially defatted flour is used to improve the nutritional quality of various cereal-based products such as *gonfa*, millet (Pennisetum glaucum) based product and *epo-ogi*, a corn (Zea mays) based gruel. In Sudan, acceptable and nutritionally superior quality *kisra* is prepared from sorghum flour fortified with defatted groundnut flour [7]. The addition of defatted groundnut flour results in an improvement of baking ease, colour and texture of the final product.

Fortification with groundnut and subsequent fermentation improves the in vitro digestibility of the sorghum flour [21]. In developing countries where sorghum is a staple diet, there is a need to have a nutritional improvement programme on sorghum. Acceptable *gari*, a commonly used cassava-based Nigerian food, can be prepared with 15 percent defatted groundnut flour which showed an increase in the amount of protein and a remarkable increase in the concentration of all amino acids.

Protein isolates - The technology now exists for the production of groundnut proteins in the form of concentrates and isolates, which are acceptable for human consumption. Groundnut protein isolates are akin to soy protein isolates. Defatted materials obtained from oil extraction processes may be soluble in neutral to base reaction washes to extract much of the protein which subsequently separated from the whey formed by reducing the pH to isoelectrical levels. Isolates once separated are neutralized with alkali and may be spray dried.[16]

Groundnut cake or meal can be used for human consumption after partial hydrolysis of protein by fermentation using certain moulds. Such products are racially digestible and nutritious [17, 26]. Spray-dried groundnut protein isolate can be used to replace non-fatmilk solids in the ice cream. Coprecipitated isolates containing protein (95%) can be prepared from various combinations of groundnut seed, cottonseed and soybean flours and rice flour [19]. Fortified milk systems were prepared by blending pasteurized whole milk with dried skim milk and groundnut protein isolate, to increase the TS to 15, 18, 20 or 23 percent. This was followed by processing at 80°C for 30 min and storage at 4°C for 24 hours. Curds were prepared by lactic culturing of the processed milk systems. Curd obtained from fortified milk showed an increase yield stress along with curd strength with enlarged concentration of added protein.

Fermented products - Groundnut cake are used after partial hydrolysis of the component protein by fermentation using certain moulds. Such products are readily digestible, tasty and nutritious. *Oncom* is a popular dish of Indonesia and can be prepared by pressing the kernels to remove oil. It is usually done by soaking the cake in water for 24 h and then draining it. High starch material such as cassavais added to it. It is then steamed, incubated with *Neurospora intermedia or Rhizopus oligosporus* and fermented for 1 to 2 days at 25 to 30°C after wrapping in banana leaves. It may be fried in oil or margarine and consumed [21].

Bakery products - Groundnut cake meal or defatted meal can be used to prepare bakery products with excellent oraganoleptic qualities [15]. Studies have shown that value added products like breads, biscuits, cookies and other products could be excellent vehicles for enhancing the utilization of groundnut protein especially in the diets of malnourished people in the developing countries [4].

Groundnut milk - Groundnut milk can be prepared by soaking kernels in 1 percent sodium bicarbonate (NaHCO3) solution for 16 to 18 hours. The kernels are grounded in aqueous medium. The wet mass is steeped for 4 to 5 hour and filtered through cheesecloth to remove the product. In India groundnut milk called Miltone® is a commercial reality. Miltone® consists of groundnut milk extended with buffalo milk. It is prepared by adding shelled groundnuts to boiling water, removed from heat and is soaked for 7 minutes. It is then drained, deskinned. They are then soaked in 2% NaHCO3 overnight. They are then rinsed with tap water; blend in warming blender with water (1:5 w/v) for 4 to 5 minutes. The homogenate is filtered through cheese cloth. Whey powder is added to the filterate at 4% level (w/v), mixed thoroughly for 1 hour and boiled for 10 minutes to get groundnut milk [21]. Ground nut milk is usually fermented with *Lactobacillus acidophilus* and used as probiotic drink [11]

Peanut milk is one option to try if you follow a casein-free diet because, contrary to its name, it does not contain real milk. Sweeteners or seasonings such as cinnamon are also added. Peanut milk provides some nutritional benefits you won't get from cow's milk such as vitamin E, magnesium and vitamin B-6, and is packed with heart-healthy unsaturated fats [11].

Mishi - *Mishi* is concentrated, spiced yoghurt prepared from whole milk in Sudan and usually consumed along with bread. *Mish*i can also be prepared from peanut milk by boiling the milk for 3 minutes then cooling to 45°C and inoculating with yoghurt culture (1:1 mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* grown in whole milk for 6 hours) at 5% level. This is then incubated at 45°C for 16 hours. Spices like garlic, ajwain and black pepper are added and refrigerated. Whey is drained through a cheese cloth and salt is added at 1% level [16].

Groundnut-based yoghurt - Groundnut yoghurt may be prepared by the pasteurization of groundnut milk containing 5 percent lactose. After cooling yoghurt culture is inoculated

and incubated at 37°C for 4h. Final product before consumption may be refrigerated .

Groundnut Dahi – The nutty flavour in peanut milk is due to the hexanal compound which is generated by the action of lipoxygenase on fatty acids. Dr. R. T. Patil and his team at the Central Institute of Post Harvest Engineering and Technology (CIPHET) under ICAR has developed a commercially viable process for the inactivation of lipoxygenase enzyme[12]. This was coupled with use of modern airless grinding and de-odourising technique. By using such prepared peanut milk, highly acceptable chocolate/vanilla flavoured beverages have been developed with about 12% total solids and 3.25% protein. The process for the preparation of acceptable curd (Dahi) with 15 % total solids and 4.25 % protein has also been optimized. .

Groundnut bars - The formulation contains 72 percent finely ground groundnuts, 12 percent maltose syrup, 9.5 percent finely ground sugar, 3 percent roasted desiccated coconut, 2 percent finely ground rice, 1 percent roasted sesame (*Sesamum indicum*) seed and 0.5 percent salt [25]. The ingredients are mixed at 60°C and passed through a peanut-butter mill. The mixture is pressed into a rectangular-shaped mould.

Groundnut butter - Commercial manufacture and consumption of groundnut butter is largely an American art. Groundnut butter is mainly used as a spread for bread or biscuits, in sandwiches, in candies and frostings or icings. It is a fair sources of calcium, iron, thiamine, riboflavin and excellent source of niacin. Manufacture of groundnut butter involves roasting for controlled browning at 160°C for 40 to 60 minutes; cooling to stop the cooking process; blanching to remove the skins (testa); and then graded to remove light, scorched or discoloured kernels [21]. Addition of salt, stabilizers and other optional ingredients including sweeteners are measured and blended with the butter prior to cooling and packaging. Other additives include hydrogenated oil, antioxidants, honey, lecithin, whey.

Groundnut cheese - Cheese like products have been made from groundnut like protein isolate just as cheese is made from cow's milk. It has good quality protein, is easily prepared and low in cost. It is being used for "Mixed" feeding of undernourished groups in the developing countries [21]. A processed cheese spread has been prepared from groundnut protein based tone milk in India. It has a smooth consistency and milky flavour.

Tofu *(curd)* - Tofu from groundnut is a famous product in China and Japan. Soaking the groundnut kernels overnight and grinding into an emulsion may prepare it. The emulsion is boiled and filtered. The curd may be precipitated from the resulting fluid by adding calcium or magnesium sulphate. The product is left to settle and transferred to boxes lined with cloth filters or spread on trays. It may be sold as slices or slabs, curd is served in soup; the wet curd can be deep fried in oil [11].

Groundnut sweets - In India, groundnut is used to prepare *laddu* and *chikki*. To prepare *laddu*, groundnut kernels are roasted and seed coat is removed, the separated cotyledons are mixed with thick, hot jaggery syrup. Small portions of the mixture are pressed to balls or *laddus*. *Chikk*i is very popular product in Western India. It is prepared by mixing roasted and decorticated groundnut kernels with hot slurry of sugar. The mixture is spread in a thick layer on a tray or similar flat surface and then cut into small pieces on cooling. Roasted groundnuts are also used in the preparations of various other traditional Indian recipes such as *khichadi, guradani, barfi* and vegetable curries [14].

National Institute for Nutrition, Hyderabad, India has introduced a sweet prepared by groundnut, jaggery and wheat flour with low fat and high energy, named *Suruchi* [14]. The product was tested on the school children for its calorific value and consumer acceptance. The United Nations Development Programme (UNDP), in partnership with the Food and Agriculture Organization of the United Nations (FAO), in collaboration with the Technology Mission on Oilseeds and Pulses Ministry of Agriculture has published a "Culinary Preparations with Groundnut" of 42 delicious preparations with groundnut with the intent to promote groundnut as food crop for sustained nutritional security [25].

Partially defatted groundnuts – The preparation procedure involves removing the oil from the groundnuts and then reconstituting and roasting the kernels. Roasted groundnut kernels without skins contains high percent of protein, oil and carbohydrates along with many essential minerals and vitamins. This process consists essentially of simple mechanical operations: i.) pressing ii.) reconstitution and iii.) drying and roasting, either raw (with skin) or blanched groundnuts are hydraulically pressed to remove the desired amount of oil. The pressed groundnuts are boiled in water to expand them and to restore their original shape and size. Salt and other ingredients can be added during the expansion step. The expanded groundnuts are then dried and roasted [22].

Groundnut protein film - Groundnut protein film is one of the alternative edible films that can be used in an intermediate moisture food (IMF) due to its promising characteristics: bland flavour, low oxygen permeability and its ability to incorporate antimicrobial agents. A study proved that the predicted sorbic acid profile in coated food showed that groundnut protein might be used to retard sorbic acid migration from surface to food core and extend the product shelf life [13].

Value-added peanut based nutraceuticals - Peanut skin has low economic value despite the high content of antioxidants such as phenolics and can be an inexpensive source of antioxidants for use as dietary supplements. Peanut skins are obtained by direct peeling, blanching, and roasting. Total phenolics (TPs), total antioxidant activity (TAA) and free radical scavenging capacity of peanut skin extracts were determined by Yu and co workers [28]. High free radical scavenging capacities of peanut skin extracts were observed with high vitamin C.

5. Conclusion

Groundnut is also consumed directly and is used in processed food and snacks. Approximately one-third of world production is used in the confectionery products. Utilization of oil, meal and confectionery groundnuts are all increasing concurrent with a gradual shift away from oil and meal into confectionery use.

Initiating strong programs can investigate the underlying functional components and properties of peanut by-products which in turn proves it's potential as food and feed additive. Another important challenge is in the potential applications of byproducts with modern technology (such as superfine grinding technology, microwave-assisted and ultrasound-assisted technology) both directly as food or feed supplements for animal and human consumption, and indirectly, as potentially health promoting byproducts in the meat supply, to offset and replace the carcinogenic effects of chemical food additives. Problems with the world food supply remain a serious matter which is the main cause of hunger and malnutrition across the world. With that as background, the development of by-products from peanut industry will make a significant contribution in all these areas in the years to come.

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