Seminar report

TROPICAL VEGETABLES: NEW ROLE AS INDUSTRIAL RAW MATERIAL

By

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DECLARATION

I, Alphy Mathew (2018-12-001) hereby declare that the seminar entitled 'Tropical vegetables: New role as industrial raw material' has been prepared by me, after going through various references cited at the end and has not copied from any of my fellow students.

Vellanikkara — Alphy Mathew

25/01/2020 — 2018-12-001

CERTIFICATE

This is to certify that the seminar report entitled 'Tropical vegetables: New role as industrial raw material' has been solely prepared by Alphy Mathew (2018-12-001) under my guidance and has not been copied from fellow students.

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1. Introduction

Vegetables are parts of plants that are consumed by humans or other animals as food. They are important for human health as they are rich in vitamins, minerals, phytochemical compounds, and dietary fibres. They are rich source of antioxidant vitamins (vitamin A, vitamin C, and vitamin E). The consumption of vegetables in adequate quantities can provide protection against some chronic diseases such as diabetes, cancer, obesity, metabolic syndrome and cardiovascular diseases. As in the saying, "Prevention is better than cure", having vegetables today will reduce the risk of many unexpected diseases in the future.

Apart from the health benefits, the production of vegetables improves the economy of a country as they are very good source of income and employment. The contribution of vegetables remains highest (59–61%) in horticulture crop production over the last five years. The characteristics of vegetables include perishability, seasonality, bulkiness and delicate nature of the products. There is tremendous production of vegetables in a shorter period. Therefore, in order to reduce the post-harvest losses and to increase substantial returns to producers, the uses of vegetables should be diversified. Usually, vegetables are consumed either in cooked form or as salads. Besides their culinary uses, they can also be used as raw material for various industries like food industry, pharmaceutical industry, cosmetics, brewing industry, paper industry *etc*.

The climate of our state is best suited for tropical vegetables like cassava, solanaceous vegetables, cucurbits, okra, moringa, cluster bean *etc*. which are having immense potential as industrial raw material.

2. Food industry

Vegetables consist of a large group of plants consumed as food. They are perishable when fresh but can be preserved by a number of processing methods. They are excellent sources of certain minerals and vitamins and are often the main source of dietary fibre. The consumption of vegetables has increased significantly as consumers have become more health-conscious. Owing to the perishable nature of the fresh produce, international trade in vegetables is mostly confined to the processed forms. Vegetables can be processed into sauces, pickles,

canned products *etc*. which add more value to the produce. Food additives like colours and emulsifiers can also be obtained from vegetables. They can also be used for making edible films and coatings.

2.1 Food products from vegetables

- Cassava

Cassava flour can be used as a substitute for wheat flour in many products, like bread, noodles, cakes, biscuits *etc*. The production cost of biscuits can be brought down by mixing cassava flour with wheat flour. Cassava is particularly used due to its good baking qualities. Starch from cassava can be used to make glucose and fructose syrups which can be used for the preparation of candies, soft drinks *etc*. Sago is another important product derived from cassava.

The other processed food products from vegetables are as follows:

- Tomato- sauce, ketchup, puree, paste *etc*.
- Chilli-sauce, powder *etc*.
- Ash gourd- Agra petha
- Pickles
- Canned products *etc.*

2.2 Natural colours

Colour and appearance create the first impression and greatly influence the acceptability of food, hence the development of food items with attractive colour and appearance is an important goal in food industry. Colour is added to food to replace the colour lost during processing, to enhance the colour already present and to colour the foods which are uncoloured. Food colours can be classified as natural colours, nature-identical colours, synthetic colours and inorganic colours. Synthetic colours are the most commonly used additives in food. Now-a-days, food producers pay more attention towards colours and additives of natural origin, since many artificial colours and additives impart negative health effects. The increased demand for natural food additives fuels the research to offer more natural ways to colour and preserve foods.

Natural colours from vegetables like tomato, amaranthus and chilli makes food more appealing and nutritious.

2.2.1 Lycopene

Lycopene is a pigment from the carotenoid family. It can be obtained from vegetables such as tomato and watermelon. It provides the similar colour shades, ranging from yellow to red. Lycopene is intended for use in baked goods, breakfast cereals, dairy products, frozen dairy desserts, bottled water, carbonated beverages, fruit and vegetable juices, candy, soups, salad dressings *etc.* The lycopene levels in food vary from 2mg/l in bottled water to 130mg/l in ready-to-eat cereals (Rath *et al*., 2010). When used as a food colour, lycopene remained stable in the food matrix under appropriate storage conditions. The stability of lycopene depends on the particular food to which it is added, as well as on the production process.

2.2.2 Betacyanins from amaranthus

Red- violet colour betacyanins can be obtained from the leaves of *Amaranthus tricolor*. The betacyanins from amaranthus are stable at low temperature (<14ºC) and the stability is comparable to synthetic colours during 20 week storage. At room temperature (25°C), amaranthus betacyanins retained more than 60 percent colour during initial four week storage. At higher temperature (37°C), they were less stable. Ascorbic acid at 0.10% to 0.50% had a slight protective effect on amaranthus betacyanin stability in jelly. They can be used in products such as jelly, ice creams and soft drinks (Cai and Corke, 1999).

2.2.3 Capsicum red pigments

Capsanthin and capsorubin are the main colouring components in chilli. Paprika is a ground spice made from dried red fruits of the larger and sweeter varieties of *Capsicum annuum*, called bell pepper or sweet pepper. The varieties of chilli that are used for paprika production are Byadaki chilli, Kashmiri chilli, Punjab Lal *etc*.

2.3 Emulsifiers from okra

Emulsifiers are food additives that are used to stabilize processed foods. They create a smooth texture, prevent the separation of components and extend shelf life of products. They are used in ice creams, mayonnaise and baked goods.

The heat treated okra extracts can act as efficient emulsifiers. They are derived from the Maillard reactions between okra protein and polysaccharide. The Maillard reactions in okra are intrinsic *ie*., no protein or polysaccharide from other source is added into the system. The

emulsifiers from okra are found to be better than proteins of well-known emulsifying ability, *ie.,* bovine serum albumin (Temenouga *et al*., 2016).

2.4 Guar gum as food additive

Guar gum is a galactomannan polysaccharide derived from guar beans (cluster bean-*Cyamopsis tetragonoloba*). In food industry, guar gum is used as a novel food additive in various food products for food stabilization. It is liked by both manufacturer and consumer because it is economical as well as a natural additive. It is used in variety of food as an additive because it changes the behaviour of water present as a common component in various food.

Table 1: Common food applications of guar gum

Food item	Properties
Ice creams	Stabilizer due to its water binding properties
Yoghurt	Decreases synerisis and improves texture
Sausage products	Acts as binder and lubricant, controls synerisis and prevent the migration of fat during storage
Bakery products	Improves the machinability of the dough

2.5 Edible films/ coatings

Edible films and coatings are thin layers of edible materials applied on food products that play an important role in their preservation, distribution and marketing. Some of their functions are to protect the product from mechanical damage, physical, chemical and microbiological activities. The use of edible films and coatings to protect and preserve food is increasing as they offer several advantages over synthetic materials, such as biodegradability and environment friendliness. Edible films and coatings can be made from cassava, cluster bean, okra mucilage *etc*.

2.5.1 Cassava starch edible films

Cassava starch can be used for making edible films. The cassava starch films are documented as odourless, tasteless, colourless and non-toxin and have high paste clarity (Tonukari *et al*., 2015). Nevertheless, cassava starches are brittle with poor mechanical properties, but the incorporation of plasticizers like glycerol reduces brittleness.

2.5.2 Guar gum edible films and coatings

Natural polysaccharides like guar gum can be used for making edible films. Guar gum powder obtained from cluster bean can be mixed with plasticizers to make edible films and coatings (Saha *et al*., 2016).

2.5.3 Okra mucilage edible films

Okra mucilage is extracted from mature okra pods. It is a renewable and inexpensive source of biodegradable material. The natural polysaccharides present in okra mucilage are galactose, rhamnose and galacturonic acid. Okra mucilage has high water solubility, plasticity, elasticity and viscosity. Polyethylene glycol is used as plasticizer while making edible films from okra. The edible films from okra have good thermal stability and low moisture content (Cotrim *et al*., 2016).

2.6 Okra mucilage as clarificant for jaggery preparation

The mature okra stem after the last harvest can be used for the extraction of mucilage. The mucilage is mixed with water and it is heated. The mucilage binds with the pigments and forms complexes which helps to settle the impurities. If fresh okra stem is not available for clarification, okra mucilage powder can also be used.

Table 2: Effect of clarification on appearance and composition of jaggery

Constituent	No clarificant	Fresh okra stem
Appearance	Reddish brown	Yellowish
Soluble proteins (%)	3.1	2.6
Insoluble matter (%)	5.3	3.1
Ash	8.1	7.2

According to Chavan *et al* (2007), 2kg fresh okra stem or 80g mucilage powder is needed for the clarification of 750L sugarcane juice.

3. Pharmaceutical industry

The common vegetables, which form part of our daily meals, have various medicinal properties. The utilization of the common vegetables properly, can prevent many of the human ailments and retain health and vigour.

3.1 Ayurvedic preparations

Vegetables are ingredients in various ayurvedic preparations. Some of them are listed below:

Ash gourd

- Kooshmandarasayanam (also called Kushmanda Avaleha) is an ayurvedic supplement that provides nourishment and strength to the body. It is an aphrodisiac, strengthening, nervine tonic, and hemostatic medicine. It provides relief from hemorrhages, fever, dry mouth (xerostomia), excessive thirst (polydipsia), vomiting, bronchitis, asthma, and physical weakness or debility in old age.

Chilli

- Dazzle ointment- it is an instant topical pain reliever and deep reaching hot analgesic.
- Chesol oil- it is an aromatic oil used for the treatment of rheumatic disorders and bronchitis.

Moringa

- Murivenna- it is a medicated ayurvedic oil formulation used for the skin diseases, cuts, wounds, and ulcers. It promotes quick recovery from the fresh as well as chronic wounds and ulcers. In addition, it is also useful for relieving pain and lowering inflammation associated with arthritis, sprains, and fractures.
- Kottamchukkadi thailam- ayurvedic oil used for the treatment of vata disorders causing neuromuscular pains, spondylosis, sciatica *etc*.

Ivy gourd

- Galacto plus granules- it is a polyherbal ayurvedic medicine for improving breast milk. It contains well-known herbal ingredients which helps to increase lactation (breast milk/mothers milk) by galactagogue and phyto-estrogenic activity

Cucumber

- Sukhaparasava ghrita- it is an ayurvedic medicine in herbal ghee form. This medicine is given during pregnancy for assurance of easy and normal delivery.

Kooshmanda rasayanam Murivenna Chesol oil

Plate 1: Ayurvedic preparations from vegetables

3.2 Health supplements

- Bitter gourd capsules- regulates the metabolism of body and has antidiabetic properties. It regulates the glucose levels in our body. It also function as an immunity enhancer and provide sharper vision. A daily dose of bitter melon pills/capsules/supplements significantly reduces the ill effects of certain diseases.
- Moringa capsules- it is made from moringa leaf powder. Moringa helps boost overall energy level and increase stamina and vitality. It also help to naturally meet the vitamin & mineral deficiencies. It is an excellent source of vitamin A, vitamin B1, vitamin B2, vitamin C, iron, protein, fibre, calcium, magnesium and potassium. Taking Moringa capsules is good for those suffering from malnutrition and those who require extra nourishment, such as athlets, body builders, sports persons, expecting& lactating mothers and growing children. The dosage is 3 capsules/day.
- Lycopene tablets and syrups – for lowering blood pressure and cholesterol

Bitter gourd capsules Moringa capsules Lycopene tablets and syrups

Plate 2: Health supplements from vegetable

3.3 Fillers and binding agents in tablets and capsules

Cassava starch serves as a filler material in tablets and capsules. In tablets, the starch is used for coating and dusting as well as binding the constituents of the tablet. In tablets and capsules, the starch also serves a special purpose, as it absorb moisture and swell after swallowing resulting in disintegration of the tablet and dispersal of the active ingredient (Tonukari *et al*., 2015).

3.4 Disintegrants in tablets

Disintegrating agents are used to disintegrate the tablets at a faster rate and super-disintegrants are agents that usually causes the fast disintegration of tablets. Modified okra gum with silica can act as super disintegrants in tablets. The efficiency is compared with a synthetic disintegrating agent- sodium starch glycolate. The sole purpose of gum was to increase the swelling capacity of the tablet by increasing the porosity of the tablet. In contact with water, the tablet mass get swelled and it helps in faster drug release. The porosity of okra gum is increased when silica is added to it. The results of the study are given in the following table:

Table 3: Disintegration time of different formulations of okra gum and sodium starch glycolate

Disintegration time	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
Modified okra gum	2min 42sec.	2min 20sec.	2min 16sec.	2min 10sec.	-	-	-	-
Sodium starch glycolate	-	-	-	-	3min 2sec.	2min 56sec.	2min 40sec.	2min 34sec.

F1- 50 mg okra mucilage
F2- 52 mg okra mucilage
F3- 54 mg okra mucilage
F4- 56 mg okra mucilage
F5- 50 mg sodium starch glycolate
F6- 52 mg sodium starch glycolate
F7- 54 mg sodium starch glycolate
F8- 56 mg sodium starch glycolate

Formulation F4 has shown the lowest disintegrating time which means that the Modified okra gum works better than the synthetic disintegrant (Puri *et al*., 2019).

4. Cosmetics

Nature knows the best ways to keep us healthy, whether it is our organs, limbs, skin, or hair. The fruits and vegetables that we often tend to forget in our diet are the best treatments for bright, glowing, and healthy skin. Vegetables are used as ingredients in cosmetics as they have antioxidant and rejuvenative properties. Any combination of vegetables works wonders for the skin, because it not only delays the signs of aging but also keeps the skin bright, fresh and prevents dryness and other skin disorders. Vegetables are used at home or salons for facial treatments to improve the skin health. Some of the examples of vegetables used in cosmetics are as follows:

- Cucumbers have long been known to help in the reduction of dark circles underneath the eyes.
- Tomato is rich in lycopene which helps to fight free radicals, and its vitamin C boosts collagen production.
- Watermelon helps to soothe sunburn and makes minor skin repairs by encouraging tissue regeneration.

Vegetables are undoubtedly the powerhouses of nutrition since they are packed with the vitamins and minerals that your hair need the most to ensure strong, healthy, and lustrous hair. The following products can be made from vegetables:

- Anti-ageing creams
- Moisturizers
- Face creams
- Hair care products
- Soaps and face washes
- Massage oils

Plate 3: Cosmetic products from vegetables

4.1 Sunscreen lotion from tomato

Tomato (*Solanum lycopersicum* L.) has sunscreen efficacy consisting of lycopene which can protect skin from UV B induced photodamage. Lycopene in tomato fruit can be used as one of the active substances in sunscreen lotions. Lycopene can provide maximum absorption at the wavelength of UV rays and is able to protect the skin from erythema and prevent skin damage induced by UV rays. Topical application of lycopene can also provide protection against the acute effects of radiation induced damage from UVB rays. Tomato (*S. lycopersicum* L.) in Indonesia expected to be used as the source of lycopene as active compounds in sunscreen cosmetics preparations to protect the skin from the sun.

The materials used in the study are fruit extracts of tomato (*S. lycopersicum* L.) in different concentrations, Tefose 63 (a mixture of polyethylene glycol (PEG) -6; Ethylene Glycol; PEG-32), cetyl alcohol, liquid paraffin, methyl paraben, propyl paraben and aquadest. The determination of the SPF value of the extracts is done using UV spectrophotometer method.

The result of the determination of SPF value with concentration 0.4%, 0.5% and 0.6% are presented in the table. It exhibited that SPF values of the extract in various concentration has ability to withstand UV rays radiation.

Table 4: Result of SPF determination of different concentrations of tomato extract

Concentration of extract	SPF (Sun Protection Factor)
0.2	10.04
0.4	17.74
0.6	33.13

From the study, it is clear that, as the concentration of tomato extract in sunscreen lotion is increased the SPF also increases (Sopyan *et al.*, 2018). Sunscreen lotion in which 0.6% of the tomato extract was added had the highest SPF.

5. Brewing industry

5.1 Ethanol from cassava

The benefits of using cassava as a raw material for ethanol production are that it can be planted on marginal lands where other agricultural crops such as sugarcane, rice, wheat and

corn cannot be grown. In addition, it can highly tolerate drought, as it survives during dry weather when soil moisture is low with high humidity. Ethanol can be made from the enzymatic hydrolysis of cassava starch. Enzymes like amylase and glucoamylase are used for the hydrolysis of cassava starch. After hydrolysis, the fermentation of enzymatic hydrolysates is done by *Saccharomyces cerevisiae.* Industrial alcohol made from cassava starch can be used as feedstock to produce a large amount of organic chemicals like organic acids (citric acid and enzymes). Several distilleries in Nigeria use cassava flour of high quality as a substrate for producing ethanol (Valeriano *et al*., 2018).

5.2 Wines from vegetables

Tomato wine Pumpkin wine Watermelon wine

5.3 Guar gum as additive in beverages

Guar gum is used in beverages for thickening and viscosity control because of its several inherent properties. The important property of guar gum is its resistance to break down under low pH conditions present in beverages. Guar gum is soluble in cold water which makes it easy to use in beverage processing plants. It improves the shelf life of beverages (Mudgil *et al*., 2014).

6. Textile industry

6.1 Cassava starch and guar gum

In the textile industries, modified starch (oxidized starch) and guar gum is utilized in sizing and dyeing that make the finished fabrics look brighter, harder and with increased weight. Textile printing or the impression of a design on fabrics requires a carrier for the dyes and pigments and modified cassava starch has found special use in these applications. Small

quantity of cassava starch is also used as thickening agents in printing inks and for application of glossy finishes. Cassava flour is normally used in the production of lower quality fabrics such as those used for making uniforms and it is selected on the basis of cheapness and availability. Cassava starch is used to make bed sheets and table clothes to give them better quality, maintain their firmness and for their completion. Modern laundries regularly use soluble starch, wrapped with an appropriate propellant in air spray container for applying starch to clothes during steam ironing. Industries now use cassava starch because it has no issue in terms of quantity, quality and timely supply.

6.2 Natural dyes from chilli (Kulkarani *et al*., 2011)

Oleoresin is the main colouring component present in chilli. Oleoresin is a mixture of esters of capsanthin, capsorubin, zeaxanthin, cryptoxanthin and other carotenoids. Different shades of yellow was obtained when copper sulphate and ferrous sulphate was used as mordants.

Fastness is the ability of a dye to remain permanent and not run or fade. Good light fastness, good rub fastness and moderate wash fastness was observed in fabrics dyed with the dye extracted from green chilli.

7. Paper industry

7.1 Moringa stem

Ekhumelo and Udo (2016) conducted a study for evaluating the potential of moringa stem for pulp and papermaking. Samples were collected from three *Moringa oleifera* trees of ages 1, 3 and 5 year old trees. The study found that *Moringa oleifera* is suitable for pulp and paper production and 5 year old *Moringa oleifera* was best suited for pulp and paper production compared to 1 and 3 years old *Moringa oleifera*. The paper made from moringa was found suitable for newsprint, wrapping, printing and writing papers.

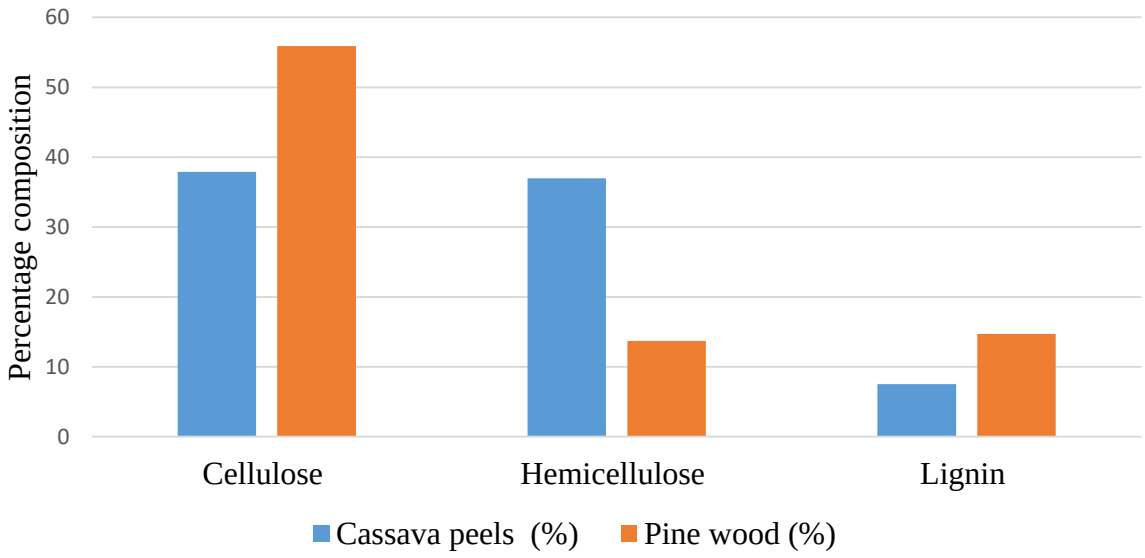
7.2 Okra stem

Okra stem after the harvest of fruits can be used as an alternative pulp fibre source. Okra stem consist of the stick (woody portion) and the fibre. Okra fibre is characterized by high α-cellulose (56.7%) and low lignin (12.6%) content and the stick by low α-cellulose (34.3%) and high lignin (25.2%) content. Both the stick and fibre had similar paper making properties (Jahan *et al*., 2012)

7.3 Paper from cassava peels

Cassava peels are the waste after the production of cassava flour. They are a potential fibre sources for pulp and paper production.

Figure 1: Comparison of chemical composition of cassava peel and a wood source



The holocellulose content of cassava peels are comparable to wood plants. The cellulose content presents in cassava peels lower than pine wood. The lignin content obtained in cassava peels is lower than wood plants, which is desirable in the pulp and paper production. In conclusion, the chemical composition indicated that the cassava peels would yield comparable pulp as in wood resources (Daud *et al*., 2013)

8. Other industrial applications

8.1 Biopesticides from cassava

The Central Tuber Crops Research Institute (CTCRI), Trivandrum has developed three biopesticide formulations from cassava leaves namely, Nanma, Menma and Shreya which are effective against borers and sucking pests. The formulation of Menma is very effective against borer pests – pseudostem weevil and rhizome weevil in banana; red palm weevil in coconut

etc. sucking pests such as mealy bug, thrips, scale insects, mites etc. in horticultural crops can be very effectively controlled by formulation Nanma. Waxy coating around mealy bug gives it protection from insecticide application, but Shreya can dissolve mealy substance and kill it. Biofumigants isolated from cassava-leaves are effective against stored product pests (George and Nedunchezhiyan, 2016).

8.2 Cassava starch as gelling agent in tissue culture media

Cassava starch can be used as an alternative for agar in tissue culture media. The Gelling property of cassava starch is due to amylose and amylopectin which are released during the hydrolysis of cassava starch. The solubility temperature of cassava starch is 50˚C and the gelling temperature is greater than 60˚C.

According to the study conducted by Ssamula and Mukasa (2015), cassava starch along with small quantities of agar gave better results in tissue culture. By using cassava starch as an alternative for agar, the cost involved in tissue culture can be reduced.

8.3 Water purification

Turbidity in water is due to the negatively charged particles and high organic matter content in water**.** On account of the surface electrical charge, these particles mutually repel each other, making it difficult for them to aggregate and settle. Thus, to overcome the repulsive charge and to destabilize the suspension, a coagulant with the opposite charge is added to the water. Aluminium, iron salts and synthetic polymers are the most widely used coagulants in turbid and wastewater treatment. The use of inorganic and synthetic coagulants have several disadvantages like reduction of pH, high costs, production of large sludge volume and low efficiency in coagulation of cold water. Aluminium intake into the body has been linked with several neuropathological diseases including percentile dementia and Alzheimer's. Due to these problems, there is a high demand to find an alternative coagulant which is preferable to be a natural coagulant. Naturally occurring coagulants are usually presumed safe for human health.

Vegetables like moringa and okra can be used for the purification of waste water. *Moringa oleifera* seed is non-toxic and a good coagulant for water treatment. Binayke and Jadhav (2013) conducted a study for evaluating the efficiency of Moringa seeds and okra as coagulants for water purification. They also evaluated the performance of Moringa seeds and okra as coagulant aids in conjunction with alum.

Table 5: Performance of moringa seeds and okra as coagulant aids in water purification

Turbidity level	**Maximum turbidity removal efficiency (%)**				
	Alum (10 mg/L)	Moringa (7.5 mg/L)	Okra (10 mg/L)	Moringa + alum (Alum- 7.5 mg/L Moringa- 5 mg/L)	Okra + alum (Alum- 10 mg/L Okra- 5 mg/L)
Low	96	76	54	88	96
Medium	92	87	68	95	97
High	98	92	74	98	98

From this table, it is clear that the dosage of alum can be decreased from 10 mg/L to 7.5 mg/L when moringa seed is used as coagulant aid. When okra is used along with alum, the turbidity removal efficiency was increased in medium turbid water.

8.4 Heavy metal adsorption by moringa seeds

Moringa seed powder also have the potential for the adsorption of heavy metals from water. Ravikumar and Sheeja (2013) conducted a study to evaluate the potential of Moringa seeds in heavy metal adsorption.

Table 6: Heavy metal adsorption by moringa seeds

Heavy metal	**Final heavy metal concentration (mg/L)**	**Removal efficiency (%)**
Copper	0.25	95
Lead	0.35	93
Cadmium	1.2	76
Chromium	1.5	70

The initial concentration of heavy metal in solution was 5 mg/L. the mechanism behind the adsorption of heavy metals by moringa seeds is by charge neutralization and interparticle bridging. The optimum dose of moringa seed powder needed is 2 mg/L.

8.5 Self defense sprays from chilli

Capsaicin is the main active ingredient in self defense sprays. It is an intense skin and eye irritant. Pepper spray contain 10-20 % solution of chilli oleoresin. 'Hotness' of preparation is determined by Scoville Heat Unit (SHU). The higher the SHU, the greater the inflammatory effect on skin and mucous membranes. The sprays used by police for riot control has 0.5- 2 million SHU (Yeung and Tang, 2015).

8.6 Adhesives

Cassava starch has good water-holding properties and stable viscosity. They are made from by-products which are supposed to be wastes, hence they have very low cost. These adhesives have applications in many industries (Tonukari *et al*., 2015). Cassava-based adhesives in oil industries are used to improve the viscosity of drilling muds in oil wells. Modified cassava starch (a mixture of clay) provides the bores with the right stickiness and water-holding capacity for drilling of oil wells or water wells. It is also used to close the walls of bore holes and prevents the loss of fluid. Cassava-based adhesives in cement industries are presently used as an additive in cement to improve the setting time.

8.7 Guar gum and its derivatives in petroleum industry (Hasan *et al*., 2018)

Demand of guar gum has increased during last few decades due to the development of different derivatives of guar gum like anionic and cationic derivatives. In petroleum industry, the derivatives of guar gum find great importance in the drilling fluids formulations, corrosion inhibitors, dispersants, and other applications.

Corrosion inhibitor- The presence of water in oil causes several problems in the handling and processing stages such as corrosion, fouling in pipelines, equipment, and poisoning of catalysts in the refinery processes. Some chemical compounds are added to protect the equipments and inhibit the corrosion processes, known as corrosion inhibitors. A corrosion inhibitor is a substance which when added in very minute concentrations to a corrosive environment minimizes or prevents corrosion. These substances adsorb either physically or

chemically at the metal-solution interface and obstructs the contact surface between the metal and the corrosive agents. They shield the metal from corrosive agents present in the solution.

Guar gum makes the fracturing fluid thicker so that it can carry sand into fractured rock. This fracture remains open due to presence of sand which creates a path for gas or oil to flow to well bore. Guar derivatives for use in fracturing fluids are hydroxypropyl guar (HPG) and carboxymethyl hydroxypropyl guar (CMHPG).

Guar gum also act as viscosity modifiers and form a part of the drilling muds. Crude oil is a water-in-oil emulsion. The water in crude oil cause several problems to the pipelines and equipments. Thus, it is necessary to break the emulsion and separate water from crude oil. The derivatives of guar gum like hydrophobic propyl methyl guar gum can be used as alternatives to the chemical demulsifiers even though they have only little application.

8.8 Biodiesel from moringa seed oil

Moringa seed oil (yield 30–40 % w/w), also known as ‘‘Ben oil’’ is used for the production of biodiesel, because of the high content of monounsaturated fatty acids in the form of oleic acid. Biodiesel from Moringa is produced by transesterification process. Moringa seed oil is a potential candidate for biodiesel production, as it meets all the main specifications of the biodiesel standards of US, Germany, and Europe (Rashid *et al*., 2008). The most important property of biodiesel from Moringa is its high cetane number of approximately 67, which is among the highest of the biodiesel fuels. Thus, it has great commercial and industrial importance.

9. Conclusion

Vegetables have multiple uses and they can be used as raw material for various industries. The advantage of vegetables is that all the parts of vegetables can be efficiently utilized. Even the waste materials after the last harvest can be efficiently used in various industries. The products from vegetables can be used as low cost alternatives for various chemicals. Tropical vegetables like, cassava, cluster bean, moringa *etc*. have immense potential as industrial raw material.

The true value of vegetables are often unknown to man. So we have to explore their hidden potentials and use them in a wise manner. Replacement of chemicals as far as possible with natural products will help the mankind to remain healthy and reduce environmental pollution.

10. Discussion

1. What is cetane number?

Cetane number is an indicator of combustion speed. Cetane number is a measure of the ignition value of a diesel fuel that represents the percentage by volume of cetane in a mixture of liquid methylnaphthalene that gives the same ignition lag as the oil being tested. It is also called cetane rating. Lower the cetane number, more time will be needed for combustion of fuels.

2. What material is currently used for clarifying sugarcane juice and what is the advantage of using okra stem over it?

At present, chemical clarificants like sodium bicarbonate and sodium carbonate is used for the clarification of sugar cane juice. The mature green stem of okra after the last harvest of fruits can be used for the clarification of sugarcane juice in jaggery preparation. The advantages of using okra stem is that we can produce organic jaggery by replacing the chemical clarificants and reduce the accumulation of agricultural waste.

3. What is the difference between edible films and coatings?

Edible coating is applied in liquid form on the food, usually by immersing the product in the solution of edible material, whereas edible film is first molded as solid sheets and then applied as a wrapping for food products.

4. What are the advantages of using cassava starch as alternative in tissue culture media? Can it replace the use of sucrose in tissue culture media?

Addition of cassava starch as gelling agent in tissue culture media reduced the dependency on agar which is costly. The cost of 100g of agar is 731 Rs, but for cassava starch it is only 30-40 Rs/kg.

Agar is an inert substance. So, usually in tissue culture media sucrose is added for the growth of plants. By using cassava starch, the addition of sucrose can be minimized as it contains sugars.

5. What are vegetable dyes?

The dyes obtained from natural sources including vegetables are known as vegetables. They can be obtained from beetroot, onion, carrot, sweet potato *etc*.

6. Give some examples for plants grown in tissue culture media in which cassava starch is used as gelling agent.

The micropropagation of banana, potato *etc*. were successfully done using cassava starch as gelling agent in tissue culture media.

11. References

Binayke, R. A. and Jadhav, M. V. 2013. Application of natural coagulants in water purification. *Int. J. Advanced Technol. Civil Eng*. 2(1): 118-123.

Cai, Y. and Corke, H. 1999. Amaranthus betacyanin pigments applied in model food systems. *J. Food Sci.* 64(5): 869-873.

Chavan J. K., Dalvi U. S., and Chavan U. D. 2007. Isolation of lady's finger (okra) stem mucilage as clarificant in jaggery preparation. *J. Food Sci Technol*. 44(1): 59-61.

Chisenga, S. M., Workneh, T. S., Bultosa, G., and Alimi, B. A. 2019. Progress in research and applications of cassava flour and starch: a review. *J. Food Sci. Technol.* 56(6): 2799-2813.

Daud, Z., Kassim, M., Sari, A., Mohd Aripin, A., Awang, H., Hatta, M., and Zainuri, M. 2013. Chemical composition and morphological of cocoa pod husks and cassava peels for pulp and paper production. *Aust. J. Basic Appl. Sci.* 7(9): 406-411.

de Alvarenga Pinto Cotrim, M., Mottin, A. C., and Ayres, E. 2016. Preparation and characterization of okra mucilage (*Abelmoschus esculentus*) edible films. In: *Macromolecular Symposia*. 367(1): 90-100.

Ekhuemelo, D. O. and Udo, A. M. 2016. Investigation of variations in the fibre characteristics of *Moringa oleifera* (Lam.) stem for pulp and paper production. *Int. J. Sci. Technol.* 5(1):19-20.

George, J. and Nedunchezhiyan, M. 2016. Role of tuber crops in food security and farm income. In: Root and tuber crops based integrated farming system: A way forward to address climate change and livelihood improvement, ICAR- Central Tuber Crops Research Institute, Regional Centre Dumuduma, Bhubaneswar, 4p.

Hasan, A. M., and Abdel-Raouf, M. E., 2018. Applications of guar gum and its derivatives in petroleum industry: a review. *Egypt. J. petroleum* 27(4): 1043-1050.

Jahan, M. S., Rahman, M., and Rahman, M. M. 2012. Characterization and evaluation of okra fibre (*Abelmoschus esculentus*) as a pulping raw material. *J. Sci. Technol. For. Prod Process*. 2(5):1-17.

Kulkarni, S. S., Bodake, U. M., and Pathade, G. R. 2011. Extraction of natural dye from chilli (*Capsicum annum*) for textile coloration. *Univers. J. Environ. Res. Technol.* 1(1): 56-60.

Mudgil, D., Barak, S., and Khatkar, B. S. 2014. Guar gum: processing, properties and food applications- a review. *J. Food Sci. Technol.* 51(3): 409-418.

Puri, A., Dev, D., Prasad, D. N., Hira, S., and Sharma, R. 2019. The modified okra gum with silica: A novel superdisintegrant for fast disintegrating tablet. *J. Drug Delivery Ther.* 9(3): 206-211.

Rashid, U., Anwar, F., Moser, B. R. and Knothe, G. 2008. *Moringa oleifera* oil: a possible source of biodiesel. *Bioresour. Technol*. 99(17): 8175-8179.

Rath, S., Olempska-Beer, Z., and Kuznesof, P. M. 2010. Lycopene extract from tomato-Chemical and Technical Assessment (CTA). Lycored natural products industries Ltd, Israel, 1p.

Ravikumar, K., and Sheeja, A. K. 2013. Heavy metal removal from water using *Moringa oleifera* seed coagulant and double filtration, Proceedings of the International Conference on Innovations in Civil Engineering (ICICE), 9-10 May 2013, Kochi. Department of Civil Engineering, SCMS School of Engineering Technology, pp. 9-12.

Saha, A., Tyagi, S., Gupta, R. K., and Tyagi, Y. K. 2016. Guar gum based edible coating on cucumber (*Cucumis sativus* L.). *Eur. J. Pharma. Med. Res.* 3(9): 558-570.

Sopyan, I., Gozali, D. and Tiassetiana, S. 2018. Formulation of tomato extracts (*Solanum lycopersicum* L.) as a sunscreen lotion. *Natl. J. Physiology, Pharmacy and Pharmacology*. 8(3): 453-458.

Ssamula, A. and Mukasa, S. B. 2015. Use of cassava starch as gelling agent during in vitro micropropagation of banana. *J. Exp. Biology*. 3(6): 575-581

Temenouga, V., Charitidis, T., Avgidou, M., Karayannakidis, P. D., Dimopoulou, M., Kalogianni, E. P., Panayiotou, C., and Ritzoulis, C. 2016. Novel emulsifiers as products from internal Maillard reactions in okra hydrocolloid mucilage. *Food Hydrocoll.* 52: 972-980.

Tonukari, N. J., Ezedom, T., Enuma, C. C., Sakpa, S. O., Avwioroko, O. J., Eraga, L., and Odiyoma, E. 2015. White gold: cassava as an industrial base. *Am. J. plant Sci*. 6(07): 972-979.

Yeung, M. F. and Tang, W. Y. 2015. Clinicopathological effects of pepper (oleoresin capsicum) spray. *Hong Kong Med. J*. 21(6): 542-52.

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKKARA

Department of Vegetable Science

VSC 591: Masters Seminar

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Admission no. : 2018-12-001

Major advisor : Dr. T. Pradeepkumar

Venue : Seminar Hall

Date : 08-11-2019

Time : 10:45 am

Tropical vegetables: New role as industrial raw material

Abstract

Vegetables are an integral part of human diet and are known as protective food, which contribute required minerals, vitamins and other nutrients. They are consumed either in cooked form or as salads. Besides their culinary uses, vegetables can also be used as raw material for various industries like food industry, pharmaceutical industry, cosmetics, paper industry *etc*. The climate of our state is best suited for tropical vegetables like cassava, solanaceous vegetables, cucurbits, okra, moringa, cluster bean *etc*. which are having immense potential as industrial raw material.

Vegetables can be processed into sauces, pickles, canned products *etc*. which add more value to the produce. Food additives like colours and emulsifiers can also be obtained from vegetables. Natural colours from vegetables like tomato, amaranthus and chilli make it more appealing and nutritious. The products from Maillard reactions in okra can be used as emulsifiers in food and they are found better than bovine serum albumin (Temenouga *et al*., 2016). The use of edible films and coatings to protect and preserve food is increasing as they offer several advantages over synthetic materials, such as biodegradability and environment friendliness. Edible films and coatings can be made from cassava, cluster bean, okra mucilage *etc*.

Vegetables are used in Indian traditional medicines since ancient times. The antioxidant and rejuvenative properties of vegetables make it an ingredient of various ayurvedic preparations, health supplements and cosmetic products.

Natural coagulants like moringa and okra can be used in conjunction with alum for water purification which will help to reduce the dependence on chemicals (Binayke and Jadhav,

2013). Moringa seeds also have the potential for adsorption of heavy metals like copper, lead, cadmium and chromium (Ravikumar and Sheeja, 2013).

The adhesives made from cassava starch have applications in oil industry, paper industry and cement industry (Tonukari *et al*., 2015). Guar gum from cluster bean can be used as corrosion inhibitor, fracturing fluid and viscosity modifier in petroleum industry (Hasan and Abdel- Rauof, 2018). Moringa seed oil can also be used for the production of biodiesel and it has the highest reported cetane number (Rashid *et al*., 2008).

Vegetables have multiple uses and it serve as raw material for various industries. The products from vegetables can be used as alternatives for some of the chemicals. Replacement of chemicals with natural products will help the mankind to remain healthy and reduce environmental pollution.

References

Binayke, R. A. and Jadhav, M. V. 2013. Application of natural coagulants in water purification. *Int. J. Advanced Technol. Civil Eng*. 2(1): 118-123.

Hasan, A. M. A. and Abdel-Raouf, M. E. 2018. Applications of guar gum and its derivatives in petroleum industry: a review. *Egypt. J. petroleum* 27(4): 1043-1050.

Rashid, U., Anwar, F., Moser, B. R., and Knothe, G. 2008. *Moringa oleifera* oil: a possible source of biodiesel. *Bioresour. Technol*. 99(17): 8175-8179.

Ravikumar, K. and Sheeja, A. K. 2013. Heavy metal removal from water using *Moringa oleifera* seed coagulant and double filtration. In: *Proceedings of the International Conference on Innovations in Civil Engineering*, 9-10 May 2013, Kochi. Department of Civil Engineering, SCMS School of Engineering Technology, pp. 9-12.

Temenouga, V., Charitidis, T., Avgidou, M., Karayannakidis, P. D., Dimopoulou, M., Kalogianni, E. P., Panayiotou, C., and Ritzoulis, C. 2016. Novel emulsifiers as products from internal Maillard reactions in okra hydrocolloid mucilage. *Food Hydrocoll.* 52: 972-980.

Tonukari, N. J., Ezedom, T., Enuma, C. C., Sakpa, S. O., Avwioroko, O. J., Eraga, L., and Odiyoma, E. 2015. White gold: cassava as an industrial base. *Am. J. Plant Sci*. 6(7): 972-979.