

Food and medicinal properties of hibiscus (*Hibiscus sabdariffa* & *Hibiscus rosa-sinensis*).

Propiedades alimentarias y medicinales del hibiscus (*Hibiscus sabdariffa* & *Hibiscus rosa-sinensis*).

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ABSTRACT

This study is based on the cultivation and scope of Hibiscus species, namely, Hibiscus rosa-Sinensis and Hibiscus sabdariffa. The objective was to find out the history of the production of Hibiscus, usage in different centuries, the most suitable regions for cultivation in India, various nutritive content, different health-related properties and benefits, new products that had been introduced, and abstract on what future may hold for the flowers. The study contains information on the antimicrobial, antioxidant, anti-cancerous properties along with several benefits like hypolipidemic effect, blood pressure-lowering effect, anti-diabetic activity, effect on lipid metabolism, antihypertensive effect, etc on the concerned flower. We have looked into the limitation of the flower, the need for urgent preservation methods to extend the shelf life of the product. As per our findings roselle leaves are used for their, antimicrobial, emollient, antipyretic, diuretic, anti-helminthic, sedative properties and as a soothing cough remedy.

Keywords: Hibiscus, Malvaceae, antimicrobial, hypo-lipidemic, candies, roselle, mesta.

RESUMEN

Este estudio se basa en el cultivo y alcance de las especies de Hibiscus, a saber, Hibiscus rosa-Sinensis e Hibiscus sabdariffa. El objetivo era averiguar la historia de la producción de hibisco, el uso en diferentes siglos, las regiones más adecuadas para el cultivo en la India, varios contenidos nutritivos, diferentes propiedades y beneficios relacionados con la salud, nuevos productos que se habían introducido y resumen sobre qué futuro puede depararles a las flores. El estudio contiene información sobre las propiedades

antimicrobianas, antioxidantes y anticancerígenas junto con varios beneficios como el efecto hipolipemiante, el efecto reductor de la presión arterial, la actividad antidiabética, el efecto sobre el metabolismo de los lípidos, el efecto antihipertensivo, etc. en la flor en cuestión. Hemos investigado la limitación de la flor, la necesidad de métodos de conservación urgentes para prolongar la vida útil del producto. Según nuestros hallazgos, las hojas de jamaica se utilizan por sus propiedades antimicrobianas, emolientes, antipiréticas, diuréticas, antihelmínticas, sedantes y como remedio calmante para la tos.

Palabras clave: Hibiscus, Malvaceae, antimicrobiano, hipolipemiante, caramelos, jamaica, mesta.

INTRODUCTION

Plants and plant products have been the subject of increased research in recent years. Plants with some historic therapeutic uses are being investigated more thoroughly in this area in order to be considered as a replacement or better alternative for chemical-based food preservatives. Plants are also a great source of natural inhibitors, and they can be used in the food industry as dietary supplements or as a natural inhibitor to protect the quality and extend the shelf life of goods. (Tiwari et. al., 2009).

Traditionally, various plants and their products have been used in foods as a natural preservative, flavoring ingredient, and as a treatment for a variety of human illnesses. Their antibacterial properties are primarily responsible for this property of action. Natural plant-derived antimicrobials are frequently particularly efficient in lowering antibiotic reliance, minimizing the likelihood of antibiotic resistance in foodborne infections, and facilitating dominant cross-contamination by foodborne pathogens (Voon et al. 2012)

Hibiscus is a blooming plant that belongs to the Malvaceae family. The genus is large, with hundreds of species native to temperate, semitropical, and tropical climates around the world. Member species are notable for their enormous, beautiful flowers, and are frequently referred to as "hibiscus" or "rose mallow," respectively. Several species, including *Hibiscus syriacus* and *Hibiscus rosa-sinensis*, are frequently cultivated as decorative plants. Hibiscus has a total of 679 species worldwide. *Hibiscus rosa-sinensis* and *Hibiscus sabdariffa* are the two most important species. Hibiscus plants defend themselves against radical violet exposure by manufacturing antioxidative phenolic resin compounds and flavonoids in plant tissues.

The Malvaceae family includes *Hibiscus sabdariffa*, sometimes known as "red sorrel" or "roselle." It is a well-known, safe medicinal plant with over 300 species found in tropical and subtropical locations like India, Saudi Arabia, Malaysia, Indonesia, Thailand, Philippines, Vietnam, Sudan, Egypt, and Mexico are among the countries involved. (Mohagheghi. M., et. al., 2005). Roselle blooms are mostly grown for human use, with Egypt, Sudan, Mexico, Thailand, and China being the top producers. Organic acids such as citric, malic, tartaric, and allo-hydroxy citric acids are abundant in roselle. Beta carotene, vitamin C, protein, and total sugar are all found in the plant (Mady, C. et. al., 2009). Roselle is well-known for its nutritional and therapeutic benefits, as it contains a variety of medically essential substances known as phytochemicals. Many parts of the Roselle plant, including seeds, leaves, fruits, and roots, are utilized in cuisine and herbal medicine as a non-pharmacological therapeutic option. Roselle extracts are used to treat a wide range of medical problems, including heart disease, helminthic disease, and cancer. The plant is also an antioxidant and is used to treat obesity.

In the ancient Indian *Hibiscus, rosa-ainensis* has been reported medicinal literature with a beneficial effect in heart disease (Ames, B.N., 1998). In recent times both experimental and clinical studies have shown that the dried powder of HRS has significant effectiveness against ischemic heart disease(IHD). In respect to the present knowledge of the physiology of IHD, the exact mechanism of its cardioprotective effects is not well investigated. In India Pink-Red Hibiscus rosa-Sinensis are very common. Hibiscus flower preparations are used for hair care. In Pacific Island, the flowers themselves are edible and are used in salads. In India, these flowers are used to shine shoes. It is also a pH indicator. China rose indicator turns basic solutions to green and acidic solutions to magenta/dark pink. Hibiscus rosa-Sinensis is also employed in Goddess worship, and the red species, in particular, plays a key role in tantra. Hibiscus rosa-Sinensis are called "kembang sepatu", in Indonesia which means "shoe flower". In Chinese herbology, it is considered to have several medical uses.

CULTIVATION IN INDIA

Mesta (*Hibiscus sabdariffa*) is cultivated in an area of about 1.5 lakh hectare. The crop has an average national productivity of 11q/ha. According to CRIJAF, its productivity has increased two folds since independence, despite facing tough competition from cheaper synthetic fibers. It is one of the important bast fiber crops which stand next to jute in

production. At the time of partition, India had to lose about 80% of the total jute production area. A particular set of climatic conditions is necessary for the production of jute crop, hence, the cultivation of jute could not be extended beyond the states of West Bengal, Assam, Bihar, Orissa, U.P., and Tripura. Consequently, the production of jute fell below the requirement of mills. Still, Mesta can be grown even in those areas where jute is not grown under wider soil and climate conditions with less care. This helped the country to inflate more area under Mesta.

In India, it is grown in larger parts covering areas from Karnataka to Tripura including Maharashtra, Andhra Pradesh, West Bengal, Bihar, Orissa, and Meghalaya. In Meghalaya and Tripura, it is grown in highlands either as a pure crop or in a mixture of rice. In Bihar and West Bengal, it is grown in sandy to sandy loam marginal lands. It is grown in the hilly districts of Koraput and Kalahandi, in Orissa. Andhra Pradesh has the maximum area under Mesta in India.

COMPOSITIONS

Roselle or Mesta (*Hibiscus sabdariffa*) is mainly cultivated for its calyx, which is of three types: green, red, and dark red (Naturland e.V Organic Farming in Tropics and Subtropics Exemplary Description of 20 Crops, 2004). The red calyxes are mostly used and are characterized by their anthocyanin concentration. Delphinidin 3-Sambubioside and Cyanidin3-Sambubioside are the major anthocyanins. *Hibiscus sabdariffa* is also rich in organic acids, minerals, amino acids, carotene, vitamin C, and total sugar in its calyx, leaves, and seeds at variable levels depending on the geographical area and the variety. According to a study by Manita–Mishra in 1992, many compounds have also been isolated and characterized from Roselle including flavonoids, anthocyanidins, triterpenoids, steroids, and alkaloids. Nutrient contents per 100 gram of different parts of *Hibiscus sabdariffa* are clearly stated in Table 1.

Table 1: Nutritional Composition

Nutrients	Calyxes	Seeds	Leaves
Protein(g)	2	28.9	3.5
Carbohydrate(g)	10.2	25.5	8.7
Fat(g)	0.1	21.4	0.3
Vitamin A (I.E)	-	-	1000
Thiamine(mg)	0.05	0.1	0.2
Riboflavin(mg)	0.07	0.15	0.4
Niacin(mg)	0.06	1.5	1.4
Vitamin C (mg)	17	9	2.3
Calcium(mg)	150	350	240
Iron(mg)	3	9	5

PRODUCTION OF MESTA (*Hibiscus sabdariffa*) FROM FY 2014 TO FY 2019 IN INDIA

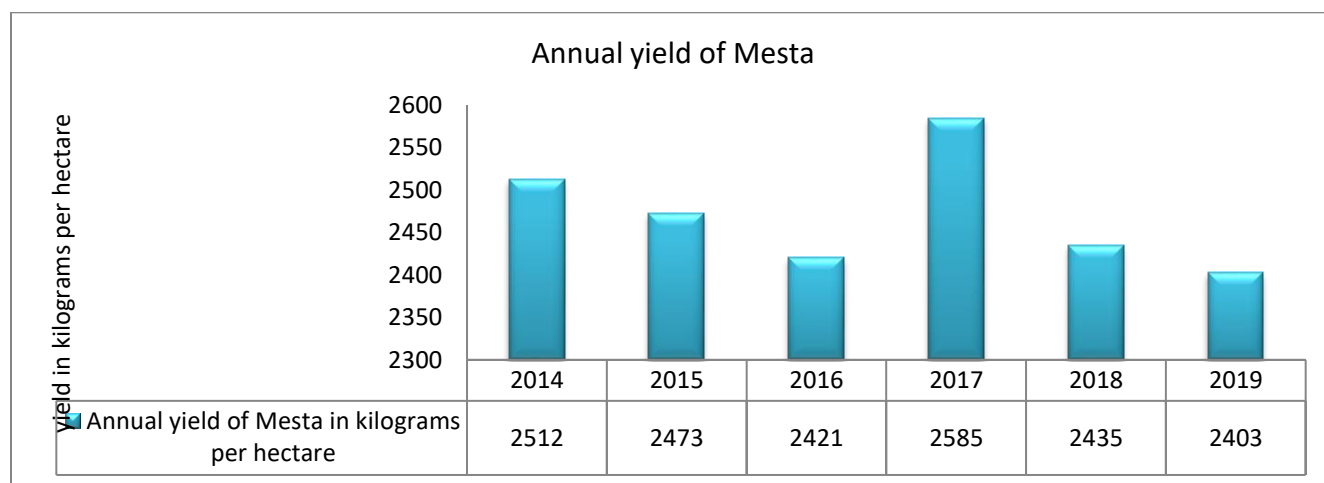


Fig 1: 2014-2019 production of mesta⁷(Statista Research Department, 2020)

DIFFERENT MEDICINAL PROPERTIES

Roselle is well-known for its antibacterial, antifungal, and anti-parasitic actions. Oil extracted from seeds of Roselle has been shown to have an in vitro inhibitory effect on *Bacillus anthracis* and *Staphylococcus albus* (Gangrade, H. et. al., 1979). Schistosomamansoni and other bacteria were also shown to be resistant to aqueous and ethanol extracts. The antibacterial action of hibiscus extract against *Streptococcus mutans*, an oral cavity bacterium, was demonstrated by Afolabi, O.C., 2008. Antibacterial potential of

hibiscus was also observed on *Campylobacter* species, in similar studies. Aflatoxin formation gets reduced by an ethanol extract of the dried leaves of Roselle and has an in-vitro inhibitory effect against some fungi (El-Shayeb, N.M. and Mabrook, S.S., 1984).

Antimicrobial properties: Roselle is commonly used to cure a variety of ailments. Olaleye (Olaleye, M.T., 2007) used the aqueous methanolic extract of Roselle and reported that the extract contained cardiac glycosides, flavonoids, saponins, and alkaloids. It exhibited antibacterial activities against *Staphylococcus aureus*, *Bacillus stearothermophilus*, *Micrococcus luteus*, *Serratia marcescens*, *Clostridium sporogenes*, *Escherichia coli*, *Klebsiella pneumoniae*, *Bacillus cereus*, *Pseudomonas fluorescens*. The findings supported traditional medicine's usage of the Roselle plant to treat abscesses, biliary disorders, cancer, and coughs, as well as the prospect of isolating antibacterial and anticancer compounds when testing antimicrobial activity against *Escherichia coli* O157:H7. Fullerton (Fullerton, M. et al., 2011) found that Roselle extract was effective against *Salmonella enterica* and *Listeria monocytogenes* isolated from food, veterinary, and clinical samples, suggesting that extracts could be used as potential antimicrobials in foods. The bactericidal activities of Roselle calyx aqueous and ethanol extracts, as well as protocatechuic acid, on *Salmonella Typhimurium* DT104, *E. coli* O157:H7, *Listeria monocytogenes*, *Staphylococcus aureus*, and *Bacillus cereus* were estimated by Chau, et al. in 2008 and shown that the inhibitory activity in dose-dependent behavior against test bacteria in ground beef and apple juice and suggested that it might be potent agents as food additives for preventing contamination from those bacteria.

Antioxidant properties: Roselle-Hibiscus anthocyanins (HAs), a group of natural pigments present in the dried calyx, were discovered to have antioxidant activity and liver-protecting qualities. HA antioxidant bioactivity in rat primary hepatocytes and hepatotoxicity was studied by Wang, C.J. et. al., in the year 2000. The results revealed that HA's, at the concentrations of 0.10 mg/ml and 0.20 mg/ml, significantly decreased the leakage of lactate dehydrogenase and the formation of malondialdehyde and the serum levels of hepatic enzyme markers (alanine and aspartate aminotransferase) decreased and reduced oxidative liver damage. The antioxidative activity was also reported in cancerous cell lines (Akim, A. et. al., 2011). McKay et. al., in the year 2010, reported in their animal models that extract of Roselle's calyces have demonstrated hypocholesterolemia and antihypertensive properties. The antioxidant potential of three fractions of the ethanol crude extract discovered in the dried flowers (HS-C: chloroform soluble fraction; HS-E: ethyl acetate soluble fraction; HS-R: residual fraction) were assessed for their ability to quench

free radicals and inhibit xanthine oxidase (XO) activity (Tseng, T.H. et. al., 1997). HS-E had the best ability to scavenge free radicals, while HS-C had the most potent inhibitory effect on XO activity. Furthermore, antioxidant bioactivities of these crude extracts were investigated on rat primary hepatocytes. Unscheduled DNA Synthesis was found to be strongly inhibited by all portions (UDS). According to these findings, dried floral extracts (HS-C and HS-E) protect rat hepatocytes from t-BHP-induced cytotoxicity and genotoxicity. Lactate Dehydrogenase (LDH), Glutamate Oxalate Transaminase (GOT), Glutamate Pyruvate Transaminase (GPT), and Malondialdehyde (MDA) levels were greatly elevated, while Superoxide Dismutase (SOD) and Glutathione levels were significantly lowered. The effects of hepatoprotective and antioxidant compounds on carbon tetrachloride (CCl₄)-induced liver damage were investigated (Yin, G. et. al., 2011).

Anti-cancerous properties: In 2011, Akim, A. et al. investigated the antiproliferative properties of Roselle juice using ovarian (Caov-3), breast (MCF-7, MDA-MB-231), and cervical (HeLa) cancer cell lines and discovered that it had the greatest antiproliferative capability against MCF-7 cancer cells. The effects of Roselle-anthocyanins (HA) on human cancer cells (HL-60) were investigated, and apoptosis of cells was seen in a dose and time-dependent way (Chang, Y.C. et. al., 2005). In 2005, Hou, D. et al. found that anthocyanin-induced apoptosis of leukemia cells was mediated by reactive oxygen species-mediated mitochondrial pathways. PCA, a phenolic compound isolated from the dried flower, was reported to reduce retinoblastoma phosphorylation and downregulate Bcl-2 protein expression, causing apoptosis in human promyelocytic leukaemia (HL-60) in a concentration and time-dependent manner (Tseng, T.H. et. al., 2000). The study revealed that cells underwent intramucosal DNA fragmentation and morphological changes characteristics of apoptosis while the action against gastric carcinoma cells by inducing apoptosis was through JNK/MAPK signaling pathways (Lin, H. et. al., 2007). The methanolic extract of Roselle on seven cancer lines implied the AGS cancer cells being most susceptible in concentration-dependent form affecting both the intrinsic and extrinsic apoptotic routes (Lin, H. et. al., 2005). Mohamed, R. et. al., in 2005, reported that the antioxidant potential of Roselle (*Hibiscus sabdariffa* L.) extracts was studied. Different plant organs, including seeds, stems, leaves, and sepals, were analyzed concerning their water-soluble antioxidant capacity, lipid-soluble antioxidant capacity, and tocopherol content. The Roselle plant's seeds are abundant in lipid-soluble antioxidants, especially -tocopherol. Its seed oil was extracted and analysed, yielding the following physicochemical results: acidity of 2.24 percent, peroxide index of 8.63 meq/kg, and extinction coefficients of 3.19 and 1.46 at 232 (k₂₃₂) and 270 (k₂₇₀), respectively. 15.53 hours of oxidative stability; 1.477 refractive index; 0.92 kg/L density;

and 15.9 cP viscosity Roselle seed oil is classified as linoleic/oleic, with the most prevalent fatty acids being C18:2 (40.1%), C18:1 (28%), C16:0 (20%), C18:0 (5.3%), and C19:1 (1.7 percent). -sitosterol (71.9%), campesterol (13.6%), -5-avenasterol (5.9%), cholesterol (1.35%), and clerosterol (1.35%) are all sterols (0.6 percent). Total tocopherols, comprising -tocopherol (25 percent), -tocopherol (74.5 percent), and -tocopherol (74.5 percent), were found at an average concentration of 2000 mg/kg (0.5 percent). Roselle seed oil's overall qualities imply that it could have significant industrial applications, in addition to the traditional usage of Roselle sepals in the preparation of karkade drink.

HEALTH BENEFITS OF HIBISCUS

Roselle is used in many folk medicines. Its mild laxative action, capacity to stimulate urine, relief during hot weather, and treatment of cracks in the feet, bilious, blisters, and wounds have all made it popular. Roselle has been used to cure sour throats and sores in Sudan for ages. In African folk medicine, Roselle leaves are used for their, antimicrobial, emollient, antipyretic, diuretic, anti-helminthic, sedative properties and as a soothing cough remedy, whereas in India, leaves are poultice on abscesses.

Hypolipidemic effects: Two capsules of Roselle extract (1g) administered three times a day (for a total of 3g/day) dramatically reduced blood cholesterol in hypercholesterolemic patients, according to a study (Lin, Tzu-Li. Et. al., 2007) Another scientific study found that an ethanolic extract from Roselle leaves has a substantial hypolipidemic impact. Roselle extract was also evaluated in a group of people who had and didn't have metabolic syndrome. The ethanolic extract of Roselle dramatically lowered hyperglycemia, total cholesterol, and low-density lipoprotein while raising high-density lipoprotein in metabolic syndrome patients.

Blood pressure lowering effect: The effectiveness of an aqueous extract of Roselle on mild to moderate hypertension was investigated in many types of research. Aqueous extract of Roselle was as effective as captopril in treating mild to moderate hypertension and there is no adverse effect with the treatment, confirming the effectiveness and safety of the extract (Herrera-Arellano, A. et. al., 2007) Even though the possible mechanism(s) of action of Roselle extract is not investigated, daily consumption of an aqueous Roselle extract resulted in a decrease in systolic and diastolic blood pressure (Haji-Faraji & Haji-Tarkhani 1999).

Anti-diabetic activity: 27 The polyphenolic components of Roselle were extracted and their effects were examined in a type II diabetic rat model (high-fat diet model). Studies revealed anti-insulin resistance properties of extract at a dose level of 200mg/kilogram and reduction in hyperglycemia and hyperinsulinemia. The extract was found effective in lowering serum cholesterol, triacylglycerol, the ratio of low-density lipoprotein/high-density protein (LDL/HDL), and also (AGE) formation and lipid peroxidation. Intestinal α -glycosidase and pancreatic α -amylase help in the digestion of complex carbohydrates present in the food into bioavailable monosaccharide and plays an important role in postprandial hyperglycemia; As a result, inhibiting these enzymes has been suggested as a viable method for controlling postprandial hyperglycemia. Hibiscus acid (hibiscus-type (2S,3R)-hydroxy citric acid lactone) has been demonstrated to be a powerful inhibitor of pancreatic-amylase and intestinal-glucosidase activity, as well as pancreatic-amylase activity (Yamada, T. et. al., 2000). In another study, conducted an in vitro study and reported Roselle extracts as an effective inhibitor of pancreatic α -amylase (Adisakwattana, S. et. al., 2012).

Effect on lipid metabolism: The effect of Roselle on lipid profile, creatinine, and serum electrolytes was studied in hypertensive patients, and it was found that the increased trend of total cholesterol and High-Density Lipid (HDL) is noteworthy, as HDL-Cholesterol is a preventive factor for coronary heart disease. The changes in urine in normal patients after consuming Roselle juice in various concentrations and durations reported a decrease in creatinine, uric acid, citrate, tartrate, sodium, calcium, phosphate, and potassium, but not oxalate in urinary excretion, which may aid in the treatment and prevention of renal stone disease.

Antihypertensive effect: Hypertension is currently recognized as a global health problem since it is linked to the development of cerebrovascular disorders, heart ischemia, and cardiac and renal failure. In 1999, Haji-Faraji & Haji-Tarkhani reported that the efficacy of the aqueous extract in hypertensive people revealed a substantial reduction in systolic and diastolic pressure differences when compared to the control group. Another study found that while systolic pressure decreased significantly, diastolic pressure remained the same. Rat studies were also carried out, and the results backed up the prevalent idea that Roselle extract contained antihypertensive components. (Onyenekwe, P.C. et. al., 1999). The anthocyanins extract was tested in humans for therapeutic efficacy, safety, and tolerability alongside the antihypertensive drug captopril (Odigie, I.P. et al., 2003) and lisinopril. The results were similar, implying that the synergistic mechanism of diuretic and ACE inhibition

results in hypotensive effects (Herrera-Arellano, A. et. al., 2004; Herrera-Arellano, A. et. al., 2007)

Other uses of Roselle/Mesta: A strong fiber obtained from the stem (called rosella hemp) is used for various household purposes including making sackcloth, twine, and cord. A yellow dye was obtained from the petals of the flowers. The Roselle seed has 20% oil content.

Use as domestic animal's food for medicinal effect: Animal studies were identified in a few places. Roselle extract as acidifiers has been reported to boost trypsin activity, improve feed conversion ratio (FCR), and fat digestibility in post-weaning pigs (Aphirakchatsakun, W. et. al., 2008). The effect of Roselle calyx in layer diets on egg production, egg quality, and Thiobarbituric Acid Reactive Substances (TBARS) value in plasma and yolk was investigated to see if lipid peroxidation as a result of fat breakdown was occurring. The amount of time extract was stored was revealed to be a key factor in lowering egg quality and increasing TBARS levels in the yolk. (S. Sukkhavanit et al., 2011)

VALUE ADDED FOOD PRODUCTS FROM HIBISCUS

Hibiscus Tea: Hibiscus tea is a caffeine-free herbal tea brewed from the dried fruit section of the Roselle called the calyx, which comes from a specific variety of hibiscus called *Hibiscus sabdarrifa*. It's crimson and has a berry flavor (Dafallah & Al-Mustafa, 1996). It is well-known in Africa, America, Europe, and Southeast Asia. The use of Roselle tea to lower blood pressure and cholesterol and prevent cardiovascular disease is the most scientifically supported claim. Other less-studied health advantages of Roselle tea include aiding digestion, improving immunity, acting as an anti-inflammatory agent, and decreasing cancer risk. Roselle tea is also high in vitamin C, minerals, and antioxidants, and it can aid with hypertension and anxiety treatment. Roselle tea is created by steeping portions of the hibiscus plant, particularly the calyx, in boiling water. It has a red color and a sweet and tangy flavor that is similar to cranberries. Like most other teas, it can be consumed hot or cold depending on your preferences (Rao, P.U., 1996).

Candies: Candy is a sweet food made from fruits or vegetables that have been impregnated with sugar syrup, then drained of surplus syrup and dried to a shelf-stable form. Apples, ginger, mangoes, guava, carrots, and citrus peels have all been utilized in the making of sweets (Mehta and Bajaj 1984). The watery extract of hibiscus flowers is made

by boiling them in water and then using it to make hibiscus candy. After that, cooked or caramelized sugar, pectin, and citric acid should be added and heated once more. The gum acacia should then be molded and kept in the refrigerator.

Limitation for application in food: Although the popularity of beverage from hibiscus sabdariffa is increasing, one of its greatest limitations for large-scale production is that it has a very short shelf life of 24hrs if not refrigerates (40). Therefore, there is an urgent need to explore various preservation methods that could be employed to extend the shelf life of this product.

Future Approach: Among the properties reported to date, its effect on lipid metabolism, antihypertensive action, and apoptosis are largely studied. Some studies on its antimicrobial effects were also documented. The calyx of Roselle is rich in citric acid and pectin and so is useful for making jams, jellies, etc. It is also used to add a red color and flavor to herb drinks and could be roasted and used as a coffee substitute. It is found as an aromatic, astringent, cooling herb that is much used in Tropics. The leaves found antiscorbutic, emollient, diuretic, refrigerant, and sedative. The plant also reported being antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, purgative, and resolvent. It is used as a folk remedy in the treatment of abscesses, bilious conditions, cancer, cough, debility, dyspepsia, dysuria, fever, hangover, heart ailments, hypertension, neurosis, scurvy, and strangury. Therefore, with much enriching chemical-biological knowledge from animal and human models using plant extracts, future studies with greater scientific robustness in terms of standardization of dose for its effectiveness, safety and tolerability will permit the formulation of safe, effective therapeutic herbal formulations which can be used as an acceptable source for curing many food and health issues and restoring general health.

CONCLUSIONS

There have been numerous Roselle crop types produced, released, and used for commercial cultivation by farmers. All of the leaves and calyces of those types have both edible and therapeutic properties. The most popular calyces are the fleshy red ones. They are used fresh in the production of wine, juice, jam, jelly, syrup, gelatin, pudding, cakes, ice cream, and flavours, as well as dried and brewed into tea, spice, and butter, pies, sauces, tarts, and other desserts. The roasted seeds can be used in place of coffee. Although the young root is edible, it is extremely fibrous. Roselle is a tropical herb that is fragrant, astringent, and cooling. Antiscorbutic, emollient, diuretic, refrigerant, and sedative are all properties of the leaves. The fruits have antiscorbutic properties. Gossypetin, anthocyanin, and glycoside hibiscus are all found in the blooms. These substances may have diuretic and

choleric properties, lowering blood viscosity, lowering blood pressure, and promoting intestinal peristalsis. The diuretic and antiscorbutic properties of ripe calyces are well-known. Antiseptic, aphrodisiac, astringent, cholagogue, demulcent, digestive, purgative, and resolvent properties have also been described for the plant. It has the potential to lower cancer risk. As a result, Roselle leaves, fleshy red calyces, and roots are vital to human nourishment and health care. Controlled research will be required in the future to demonstrate the efficacy of different portions of Roselle under varied settings.

REFERENCES

- Adisakwattana, S., Ruengsamran, T., Kampa, P., Sompong, W., (2012). In vitro inhibitory effects of plant-based foods and their combinations on intestinal α -glucosidase and pancreatic α -amylase. *BMC Complementary and Alternative Medicine*;12(1):110.
- Afolabi, O.C., Ogunsola, F.T., Coker, A.O. (2008) Susceptibility of cariogenic *Streptococcus mutans* to extracts of *Garcinia kola*, *Hibiscus sabdariffa*, and *Solanum americanum*. *The West African Journal of Medicine*;27(4):230–233.
- Ames, B.N. (1998) Micronutrient prevents cancer and delay ageing. *Toxicology Letter* 102-103, 5-18.
- Akim, A., M. Lim, C.H., Rahmat, A., Zakaria, Z.A. (2011). Antioxidant and anti-proliferative activities of Roselle juice on Caov-3, MCF-7, MDA-MB-231 and Hela cancer cell lines. *African Journal of Pharmacy and Pharmacology*;5(7):957-65.
- Aphirakchatsakun W, Angkhanaporn, K., Kijparkorn, S. (2008). The effect of Roselle (*Hibiscus sabdariffa* Linn.) calyx as antioxidant and acidifier on growth performance in postweaning pigs. *Asian Australasian Journal of Animal Sciences*;21(4):574-81.
- Chang, Y.C., Huang, H-P, Hsu, J.D., Yangm S-F., Wang, C.J. (2005). *Hibiscus anthocyanins* rich extract induced apoptotic cell death in human promyelocytic leukemia cells. *Toxicology and Applied Pharmacology*; 205(3): 201-212.
- Chao, C., Yin, M. (2008) Antibacterial Effects of Roselle Calyx Extracts and protocatechuic Acid in Ground Beef and Apple Juice. *Foodborne Pathogen and Diseases*;6(2):201-208

- Dafallah, A.A., Al-Mustafa, Z. (1996). Investigation of the anti-inflammatory activity of *Acacia nilotica* and *Hibiscus sabdariffa*. *The American Journal of Chinese Medicine*; 24(3-4):263-9.
- El-Shayeb, N.M., Mabrook, S.S. (1984) Utilization of some edible and medicinal plants to inhibit aflatoxin formation. *Nutrition Reports International*; 29:273–282.
- Fullerton, M., Khatiwada, J., Johnson, J.U., David, S., William, L.L. (2011). Determination of antimicrobial activity of sorrel (*Hibiscus sabdariffa*) on *E. coli* O157:H7 isolated from food, veterinary and clinical samples. *Journal of Medicinal Food*; 14(9): 950-956.
- Gangrade, H., Mishra, S.H., Kaushal, R. (1979) Antimicrobial activity of the oil and unsaponifiable matter of red roselle. *Indian Drugs*; 16(7):147–148.
- Haji-Faraji, M., Haji-Tarkhani, A. (1999). The effect of sour tea (*Hibiscus sabdariffa*) on essential hypertension. *Journal of Ethnopharmacology*; 65(3):231–236
- Hansawasdi, C., Kawabata, J., Kasai, T. (2000). Alpha-amylase inhibitors from roselle (*Hibiscus sabdariffa* Linn.) tea. *Bioscience Biotechnology and Biochemistry*; 64(5): 1041–1043.
- Herrera-Arellano, A., Flores-Romero, S., Chávez-Soto, M.A., Tortoriello, J. (2004). Effectiveness and tolerability of a standardized extract from *Hibiscus sabdariffa* in patients with mild moderate hypertension: a controlled and randomized clinical trial. *Phytomedicine*; 11(5):375-82.
- Herrera-Arellano, A., Miranda-Sanchez, J., Avila-Castro, P., Herrera Alvarez, S., Jimenez-Ferrer, J.E., Zamilpa, A., Roman-Ramos, R., Ponce-Monter, H., Tortoriello, J. (2007). Clinical effects produced by a standardized herbal medical product of *Hibiscus sabdariffa* on patients with hypertension. A randomized, double-blind, lisinopril-controlled clinical trial. *Planta Medica*; 73(1):06-12.
- Hou, D., Tong, X., Terahara, N., Luo, D., Fujii, M. (2005). Dephinidin 3-sambubioside, a *Hibiscus* anthocyanin, induces apoptosis in human leukemia cells through reactive oxygen species-mediated mitochondrial pathway. *Archives of Biochemistry and Biophysics* 440(1): 101-109.
- Lin, H-H., Chen J-H., Kuo W-H., Wang C-J. (2007). Chemopreventive properties of *Hibiscus sabdariffa* L. on human gastric carcinoma cells through apoptosis induction and JNK/p38 MAPK signaling activation. *Chemical-biological Interactions*; 165(1):59-75

- Lin, H-H., Huang H-P., Huang C-C., Chen J-H., Wang C-J. (2005). *Hibiscus* polyphenol rich extract induces apoptosis in human gastric carcinoma cells via p53 phosphorylation and p38 MAPK/FasL cascade pathway. *Molecular Carcinogenesis*; 43(2):86-99
- Lin T-Li, Lin H-H., Chen C-C., Lin, M-C., Chou, M-C., Wang, C-J. (2007). *Hibiscus sabdariffa* extract reduces serum cholesterol in men and women. *Nutrition Research*; 27(3):140-145.
- Mady, C., Dornier, M., Sakho, M., Ndiaye, A., Reynes, M., Sock, O. (2009). The bissap (*Hibiscus sabdariffa* L.): composition and principal uses. *Fruits*. 2009; 64:179-193
- Manita-Mishr. (1999). Chemistry and Pharmacology of some *Hibiscus* sp. *Annual Review Journal of Medicine & Aromatic Plants Sciences*; 21(4):1169-1186.
- Mckay, D.L., Chen, C.Y., Saltzman, E., Blumberg, J.B. (2010). *Hibiscus sabdariffa* L. tea (tisane) lowers blood pressure in prehypertensive and mildly hypertensive adults. *The Journal of Nutrition*; 140(2):298-303.
- Mohamed, R., Fernandez, J., Pineda, M., Aguilar, M. (2007). Roselle (*Hibiscus sabdariffa*) Seed Oil Is a Rich Source of γ -Tocopherol. *Journal of Food Sciences*; 72(3): 207-211.
- Mohagheghi, A., Maghsoud, S., Khashayar, P., Ghazi-Khansari, M. (2011). The effect of *Hibiscus sabdariffa* on lipid profile, creatinine, and serum electrolytes: a randomized clinical trial. *International scholarly research network. ISRN Gastroenterology*; 2011: 1-4.
- Naturland, E.V. (2004). *Organic Farming in Tropics and Subtropics Exemplary Description of 20 Crops*. 1st Ed, Germany, 2004. P.1-22 Published by Statista Research Department, Oct 16'2020.
- Odigie, I.P., Ettarh, R.R., Adigun, S.A. (2003). Chronic administration of aqueous extract of *Hibiscus sabdariffa* attenuates hypertension and reverses cardiac hypertrophy in 2K-1 hypertensive rats. *Journal of Ethnopharmacology*; 86(2-3):181-5.
- Olaleye, M.T. (2007). Cytotoxicity and antibacterial activity of methanolic extract of *Hibiscus sabdariffa*. *Journal of Medicinal Plant Research*; 1(1):09-13.
- Omenu, A.M., Edema, M.O., Atayese, A.O., Obadina, A.O. (2006). A survey of the microflora of *Hibiscus sabdariffa* (Roselle) and resulting zobo juice. *African Journal of Biotechnology* 5(3):254-259.

- Onyenekwe, P.C., Ajani, E.O., Ameh, D.A., Gamaniel, K.S. (1999). Antihypertensive effect of roselle (*Hibiscus sabdariffa*) calyx infusion in spontaneously hypertensive rats and a comparison of its toxicity with that in Wistar rats. *Cell Biochemistry and Function*; 17(3):199-206.
- Rao, P.U. (1996). Nutrient composition and biological evaluation of mesta (*Hibiscus sabdariffa*) seeds. *Plant Foods for Human Nutrition*; 49(1):27-34.
- Robert, S.M. (2005). Roselle production: Botanical description.
- Sukkhavanit, P., Angkaporn, K., Kijparkorn, S. (2011). Effect of Roselle (*Hibiscus sabdariffa* Linn.) calyx in laying hen diet on egg production performance, egg quality and TBARS value in plasma and yolk. *Thai Journal of Veterinary Medicine*;41(3):337-44
- Tseng, T.H., Kao, E.S., Chu, C.Y., Chou, F.P., Lin, W.H.W., Wang, C.J. (1997). Protective effects of dried flower extracts of *Hibiscus sabdariffa* L. against oxidative stress in rat primary hepatocytes. *Food Chemical and Toxicology*; 35(12):1159-64.
- Tseng, T.H., Kao, T.W., Chu, C.Y., Chou, F.P., Lin, W.L., Wang, C.J. (2000). Induction of apoptosis by Hibiscus protocatechuic acid in human leukemia cells via reduction of retinoblastoma (RB) phosphorylation and Bcl-2 expression. *Biochemical Pharmacology*; 60(3): 307-315
- Wang, C.J., Wang, J.M., Lin, W.L., Chu, C.Y., Chou, F.P., Tseng, T.H. (2000). Protective effects of *Hibiscus* anthocyanins against tert-butyl hydroperoxide-induced hepatic toxicity in rats. *Food and Chemical Toxicology*; 38(5): 411-416.
- Yamada, T., Hida, H., Yamada, Y. (2007). Chemistry, physiological properties, and microbial production of hydroxycitric acid. *Applied Microbiology and Biotechnology*; 75(5): 977-982
- Yin, G., Cao, L., Xu, P., Jeney, G., Nakao, M. (2011). Hepatoprotective and antioxidant effects of *Hibiscus sabdariffa* extract against carbon tetrachloride-induced hepatocyte damage in *Cyprinus carpio*. *In Vitro Cellular and Developmental Biology. Animal*. 2011;47(1):10-5.