The Effects of Pretreatment on The Qualities of Sweet Potato Flour – A Review

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Abstract- Pretreatment is a process that is commonly applied before drying of agricultural products, it inactivates enzymes and improves quality of dried products while accelerating the drying process. This article aims to review the effects of different types of pretreatment on the quality of sweet potato flour. The methods of pretreatment frequently used for the processing of sweet potato prior to drying include Thermal blanching (Hot Water, Steam, Ohmic heater and Microwave), Non thermal blanching (Ultrasound, Freezer, Pulsed electric field and High hydrostatic pressure), Hyperosmotic solutions (Salt, Sugar), Alkaline liquor (Potassium Carbonate, Ethyl oleate solutions), Acid liquor (Citric Acid, Ascorbic Acid), Sulphite solution (Sulphur dioxide gas, Water-soluble sulphide salts for example potassium metabisulphite (K2S2O5), sodium metabisulphite (Na2S2O5)and sodium hydrogen sulphite (NaHSO3).) and Carbonic maseration (Carbon dioxide (CO2). Pretreatment has been proven to retain the colour of sweet potato, enhance nutritional qualities and also improve the functiomal characteristics of sweet potato flour.

Indexed Terms- Blanching, Pretreatment, Sulphiting, Sweet potato, Quality

I. INTRODUCTION

1.1 PRETREATMENT

Pretreatment of food is a process that modifies its structure and quality before further processing. Pretreatment is commonly used prior to drying of agricultural products to enhance the process of drying, inactivate enzymes, reduce drying time, prevent discoloration and also improve the quality of the resulting dried products. (Li-Zhen Deng et al., 2017, Dariusz, 2020).

1.2 IMPORTANCE OF PRETREATMENT

Pretreatment is a very important unit operation prior to processing of food (Senadeera et al., 2000). There has been many reports that pretreatment accelerates drying rate and also improves the quality of dried food products by removing the intercellular air from the tissues of the product, texture softening, enzyme destruction, killing microorganisms and also wax dissociation on the products skin as well as the formation of fine cracks in the skin. (Jayaraman and Gupta, 2006).

Blanching expels the intercellularly entrapped air in the tissue of the food product and eliminates cell membrane and cell walls' resistance to water diffusion by the softening of the structure (Mukherjee and Chattopadhyay, 2007). Blanching also cause inactivation of the enzymes that have the tendency to degrade food quality (Rufus, 2012). It increases the final product's acceptability (Babajide et al., 2006). The structural softening caused as a result of blanching facilitates the removal of moisture (Senadeera et al., 2000).

Pretreatment carried out prior to drying is necessary because it retains the antioxidant compounds (Li-Zhen Deng et al., 2017). The anthocyanin level of sweet potato is maintained by microwave blanching (Liu et al., 2015). Microwave blanching also prevents the degradation of ascorbic acid in green asparagus (Hong and Lu, 2012). The carotenoid pigments of red pepper was increased and the ascorbic acid oxidase which causes vitamin C degradation of dried crystal radish was inactivated by pretreatment with pulsed electric fields (Liu et al., 2016). The phenolic compounds in mushroom were preserved by ultrasonic pretreatment and the antioxidant activity of aloe was increased by high hydrostatic pressure pretreatment (Vega-G alvez et al., 2011).

Pretreatment also increases the crispness of dried food products and enhances the capacity of food products to rehydrate after drying (Rastogi, 2012; Doymaz and Ozdemir, 2014). It causes tissues to form uniform microstructure (Jiang et al., 2015), modifies some tissue properties reduce initial water content which leads to fast drying rate and generally reduces the reactions that may lead to the deterioration of food product during drying and storage (Li-Zhen Deng et al., 2017).

1.3 TYPES OF PRETREATMENT METHODS

There are two major types of pretreatment methods.
Physical Pretreatment and Thermal blanching

Thermal blanching is a pretreatment method that is popularly applied to food products before drying, this enables the inactivated ion of the enzymes that cause spoilage of fresh agricultural products, soften tissues which aid a faster drying process, removes intracellular air that cause oxidation and reduce the microbial load of food products (Li-Zhen Deng et al., 2017).

Hot water blanching which is carried out by dipping fresh food products in hot water at a constant temperature between 70ºC and 100ºC for some minutes is a popular pretreatment method carried out before drying (Guida et al., 2013. Hot water blanching accelerates the drying rate of food by changing the physical properties of the food (Jangam, 2011), it prevents the decline if food quality by removing intercellular air from tissues, enzyme inactivation and microorganisms destruction (Neves et al., 2012; Mukherjee and Chattopadhyay, 2007). Conventional hot water blanching is very common, its equipment is simple and easy to operate hence its commercial acceptability (Doymaz, 2014). Hot water blanching has been applied on agricultural products to improve the food quality and accelerate drying rate (Doymaz, 2015; Cheng et al., 2015; Filho et al., 2016; Ando et al., 2016).

Steam blanching systems replaced hot water blanching because nutrients do not dissolve into hot water in steam blanching and water is not wasted (Li-Zhen Deng et al., 2017). Steam blanching pretreatment retains minerals and water-soluble components better than water blanching as leaching is minimal in steam blanching. Steam blanching retains ascorbic acid (Lin & Brewer, 2005) and its high enthalpy content inactivates biological enzyme (Ndiaye et al., 2009). In steam blanching, condensation of steam occur on the surface of food products because of the wide difference in temperature between the food product and steam, this produces non uniformity in blanching of the food (Li-Zhen Deng et al., 2017). Tissue softening and undesirable quality changes also arise when steam velocity is low and heating takes a longer time (Li-Zhen Deng et al., 2017).

Ohmic heating (OH) blanching is also a thermal process. In OH, heat is produced internally when alternating electrical current passes through a food system that serves as an electrical resistance (Jakob et al., 2010; Shirsat et al., 2004). The temperature of food product is speedily increased when put between two electrodes. OH pretreatment gives fast and relatively uniform heating and reduces treatment time which is critical to avoid extreme heat damage (Zareifard et al., 2003). OH is safe for the environment (Varghese et al., 2014), it saves energy and gives rise to a food product of high quality that is safe from microbes (Kulshrestha & Sastry, 2006). Ohmic pretreatment at a low electrical frequency has been reported to be more favorable for subsequent drying (Salengke & Sastry, 2005). In ohmic blanching however, electrolysis with the subsequent production of hydrogen at the cathode and oxygen at the anode of water may hasten the degradation of food quality (Sarkis et al., 2013), the rate of corrosion of electrodes may be faster because of the ionic substances (acids and salts) introduced (Xiao et al., 2017), dynamic and static performance of the temperature controlling and heating uniformity for complex heterogeneous foods may also be difficult to achieve (Sakr & Liu, 2014).

Microwave heating is the use of electromagnetic waves of certain frequencies to generate heat in a food material (Spigno, 2016), the electric energy conversion is assessed to be about 50% and the efficiency as high as 65% (Nguyen et al., 2013). When food materials are heated by microwaves, microwaves dielectrically heat the food due to the rotation of the molecular dipole and the agitation of charged ions in a high frequency alternating electric field (Spigno, 2016). Unlike slow heat conduction through a product's surface, heat is created volumetrically throughout the product (Regier & Schubert, 2001; Rahath et al., 2016). While some sites overheat, others are left at a lesser temperature and have insufficient lethality (Vadivambal & Jayas, 2010). The non-uniform heating of the microwave heating pretreatment is made worse by the microwave's restricted penetration depth (Koskiniemi et al., 2011).

Non-thermal process

According to Lee et al. (2006) and Belie et al. (2000), thermal pretreatments have been shown to generate unintended changes in fruit and vegetable quality features, such as tissue cell membrane disintegration, protein denaturation, heat destruction of phytochemicals, and poor firmness and crispness. Non-thermal processing techniques are receiving more and more attention in the food business due to its significant superiority in preventing the quality degradation of agro-products (Rastogi, 2011).

Ultrasonic field

Ultrasound, with a frequency ranging from 20 kHz to 1 MHz, is a mechanical wave that needs an elastic medium to propagate (Paniwnyk L., 2016). Cavitation that occurs with ultrasound is a phenomena where sound waves come into contact with a liquid medium. As a result, thousands of cavities and bubbles are created (Berm_udez-Aguirre & Barbosa-C_anovas, 2016). Due to the minimal heating effect of ultrasonic pretreatment, food components that are sensitive to heat can be well protected, even when done at room temperature (Chemat et al., 2011). Ultrasound pretreatment research on agricultural products has attracted a lot of attention (Rodrigues & Fernandes, 2007; Scheossler et al., 2012). Ultrasound has been proven to improve the drying rate by changing the micro-structure of plant tissue (Rodrigues & Fernandes, 2007; Tao et al., 2016; Tao & Sun, 2015). It has also been shown to improve product quality by shortening drying times and increasing compound extraction abilities (Cakmak et al., 2016). Lately, ultrasound has been widely used as a pretreatment process to aid in the drying of agricultural products. Reducing processing time and maintaining some degree of product quality are benefits of ultrasonic pretreatment. Because it is difficult to scale up the equipment to industry size while maintaining the same operating conditions and outcomes, ultrasonic technology is still only available at the laboratory scale. Due to the need for a coupling medium, such as gel, water, or oil, for ultrasound to propagate, phytochemicals are lost more readily from plant tissues to the medium and the use of ultrasonic pretreatment in the food business is limited. (Alvarez-Arenas, 2010)

Freezing

Pretreatments by freezing are frequently carried out for many hours at 20 ºC before being thawed to room temperature. Large ice crystals that develop during freezing cause the cellular structure to break down and the porous structure to set (Sripinyowanich & Noomhorm, 2013). This promotes mass transfer and allows for water migration. Fruits and vegetables have been frozen as a pre-drying treatment to speed up the drying process and preserve product quality (Ando et al., 2016; Albertos et al., 2016). According to Pimpaporn et al. (2007), pretreating dried potato chips with freezing decreased their roughness and increased their lightness and crispness. Freezing pretreatment promotes faster heat transfer between frozen cells and quick water evaporation from ice crystal state under vacuum conditions therefore it has been used before vacuum drying to achieve a higher rate of heat transfer while maintaining product quality (Shyu & Hwang, 2001). The incapacity of freezing pretreatment to inactivate the enzymes causing browning reactions is one reason why it is not frequently used. It is only appropriate for specific high-value foods and may result in nutritional loss while thawing (Li-Zhen Deng et al., 2017). It also demands a high operating cost.

Pulsed electric field

One other non-thermal approach is called pulsed electric field (PEF) which applies high-voltage, short-duration electric pulses to food that is positioned between two electrodes. The typical range of these pulses is 15–80 kV/cm (Evrendilek, 2016). PEF is typically used on liquid or semi-solid foods to inactivate enzymes and bacteria at room temperature and mild ambient conditions, all without appreciably changing the food's color, flavor, texture, or nutritional content (Ade-Omowaye et al., 2001). It has been demonstrated recently that PEF causes tissue disintegration and cell membrane permeability to improve mass transfer of plant materials (Knorr et al., 2011). This can be achieved at short treatment times and moderate electric fields of 200–1000 V/cm (Fincan & Dejmek, 2002; Lebovkaa et al., 2007). According to Amami et al. (2008) and Wiktor et al. (2014), PEF has been used as a pretreatment for agro-products and has been shown to significantly improve the drying process of foods by enhancing the permeability of cell membrances and preserving food quality attributes by inactivating enzymes or shortening drying time. PEF helps to lower processing temperatures and reduce residence durations, thus enabling extremely effective inactivation of microorganisms while maintaining product quality (Toepfl et al., 2005). Depending on the product, applying PEF pretreatment to food before drying might shorten the drying process by more than 20% and increase the pace of drying (Ade-Omowaye et al., 2001). According to Ranganathan et al. (2015), PEF has a great deal of potential for limiting unfavorable changes in quality products at lower temperatures and reducing residence times to preserve the products' nutritional value and fresh-like character. Wiktor et al. (2014); Amami et al. (2008); Amami et al. (2005); Dev & Raghavan (2012). PEF produces cell damage and tissue softness (Faridnia et al., 2015), it is unable to inactivate enzymes at settings suitable for microbial inactivation (50–1000 kJ/kg) and comes with a high capital equipment cost (Li and Farid 2016). According to Li-Zhen Deng et al. (2017), direct food material contact with an electrode can cause electro-chemical reactions during PEF treatment, cause the electrode to corrode, and produce hazardous materials (Amami et al., 2008; Amami et al., 2005; Dev & Raghavan, 2012; Wiktor et al., 2014).

High hydrostatic pressure

High hydrostatic pressure, or HPP, is a pressure-based technology that is novel and still in its infancy. It entails delivering materials with a high-pressure shockwave (between 100 and 800 MPa) via water for the appropriate dwell time and temperature (Hulle and Rao, 2015; Ueno et al., 2009). Fruits and vegetables that have been prepared with HHP have had the benefit of increased drying rates due to diffusion brought on by high-pressure-induced cell permeability (Ueno et al., 2009; Al-Khuseibi et al., 2005; Yucel et al., 2010). Plant materials undergo extensive shape and structure destruction during high pressure processing; Ueno et al. (2009) reported that tissue softening induced by HHP treatment results in the destruction of cell membranes and partial liberation of cell substances. It has been demonstrated that HHP improves the diffusion coefficients of water and soluble solids, thereby accelerating the water loss of samples (Nunez-Mancilla et al., 2011; Verma et al., 2014; Rastogi et al., 2000). Due to low product throughput and high equipment costs, the utilization of HHP systems in industrial scale-up production is limited. HHP systems have high equipment costs (Li & Farid, 2016). Enzyme inactivation caused by HHP is unpredictable. Pressurized media may seep into meals, and HHP breaks down the structure and texture of solid plant materials (Jermann et al., 2015).

Chemical Pretreatment

Hyperosmotic solution

One of the most popular pretreatments before drying that lowers energy consumption and enhances food quality is osmotic pretreatment (Li-Zhen Deng et al., 2017). Food is submerged for several hours in a hypertonic solution, usually made of sugar or salt. Plant cellular structure functions as a semi-permeable membrane during osmotic pretreatment, causing countercurrent mass transfer, the solute to flow into the products and moisture to move from the interior to the hypertonic solution (Ciurzy_nska et al., 2016). The characteristics of the material and the process parameters, such as the processing temperature, solution concentration, and solution to solid mass ratio, affect the rate of mass transfer during osmotic processing (Ahmed et al., 2016). According to Nieto et al. (2001), shrinkage and solute uptake increase a product's resistance to water flux, which might negatively impact the drying rate of that product.

Alkaline Liquor

Since hydrophobic wax covers the outer surface of whole berry fruits, the alkaline dipping pretreatment is primarily applied to them (Li-Zhen Deng et al., 2017). The primary component of the wax coating is oleanolic acid, which hinders drying by producing a slow rate of moisture evaporation (Serratosa et al., 2008). By increasing the drying rate and shortening the drying time, alkali liquor dipping pretreatment helps to prevent product quality degradation. Alkaline emulsions boost sugar concentrations near the skin by decreasing PPO activity or increasing drying rates. This lowers water activity and slows down the browning reaction (Grncarevic and Hawker, 2010). The chemical agents' composition, concentration, pH, temperature, and dipping time all have an impact on the drying process that is sped up by alkali dipping (Esmaiili et al., 2007). Due to alkaline media and the oxygen-producing micro-crack in the epidermis, alkali dipping pretreatment may cause ascorbic acid to leach, degrade, and oxidize (Vasquez-Parra et al. 2014). Furthermore, the presence of alkaline liquor residue in dried goods may lead to problems with food safety and be harmful to human health. According to Carranza-Concha et al. (2012), akaline liquor dipping technology is usually only used when a significant drying time reduction is required.

Sulphite Solution

In order to minimize darkening during drying and stop food quality loss during processing and storage, sulphitation, also known as sulphuring, has been widely employed in the food business (Miranda et al., 2009). Most of the SO_2 that is absorbed by food is transformed into the bisulphate ion. Using sulphites at low concentrations prevents microbial activity and both enzymatic and non-enzymatic browning (Li-Zhen Deng et al., 2017). By preventing PPO activity and oxygen depletion, sulphite inactivates PPO through an interaction between sulphite ions (Van Hal, 2000). Along with its benefits of color retention, spoilage prevention, and nutritional attribute preservation, it also functions as an antioxidant by limiting the loss of ascorbic acid and shielding lipids, essential oils, and carotenoids from oxidative deterioration during processing (Mujumdar, 2006). Processing variables such as the food material's condition, solution concentration, processing duration, and soaking liquor's pH have an impact on how well sulphiting works (Li-Zhen Deng et al., 2017). Sulfite pretreatment is remarkably effective at preserving product color, but it has also been shown to produce unwanted flavor, soften food texture, and cause the loss of some water-soluble nutritious components (Garcia-Martinez et al., 2013). Food products with sulphite preparation leave chemical residues that might cause health issues, including asthmatic reactions in certain sensitive people (Geu-cleu et al., 2006; Kamiloglu et al., 2016).

Acid Liquor

Acid pretreatment is frequently used to increase pigment stability, change the texture of agricultural products, and inactivate enzymes to improve product quality. Since polyphenol oxidase prefers a pH between 6.0 and 7.0, lowering the media pH to 3.0 will inhibit polyphenol oxidase activity and slow down the pace of enzymatic browning (Li-Zhen Deng et al., 2017). Because acid solutions have chelating capabilities, they can improve the stability of pigments like betalains and anthocyanins and maintain the texture of the product (Ngamwonglumlert et al., 2016). (Hiranvarachat et al., 2011). The most common organic acid for modifying food texture and acting as an anti-darkening agent is citric acid. According to reports, citric acid speeds up the drying process because it causes pectin to relax in an acidic environment, which helps remove moisture (Hiranvarachat et al., 2011). Temperature, dipping duration, and solution concentration all affect how well a pretreatment of citric acid preserves color and speeds up drying (Zhu et al. 2007). Ascorbic acid has also been used as an antioxidant to pretreat agricultural products prior to drying; however, because it cannot fully permeate the food's cellular matrix, it is thought to be less effective in reducing enzymatic browning. For this reason, it is often combined with citric acid (Zhu et al. 2007). Pan et al. (2008) also confirmed that the combination of citric acid and ascorbic acid reduced drying time and enhanced product color.

Carbondioxide

Carbon dioxide (CO2) pretreatment has several advantages, it is safe for food and its quality and it is environmentally friendly. Developed by Michel Flanzy in 1934, the technique's general application is known as carbonic maceration (CM) technique. It entails placing the samples in a closed tank with an atmosphere rich in carbon dioxide, which is reflected almost immediately inside plant materials by a shift from respiratory to fermentative anaerobic metabolism

(Tesniere & Flanzy, 2011). CM increases the rate of drying by causing a drop in pH, violent cell rupture, alteration of the cell membrane, inactivation of important enzymes, and extraction of intracellular materials (Gunes et al., 2005; Zhao et al. 2016). According to Zhao et al. (2016), the use of CM in food production results in acidic conditions with low pH values and quick drying times, which enhance the nutritious components' preservation. CM preparation causes some anaerobic respiration, it changes the texture and flavor of products (Chen et al., 2017). It has a great deal of potential to speed up the drying process and enhance the caliber of the dried goods. No toxic chemical reagent residues are present in it. CM pretreatment entails treating for a duration of 12 to 72 hours. The product's texture and flavor may deteriorate during this time due to insufficient efficiency, which may prevent CM from being applied.

II. SWEET POTATO

The dicotyledonous plant known as sweet potato (Ipomoea batatas L.) is a member of the Convolvuceae family. According to Padmaja et al. (2012), the edible sweet potato tuberous root can be long and tapering, ovoid, or round, with peels that range in colour from white to brown, purple, or red, and flesh that can be white, pale cream, orange, or purple.product may be a necessary part of the CM pretreatment.

2.1 NUTRITIONAL AND PHYSICAL QUALITIES

Carbs, vitamins A, B6, and C, riboflavin, copper, salt, chloride, phosphorus, calcium, pantothenic acid, and folic acid are all abundant in sweet potatoes (Degras, 2003; Kassali, 2011). Sweet potatoes are a staple food in most parts of the world and have a high nutritional content, around 50% more than Irish potatoes (Marczak et al., 2014). (Ofori et al., 2005). The tubers contain per 100g portion, 20.1g carbohydrates, 1.6g protein, 0.05g fat, 3g dietary fibre, 30mg calcium, 0.61mg iron, 55mg sodium, 337mg potassium, 2.4mg Vitamin A and 14,187IU Vitamin C (Allen et al., 2012). According to Maloney et al. (2012), when sweet potatoes are processed, proteins that may be of value can be recovered from the peel. USDA (2009) states that in addition to being high in carbohydrates, sweet potatoes are also high in dietary fiber, contain a lot of water, and give 359 kJ of energy with a low total fat content of around 0.05 g per 100 g. Additionally rich in minerals like potassium, calcium, magnesium, salt, phosphorus, and iron are sweet potatoes (USDA, 2009).

2.2 PRODUCTION CAPACITY

According to the Food and Agriculture Organization of the United Nations (FAO), 2017, Sweet potatoes are a major food and industrial crop in Nigeria, with an estimated annual production of 4.01 million tons on approximately 1.62 million ha with mean estimated yields of 24,778 hg/ha. With about 80% of the global sweet potato production coming from China, the country leads the globe in sweet potato production. Nigeria is the continent's top producer of sweet potatoes, ranking second globally behind China (FAO, 2024).

2.3 CHARACTERISTICS

Since sweet potatoes grow well in a variety of farming environments and are rarely attacked by pests, pesticides are rarely required. Although it can be cultivated in a range of soil types, the plant grows best in well-drained, light- and medium-textured soils with a pH range of 4.5–7.0 (Woolfe, 2003). Poor soils can support its growth with minimal fertilizer. If lime is not applied at planting in this sort of soil, sweet potatoes, which are extremely sensitive to aluminum toxicity, may wither away around six weeks after planting (Woolfe, 2003).

2.4 DETERIORATION LEADING TO LOSSES

According to Wolfe (2003), sweet potato roots have high moisture content (60–70%), a free sugar content (4–15%), a thin and sensitive epidermis, and a high respiration rate right after harvest. The texture is additionally softened by the heat production that follows. The sweet potato is a highly perishable crop due to all these characteristics. Sweet potatoes cannot therefore be kept in storage for an extended period of time after being separated from the plant (Mtunda et al., 2001; Rees et al., 2001). Sweet potato roots have a variable shelf life, ranging from a few days to several weeks, contingent upon the cultivar, harvesting procedures, and storage conditions (Mtunda et al., 2001). In tropical and sub-tropical areas, sweet potato post-harvest losses resulting from physiological, biological, and physical factors are frequently significant (Onwueme and Charles, 1994). Pre-harvest and harvest circumstances are primarily referred to as physical variables. The main soil parameters that affect pre-harvest conditions are temperature and moisture content. Based on agro-ecology, various soil variables have varying degrees of relevance. The most important harvest component is mechanical damage, which is mostly experienced during harvesting, transportation, and marketing (Rees et al., 2001; Tomlins et al., 2000; Mtunda et al., 2001).

2.5 USES/ ECONOMIC IMPORTANCE OF SWEET POTATOES

Sweet potatoes can be baked, roasted, fried, or boiled. According to the Japanese Society of Root and Tuber Crops (JRT), 2000, it is used to manufacture yoghurt and sweet potato beverages. In addition to being processed into crisps and flour, sweet potatoes are also utilized as a stabilizer in the ice cream business and in baking, either alone or in combination with cereal flour (FAO, 1990). Sweet potatoes are boiled, pounded, and served with soup in Nigeria. In order to make pounded yam, it is also added to yam. The sweet potato has evolved from a basic staple meal to a significant commercial crop with a variety of applications, including as a snack, a component in a variety of dishes, and a supplementary vegetable, thanks to advancements in research and development (Oke and Workneh, 2013). According to Lopez et al. (2000), sweet potato flakes, also known as sweet potato buds, were produced in Guatemala with a higher β-carotene concentration to treat children's vitamin A insufficiency. Sweet potatoes from the fresh market can be baked, boiled, grilled, broiled, and microwaved. Some nations distill alcohol from sweet potatoes. In addition, sweet potatoes are used in stews, stir-fries, casseroles, dipping vegetables, sautéed veggies, pasta sauces, green salads, and soups (Dawkins and Lu, 1991). One can dry or dehydrate sweet potatoes to make chips, flakes, or flour. To make dices, slices, patties, or French fries, it can also be frozen. Pie fillings, candied goods, and baby feeds can all be made with canned sweet potatoes. In addition, sweet potatoes are a common ingredient in frosting, pie fillings, cakes, ice creams, custards, cookies, and other bread items.

Sweet potatoes are dried to create flakes that are easily reconstituted for use directly in a variety of products, such as mashed sweet potatoes, pies, and other items, thanks to advancements in drying technology (Dawkins and Lu, 1991). In addition to being eaten fresh, the tops and roots of sweet potatoes can be turned into fermented silage and dry meal for feeding pigs, cattle, and poultry.

Sweet potatoes have been rediscovered as a functional food with high amounts of different phytochemicals that may have a variety of positive health impacts, in addition to their nutritional value (Tsuda et al., 1998). The majority of research on the phytochemicals found in sweet potato roots or leaves suggested that the high polyphenol content was linked to benefits for health and/or disease prevention. According to research, there was a correlation between the amount of phenolic content in sweet potato extract and its ability to prevent cancer (Fukumoto and Mazza, 2000).

Sweet potatoes have a wide range of potentially very profitable industrial uses (Adewumi and Adebayo, 2008). Sweet potatoes yield starch, which is used to make starch syrup, glucose and isomerized glucose syrup, lactic acid drinks, bread, and other confections. In Japan, distilled spirits known as shochu are also made from starch. Additionally, noodles and isomerized saccharides—a sweetener for soft drinks—are made from sweet potato starch. Roast sweet potatoes are used to make sweet potato beer (Prain et al., 1997). Animal feed made from sweet potato roots and leaves includes fermented silage and dried meal (Scott, 1992; Woolfe, 2003).

III. USES OF SWEET POTATO FLOUR

When preparing buns, chapattis, mandazis, and other baked goods, sweet potatoes—whether raw, grated, cooked, mashed, or converted into flour—may be used in place of more costly wheat flour (Hagenimanaetal, 1998). The flour can replace up to 20% of wheat flour when used as a dough conditioner for bread, biscuits, and cakes. It can also be used to make gluten-free pancakes (Shihetal, 2006). Processed food items can benefit from the inherent sweetness, color, and flavor that sweet potato flour brings. It can also help meet daily requirements for β-carotene, thiamine, iron, vitamin, and protein. It can also be used as a source of energy, nutrients, and minerals. According to Van Hal (2000), sweet potato flour supplies 14–28% of the magnesium and 20–39% of the potassium dietary reference intakes (DRIs). In order to improve the volume, texture, flavor, shelf life, and general quality of bread made using sweet potato flour either entirely or partially substituted for wheat flour, additions are chosen. Cakes, biscuits, noodles, jam, jellies, sauces, fortified flour, ice cream, wines, industrial starch, crackers, and other foods are among the many recipes that use sweet potato flour (Nungo, 2004).

IV. EFFECT OF PRETREATMENT ON SWEET POTATO FLOUR

4.1 EFFECT ON PHYSICAL QUALITIES

Jigar et al. (2022) found that the L* value, or lightness index of food product, was highest in KMS pretreated sweet potato flour and lowest in hot water blanching pretreated sweet potato flour in their investigation of the effects of pretreatments and temperature on chemical attributes of sweet potato flour. The sweet potato flour that was pretreated with KMS was determined to be better and had the significantly highest L* value when considering the individual effects of the pretreatments. These findings were consistent with those of Ahmed et al. (2010), who investigated the impact of pre-treatments on the sensory characteristics of sweet potato flour and found that sulphitation treatment increased the L*value. Sulphite is a useful color preservative that also slows down both enzymatic and non-enzymatic reactions.

4.2 EFFECT ON NUTRITIONAL QUALITIES

In their 2019 study, "Physicochemical and Functional Properties of Chemically Pretreated Ndou Sweet Potato Flour," Ngoma et al. found that sweet potato samples pretreated with sodium metabisulphite at a concentration of 15 g/L resulted in a low moisture content (5.54%), while samples pretreated with citric acid at a concentration of 10 g/L had a higher moisture content (7.70%). The potential of sodium metabisulfite to cause dehydration in sweet potato slices by altering the permeability of cellular membranes may be the cause of the reduced moisture content (Lewicki, 1998). Pretreatment is applied to assist in limiting moisture losses and enhance the drying properties of tuber crops (Olagunju et al., 2018). Fana et al. (2015) examined the proximate composition (crude fat, crude protein, crude fiber, carbohydrate, ash, and moisture) of the flour and found a significant difference in the OFSP flour as affected by pre-treatments and drying methods. The study also examined the effects of drying methods and pre-treatments on the chemical composition, microbiological composition, and sensory quality of orange-fleshed sweet potato flour and porridge. The lowest moisture content was found in the salt treated in fluidized bed dried product. This was shown to be caused by the high temperature of the fluidized bed applied at a moderately short period compared to solar and sun dryer, as well as the salt brining, which dehydrates the OFSP tuber.
Food proteins supply the necessary amino acids needed for metabolism and are vital nutrients for the body's structural and functional needs (Melese and Keyata, 2022). Tubers have low protein content (Alam et al., 2016). Fana et al. (2015) found that sweet potatoes pretreated with salt, citric acid, and blanching techniques had higher crude protein content than samples that were not pretreated in their investigation of the effects of pre-treatments and drying methods on the chemical composition, microbial, and sensory quality of orange-fleshed sweet potato flour and porridge. Additionally, Fana et al. (2015) demonstrated that sweet potatoes treated with citric acid and then blanched and salted had a high crude protein level. Nevertheless, during treatments, blanching techniques produce leaching losses of nutrients, including proteins, from the samples (Malomo et al., 2013). According to Jigar et al. (2022), pretreatment had the greatest impact on protein content in KMS-pretreated flour and the least in hot water blanching-pretreated sweet potato flour. The results are consistent with those of Olatunde et al. (2016), who investigated the qualitative features of sweet potato flour as impacted by variety, pretreatment, and drying technique. They discovered that the protein content of pretreated flour that was hot water blanched was lower than that of the sample that was pretreated with CaCl2.

The minerals present are indicated by the samples' total ash content (Idowu et al., 2013). According to Ngoma et al. (2019), sweet potatoes with varying quantities of citric acid and sodium metabisulfite exhibited a significant ash level. During soaking, solutes from sodium metabisulphite solution may have moved to sweet potato slices, which could explain this (Melese and Keyata 2022). However, because of leaching losses during immersion in the hot water, the tuber crops treated with the blanching approach exhibited low ash content (Fana et al., 2015). Chen et al. (2017) verified that blanching causes disintegration, gelatinization, and starch to leak out of the cell structures. According to Jigar et al. (2022), sweet potato flour that had been prepared with CaCl2 had the highest ash content, whereas sweet potato flour that had been regulated had the lowest ash content. Calcium was added during the pretreatment stage therefore the ash level of the CaCl2 samples was somewhat higher than that of the KMS, hot water blanching, and controlled samples (Jigar et al., 2022). These findings were consistent with those of Ndangui et al. (2014), who found that ashes were marginally higher in CaCl2 samples than in blanching and control samples. This difference was probably caused by the calcium that was added during the pretreatment stage.

Fibers are indigestible carbohydrates that contribute to less intestinal transit and bulkiness in the feaces. Reduced cholesterol levels are greatly aided by fiber (Papathanasopoulos and Camilleri, 2010; Raninen et al., 2011). According to Fana et al. (2015), the unblanched sweet potato flour sample had a high fiber content, whereas the chemically treated (salted and citric acid) sample had a low fiber level. These results demonstrate that processing conditions can produce flour with a higher dietary fiber content, which is beneficial to consumers' health since obesity, constipation, gallstones, diabetes, and coronary heart disease are all conditions that are typically reduced when an adequate amount of dietary fiber is consumed (Ajayi, 2020). (Melese and Keyata 2022). The sweet potato that had been processed with CaCl2 had the highest fiber content (Jigar et al., 2022). These findings aligned well with those of Olatunde et al. (2016).

Fats are vital to the composition and functioning of cells and are also important as an alternate energy source. According to Ngoma et al. (2019), samples of sweet potatoes that were not treated had lower fat contents than samples that were treated with sodium metabisulfite. However, Ahmed et al. found that sodium metabisulfite has no effect on sweet potato flour's lipid content. Girma et al. (2015) indicated that low-fat content will improve the shelf life of food goods by minimizing the danger of rancid taste development. Citric acid treatments were shown to diminish the fat content in Ndou sweet potato flour samples (Ngoma et al., 2019).

According to Obadina et al. (2016), one of the most significant components of tuber crops as sources of dietary energy is carbohydrates. High temperature blanching and drying of sweet potato flour boosts its high carbohydrate content (Fana Haile et al., 2015). Sweet potato flour has been shown to contain more protein, fat, and ash after chemical treatment; however, leaching during blanching caused these nutrients to be lessened (Fana Haile et al., 2015; Ngoma et al., 2019). According to Jigar et al. (2022), hot water blanching pretreated sweet potato flour had the least amount of pretreatment influence on starch content. The minimal starch content of the flour produced by the hot water blanching process may have resulted from plasmolysis-induced starch granule leaking into the blanching water (Jigar et al., 2022). Significant differences in starch content values were observed by Olatunde et al. (2016) as a result of sulphitation and pre-treatments including blanching.

According to Jigar et al. (2022), pretreatment of sweet potatoes increased their total sugar content when they were prepared with CaCl2 and decreased it when they were blanched in hot water. More leaching losses of reducing sugars may be the cause of the flour prepared by hot water blanching treatment's decrease in total sugar content (Jigar et al., 2022). Ahmed et al. (2010) found that total sugar was marginally greater in CaCl2 pretreatment samples than in blanching and control samples in their investigation of how peeling, drying temperatures, and sulphite treatment affect the physicochemical attributes and nutritional quality of sweet potato flour. It was stated that the complexation of carbohydrates by calcium was the cause of this little rise. The total sugar content of the CaCl2-treated samples was marginally higher than that of the control and NaHSO3-treated samples.

Jigar et al. (2022) discovered that pretreatment had a high effect on total soluble solids (TSS) in sweet potato flour pretreated with CaCl2 and a minimal effect in sweet potato flour prepped with hot water blanching. Leaching of the dissolved solids out of the tissues during blanching may account for the minimum total soluble solid content of the flour prepared by hot water blanching pretreatment. The

TSS level of dehydrated onion rings, cauliflower segments, and okra slices that had been pre-treated with KMS and citric acid prior to dehydration was significantly affected, according to Aina et al. (2009), whose results were in good agreement with ours.

4.3 EFFECT ON FUNCTIONAL QUALITIES

The bulk density, as defined by Ngoma et al. (2019) and Bello and Ekeh (2014), is a measurement of the relative amount of packaging material used to determine the storage, transportation, marketing, and wet food processing sectors. Additionally, it provides scientific data about a product's porosity, which may have an impact on the choice and layout of packing materials (Adeleke and Odedeji, 2010). The results published by Ngoma et al. in 2019 demonstrated how the concentration of chemical treatment affected the samples of sweet potato flour. Specifically, samples treated with sodium metabisulfite and citric acid had the highest bulk density values, while samples treated with hot distilled water had the lowest. The findings suggested that chemical processes, in particular the application of sodium metabisulfite, could raise the bulk density values of sweet potatoes. For food preparations to lower paste thickness in food products, the flour's high bulk density value is crucial (Chandra et al., 2015).

When food products are being prepared, a higher water absorption capacity (WAC) may improve food body, homogeneity, and yield (Osundahunsi et al., 2003). According to research by Ngoma et al. (2019), sweet potato flour that had been pretreated with different concentrations of citric acid and sodium metabisulphite had significantly higher WAC than the control samples. This increase may have been caused by hydrophilic substances like charged or polar side chains of proteins and carbohydrates, which are essential chemical components that enhance water absorption capacity (Ojo et al., 2017).

The capacity of starch molecules to hold water through hydrogen bonding is determined by the granules' absorption index after heating, and this is correlated with the concentration of amino acids and starch (Liu and Liu, 2003). Swelling power (SP) is a measure of this capacity. According to Zhu (2014), raising the temperature can cause the crystalline portion of the starch to become disrupted and hydrated, which can cause granule rupture and the starch chains to become amorphous. According to Ngoma et al. (2019), pretreatment sweet potato samples had a substantially greater SP than control samples. Changes in the structure of the starch granules may be the cause of the SP increase (Melese and Keyata 2022).

CONCLUSION

Pretreatment has significant effects on the quality of sweet potato flour. Different pretreatment methods have been applied to sweet potato tubers to enhance the flour lightness color resulting in a product that is attractive to the consumers, improve the ash content, dietary fiber, protein and carbohydrate content of the flour and enhance the functional properties of the flour which is essential for the production of other valuable food products from the sweet potato flour

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