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# Nutritional and Sensory Property of Chips Made from Potato (S. T.)

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### Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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## ABSTRACT

The purpose of this paper was to summarize nutritional and sensory property of chips made from potato (*Solanum tuberosum* L.). 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 important 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 improves chips color, texture, sweetness, and reduce sourness and bitterness thereby increasing its overall acceptability. 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.

**Keywords:** Chips; potato; dry matter; specific gravity.

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## 1. 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 [1,2]. 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 [3,4]. The worldwide production of potato exceeded 330 million tons/year. Potato contains dietary antioxidants, which may play a part in preventing diseases related to ageing [5]. Since 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 grown for animal feed, industrial uses and for seed tuber production the main use is still as direct food.

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 its high dry matter, and low reducing sugar and phenol contents [8,9]. High dry matter content increases chip yield, crispy-consistency, and reduces oil absorption during frying [10,11]. Low reducing sugars and phenol contents are required to avoid dark color and bitter taste of processed products, which negatively affect consumer acceptance [12,13]. 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 [15,16]. Studies have shown significance differences in chip quality as a result of varying chemical composition of the potato tubers [17,18]. 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, potato crop produces more edible energy and protein per unit area and time than other food crops, and secondly, 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 potato 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 [23,24]. 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 potatoes are not suitable for the production of processed products due to low dry matter content. It is important for researchers to recommend farmers to use only those varieties that make good quality products both at harvest and during storage periods. 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 of 76 and 68%, respectively in potatoes [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 tons per hector, makes the potato a suitable crop for places where land

is limited and labor is abundant [5] 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, Potato 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. The objective of this review is to understand and summarize nutritional importance of chips made from potato (*Solanum tuberosum* L.).

## 2. DESCRIPTION OF CHIPS

Recently, Potato chips have become a heavily marketed snack foods throughout the world. 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 (B1, B3, B5, B6, folate, pantothenic acid, riboflavin) and large amount of vitamin C. Potato is very low 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]. Chips is frying product made from potato by using high temperature. Several oils can be used for frying potato chips, including soybean oil, palm oil, and safflower or groundnut oil.

## 3. 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% due to the differences in genotypic characteristic among the varieties of potato [32]. The contents of glucose and sucrose are high in young tubers and decrease with plant maturity. Kimondo [33] 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 processed potatoes, as studies have shown that reducing sugar content 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°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 be unacceptable to the consumers due to its sweetness. This sweetening is more likely to occur after a period of storage, particularly at holding temperatures (below 4°C) that promote low-temperature sweetening.

## 4. TUBER DRY MATTER CONTENT AND SPECIFIC GRAVITY

The dry matter yield of a potato is the major determinant of texture of the raw or cooked product [39]. It is one of the most important factors that contribute to favorable mouth feel [40].

Potato chips processing requires tubers with dry matter content of greater or equal to 20% and specific gravity of greater or 124 equal to 1.080 [38]. Kabira et al. 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.

## 5. SENSORY ATTRIBUTES

### 5.1 Color

Color in processed products such as potato chips can be affected by several factors including product composition and processing conditions [37] that influence 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]. Marquez et al. [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 destroys 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 minimize 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]. Rodriguez et al. [43] found that reducing sugars had the biggest influence on lightness, producing the brighter colors when these sugars were absent; however, reducing sugars did not entirely predict color quality when present at low concentrations. Color is one of the most important quality factors that need to be considered during frying. In general, a yellowish brown color [44], uniform light golden [45], and lighter colored are preferred in potato chips.

## 5.2 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. Moyano et al. [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 [47,48].

## 5.3 Bitterness

Asmamaw et al. [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 sensory panel. According to [29], blanching and drying temperature significantly affected the hardness of potato chips positively while the drying method did not show any significance influence on the hardness. Krokida et al. pointed out that blanching caused starch gelatinization and softening of structure leading to less hardness of dried starchy products. The authors also reported that unblanched chips had the maximum hardness in all of the cases. Pimpaporn et al. [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 the loss of firmness [52]. In vegetables, bitterness is considered as prevention for consumption [53].

## 5.4 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 (Ribo nucleic acid), and lipids. Plant genotype, production environment, and storage environment influence the levels of these compounds and the enzymes that react with flavor precursors 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 whenever the cooking temperature is 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]. Ereifej et al. [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°C and volatile flavor compounds are produced as secondary products [15]. Lisinska et al. [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. Glykoalkaloid found in potatoes

could contribute to bitter off flavors of burning sensation at elevated concentration [60].

### 5.5 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 loss of water soluble nutrients (sugars, vitamins, and minerals) [52]. During pre-treatment, changes occur in the cell membranes that play a key role in the changes that occur within the tissue during further processing [62].

### 5.6 Overall Acceptability

Andersson et al. [63] 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 affect the enzyme activity that lead to quality degradation.

## 6. CONCLUSION

Potato is one of the staples of the human diet and is an important raw material in the starch industry as well. Thus, 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 single 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 increase. Flavor is one of the important quality factors of potato chips and is affected mainly type of due to the oil used to fry chips, flavor compounds inherent in the raw potatoes, and added.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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