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Kettle Steam Generator and Process of Blanching for the Retention of Constituents in Dry Hibiscus Sabdariffa Leaves

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Abstract: *Local medicinal culture have had the practice of boiling specific leaves and roots of choice plants whereby the internal healing and growth ingredients are expelled out and consumed to effect healing or as beverage. This was the practice of our fore fathers and the culture is still subsisting. Hibiscus, Lemon, and other plant leaves contain various health and medicinal ingredients pertinent for growth and the cure of many ailments. The goal of employing these plant leaves for beverages and herbal medicine is to assimilate and exploit the full effects of the natural constituents in the leaves. The present system in Nigeria whereby the fresh leaves are firstly dried in the sun or tray driers and boiled to expel the edible constituents exposes the material to direct radiation which diminishes the quality of the said constituents and in some cases degrade them completely. The radiation occasioned degradation majorly attacks the leaf pigment and colouration housing some of the medicinal and nourishing elements essentially for which the plant leaves are sought. As a result batches of processed dried leaves usually vary in the percentage constituent content wherefore effect cannot be obtained from similar dosages. This phenomenon is easily evidenced in the conspicuous loss of colour. This mechanical contrivance is a product of research at the Technology Incubation Centre (TIC), Nnewi, Anambra State to enable the production of dry Hibiscus Sabdariffa leaves without thermal degradation of the pertinent ingredients. This is achieved by picking and washing the fresh leaves, followed by blanching with steam produced at the specified pressure before drying at set temperature in tray driers or solar drying. The sequence and drying operations at specific temperature are critical to production of quality dry leaves. Granulation of the product allows for measured quantities to be dissolved in water or any other solvent for easy isolation and determination of various natural constituents in a specific size thereby affording prescription guide for intake of product as beverage or medicine. Specified quantities of granulated product or powder are easily packed in tea bags and sold. This invention is employed in the production of Ijele Zobo Tea, a popular hibiscus sabdariffatea in Nigeria.*

Keywords: *Hibiscus, Leaves, Radiation, Constituents, Blanching*

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I. Introduction

Hibiscus sabdariffa is a species of hibiscus, native to the old world tropics, used for the production of bast fiber and as an infusion (herbal tea). The plant is an annual or perennial herb or woody-based sub-shrub, growing up to 2-2.5 m (7-8 ft) tall. The leaves are deeply 3- 5 lobed, 8-15 cm long arranged alternatively on the stems. The flowers are 8-10 cm in diameter, white to pale yellow with a dark red spot at the base of each petal and have a stout fleshy calyx at the base 1-2 cm wide, enlarging to 3-3.5 cm, fleshy and bright red as the fruit matures. It takes about 6months to mature. The plant is widely cultivated for its strong fibers and it is well known for its edibility and medicinal properties, though the calyx is the most frequently used portion of the plant, the leaves and seeds are often made into salads, curries and potherbs. They are rich in vitamins, natural carbohydrate, protein, tannins, gums and other antioxidants including minerals. The chemistry of the calyx revealed that per 100 g, it contained 49 calories, 84.5% water, 1.99 protein, 0.1 g fat, 12.3 g total carbohydrate, 2.3 g fiber, 1.2 g ash, 1.72 mg calcium, 57 mg phosphorus, 2.9 mg iron, 300 g vitamin A equivalent and 14mg ascorbic acid (Okereke *et al.,* 2015).

Essential oils are natural products obtained from plants. They were formed by varied and complex volatile mixtures of chemical compounds, with predominance of terpene associated to aldehyde, alcohols and

ketone which were deposited in various structure of the plant (Tajidin *et al.,* 2012). The chemical components contained in the flowers of Hibiscus sabdariffa include anthocyanins, flavonoids and polyphenols. The petals are potentially a good source of antioxidant agents as anthocyanins and ascorbic acids. Roselle calyx contains a rich source of dietary fiber, vitamins, minerals and bioactive compounds such as organic acids, phytosterols, and polyphenols, some of them with antioxidant properties. The phenolic content in the plant consists mainly of anthocyanins like delphinidin-3-glucoside, sambubioside, and cyaniding 3-sambubioside mainly contributing to their antioxidant properties (Zaman *et al.*, 2017).

The aqueous methanolic extract of Roselle exhibits antimicrobial activity against many bacterial spp. Roselle - Hibiscus anthocyanins (HAs), which are a group of natural pigments existing in the dried calyx exhibited antioxidant activity and liver protection (Puro et al., 2014). The red colour of Roselle petals, essentially the anthocyanins, is an attractive source of natural food colourants (Goda et al., 1997). Anthocyanins possess a high thermostability and contribute towards antioxidative, antiinflammatory, cardioprotective and hepatoprotective activities (Azevedo et al., 2010). According to many authors, anthocyanins inhibit the growth of human cancer cells and low density lipoprotein (LDL) oxidation. Therefore, the addition of natural anthocyanins as food colourants would not only enhance the decorative value of the food but also improve its beneficial properties (Shruthi *et al.,* 2016).

Primary colours; red, green and blue denote different phytochemical compounds which are bases of the medicinal values of the plant parts that exhibit the colours. Plants and plant parts with black colour may have anticancer effect whereas plants parts with white colour may have antidiabetic, antiasthmatic, antihypertensive and antioxidant activities. Plants with yellow, red, purple, pink and cyan colour may have antimicrobial and antioxidant activities (Saganuwan, 2018). The anthocyanin pigment Cyanidin was confirmed to be the most predominant anthocyaninpigment in the Hibiscus sabdariffa and for this reason, most of the therapeutic action of the plant is attributed to this compound (Hadi and Abu-Raghif, 2017).

II. Statement of the Problem

Roselle calyx (Hibiscus Sabdariffa leaf) is highly perishable even though it has many essential nutrients such as vitamins, minerals and other quality attributes. However, due to its high perishability, processing it into more stable forms like jellies, jams, juice and powder will go a long way to extend its shelf life. Drying as a processing method ensures safe level moisture content reduction of products thereby minimizing quality deterioration for more economic returns. As one of the oldest methods of preserving food, drying eliminates water from food by directly exposing food to hot air from the sun until it is in equilibrium with the surrounding air. Preservation of food by drying is mostly done to maintain its value as well as increasing the number of days to spoilage (Amoasah *et al.,* 2018)

Table 1 depicts the physicochemical properties of fresh and dried roselle calyces. Total flavonoids, total anthocyanins and DPPH inhibition (%) were decreased after drying of roselle calyces. It was observed that drying processes were also responsible for flavonoids degradation. The degradation of flavonoids not only depends on temperature and magnitude of heating; it may depend also on other parameters such as pH, phytochemicals, structure and even the presence or absence of oxygen many factors or combination of factors such as pH and acidity, phenolic compounds, sugar and sugar degradation products, oxygen, and ascorbic acid. The drying processes were also influenced in the ascorbic acid contents of dried roselle calyces. This may be due the facts that ascorbic acid is very unstable when exposed to ultra violet radiation and high temperature. Drying affects the antioxidant activity of plant materials. Increased temperature and water removal generally cause a loss of chemical compounds with antioxidant properties. In case of chromatic parameters it was observed that the dried roselle calyces were darker (lower L* values) than the fresh roselle calyces. Redness values (a*) was found to be higher in oven-dried samples and yellowness values (b*) values was found to be higher in sun-dried samples. The highest hue angle (H*) was recorded in sun-dried sample (Zaman *et al.,* 2017).

Table 1: Physicochemical properties of fresh and dried roselle calyces

Parameters	Fresh calyces	Oven- dried calyces	Sun-dried calyces
pH	2.07a ± 0.01	2.71b ± 0.02	2.67b ± 0.01
Titratable acidity (% Citric acid)	20.22a ± 0.03	18.82b ± 0.02	19.12b ± 0.03
Ascorbic acid (mg/100g)	66.52a ± 0.04	58.48c ± 0.01	52.42c ± 0.02
Total phenol (mg/100g)	1018a ± 0.32	2019b ± 0.34	2010b ± 0.32
Total flavonoids (mg/100g)	388a ± 0.11	322b ± 0.16	310b ± 0.12
Total anthocyanins (mg/100g)	326a ± 0.12	298c ± 0.13	282c ± 0.14
DPPH inhibition (%)	92.12a ± 0.10	86.14b ± 0.14	79.28b ± 0.13
Color	28.76a ± 0.01	23.74b ± 0.01	21.76c ± 0.02
L*	18.82a ± 0.04	15.82b ± 0.03	14.78c ± 0.01
a*	3.22a ± 0.02	5.38b ± 0.02	6.49c ± 0.01
b*	9.73a ± 0.04	18.79b ± 0.03	23.76c ± 0.04

H* C*	19.09a ± 0.03	16.70b ± 0.02	16.14c ± 0.02

This work contrives a process of drying Roselle calyces and leaves of other plants without deteriorating the flavonoids and other chemical elements content in the fresh components. This method assures that the constituent compositions in equal masses of dried leaves are also equal thereby making secondary products standardization possible. This novel process is a product of labouratory investigations to determine the effect of different blanching methods on the constituents' quality retention of plant leaves when dried.

III. Kettle steam generator

This invention is the result of research investigations carried out to generate a process which would lead to the retention of fresh leaf constituents when the leaves Hibiscus Sabdariffa are dried. Blanching is known to have a very important effect to product quality by temperature and time: glue status of protoplasm will be swelled, condensed and separated to cut of cell membrane, create high permeability of cell membrane. So water vapor exists freely, drying more easily. Blanching also inactivates oxidative-reductive enzyme, activate chlorophyllase enzyme, increase organic acidity inside tissue, and better maintain green color of chlorophyll (Nguyen, 2014). Three blanching treatments were selected namely boil blanched water, steam blanching, and boil blanched water with Na_2CO_3.Roselle calyx (leaves) were sorted and washed with clean water. The leaves were weighted out equally in triplicate and each sprayed on muslin cloth. In one experiment one muslin cloth containing the fresh leaves was dipped in boiling clean water for two minutes. The other was dipped in boiling water/sodium carbonate solution for two minutes. The density of the room temperature water/sodium carbonate solution is 1.25 hydrometer reading. The third muslin bag of leaves was sprayed with steam at pressure of 2 bars for two minutes.

Table 2: Effect of blanching treatments on proximate and physiochemical composition of Hibiscus leaves powder

Blanching Treatments	Moisture	Crude fat	Total flavonoids (mg/100g)	Total anthocyanins (mg/100g)	Ash
Unblanched	5.6	3.2	388a ± 0.11	326a ± 0.12	8.7
Boil blanched	5.2	1.5	322b ± 0.16	298c ± 0.13	5.0
Boil blanched + Sodium bicarbonate	5.4	2.1	310b ± 0.12	282c ± 0.14	6.7
Steam blanched	5.0	1.9	369a ± 0.13	321b ± 0.11	5.9

Table 2 is the result showing the proximate values in terms of moisture content, crude fat and ash alongside the physiochemical properties where 'a' and 'b' are the redness and yellowness values. All samples were dried in cabinet tray dries at temperature of 80^0 C. similar results were achieved with solar drying at 56^0 C. The entire research investigations show that the process which retains flavonoids and anthocyanins in in Dry Roselle calyx is the steam blanching process with tray cabinet drying or solar drying at requisite temperatures.

The investigation led to the development of a Kettle Steam Generator to ensure that steam is supplied for blanching at a pressures equal to or less than 2 bars and temperature of 100^0 C. The Kettle Steam Generator is a stainless container of about 10 liters but could be constructed to any size. It is placed on the fire to generate steam and can be fired by any of the conventional fuels namely wood, coal, gas and electric. The important features are the inclusion of a spring loaded relief valve with pressure gauge set at 2 bar or any lesser value. Experimentations at steam pressures above 2 bars tend to cook the fresh leaves. Figure 1 is the schematic diagram of the Kettle Steam Generator showing the Pressure Control and Steam Discharge Valve to ensure set pressure and operational convenience. The materials of the contrivance are stainless steels. The Isometric and Exploded views of the contrivance as well as the Exploded views of the Pressure Control and Steam Discharge Valve are depicted in figure 2-5.

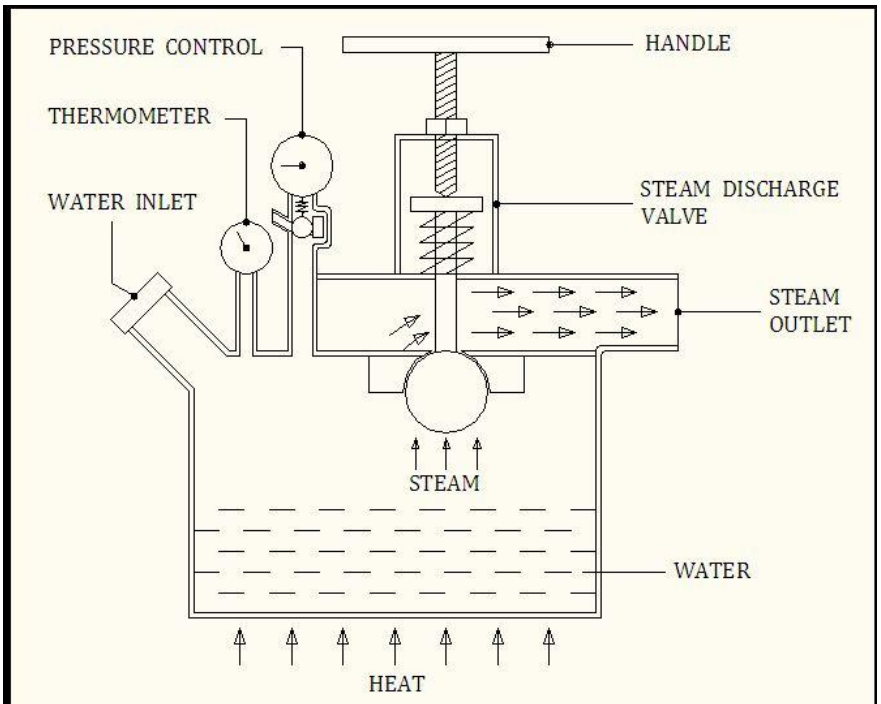

FIGURE 1: SCHEMATIC VIEW OF KETTLE STEAM GENERATOR

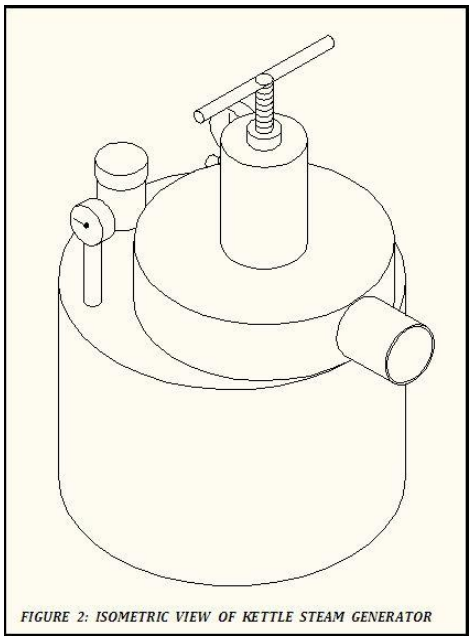

FIGURE 2: ISOMETRIC VIEW OF KETTLE STEAM GENERATOR

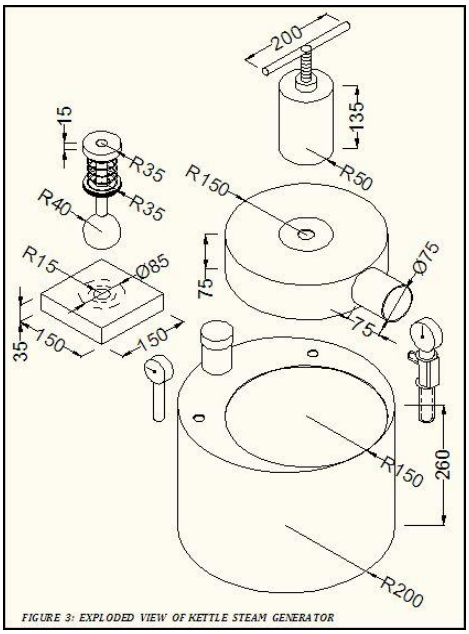

FIGURE 3: EXPLODED VIEW OF KETTLE STEAM GENERATOR

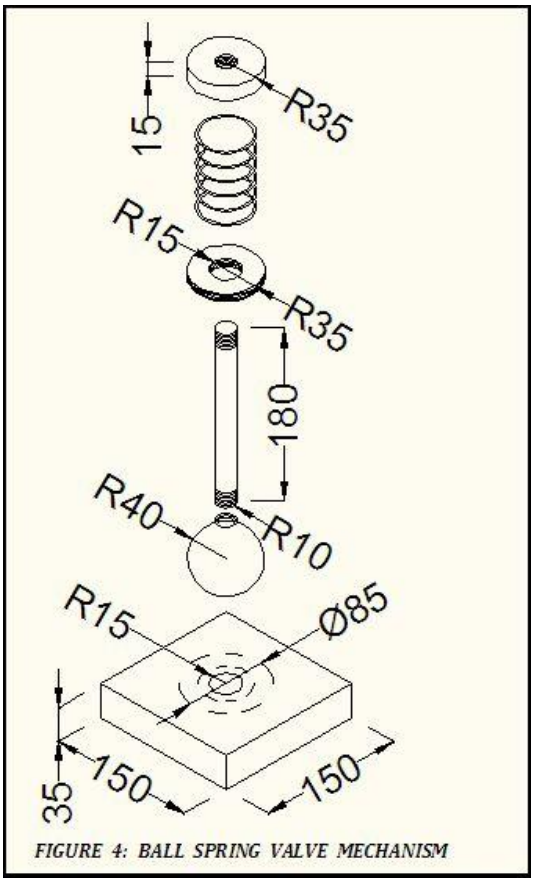

FIGURE 4: BALL SPRING VALVE MECHANISM

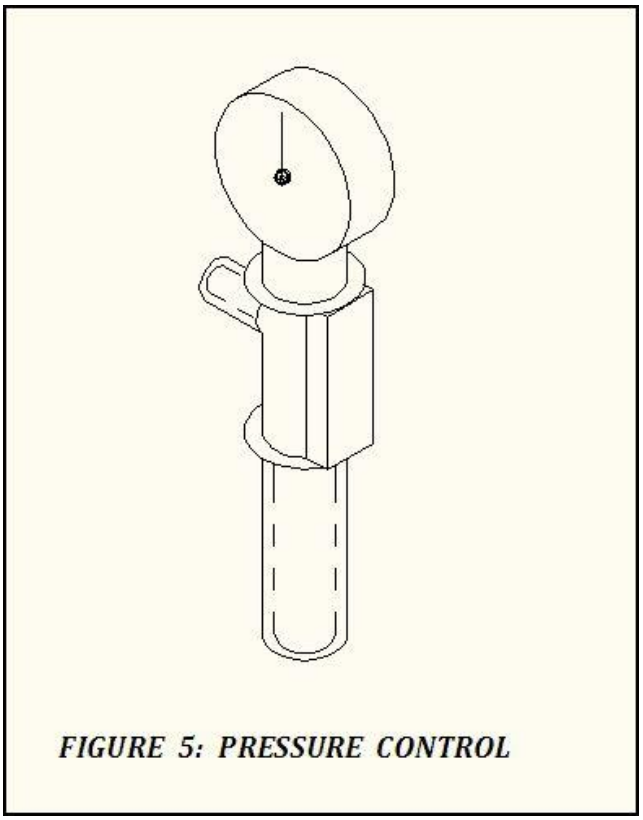

FIGURE 5: PRESSURE CONTROL

IV. Conclusion

It is recommended to maintain nutrient values of leaves through steam blanching at pressures below 200kPa. Manual steam blanching can be employed but a Kettle steam generator ensures regulated blanching at the requisite pressure. The Kettle Steam Generator is a stainless container of about 10 liters but could be constructed to any size. It is placed on the fire to generate steam and can be fired by any of the conventional fuels namely wood, coal, gas and electric. The important features are the inclusion of a spring loaded relief valve with pressure gauge set at 2 bar or any lesser value. The contrivance was patented in Nigeria in 2018 as a joint collaboration between the National Board foe Technology Incubation (NBTI) and Hydraulic equipment Development Institute, (HEDI), Kano with input from Agricultural and Bio-Resources Engineering, Ahmadu Bello University.

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