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Conservation Methods of Food in South America

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Declaration

I hereby declare that I have done this thesis entitled Conservation Methods of Food in South America independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 20th April 2018

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Linda Jarošová

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Abstract

The subject of the thesis was the research focused on the current preservation methods of food processing for their long-term preservation in the conditions of rural areas of tropics and subtropics of South America. In the introductory part, the thesis deals with principles and methods of conservation from the simplest, natural forms to the forms that cannot be used without modern technologies. The paper describes which foods are currently readily available for less economically developed areas of South America and crucial for their preservation to meet the basic living needs of the population in these locations. The research itself is based on the literature available on the Internet.

The overall aim of the work was to examine whether the current methods of preserving food in the areas under review are based only on traditions derived from natural forms of food preservation and whether new technologies for quality and risk-free food storage are available to the population living in these areas at the present time.

The output of the paper is the initiative to seek out opportunities in educating and economically supporting a group of people maintaining their traditions to ensure their sustainable development, where it is food which plays the most important role. In the near future, population and economic development can be expected in these areas and the food issue in terms of its preservation will be important not only for the local population but also for any export meeting the conservation standards according to the world-wide standards.

Key words: preserving food, research, long-term storage, tropic and subtropics in South America, natural and modern forms of food preservation

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1. Introduction

The theme of the thesis is an analysis of the knowledge resulting from the search of available information on the Internet and literature focusing on the preservation or conservation of food in the indigenous housing estates of South America based on the original cultural principles.

This paper presents ways of conserving commonly produced foods under existing conditions and possibilities based on original methods and principles passed on from generation to generation.

The thesis describes individual economically vital crops for the population that are and must be preserved to ensure sustainability during the absence of these crops naturally in nature or in the case of climatic crisis situations.

The conclusion of this work is to give consideration to the need to take into account the future development of the company in the monitored localities and to focus on the proper management of the food potential in terms of population development as well as the economic use of surplus produced food by the correct and safe conservation method recognized for international trade.

2. Aims of the Thesis

Objective of this thesis was the investigation of available literature sources and electronic information databases to analyse traditional methods of conservation of food used in rural areas of South America. Specific objective was to describe conservation methods used in rural areas of tropics and subtropics and investigate processing methods of typical products in South America.

3. Methods

A systematic literature review was performed using an electronic search of ScienceDirect, Web of Kowledge, FAO, ProQuest, Wiley Online Library and Google Scholar. Terms as "food", "conservation", "food spoilage", "preservation", "tropic", "South America", "traditional" were used for data search.

4. Literature review

4.1. Food preservation

The term food preservation refers to any of a number of techniques used to prevent food from spoiling. It includes methods such as canning, pickling, drying and freeze-drying, irradiation, pasteurization, smoking, and the addition of chemical additives (Lerner 2006). Food preservation is to prevent the growth of microorganisms (such as yeasts), or other microorganisms (although some methods work by introducing benign bacteria or fungi to the food), as well as slowing the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation (Madison 2007). Food preservation has become an increasingly important component of the food industry as fewer people eat foods produced on their own lands, and as consumers expect to be able to purchase and consume foods that are out of season.

The vast majority of instances of food spoilage can be attributed to one of two major causes, namely the attack by pathogens (disease-causing microorganisms) such as bacteria and moulds, or oxidation that causes the destruction of essential biochemical compounds and/or the destruction of plant and animal cells. The various methods that have been devised for preserving foods are all designed to reduce or eliminate one or the other (or both) of these causative agents (Lerner 2006).

For example, a simple and common method of preserving food is by heating it to some minimum temperature. This process prevents or retards spoilage because high temperatures kill or inactivate most kinds of pathogens. The addition of compounds known as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) to foods also prevents spoilage in a different way. These compounds are known to act as antioxidants, preventing chemical reactions that cause the oxidation of food resulting in its spoilage. Almost all techniques of preservation are designed to extend the life of food by acting in one of these two ways (Lerner 2006).

4.1.1. History of food preservation

Food, by its nature, begins to spoil the moment it is harvested (Mack 2001). The search for methods of food preservation can probably be traced to the dawn of human civilization. People who lived through harsh winters found it necessary to find some means of insuring a food supply during seasons when no fresh fruits and vegetables were available (Lerner 2006). In frozen climates, they froze meat on the ice; in tropical climates, they dried foods in the sun. These early methods of food preservation enabled ancient man to put down roots, live in one place and form communities. They no longer had to consume the kill or harvest immediately, but could preserve some for later (Mark 2001). Among the most primitive forms of food preservation that are still in use today are such methods as smoking, drying, salting, freezing, and fermenting (Lerner 2006).

In ancient times, the sun and wind would have naturally dried foods. Evidence shows that Middle East and oriental cultures actively dried foods in the hot sun as early as 12,000 B.C. (Mack 2001).

4.1.1.1. Drying, the oldest method of preserving food

Figure 1. Food processing in human history (Pinterest)

Because most disease-causing organisms require a moist environment in which they survive and multiply, drying is a natural technique for preventing spoilage. Indeed, the act of simply leaving foods out in the sun and wind to dry out is probably one of the earliest forms of food preservation. Evidence for the drying of meats, fish, fruits, and vegetables go back to the earliest recorded human history (Figure 1) (Lerner 2006). The Romans were particularly fond of any dried fruit they could make (Mack 2001). At some point, humans also learned that the drying process could be hastened and improved by various mechanical techniques. For example, the Arabs learned early on that apricots could be preserved almost indefinitely by macerating them, boiling them, and then leaving them to dry on broad sheets. The product of this technique, quamaradeen, is still made by the same process in modern Muslim countries (Lerner 2006).

Also, early humans probably discovered by accident that certain foods exposed to smoke seem to last longer than those that are not. Meats, fish, fowl, and cheese were among such foods. It appears that compounds present in wood smoke have antimicrobial actions that prevent the growth of organisms that cause spoilage (Lerner 2006).

In the early 1900s, natural draft dehydrators were created to dry fruits, vegetables and herbs in areas that did not have enough strong sunlight for drying. These early dehydrators were designed with fire pits on the bottom and exhaust vents at the top. As the fire heated the air, it was carried upwards creating the critical air flow and low humidity that is essential for dehydration (Wilson 1991).

4.1.1.2. Pickling – preserving foods in vinegar (or other acid)

Vinegar is produced from starches or sugars fermented first to alcohol and then the alcohol is oxidized by certain bacteria to acetic acid. Wines, beers and ciders are all routinely transformed into vinegars.

Pickling may have originated when food was placed in wine or beer to preserve it, since both have a low pH. Perhaps the wine or beer went sour and the taste of the food in it was appealing. Containers had to be made of stoneware or glass, since the vinegar would dissolve the metal from pots. Our ancestors never wasted anything and were able to find uses for everything. The left over pickling brine found many uses. The Romans made a concentrated fish pickle sauce called “garum”. It was powerful stuff packing a lot of fish taste in a few drops (Mack 2001).

There was a spectacular increase in food preservation in the sixteenth century owing to the arrival of new foods in Europe. Ketchup was an oriental fish brine that traveled the spice route to Europe and eventually to America where someone finally added sugar to it. Spices were added to these pickling sauces to make clever recipes. Soon chutneys, relishes, piccalillis, mustards, and ketchups were commonplace. Worcester sauce was an accident from a forgotten barrel of special relish. It aged for many years in the basement of the Lea and Perrins Chemist shop (Wilson 1991).

4.1.1.3. Freezing – from the cave to the fridge

Freezing was an obvious preservation method in the appropriate climates. Any geographic area that had freezing temperatures for even part of a year made use of the temperature to preserve food. Less than freezing temperatures were used to prolong storage times. Cellars, caves and cool streams were put to good use for that purpose vegetables (Wilson 1991).

In America, estates had icehouses built to store ice and food on ice. Soon the "icehouse" became an "icebox." In the 1800s mechanical refrigeration was invented and was quickly put to use. Also in the late 1800s, Clarence Birdseye discovered that quick freezing at very low temperatures made for better tasting meats and vegetables (Wilson 1991).

4.1.1.4. Canning – breakthrough in food preservation

Canning was pioneered in the 1790s by the Frenchman Nicolas Appert. He discovered that the application of heat to food in sealed glass bottles preserved the food from spoilage. In 1800, Napoleon offered an award of 12,000 francs to anyone who could devise a practical method for food preservation for armies on the march. Appert won the award. Appert had found a new and successful method to preserve foods, but he did not fully understand it. He thought that the exclusion of air was responsible for the preservations. It was not until 1864 when Louis Pasteur discovered the relationship between microorganisms and food spoilage that it became clear. Just prior to Pasteur's discovery, Raymond Chevalier-Appert patented the pressure retort (canner) to can at temperatures higher than 212ºF. However, not until the 1920s was the significance of this method known in relation to the prevention of botulism in low acid foods (Huyck 2012).

4.1.2. Methods of food preservation

4.1.2.1. Drying

Food dehydration is the process of removing water from food by circulating hot air through it, which prohibits the growth of enzymes and bacteria (Ahmed et al. 2013). Drying involves the removal of moisture from the outer layers and the migration of moisture from the inside to the outside, so the pieces of food must be thin (Bender 1992). Dried foods are tasty, nutritious, lightweight, easy-to- prepare, and easy-to-store and use. The energy input is less than what is needed to freeze or can, and the storage space is minimal compared with that needed for canning jars and freeze containers (Ahmed et al. 2013).

The minimum moisture content necessary for bacterial growth varies with the type of organism. The lowest value for normal bacteria is water activity 0.91; for normal yeasts it is 0.88; for normal moulds 0.80; and for salt-tolerant (halophilic) bacteria it is 0.77. So water activity must be reduced below these levels to preserve the food (Bender 1992).

The energy input is less than what is needed to freeze or can, and the storage space is minimal compared with that needed for canning jars and freeze containers. The nutritional value of food is only minimally affected by drying. Vitamin A is retained during drying; however, because vitamin A is light sensitive, food containing it should be stored in dark places. Vitamin C is destroyed by exposure to heat, although pre-treating foods with lemon, orange, or pineapple juice increases vitamin C content. Dried fruits and vegetables are high in fiber and carbohydrates and low in fat, making them healthy food choices (Ahmed et al. 2013). Muscle meat of almost any kind can be dried but it is necessary to use lean meat since fat becomes rancid during the drying process (Bender 1992).

Today, a host of dehydrating techniques are known and used. The specific technique adopted depends on the properties of the food being preserved (Lerner 2006).

4.1.2.1.1. Sun Drying

Figure 2. Sun drying (robertharding)

The traditional practice of grain drying is to spread crop on the ground, thus exposing it to the effects of sun, wind and rain (Figure 2). The sun supplies an appreciable and inexhaustible source of heat to evaporate moisture from the grain, and the velocity of the wind to remove the evaporated moisture is, in many locations, at least the equivalent of the airflow produced in a mechanical dryer (FAO 1994).

A minimum temperature of 30 °C is needed with higher temperatures being better. Because the weather is uncontrollable, sun drying can be risky. Humidity below 60 percent is best for sun drying. The cool night air condenses and could add moisture back to the food, thus slowing down the drying process (Ahmed et al. 2013). In rainy weather, even though drying will be slow, every effort should be made to prevent freshly-harvested products from over-heating with deterioration in quality by spreading on floors rather than let it remain in heaps and sacks. Field drying may render the grain subject to insect infestation and mould growth, prevent the land being prepared for the next crop and is vulnerable to theft and damage from animals (FAO 1994).

Drying on flat exposed surfaces is the most common way of drying grain after harvesting and threshing. For drying small amounts on the farm grain may be spread on any convenient area of land. Contamination with dirt cannot be easily avoided with this method and cleaner dried grain can be obtained by drying the grain on plastic sheets, preferably black. Purpose-constructed drying floors are commonly used where there is a need to dry large. The floors are made of concrete or brick (FAO 1994), or if possible over a sheet of aluminum or tin (Ahmed et al. 2013). Floors should be constructed to withstand the movement of vehicles and sloped or channelled to hasten the runoff of rainwater (FAO 1994).

The method of banana drying by the indigenous people in the Pacific is carried out according to the principles of the local traditions when, at first, ripe banana fruits are selected according to the color of their skin, then cut into thin slices and placed on a frame structure coated with a cloth. The structure carrying banana slices is covered with a thin but dense mesh that prevents contact with insects, and is placed in an unshaded place with exposure to direct sunlight. During sun drying, to achieve even drying, banana slices are turned manually two to three times a day until they are completely brown but not heavy. The drying itself takes about three to six days depending on the intensity of sunlight and climatic conditions (e.g. air humidity). Dried banana slices are then packed into banana leaves or jars to avoid moisture absorption (FAO 1983–1995).

4.1.2.1.2. Modern drying

Modern drying techniques make use of fans and heaters in controlled environments. Such methods avoid the uncertainties that arise from leaving crops in the field to dry under natural conditions. Controlled temperature air drying is especially popular for the preservation of grains such as maize, barley, and bulgur (Lerner 2006).

An improved technology in utilizing solar energy for drying grain is the use of solar dryers (Figure 3) where the air is heated in a solar collector and then passed through beds of grain (FAO 1994). A foil surface inside the dehydrator helps to increase the temperature. Ventilation speeds up the drying time. Shorter drying times reduce the risks of food spoilage or mold growth (Ahmed et al. 2013).

Figure 3. Solar drying (Natural Farm Fresh Myanmar)

Osmotic dehydration is the removal of water by immersing the food in a solution of salt or sugars of high osmotic pressure. Water is transferred from the food to the solution by virtue of the difference in osmotic pressure (Berk 2013).

Freeze-drying (Figure 4.) is a dehydration process especially suited to the conservation of biological products. In comparison with other drying processes, freeze-drying is considered as a reference for manufacturing high-quality dehydrated product. The direct transition of water from solid to vapor (sublimation), without a liquid phase, helps to preserve most of the initial raw material's properties such as appearance, shape, taste, color, and flavor. As an important functional property, the freeze-dried product has a high rehydration capacity. The main limit to the industrial development is its cost due to the low productivity (Caballero et al. 2003).

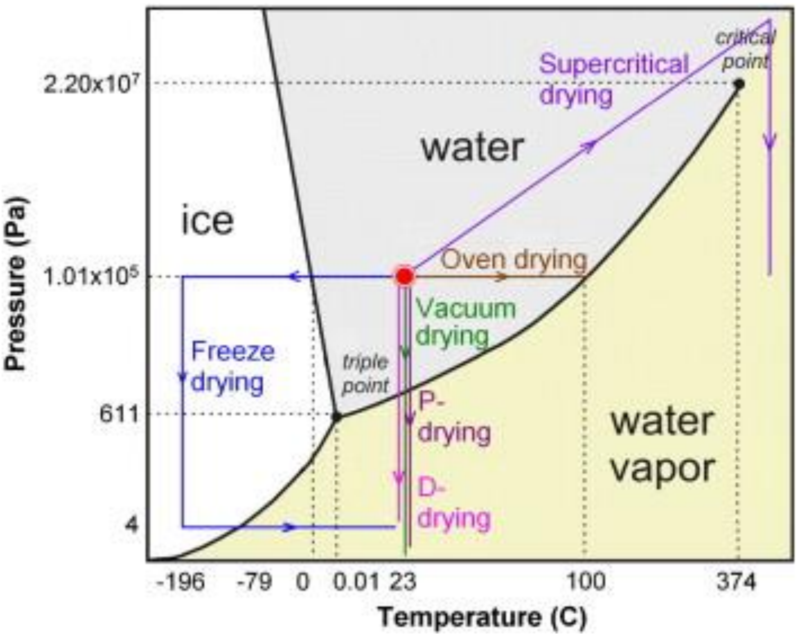

Figure 4. Freez drying and vakuum drying (Freeze Dry Inc)

Vacuum drying (Figure 4) is a form of preservation in which a food is placed in a large container from which air is removed. Water vapor pressure within the food is greater than that outside of it, and water evaporates more quickly from the food than in a normal atmosphere. Two of the special advantages of vacuum drying are that the process is more efficient at removing water from a food product, and it takes place more quickly than air drying. In one study, for example, the drying time of a fish fillet was reduced from about 16 hours by air drying to six hours as a result of vacuum drying (Lerner 2006).

4.1.2.2. Salting

Figure 5. Salting (Nofima)

Salt (chemical name sodium chloride) has been used as a food preservative for centuries (Figure 5). In effect it was the first natural ‘chemical’ preservative added to foods and has been used extensively in the preservation of fish, meat and vegetables ever since. The value of salt in preserving foods was so highly prized by the Ancient Romans that it was used as a form of currency. Salt remained the most used form of food preservation until much more recent times when modern food preservation methods were developed such as refrigeration, freezing and canning foods (ACS 2018). In the 1800’s it was discovered that certain sources of salt gave meat a red color instead of the usual unappetizing grey. In this mixture of salts were nitrites (saltpeter) (Nummer 2002). In fact the value of salt in food preservation still continues today where it is often used in combination with other preservation methods, it also remains a primary method of food preservation in countries/ areas where there are limited refrigeration facilities or access to newer technologies (ACS 2018).

Salt preserves food by dehydrating the micro-organisms responsible for food spoilage (O’Sullivan & Downey 2016). It is often referred to as salting, salt curing, corning (pieces of rock salt used for curing are sometimes called corns, hence the name "corned beef") (Parish 2006). The basic mechanism involved is the phenomenon known as osmosis, by which the salt draws the available water out of the microbial cells (O’Sullivan & Downey 2016) and bacteria (ACS 2018). Reducing the amount of water available to bacteria inhibits or slows bacterial growth and reproduction (O’Sullivan & Downey 2016; ACS 2018). High concentrations of salt can also rupture bacterial cells due to differences in pressure between the outside and inside of the microorganism. Salt is also effective in protecting foods against moulds and yeast- it prevents the fermentation of yeast and the growth of moulds by reducing water supply (ACS 2018).

Curing may utilize solid forms of salt or solutions in which salt is mixed with water. For instance, brine is the term for salt solutions used in curing or pickling preservation processes (Parish 2006). Vegetables are generally preserved by pickling them in a salt and water solution (brine), while meat may be rubbed with salt and dry cured or may be injected with a salt solution (ACS 2018).

Salt, whether in solid or aqueous form, attempts to reach equilibrium with the salt content of the food product with which it is in contact. This has the effect of drawing available water from within the food to the outside and inserting salt molecules into the food interior (Parish 2006). Salt will not prevent all microbial growth as although most microbes cannot grow in conditions where the concentration of salt is above 10%, preserving foods with a solution that is over 10% salt will have detrimental effects on the flavour, texture and structure of the preserved food. Most often foods must be preserved in much lower salt concentrations to retain the desirable qualities of the food (ACS 2018).

4.1.2.3. Smoking

It appears that compounds present in wood smoke have antimicrobial actions that prevent the growth of organisms that cause spoilage. Today, the process of smoking has become a sophisticated method of food preservation with both hot and cold forms in use. Hot smoking is used primarily with fresh or frozen foods, while cold smoking is used most often with salted products. The most advantageous conditions for each kind of smoking—air velocity, relative humidity, length of exposure, and salt content, for example—are now generally understood and applied during the smoking process. For example, electrostatic precipitators can be employed to attract smoke particles and improve the penetration of the particles into meat or fish. So many alternative forms of preservation are now available that smoking no longer holds the position of importance it once did with ancient peoples. More frequently, the process is used to add interesting and distinctive flavors to foods (Lerner 2006).

4.1.2.4. Fermentation

The most common meaning of fermentation is the conversion of a sugar into an organic acid or an alcohol. Fermentation occurs naturally in many foods and humans have intentionally used it since ancient times to improve both the preservation and organoleptic properties of food (Paulová et al. 2013). It is used both in households andindustries for food processing and preservation. More precisely, fermentation is a microbial technique and the reaction to be controlled in favorable and desirable conditions for food safety and quality after fermentation (Ganguly 2013). It is used for the intentional use of microorganisms such as bacteria, yeast, and fungi to make products useful to humans (biomass, enzymes, primary and secondary metabolites, recombinant products, and products of biotransformation) on an industrial scale (Paulová et al. 2013) brought about by the production of carbon dioxide by the microbial or yeast activity. The preservation effect during fermentation is attributed to the production of lactic acid in sour foods such as yoghurt, dry sausages, pickles, sauerkraut and vinegar (Ganguly 2013). Two types of fermentations are used: lactic acid and ethanolic fermentation. The function of both is to change conditions, so unwanted spoiling or pathogenic microorganisms would not grow and alter the food (Chojnacka 2010).

Fermentation consists of two distinct methods: aerobic and anaerobic fermentation (Hahn 1988).

As an example of traditional fermentation techniques, the flour processing of "fufu", "gari" and "lafun" products produced in Africa. For aerobic fermentation, the peeled and sliced cassava roots are first surface-dried for 1-2 hours and then heaped together, covered with straw or leaves and left to ferment in air for 3-4 days until the pieces become moldy. The fermented moldy pieces are sun-dried after the mold has been scraped off. The processed and dried pieces are then milled into flour, which is prepared into a "fufu".

In anaerobic fermentation, grated cassava for processing into "gari" is placed in sacks and pressed with stones or a jack between wooden platforms. Whole roots or pieces of peeled roots for processing into "gari" are placed in water for 3-5 days. The optimum temperature for the fermentation for "gari" processing is 35°C, increasing up to 45°C.

For "lafun" production in Nigeria, peeled or unpeeled cassava tubers are immersed in a stream, in stationary water (near a stream) or in an earthenware vessel, and fermented until the roots become soft. The peel and central fibres of the fermented roots are manually removed and the recovered pulp is hand mashed or pounded (Hahn 1988).

4.1.2.5. Canning

Canning is the newest of the food preservations methods (Huyck 2012). Canning can be a safe and economical way to preserve quality food at home.

Many vegetables begin losing some of their vitamins when harvested. Nearly half the vitamins may be lost within a few days unless the fresh produce is cooled or preserved. Within 1 to 2 weeks, even refrigerated produce loses half or more of some of its vitamins. The heating process during canning destroys from on-third to one-half of vitamins A and C, thiamin, and riboflavin. Once canned, additional losses of these sensitive vitamins are from 5 to 20 percent each year. The amounts of other vitamins however, are only slighhtly lower in canned compared with fresh food. If vegetables are handled properly and canned promptly after harvest, they can be more nutritious than fresh produce sold in local stores (USU Extension 1995; USDA 2015).

Canning is a process by which foods are placed in jars or cans and heated to a temperature that destroys microorganisms and inactivates enzymes. This heating and later cooling also forms a vacuum seal. The vacuum seal prevents other microorganisms from recontaminating the food (Huyck 2012).

For preservation, good fresh, well-cleaned food is selected. They should be preserved shortly after harvesting, at vegetables until 12 o'clock, on fruit in a few days. Otherwise, it is necessary to keep it in a cool place. Many fresh foods contain from 10 percent to more than 30 percent air. How long canned food retains high quality depends on how much air is removed from food before jars are sealed. Raw-packing is the practice of filling jars tightly with freshly prepared, but unheated food. Raw-packing is more suitable for vegetables processed in a pressure canner. Hot-packing is the practice of heating freshly prepared food to boiling, simmering it 2 to 5 minutes, and promptly filling jars loosely with the boiled food. Hot-packing is the best way to remove air and is the preferred pack style for foods processed in a boiling-water canner (USU Extension 1995).

Filling into glass or metal containers (USU Extension 1995; Hui et al. 2003) is accomplished mechanically or by hand (Hui et al. 2003). Metal containers can be used only once (USU Extension 1995). Glass containers are suitable for processed vegetables. Transparency of glass makes it the ideal choice for many products displayed for the consumer on the retail shelf (Hui et al. 2003).

The exhausting operation is to create an anaerobic environment (vacuum) in the can, which would inhibit microbial spoilage and minimize the strain on the can seams or pouch seals during processing.

Can containers should be closed immediately after filling to prevent excessive cooling of the surface of the product. Faulty seaming can result in deformations in the can during processing and eventual recontamination. Glass jars are closed with a screw cap (Hui et al. 2003). Metal containers require special sealing equipment and are much more costly than jars (USU Extension 1995). The unfilled space above the food in a jar and below its lid is termed headspace. This space allows for the expansion of the food during processing (Hendren et al. 2008).

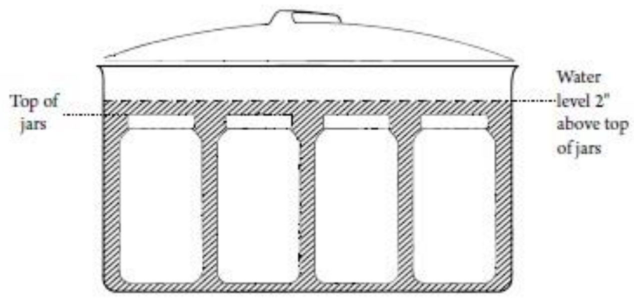

Figure 6. Waterbath with level water (Ingham)

The objective of thermal processing is to effect sterilization of the contents in the sealed container. This is usually achieved by heating for a predetermined time and temperature under the given heating medium. The often used heating medium for food thermal processing can be saturated steam, heated water, or a steam–air mixture, which is largely determined by the type of package (Hui et al. 2003). A boiling waterbath or canners (Figure 6) is used for fruits, tomatoes and pickled vegetables. These acidcontaining foods may be processed safely in boiling water for a specified length of time, depending on altitude (Hendren et al. 2008). Following the retort operations, the containers are adequately cooled to slightly above the room temperature (which helps in efficient surface drying), labeled, and stored (Hui et al. 2003).

The processing times in these guides ensure destruction of the largest expected number of heat-resistant microorganisms in home-canned foods. Properly sterilized canned food will be free of spoilage if lids seal and jars are stored below 35 °C. Storing jars at 4.5 °C to 21 °C enhances retention of quality. With increasing altitude, the air pressure changes, which affects the boiling point of water. The higher the altitude, the lower the air pressure (kPa) and the lower the boiling point (° C). E.g. at an altitude of 0 m is an air pressure of 100 kPa and a boiling point of 100 ° C and at an altitude of 3000 m is an air pressure of 69.1 kPa and a boiling point of 90.9 ° C. For this reason, it is necessary to take into account the aforementioned physical conditions when preserving foods at elevated altitudes and to extend the boiling period in such a way that the preservation is effective against the influence of bacteria in order not to spoil the food preserved (USU Extension 1995).

4.1.2.6. Jam, jellie, marmalade

A solid gel made from the pulp of a single fruit or mixed fruits (FAO – AGS 2007). Jams, jellies and marmalade can be made from a variety of fruits and some vegetables such as carrot and pumpkin. They are sometimes referred to collectively as preserves. One important feature of preserves is the high acidity which prevents the growth of food poisoning bacteria and also helps maintain the colour and flavour of most fruits (Azam Ali 2007). When made properly, jams and marmalades are safe products due to the high acid and sugar content (FAO – AGS 2007). However, some moulds and yeasts are able to grow at levels of high acidity and these can spoil the food (Azam Ali 2007).

Jams are solid gels made from fruit pulp or juice, sugar and added pectin. The fruit content must be at least 40% (Azam Ali 2007; FAO – AGS 2007). In mixed fruit jams the first-named fruit must be at least 50% of the total fruit (FAO – AGS 2007). The total sugar content must be no less than 68% (Azam Ali 2007; FAO – AGS 2007). In tropical climates, 70% sugar is preferable (FAO – AGS 2007). Jellies are crystal clear jams, produced using filtered fruit juice instead of fruit pulp. Marmalades are produced mainly from clear citrus juices and have fine shreds of peel suspended in the gel. The fruit content should not be less than 20% citrus fruit and the sugar content is similar to jams (Azam Ali 2007).

Before the process itself fruit should be washed in clean water, peeled and the stones removed. Fruit should be as fresh as possible and slightly under-ripe. Over-ripe or bruised fruit will not make good jam as it has low levels of pectin and acid.

To produce a clear juice for jelly, the juice should be filtered using a muslin cloth bag (FAO – AGS 2007). Acids are added to fruit juice to bring the pH within the range 3.0-3.3 which is necessary for jam making (Azam Ali 2007; FAO – AGS 2007). As the acidity varies in different types of fruit and also in different samples of the same fruit, it may be necessary to check for the correct acidity if different fruits are used. The only acids that are allowed to be added to jam are citric acid, tartaric acid and malic acid (Azam Ali 2007). It is measured using a pH meter and adjusted by adding citric acid or sodium bicarbonate (if the acidity is too high, for example with limes). Pectin is added to the pulp at this stage. Pectins are naturally present in fruits. Some fruits contain higer levels than others. The richest sources are citrus peels, passion fruit and apple. Strawberries and melon contain low levels. In general, the pectin level decreases as the fruit matures. Low-pectin fruits are often mixed with high pectin fruits to achieve the correct level. Pectin is needed to make the fruit set into a gel. Pectin is a light brown powder or a dark liquid concentrate (FAO – AGS 2007).

If possible, refined, granular, white sugar should be used. The sugar should be dissolved in water to make a strong syrup and then filtered through muslin cloth or a fine mesh before it is added to the fruit pulp. Processors may consider adding some artificial colour to these products to improve their appearance. It is better if natural fruit colours can be used – for example, adding dark red fruits or berries can give a more attractive and natural colour to jams (Azam Ali 2007).

The aim of boiling is to reduce the water content of the mixture and concentrate the fruit and sugar in as short a time as possible (Azam Ali 2007). There are two stages of heating. First, the fruit should be heated gently to soften the flesh and extract the pectin. This is followed by rapid boiling to evaporate the water until the final sugar content is reached (FAO – AGS 2007). The end-point of boiling is measured using a refractometer (Azam Ali 2007; FAO – AGS 2007).

Filled into a glass jars with new metal lids, paper, polythene or cloth lids or Plastic containers with foil lids. The jars before filling should be clean and sterilised. The ideal temperature for pouring is 82-85°C. Hotter than this and condensation will form under the lid. This will drop down and dilute the jam, allowing mould to grow. Colder than this and the jam will be difficult to pour. Containers should be filled to about 9/10ths of their volume (FAO – AGS 2007). Jam stored in glass jars will have a longer storage life (up to 12 months) than those packed in plastic bottles (up to 4 months). For the optimum storage time, jams should be stored in a cool dry place, away from direct sunlight (Azam Ali 2007).

4.1.2.7. Storing

Storing is the easiest method for keeping your harvest, but most vegetables don't have a long shelf life. Root vegetables and vegetables that can be cured, like onions and winter squash, will last the longest.

For the longest durability it is recommended to keep it to be fully mature and healthy vegetables. Any bruised or immature vegetables should be eaten fresh or preserved by other means. Vegetables should be cleaned and dried before cooling (Iannotti 2018).

4.1.2.8. Root crops – special method in the Pacific

Most types of root crops can be "field stored", meaning left in the ground to grow, for varying lengths of time until they are needed for eating. The time varies from a few months to many years in the case of Cytosperma taro. In fact, given that some root crops, such as Colocasia taro, can perish quite quickly following harvesting, field storage is often the best solution for keeping root crops fresh.

When field storage is not practicable, there are some traditional methods of preservation that can be used to extend the shelf life of root crops. One such method involves storing the tubers underground in purpose-built pits lined with coconut husks or banana leaves that are then covered with soil. The tubers may be kept for up 2 to 3 months in this fashion.

It is also possible to bake the tubers in a hot earth oven until an external crust is formed. The tubers can then be stored for up to a week or more before eating. Or, they can be preserved by parboiling the root, slicing it thinly and then sun-drying the tuber slices. Taro root prepared in this fashion will keep up to several months when stored in a tightly sealed jar, tin or plastic bag.

In Hawaii and Tahiti, taro is also stored as poi – a food that is commonly consumed during traditional feasts. Poi is made from Colocasia taro that has been steamed in an earth oven, peeled and then pounded on a flat stone or a special wooden bowl (kumete) to form a paste-like texture. During the process of pounding, a small amount of water is added to achieve the best consistency of the mixture to form the poi. It can then be eaten fresh, stored overnight to mature (ferment) for flavour, or stored for several weeks before being consumed.

The spread of freezers through the Pacific region has obviously provided a modern method of preserving root crops for long-term storage. Peeling and freezing of root crops can provide convenient storage for several months and is increasingly used by Pacific agricultural exporters to bypass stringent quarantine requirements imposed by developed trading partners (FAO 2010).

4.2. Methods of preservation in South America

4.2.1. Potato

Figure 7. Potatoes in the snow on the ground freeze-drying and turning into chuño Bolivia (James Brunker)

Potato cultivation formed the basis of the 13th century Inca Empire (Zuckermann 1999) which existed in the Andean region typically at an elevation around 4,000 to 4,300 m (de Haan et al. 2010). The sun can be intense, but the temperature can drop to freezing at night; a swing of 50 to 60 degrees Fahrenheit during a day is not uncommon. Added to this there is limited rainfall and poor soil, so typical crops such as corn or wheat cannot likely survive. But the potato can (Zuckermann 1999).

The cultivated potato in the high Andes of central to southern Peru and Bolivia is traditionally freeze-dried (Figure 7) to assure long-term storability and consequent availability of food during periods of scarcity (de Haan et al. 2010).

The elaboration takes advantage of severe frosts at night alternated with high daytime levels of solar radiation and low levels of relative humidity during the months of June and July (Sattaur 1988). The combination of sunny days and freezing cold nights causes breakdown of the cell walls, making it feasible for farmers to squeeze out the moisture from the tubers through treading with their feet (de Haan *et al.* 2010). Potatoes are about 80% water, and are therefore susceptible to freezing during the cold nights presumably leaving them inedible. But, therein hides an advantage. First the farmers place the potatoes out on the ground overnight to freeze them, and then in the morning, they trample the potatoes with their feet and leave them exposed to the intense warmth of the sun. This process (repeated three times) drives the moisture out of the potatoes (Zuckermann 1999). The final product is known as chuño (Cardenas 1989; López Linage 1991). Unused, the chuño can be stored in a frozen and sealed room (Zuckermann 1999) for up to ten years (Zuckermann 1999; de Haan et al. 2010).

4.2.2. Jerky

Figure 8. Ch'arki drying process (Pinterest)

The word jerky, referring to a dried, salted and pounded form of all kinds of animal meat, has its origins in the South American Andes, perhaps about the same time as the llama and alpaca were domesticated. Jerky is from "ch'arki" (Figure 8), a Quechua word for a specific type of dried and deboned camelid (alpaca and llama) meat, perhaps produced by South American cultures for some eight or so thousands of years (Hirst 2017).

This technique was used for large-scale preservation of meat in Latin America (Heinz & Hautzinger 2007), which were no doubt used by historic and prehistoric peoples (Hirst 2017), when and where a functioning cold chain was not yet fully developed (Heinz & Hautzinger 2007). Jerky can be made from beef, llama, sheep, alpaca (Bender 1992). The traditional method of processing ch'arki required that it be done at relatively high elevations during the dry part of the winters (Hirst 2017). For this product, the fresh meat from fore and hindquarter is cut into large pieces of about 5 kg, and approximately 5 cm thick. The pieces are submerged in tanks in a saturated salt solution for one hour and then drained on slats or racks. For the following dry-salting, the flat meat pieces are piled on a sloping concrete slab under a roof. Alternate layers of salt and meat are put up to reach a height of about 1 m. The pile is then covered with wooden planks and pressed with heavy weights. After eight hours the pile is restacked so that the top meat goes to the bottom of the pile. The restacking process with fresh layers of salt is repeated daily for five days. After five days, the salted meat is ready for the actual drying. Before initiating drying, the meat pieces are washed to remove excess salt adhering to the surface. The meat is then exposed to the air and sun on wooden racks which are oriented north-south, thus permitting an even solar coverage (Figure 8). The meat pieces are exposed to the sun daily for four to eight hours over a period of four to five days. After each period of exposure the pieces are collected, stacked in piles on concrete slabs and covered with an impermeable cloth to protect them against rain and wind and to contain the previously absorbed heat. When sufficiently dry, the meat pieces are either marketed without packaging or simply wrapped in jute sacks. Plastic sacks are not suitable, because the product still contains some of its original moisture content, and this moisture must be allowed to drain freely from the product during storage. Due to its low moisture and high salt content (5% and more) (Heinz & Hautzinger 2007), ch'arki keeps for months under ambient temperature conditions and is resistant to infestation by insects and mould growth (Bender 1992). The salt must be reduced by immersing the meat pieces in water in order to make it palatable for consumption (Heinz & Hautzinger 2007). Preserved jerky can be later rehydrated through prolonged water soaking, and in South America, ch'arki is most commonly consumed as reconstituted chips or small pieces in soups and stews (Hirst 2017).

4.2.3. Chilli peppers

There are multiple ways how to dry peppers and different types of peppers are more conducive to the drying method. Experts say that the drying method works best for the waxier peppers but if dried properly it can work for almost any of them. The easiest way to dry chillies is by using a dehydrator. If a dehydrator is not available, another option when drying chillies is to lay them out in the sun, giving the peppers enough ventilation and warmth to achieve the proper consistency. Too much heat will make the pepper too brittle making it hard to work with and not enough ventilation will make, the peppers too moist allowing mould to form. The best way to prepare chilli peppers is to rinse them in salt water to prevent mould from forming and then use an appropriate drying method. Once the chillies are dried, the best storage method is in an airtight container either whole or in a coffee grinder to create chilli pepper (Rosato 2017).

4.2.4. Quinoa

This activity through which the grain is obtained includes drying or stacking (Bojanic 2011), threshing the seedheads (National Research Council 1989), and then shipment to an industrialized center which removes all fine debris, the chaff, and the bitter saponins which protect the plants from insects and birds (Stenn 2017). Seed must be especially dry when stored because it germinates quickly (National Research Council 1989). It is recommended that the grain is stored in sacks made of woven llama wool, or new or good condition polypropylene bags (Bojanic 2011).

Drying or stacking involves arranging the plants in stacks immediately after cutting (Bojanic 2011). The plants are piled with the panicles inwards, and the center elevated, so that water can run off. The plants are maintained there for 7 to 15 days. Predrying causes a reduction in the water content of the plant and protect the plants against rain or frost (Domínguez 2003).

Figure 9. Drying methods: Arcos and Taucas (foto: FAO)

There are three methods of stacking or drying: Arcos, Tauca and Chucus (Figure 9).

Arcos stacking method involves stacking the plants in the form of an x (cross) resting on a base of thola or other native species with the panicles leaning upwards. Drying is facilitated because there is more air circulation and the ears are sufficiently exposed to the sun for drying. This method is time consuming to prepare but in this way the harvest can be dried in less than three weeks (Bojanic 2011).

Taucas consists of building mounds or stacks of plants with the panicles ordered towards the same side and on a piece of material such as canvas or nylon. The length can be 10 to 15 m and a height of 1m, this method may take a little longer to dry, but because of its concentration in one place it facilitates threshing. The disadvantages of this method are that drying is nonuniform, and the harvest is exposed to rain and wind (Bojanic 2011).

Chucus are cone shaped mounds of quinoa plants, which are scattered throughout the whole field. The mounds are made by standing the plants up in a circle with the panicles toward the top to give more stability to the chucu. They are usually tied in the middle with a rope. This method permits faster drying (Bojanic 2011).

Threshing is the separation of grains from the panicle. There are several different methods of threshing: manual, threshing with animals (horses, donkeys) (Domínguez 2003), semi-mechanical, mechanical.

Manual threshing is one of the most difficult tasks in quinoa production, and is practiced in places inaccessible to vehicles (Bojanic 2011). Panicles are hit against a hard surface or rubbed with the hand to separate the seeds from the plant. The black seeds of wild quinoa are eliminated, as they reduce product quality.

In threshing with animals, the panicles are placed in heaps, and the animals are allowed to pass over the material. A disadvantage is that the product is mixed with animal wastes, which reduces product quality (Domínguez 2003).

In semi-mechanical threshing in the Southern Altiplano the use of vehicles (tractors, trucks, etc.) has been adopted to carry out this method of threshing. The panicles are placed towards the inside of the two rows so that in multiple passes the vehicle is able to separate the grains. The difficulty is in the following sifting and winnowing which are performed manually (Bojanic 2011).

In mechanical threshing the plants are threshed in stationary threshers, which may be operated by a tractor or by self-propelled motors.

The purpose of cleaning is to separate soil, stones, excrement, and small and broken seeds from the seed material. In the traditional winnowing, the seed material falls to the ground from the hands, or to a cloth or plastic, taking advantage of the afternoon wind currents (Domínguez 2003). The seed of most quinoa varieties must be processed before use to remove the bitter saponins. Saponins are used in pharmaceuticals as mild cleansers (Stenn 2017). In the normal household, this is done by soaking, washing, and rubbing. On a commercial scale, mechanical milling, or a mixed washing and milling procedure, are the most common methods (National Research Council 1989). Then the threshed seeds are washed in washing stage. Wet seeds are quickly dried using a centrifuge machine (Stenn 2017).

The clean seeds are put on a cloth and exposed to the sun for 3 days, while they are removed at night to eliminate the remaining excess moisture in the grains (Domínguez 2003), or wet quinoa is prepared and put on the drying table where it is dried to 12% (Stenn 2017). Drying prevents fermentation (Domínguez 2003).

Quinoa grains are traditionally toasted or ground into flour. They can also be boiled, added to soups, made into breakfast foods or pastas, and even fermented into beer. Quinoa flours, flakes, tortillas, pancakes, and puffed grains are produced commercially in Peru and Bolivia (National Research Council 1989).

4.2.5. Cassava

Figure 10. Cassava (Jon Yaneff)

Cassava or manioc is an American original crop (Figure 10), spread across South America. According to an Indian legend, the aborigines were able to eliminate the poison from this root, make it edible when cooked, and therefore cassava symbolizes the conversion of death into life. Although cassava roots are rich in calories, they are grossly deficient in proteins, fat, and some of the minerals and vitamins (Charles et al. 2005). Cassava contains potentially toxic substances, lotaustralin and linamarin, both cyanogenic glycosides, which generate hydrocyanic acid (HCN) by means of an enzyme, linamarase, present in the tuber tissue (Montagnac et al. 2009). Therefore, traditional processing procedures must aim at reducing cyanide and improving storability, convenience and palatability (Hahn et al 1988).

Fresh cassava roots cannot be stored for long because they rot within 3-4 days of harvest. They are bulky with about 70% moisture content, and therefore transportation of the tubers to urban markets is difficult and expensive. The roots and leaves contain varying amounts of cyanide which is toxic to humans and animals, while the raw cassava roots and uncooked leaves are not palatable. Therefore, cassava must be processed into various forms in order to increase the shelf life of the products, facilitate transportation and marketing, reduce cyanide content and improve palatability (Hahn et al. 1988).

Traditional cassava processing methods originated from tropical America, particularly northeastern Brazil (Jones 1959). The processing methods include peeling, boiling, steaming, slicing, grating, soaking or seeping, fermenting, pounding, roasting, pressing, drying, and milling. These traditional methods give low product yields which are also of low quality (Hahn et al. 1988). For example, in Colombia, cassava is mainly used for the production of starch and its extraction is carried out since ancient times. Either a chemical or an enzymatic process can be used to extract cassava starch (Vargas-Aguilar 2010).

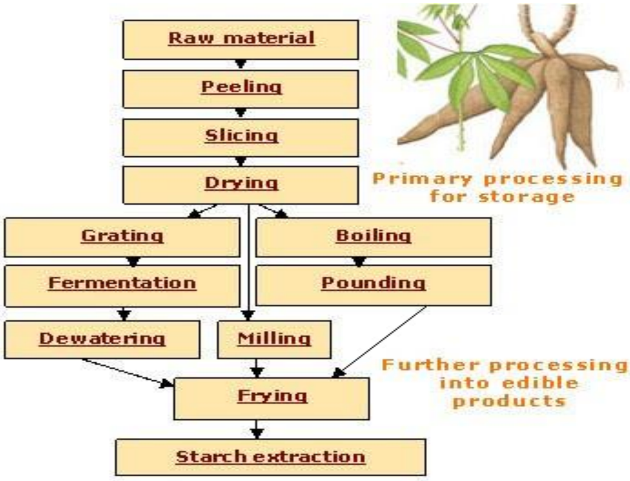

Figure 11. Processing of cassava (Mixph)

To produce fermented sour starch of cassava (Figure 11), the roots are washed to remove all foreign matter and grit or coating. Subsequently, they should be grated to obtain a dough containing the starch, which is washed, filtered, and decanted into open settling tanks. The starch precipitates and is introduced into closed containers under anaerobic conditions to carry out a natural fermentation process for a long period (approximately 20 to 30 d, depending on climatic conditions), with the final pH ranging between 3.5 and 4.0. In some areas, especially those with warm climates, the fermentation tanks are buried to maintain a constant temperature (Chaves-López et al. 2014). Fermentation of cassava root flour enhances its nutrient content through the biosynthesis of vitamins, essential amino acids, and proteins, (improving protein quality), and fiber digestibility. It also enhances micronutrient bioavailability and helps degrade antinutritional factors (Achinewhu et al. 1998). It is to underline that during sour starch production, from 40% to 70% of the cyanide content is released in the water used to wash cassava, while 5% to 10% is present in the cassava bran that is usually used for animal feed, and finally about 4% is reduced after fermentation and sun-drying to less than 1% (1 to 5 ppm) (Arguedas & Cooke 1982). From the technological point of view, it is important to underline that after fermentation sour starch is sun-dried to obtain a stable product with 10% to 25% moisture content (Brabet & Dufour 1996).

Upon completion of the drying process, the starch in the form of dough is ground and sifted through sieves of pore size between 100 and 120 US mesh, to form a fine powder (Chaves-López et al. 2014). In the Colombian baking industry, this starch is sought for the manufacture of pandebono, pandeyuca, and snacks, due to its typical flavor and texture (Montoya-Henao 2007).

4.2.6. Cocoa

Figure 12. Cocoa beans (Sciences horts)

Cocoa beans originate from tropical rainforests (Figure 12). In American continents extending from the Amazonian basin of South America to southern Mexico. The place of origin of cacao trees was the Upper Amazon near the Colombian-Ecuadorian border, on the eastern flanks of the Andes (Motamayor et al. 2002; Chaves-López et al. 2014). It was brought to Mesoamerica by early humans, and the use and domestication of this crop may have started 4000 years ago (Powis et al. 2011).

The process to obtain cacao beans: after opening the cacao pods and wet bean removal at the plantation, the collected fresh cacao pulp-bean mass undergoes a spontaneous fermentation for several days (2 to 7 days) depending on variety of cacao plant, climate, local practices of fermentation which include heaps, wooden fermentation boxes, canoes made of thick tree trunks called "pozuelos," barrels, or baskets, frequency of bean mixing or turning, volume of cocoa to ferment, maturity and the sanitary condition of the beans (Schwan 1998; Cubillos et al. 2008; Ortiz de Bertorelli et al. 2009; Moreira et al. 2013; Zapata Bustamante et al. 2013; Chaves-López et al. 2014). Traditionally, in all types of fermentation the mass of fermenting beans is usually covered with jute or sisal bags. During fermentation, important changes take place, which are essential for the development of the characteristic future cocoa and chocolate flavors, that is detachment of the mucilage that surrounds the bean to facilitate preservation, death of the embryo that prevents germination and a chain of biochemical reactions inside the beans, which generate a volume increase and a characteristic color change (Chaves-López et al. 2014). Yeast growth and activity are essential for cocoa fermentation and development of chocolate characteristics (Ho et al. 2014). Yeasts create anaerobic conditions that allow the growth of LAB, which ferment sugars, produce lactic acid, and assimilate citric acid (Chaves-López et al. 2014). Fungal contribution to fermentation is restricted to the first 36 hours of fermentation, because the increasing temperature and ethanol concentration of the bean mass act as limiting factors (Ardhana & Fleet 2003).

The drying process of cacao reduces acidity and astringency, and it decreases volatile compounds (Afoakwa and others 2008; Chaves-López et al. 2014). This process is performed by sunlight or artificially under controlled temperature, which should not exceed 60 °C. Although many Colombian small farmers use sunlight for drying, the artificial drying predominates in large-scale operations (Espinal et al. 2005). As pointed out in recent publications, drying is the most important unit operation that affects polyphenols such as flavonoids and their antioxidant activity (Di Mattia et al. 2013).

These processes are crucial for the development of the sensory quality of cocoa beans. Aroma and flavour profiles develop predominantly during drying and fermentation but also the later roasting impacts flavour via the Maillard reaction. In general, soil composition, climatic conditions, and primarily farming practices are other fundamental factors that ensure the special chocolate aroma and flavour (Federacion Nacional de Cacaoteros 2004).

4.2.7. Sugarcane

Figure 13. Sugarcane juice (Fitness-Spell)

The sugarcane, genus Saccharum (FAO – AGS 2007; Geremias de Andrade et al. 2014), is very versatile and economically feasible. Its successful production is justified by the easy adaptation to Brazilian climate and soil while it is cultivated in much of national territory (Geremias de Andrade et al. 2014).

Sugarcane is indigenous to tropical South and Southeast Asia. The center of origin is probably in northern India where forms with the smallest chromosome numbers occur (Sharpe 1998). Different species likely originated in different locations, occurring in the wild from eastern and northern Africa, through the Middle East, to India, China, Taiwan, and Malaysia, and through the Pacific to New Guinea. Sugarcane has been cultivated since ancient times and it was one of the first "cash crops" of early colonial America. It grew plentifully in the southern states, and was a major source of income for many plantations.

The countries that produce the largest amounts of sugarcane are Brazil, India, China, Mexico, Thailand and Pakistan. Brazil alone accounts for almost 25% of the world production and was the largest producer of sugarcane in the world. Brazil produced 588 million tons of sugarcane in 2012/13. Brazil uses sugarcane to produce sugar and ethanol for gasoline-ethanol blends (gasohol), a locally popular transportation fuel (DAFF 2014).

This raw material of sugarcane is mainly composed of juice (Figure 13) (composed of water, sugars, ash and nitrogen materials) and bagasse (consisting mainly of fibers) (Geremias de Andrade et al. 2014). The most important part of the sugarcane plant are the stalks, because sugars and other substances accumulated by the sugarcane during its growth are found in it (FAO – AGS 2007).

Sugarcane is used for sugar production, as raw material in human food industries, as a fertiliser and as livestock fodder. The primary use for sugarcane is to process sugar, which is then used in producing cakes, candies, preservations, soft drinks, alcohol and numerous other foods (DAFF 2014).

The objective of industrial sugarcane processing is to obtain highly purified sugar and ethanol (Cheavegatti-Gianotto et al. 2011). The process involves crushing (Geremias de Andrade et al. 2014) and pressing (Cheavegatti-Gianotto et al. 2011) of the sugarcane in electric or manual grinders (Geremias de Andrade et al. 2014) to obtain juice, which goes through several phases of purification and concentration, followed by crystallization (in the case of sugar production) or fermentation and distillation (in the case of ethanol production) (Cheavegatti-Gianotto et al. 2011). The main component of the sugarcane juice in the production of sugarcane syrup and rapadura (Figure 14) is sucrose (FAO – AGS 2007). Sucrose and ethanol, which are pure and chemically defined substances, are obtained at the conclusion of both processes (Cheavegatti-Gianotto et al. 2011).

At the beginning of the process the sugarcane is scraped (Geremias de Andrade et al. 2014), cut and cleaned. Clean or yet washed sugarcane passes through rollers of the electric milling equipment, where the extraction of the juice occurs and a fibrous by-product so-called bagasse is the leftover (FAO – AGS 2007; Cheavegatti-Gianotto et al. 2011). In the mills, this byproduct of sugarcane processing is burned to generate energy (Cheavegatti-Gianotto et al. 2011) to be used in concentration of the sugarcane juice. Milling is followed by the filtering, which has as an objective to remove these light impurities that stay in the top. For this, a filter of coarse mesh is used. This stage is of extreme importance because it allows the work with cleaner broth of sugarcane, contributing for the attendance of the quality requirements. The normal sugarcane juice has a pH around 5.7. In case it is below this value, it is necessary to correct the acidity in order to avoid an excessive darkening of the product, besides the excessive inversion of sucrose, which is harmful in the case of rapadura production. This correction is accomplished in the juice destined to the production of this product. In the case of sugarcane syrup, this operation is not necessary (FAO – AGS 2007), it may have a pH between 5.0 and 5.5 (Geremias de Andrade et al. 2014). Control of pH is done with litmus paper, alkaline solution (NaOH) or (KOH) or pH-meter. The juice concentration is made by boiling. The juice is poured into large bowels, where it will be warmed. As boiling goes on, the juice must be constantly stirred until becoming concentrated. During this phase, a consistent foam will appear on the surface of the juice. This foam contains some impurities that must be removed. The juice is cleaned with a skimmer. These impurity removals guarantee a clearer and purer product. The qualities of the sugar, 'rapadura' and sugarcane syrup will depend on the efficiency of the juice cleaning work (juice cleaning) accomplished at this phase. The cleaning of the juice is one of the most important phases in the production process, since the appearance of the product is a factor that leads the consumer to buy it. The concentration temperature of the syrup and its final Brix for "rapadura" however ranges from 110ºC to 114ºC (FAO - AGS. 2007).

Pasteurisation of sugarcane juice is process at a temperature 95 °C/30 second in an electric plate heat exchanger. After that it is cooled down at a temperature of about 10°C and packed in 250 ml bottles. Bottling is performed using a gravimetric filler. The processed juice is stored at 7 ± 0.5 °C. Sugarcane juice is characterized as a drink coloring in brown and dark green tones, its variable composition depending on the variety, maturity stage, soil, climatic and agricultural conditions (Geremias de Andrade et al. 2014).

The raw sugar obtained directly from sugarcane processing consists of 99.8% sucrose and 0.2% impurities. Refined white sugar is obtained by dissolving raw sugar and removing the insoluble material and natural colorants through physical processes (Cheavegatti-Gianotto et al. 2011). After this additional purification step, the sucrose content of refined white sugar reaches 99.9% (Rein 2009). Sugar helps to preserve jams, cereals, cakes, candies, cookies and drinks (DAFF 2014).

Sugarcane syrup, known in the northeast as “mel de engenho,” is syrup produced through the concentration of sugarcane juice. It is also called “liquid rapadura” due to the similarity of these substances. Rapadura is a concentrated product of sugarcane juice without the separation of molasses from the crystals whose color can vary from golden to dark brown. It is a whole, unrefined sweetener that can be used in the same way as sugar with the additional flavor of molasses. Rapadura and sugarcane syrup are the main products of the artisanal sugarcane production system. These speciality products are produced on small farms that are characterized by their low technology levels and intensive use of labor.

Figure 14. Rapadura (Pinterest)

In addition to bagasse, during the processing of sugar cane, another by-products are filter cake, which is obtained from the rotation filters after residual sucrose is extracted from the sugar production leftover (sludge), is rich in minerals and organic matter, mainly proteins and lipids and is commonly used as a fertilizer or in animal feed, and vinasse, that consists of suspended solids and organic and mineral substances, mainly potassium and is used in the formulation of animal feed and as field fertilizer (Cheavegatti-Gianotto et al. 2011).

The market for cane juice and its final consumption is part of the informal food sector and consists, mainly, of street vendors, often in precarious sanitary conditions, on the other hand, its sale in kiosks located in coastal areas and shopping centers in Brazil is increasing (Geremias de Andrade et al. 2014).

4.2.8. Cachaça

Cachaça-a spicy, sweet and fruity clear liquor distilled from fermented sugarcane juice, which is produced in Brazil and contain alcohol by volume of 38 to 48 percent (Cheavegatti-Gianotto et al. 2011; Freire Bruno 2012; Tonton 2015) in volume, at 20 °C (Cheavegatti-Gianotto et al. 2011; Freire Bruno 2012).

In Brazil, cachaça (or aguardente) production started during the colonial period, shortly after sugarcane was introduced in the 16th century (Cheavegatti-Gianotto et al. 2011) and since then the cachaça market has continued to evolve and the spirit's quality has improved. Up to 2013, in the United States, cachaça was sometimes labeled as "Brazilian rum", causing consumer confusion with rum produced elsewhere, such as the Caribbean countries. But as of two years ago, an agreement between the US Brazilian governments have established that all Brazilian spirits come in the US must be named "cachaça" (Tonton 2015).

Cachaça, rum and even rhum agricole are all distilled from sugarcane. But each spirit is produced through slightly different processes. Technically, cachaça can only be made in Brazil from fresh cane juice, which is fermented and single distilled. Rum, on the other hand, can be made anywhere, and is usually produced from molasses, a cooked byproduct of sugar production, and distilled to much higher percentages of alcohol by volume. Rhum agricole is more similar to cachaça and is made from freshly squeezed sugarcane juice as opposed to molasses within the French island of Martinique, which has its own controlled appelation under European Union law. The juice can only be taken from sugarcane grown in 23 designated regions of the island (Tonton 2015).

Before the cachaca is processed, it is necessary to process the sugarcane. Because sugarcane must be juiced for fermentation within 24hrs of being cut, picking the correct order for the plantation to be cut is essential (Abelha 2018). This juice contains about 15% sugar, so it's sweet, vegetal, and slightly savory (Novo Fogo 2018). After cleaning and pressing the sugar cane and filtering the sugarcane juice, specific ingredients and flavor enhancing agents are added such as maize flour, rice bran, and corn meal (Make me a cocktail 2013), wild yeast and after which the process of fermentation is started (Novo Fogo 2018). Fermentation (Figure 15) is kick started for the season by an organic mash and from then on for the rest of the season a sour-mash technique, where some of one fermenting batch is taken to kick-start the next, is employed. We use natural yeasts that live on the local sugarcane (Abelha 2018). During fermentation, the yeasts convert sugars into alcohol in less than 24 hours, producing a wine of approximately 7%-9% ABV (Novo Fogo 2018).

Figure 15. Fermentation proces of sugarcane juice for cachaça (Abelha)

The cachaças "wine" composition is quite complex and contains liquid, solid and gaseous substances. Ethanol is the main liquid component, with 5 to 8% v/v, and water is the substance present in the greatest amount - about 89 to 92% v/v. Other liquid components present in smaller amounts are glycerol, lactic acid and butyric acid; volatile components such as esters, acetic acid, propanoic acid, aldehydes and higher alcohols, among others. According to the components' volatility, it is possible to isolate the volatile components from the non-volatile ones.

A distillation process is used to isolate, select and concentrate specific volatile components of the "liquid mixture" by heating it. Cachaças can be produced by two very different systems: "continuous" and "by batches". In the traditional continuous system the distillation column used is continuously fed with the "wine", while in the "by batches" system, typical of alembics, the whole wine volume to be distilled is transferred to a pan before the distillation starts.

Figure 16. The distillation kettle (Day Trippers)

The distillation kettle (Figure 16) (or pan) heating process may be direct or by steam. This process should be slow and gradual, since abrupt heating of the “wine” may cause the apparatus to overflow (Freire Bruno 2012). Steam is used to heat the sugarcane wine. The alcohol in that mixture evaporates before water and other organic compounds, and these vapors are condensed back into liquid alcohol. It captures the best part of that liquid known as the curaçao, or the “heart” and recycle the rest of the distillate (the “heads” and “tails”) to use as fuel, fire starter, and cleaner čistič (Novo Fogo 2018). About 10% of the distillate the heart is used to produce the final Cachaça, so about 40litres per distillation (Abelha 2018). The first batch that is distilled is known as cabeceira, which is often utilized to make liqueurs. The cachaça boa, which is the second distillation batch, is considered 18 percent proof and is aged in barrels and bottled, which is eventually exported to other countries. Lastly, the third distillation batch, which is known as agua fraca, is 12 percent proof (Make me a cocktail 2013). After distillation a small dilution is made using water from the natural aquifer underneath the fazenda (Abelha 2018).

Cachaça is classified by the way it is stored before it's bottled. Cachaça that is not stored in wood after distillation, or just stands in stainless steel containers before bottling, is labeled branca (white) (Tonton 2015). There it will be 6 months to a year before bottling (Abelha 2018; Novo Fogo 2018). Same goes for cachaça that rests in woods that do not release any color (such as peanut, jequitibá, and freijó). White cachaça is also sometimes called clássica (classic), tradicional (traditional) or prata (silver). Amarela or yellow cachaça is stored or aged in wood, which causes a substancial change in its color. Producers may call these ouro (gold) or envelhecida (aged) (Tonton 2015).

Wood barrels are widely used in the alcohol beverages industry as a way to enhance a spirit's aroma and flavor, and also to "soften" the spirit. Around 60 percent of the aroma from an aged beverage comes from the wood in which it rested. But cachaça is one of the only spirits in the world that can be aged in indigenous Brazilian wood. In Brazil, cachaça producers age their spirit in many types of wood beyond non-native oak, such as amburana, cabreúva, jequitibá, ipê, and balm. Stored cachaça is kept in wooden barrels of any size for a non-specified period of time. Meanwhile, aged cachaça must contain over 50 percent of a spirit that is at least one year old and rested in barrels of up to 700 liters. Aged cachaça is then divided into "Premium" (aged for a period not shorter than one year) and "Extra Premium" (for a period not shorter than three years). In both case, 100 percent of the cachaça needs to be aged in suitable barrels (Tonton 2015).

As Brazil's most popular spirit, cachaça is distilled throughout the country, from small home distilleries to large industries, yielding 800 million liters of spirit annually-30 percent of which comes from small-batch producers and is Best known for its role in Caipirinha (Cheavegatti-Gianotto et al. 2011; Tonton 2015).

5. Conclusions

It has been found out that food preservation in tropical and subtropical areas of South America by natural methods is based on established standards that people have been practicing for centuries to this day. The information learned shows that the most common method of preserving food is drying because of its low cost, since the method is only limited by climatic conditions and space. However, these methods may be inadequate due to population growth in the future, and therefore we need to look at alternative, in the developed world commonly used, methods of food preservation and food sources. Surplus food resources can be preserved by other customary ways that can ensure their longer shelf life for the needs of the South American population in the locations in question or for exports to support their economic self-sufficiency, development and prosperity in other areas of sustainability. Only a new technical and technological approach to utilization of the potential of natural resources and changes in the economy will ensure the economic expansion of the society's development in the monitored area of South America. This paper creates a stimulus for further reflections leading to solutions to the sustainability and economic development of less economically developed areas of South America.

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