Review Paper

REVIEW ON NUTRITIONAL IMPORTANCE OF CHIPS MADE FROM POTATO (Solanum tuberosum L.).

Abstract: The purpose of this paper is to summarize nutritional importance of chips made from potato (solanum tuberosum l.) reviewing different related literatures. Potatoes have an important role in human nutrition. It is a source of carbohydrates, protein, vitamins and minerals in the diets. Tuber quality is an import attribute for processing, and should be enhanced for increasing farmers' income and livelihood. The acceptability of potatoes for processing as chips is largely dependent on the quality of the end products. Blanching improved chips color, texture, sweetness, and crispness whereas reducing sourness and bitterness finally increased the overall acceptability. In all cases, blanching resulted in a better acceptability of potato chips. French fries and potato crisps are the most consumed processed potato products in large cities. High specific gravity is a sign of that the raw potatoes will produce high chip volume due to high dry matter content and has crispy texture. Tuber with low reducing sugar produce light color chips and is more acceptable by consumers.

Key word: chips, potato, dry matter, specific gravity.

INTRODUCTION

Potato is a member of the family Solanaceae and the genus *Solanum* which is one of the most productive and widely grown horticultural food crops in the world. Potato (Solanum tuberosum L.) is the fourth most important food crop in the world, after wheat, maize, and rice [1] and [2]. The crop plays a significant role in human nutrition worldwide, where more than 320 million tons of potatoes are produced annually on 20 million hectares of land [3]. The worldwide production of potato exceeded 330 million tons/year. This figure exceeded only by wheat, maize and rice [4]. Potato also contains dietary antioxidants, which may play a part in preventing diseases related to ageing [5]. Because potato contains nearly all important vitamins and nutrients, it supports life better than any other crop when consumed as the sole diet [6]. Although, potato is also grown for animal feed, industrial uses and for seed tuber production the main use is still as direct food, and

increasing proportion is processed into snack food. Potato is mainly important for subsistence farmers, but it may also be a cash crop [7].

Processing quality of potato tubers for chip production is determined by high dry matter, and low reducing sugar and phenol contents [8] and [9]. High dry matter content increases chip yield, crispy-consistency, and reduces oil absorption during frying [10] and [11]). Low reducing sugars and phenol contents are required to avoid dark color and bitter taste of processed products, which negatively affect consumer acceptance [12] and [13]. Dry matter of potato tubers and chip color are genetically controlled and influenced by environmental conditions during growing season and storage temperature [14]. One of the factors affecting the quality of processed product of potato is the physicochemical characteristics. For instance, not all the potato varieties will produce high quality potato chips [15] and [16]. Studies have shown significance differences in chip quality as a result of varying chemical composition of the potato tubers [17] and [18]. The physical and chemical characteristics of the potato tubers vary from one variety to another and within the same variety depending on growing conditions (e.g. soil temperature and soil moisture), harvesting and handling conditions (storage) [17]. The importance of potato in developing countries could be attributed to two main reasons: Firstly, that potato crop produces more edible energy and protein per unit area and time than other food crops, and secondly, that potato fits well into multiple cropping systems prevalent in tropical and subtropical agro-climatic conditions [19]. This is further supported by [20] indicating that potato area in Sub Saharan African countries has grown as a result of increasingly emerging market oriented farmers in response to huge demand from growing urban markets. Moreover, because of its bulky in nature, it does not normally enter into international trade unlike major cereals. Only a fraction of its total production enters foreign trade [21]. The crop serves as a buffer to rising food prices, especially cereals [20]. Potatoes are a principal source of carbohydrates and protein, and also contribute some vitamins and minerals in the diets. Potato (Solanum tuberosum L.) is an important food security and cash crop in Ethiopia [22]. With increasing urbanization, the use of the crop not only as fresh tubers but also as processed products such as French fries and crisps is rising in the country [23] and [24]. Potato provides not only carbohydrate, proteins, and vitamins but also minerals that are important in the diet for human wellbeing [25], and is important for nutritional security. It is noteworthy that potato absorbs large quantities of plant nutrients, especially nitrogen (N), potassium (K) and phosphorus (P) from the soil [26]. Potassium and N are found in

the largest amounts in a potato plant, followed by Calcium (Ca) and Magnesium (Mg) [27]. According to [28], some varieties are not suitable for the production of processed products due to low dry matter content. It is important for researchers to recommend ~~to growers~~ to use only those varieties that make good quality products both at harvest and ~~after storage for various periods of time.~~ The production of lighter color chips acceptable to the market often requires some pretreatment of the sliced potatoes in the processing plants [29]. Prior to drying most food products are usually subjected to one form of pretreatments, among which blanching is one of the most important techniques [29]. Blanching refers to the process of immersion of raw vegetables in a heated fluid (water, oil or acid) for a period of time. Blanching has a leaching effect on the sugars and serves to even out variations of sugar concentrations at or near the surfaces of the French fry strips. This gives a lighter and more uniform color on frying. It is also used to extract the reducing sugars and asparagines from the surface of potatoes in order to reduce browning, particularly the formation of brown spots [30]. Blanching reduced glucose and asparagines content by average ~~is about~~ 76 and 68%, respectively in potatoes ~~according to~~ [10]. Potato is a high yielding tuber crop with a short cropping cycle of about 3-4 months. This coupled with high potential yield of about 40 t/ha, makes the potato a suitable crop for places where land is limited and labor is abundant [5] ~~such~~ as in sub-Saharan Africa. Potato is a smallholder cash crop of the future with a potential to improve their livelihoods and reduce poverty. Furthermore, it can provide a cheap but nutritionally rich staple food, contributing protein (low in amount, but high in biological value), vitamin C, zinc, and iron. Potato offers employment opportunities to all those involved in potato value chain from production to consumption.

General objective

- To understand and summarize nutritional importance of chips made from potato (solanum tuberosum l.).

Description of Chips

Chips is frying product made from potato by using high temperature. ~~Chips can be used us snack food and sell out in large cities and hotels.~~ Potato has high contents of protein (high percentage of essential amino acids: lysine, leucine, phenylalanine, threonine and valine), minerals

(potassium, phosphorus and magnesium nutrient salts) several vitamins (B_1, B_3,B_5, B_6, folate, pantothenic acid, riboflavin) and large amount of vitamin C. Potato is ~~poor~~ in fat but rich in carbohydrate and several micronutrients. Potato also contains dietary antioxidants, which may play a part in preventing diseases related to ageing [5]. Several oils can be used for frying potato chips, including soybean oil, palm oil, and safflower or groundnut oil. Chips contain of carbohydrates, protein, fat, vitamins (B_1, B_3,B_5, B_6, folate, pantothenic acid, riboflavin B1,,B5&B9)& minerals.

Reducing Sugar

The disaccharide sucrose, and the two monosaccharides, the glucose and fructose, are the three major types of sugars in potato tubers [31]. The sugar content of potatoes varies from 0.2 to 0.6% ~~and it is a genotypic characteristic which varies with varieties [32~~]. The contents of glucose and sucrose ~~were~~ high in young tubers and ~~decreased according to maturation~~. [~~33]has~~ also described that the maximum contents of sugars were obtained 1-2 weeks after tuber initiation, and then the sugars decreased along with growth of the tubers and reached a minimum before the end of the growing season. The quality of potatoes is dynamic and continues to change as a result of physiological activity owing to accumulation of reducing sugars and depletion of starch [34]. The reducing sugar content is critical in the quality of processing potatoes, as studies have shown that it negatively influences the color and flavor of the finished product due to Maillard reactions that take place during frying [35]. The Maillard reaction, is initiated at high temperatures (> 120^{o}C) due to the condensation of free amino acids and reducing sugars [36]. Among the sugars, the reducing sugars (glucose and fructose) are of most concern, as they are chemically reactive and involved in the non- enzymatic browning reaction thus determining the eventual fry color of the potatoes [37]. The level of reducing sugars that are generally acceptable for processing of chips is 0.2–0.25% and French fries is 0.3–0.5% [38]. The sugar content of the harvested crop is also important for the fresh market, and sucrose levels above 1% fresh weight (FW) are reported to ~~give an unacceptably sweet taste to the boiled potatoes~~. This sweetening is more likely to occur after a period of storage, particularly at holding temperatures (below 4^{0}C) that promote low-temperature sweetening.

Tuber dry matter content and specific gravity

The dry matter yield of a potato isthe major determinant of texture of the raw or cooked product [39]. It is one of the most important factors ~~of~~ that contribute to favourable mouth feel and consu

mer acceptance in the sensory evaluation [40]. Potato chips processing requires tubers with dry matter content of greater or equal to 20% and specific gravity ~~of~~ greater or equal to 1.080 (Ka bira and Lemaga, 2006).It is one of the most important factors ~~of~~ that contribute to favourable m outh feel and consumer acceptance in the sensory evaluation[40] . Potato chips processing requir es tubers with dry matter content of greater or equal to 20% and specific gravity of greater or equal to 1.080 [38].[28] reported that potatoes with a dry matter content of 20 to 24% are ideal for making French fries while those with a dry matter content of up to 24% are ideal for preparing crisps. High specific gravity is an indication that the raw potatoes will produce high chip volume due to high dry matter content.

Sensory attributes

Color

Color in processed products such as potato chips can be affected by several factors including product composition and processing conditions [37] ~~and~~ influences consumer acceptability [41]. For instance, common browning of foods during heating occurs when reducing sugars and a free amino acid or amino group react in the Maillard reaction [41]. [42] studied color development during potato frying and found that both reducing sugars and amino acids are involved in the color development of fried potatoes, reducing sugars being the limiting factor. According to [28] hot water blanching at 65-100°C before frying destroy enzyme activity and leaches out, reducing sugars and other chemical constituents that cause off color and off flavor. Blanching treatments are used to reduce browning of fried products by leaching out Maillard reactions which play a predominant role in color and acrylamide formation during frying [10]. Blanching lead to lighter ~~in color potato chips~~ than those of the control after frying at 150°C [10]. ~~[37]~~ found that reducing sugars had the biggest influence on lightness, producing the brighter colors when they were absent; however, reducing sugars did not entirely predict color quality when present at low concentrations.

~~145~~ Color is one of the most important quality factors that ~~have to~~ be considered during frying of ~~potato chips~~ [43]. In general, a yellowish brown color [44], uniform light golden [45], and lighter colored are preferred.

Texture

In general, chips prepared from tubers with higher dry matter have weak structure compared with those prepared from tubers that have lower dry matter. [46] showed that the texture of potato chips was found to be directly related to specific gravity, total solids, starch content, cell size, and surface area and pectin. Crisps obtained from potatoes rich in dry matter (above 25%) can exhibit hard textures, whereas crisps made of tubers with low dry matter content are characterized by greasy and sticky textures. Texture in food products has dominant contribution to the overall quality and acceptability [47]. Crisp texture is connected with the dry matter content of raw potato tubers [48].

Bitterness

[49] showed that the loss in taste of chips prepared from tubers stored for extended period may due to the increase in the concentration of glykoalkaloids level of tubers. In all cases blanched samples get better score by the panels. According to [29] blanching and drying temperature significantly affected the hardiness of potato chips under certain conditions while the drying method did not show any significant influence on the hardiness. They pointed out that blanching caused starch gelatinization and softening of structure leading to less hardness of dried starchy products. They also reported that unblanched chips had the maximum hardness in all of the cases. [50] found that blanching reduces the hardness and shrinkage of the product. While blanching at low temperatures (55 to 75°C) lead to a firm texture [51], blanching at high temperatures (80 to 100°C) for alternatively long period of times (15 min) leads to loss of firmness [52]. In vegetables, bitterness is considered a deterrent for consumption [53].

Flavor

Potato flavor results from the combination of taste, aroma, and texture. Flavor precursors synthesized by the plant are present in raw potatoes and consist mainly of sugars, amino acids, RNA, and lipids. Plant genotype, production environment, and storage environment influence the levels of these compounds and the enzymes that react with them to produce flavor compounds. During cooking, flavor precursors react to produce the Maillard reaction compounds and the sugar, lipid and RNA degradation products that contribute to flavor [54].

The flavor of the potato chips is more complex than that of boiled, backed or mashed potatoes since the cooking temperatures are higher, and the absorbed oil contributes to the overall flavor profile of the product [55]. In fried potato products, flavor compounds are not only inherent in

the raw potato but also from the frying oil, Maillard reaction products with lipid oxidation products [56] the complete composition and understanding of fried potato flavour has not been fully established [57]. Variations in flavor exist between varieties although there is little published research [58]. [59] reported sensory differences in the aroma and taste of potato chips made from different cultivars that varied in level of dry matter, Sugars, amino acids and lipids.

It is generally understood that the bulk of flavor producing compounds in raw potatoes are volatile [57]. The major classes of volatile compounds released by raw potatoes are acid, aldehydes, alcohols, amines, esters furans, hydrocarbons, ketones, pyrazines, payridines and thiazoles [57]. However, [60] suggested that a potato flavour might be influenced by non-volatile compounds such as amino acids and sugars. Browning become very rapid at temperature higher than 150^{o}C and volatile flavor compounds are produced as secondary products [15]. [48] reported that the desirable flavor of potato chips is limited by the high dry matter content as well as the low sugar concentration. The flavor and odour of light colored chips are less intense than those of dark colored chips [48]. Glycoalkaloid found in potatoes could contribute to bitter off flavours of burning sensation at elevated concentration [60].

Crispiness

For potato chips, a very crispy texture is expected since it is an indicator of freshness and high quality [61]. The crispy structure of potato chips is the result of changes at the cellular and sub-cellular levels in the outermost layers of the product. Blanching causes a permanent modification of the cellular structure in the potato tissue [52]. The heat treatment during blanching affects the typical potato cell by altering the cytoplasmic membrane. Heat destroys the differential permeability of the membrane letting water to enter the cells and intercellular spaces there by expelling gases and other volatiles, causing ~~also~~ loss of water soluble nutrients (sugars, vitamins, and minerals) ~~to the blanch water~~ [52]. During pre-treatment, changes occur in the cell membranes, ~~which~~ play a key role in the changes that occur within the tissue during further processing [62].

Overall acceptability

[52] reported that in the case of potato processing, blanching is used to inactivate peroxides, to improve the texture, color and, to some extent, the flavor of final product. Potato blanching ~~helps in activate enzymes~~ that lead to some quality degradations [63].

Conclusion

Potato is one of the staples of the human diet and is an important raw material in the starch industry as well. Thus, ~~the~~ potatoes are a very significant part of the diet in many countries and can make a significant contribution to human nutrition. It is one of the basic crops, which significantly impact nutritive status of the world population. Because it contains nearly all important vitamins and nutrients, so that, it support life better than any other crop when eaten as the sole article of diet. It is a major part of the diet of half a billion consumers in the developing countries. Potato is an important food and cash crop in Eastern and Central Africa, playing a major role in national food security and nutrition, poverty alleviation and income generation, and; provides employment in the production, processing and marketing sub-sectors. The protein content of potato is similar to that of cereals and is very high in comparison with other roots and tubers. In addition, the potato is low in fat and rich in several micronutrients. Generally Potato with high specific gravity and dry matter are preferable for chips making and its frying product has crispy texture. The presence of low reducing sugar content makes the cultivars suitable for chips processing. Chips with light color are more acceptable by consumer and have low level of reducing sugar. As the level of glykoalkaloids increases the level of bitterness ~~become~~ increase. Flavor is one of the important quality factors of potato chips and is affected mainly by the type of oil used ~~to fry chips~~, flavor compounds inherent in the raw potatoes, and added.

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