Abstracts

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OAT MILK - SUSTAINABLE USE OF A PLANT BIOMASS FOR FOOD PRODUCTION

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Summary

From a sustainable perspective, this study attempts to define characteristics of a milk produced from oats - a non-animal product. Climate change contribution, land requirements and investment capital were the variables chosen to define sustainability.

A type of oat milk was studied that has been developed and on the market since 1995. The product is rapidly increasing its share of the non-dairy products market in Sweden and Europe. It is a cow milk supplement that provides good nutritional value. Persons who are allergic to milk protein or gluten or who are lactose intolerant can consume this oat milk. Absolute numbers for sustainability aspects of oat milk is difficult to assess, so oat milk numbers are compared with large-scale production numbers for cow milk under Swedish conditions.

Given equal impact on climate, nearly 4 times more oat milk than cow milk can be produced; given equal production area, about 2.5 times more oat milk; and given the same investment capital, at least 4.5 times more oat milk. These numbers are estimates, but they indicate one interesting path of development at a time when climate impact and resources, such as land and money, are becoming increasingly important.

Introduction

Humans are demanding more and better food: more, due to rapid increases in population and better, due to higher living standards. In recent decades, lifestyle

changes, especially in India and China, are placing substantial demands on food production and consumption. We are also increasingly aware of how food contributes to climate change. Scientists are releasing more detailed - and frightening - reports: a day seldom goes by that consumers are not faced with more facts on the connection between food and climate impact. Food produced from animal products has a much greater impact on climate than food produced from non-animal products. What will happen when Asian food demand is comparable to European?

This paper focuses on one product, a beverage produced from plants: oats. Although oat milk is not a new beverage, due to a novel Swedish production method, the type of oat milk studied here is different.

The objective was to explore some of the sustainable properties of oat milk in a comparison with conventionally produced cow milk (= large scale production): how do the two production methods compare concerning greenhouse effect, land requirements and investment capital needs? Calculations[1] were based on Swedish conditions. The functional unit (fu) was 1,000 1-litre cartons (Tetra Pak) of each product, stored close to the production facility.

The study also attempted to investigate large-scale effects. Findings were interpolated to explore probable consequences of oat milk and cow milk production for 20 million schoolchildren.

Dangers from greenhouse effect

The worldwide debate on whether or not global warming is human-induced seems to be nearing a consensus among researchers and politicians. According to the Intergovernmental Panel of Climate Change (IPCC)'s report: Climate Change 2007, presented in November 2007 : [2]

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. ... GHG (GreenHouse Gases) emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.

Based on the IPCC report, the European Commission states :[3]

Human activities that contribute to climate change include in particular the burning of fossil fuels, agriculture and land-use changes like deforestation. These cause emissions of carbon dioxide (CO_2), the main gas responsible for climate

1 Hur bra är havredryck sett ur ett GWP-perspektiv? October 2008. (How good is oat milk from a GWP-perspective?) Internal report.
2 Fourth Assessment Report (AR4)
3 http://ec.europa.eu/environment/climat/home_en.htm

change, and of other greenhouse gases. To bring climate change to a halt, global greenhouse gas emissions must be reduced significantly.

The Food and Agriculture Organisation (FAO) of the UN is outspoken concerning food production[4] and estimates:

... that livestock are responsible for 18 percent of greenhouse gas emissions, a bigger share than that of transport. It accounts for nine percent of anthropogenic carbon dioxide emissions, most of it due to expansion of pastures and arable land for feed crops. It generates even bigger shares of emissions of other gases with greater potential to warm the atmosphere: as much as 37 percent of anthropogenic methane, mostly from enteric fermentation by ruminants, and 65 percent of anthropogenic nitrous oxide, mostly from manure. Livestock production is one of the major causes of the world's most pressing environmental problems, including global warming, land degradation, air and water pollution, and loss of biodiversity.

Of the nearly one-fifth of greenhouse gas emissions that livestock are responsible for, much is produced by the milk-meat system. The climate change issue has expanded from how food is produced and transported to include the type of food we choose to eat - especially in western countries. So the more food we choose, which is produced from animal products, the greater the impact on greenhouse gas emissions.

Higher demands on environmental food labelling in Sweden and Europe

Because of heightened awareness of the impact that food has on the climate, Swedish authorities, industry and organisations are implementing food labelling systems that reflect environmental impact. For instance, the Swedish Food Administration is currently rewriting national food and nutrition guidelines to match the environmental objectives for Sweden, defined by the Swedish government. Industry, supported by the government and in line with European Commission aims, is exploring how to label food so consumers make purchases based on environmental quality. The most radical labelling system - the carbon footprint - shows total environmental impact of a food by indicating the amount of CO2 equivalent it contributes to global warming.

Oat milk and cow milk

Although oat milk is not a new beverage, due to a novel Swedish production method that uses state-of-the-art food biotechnology, the type of oat milk studied here is new. Oat milk is based on a milk-like liquid extracted from oats and is thus a non-animal product. Figure 1 illustrates the main phases in oat milk production.

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4 http://www.fao.org/ag/magazine/0612sp1.htm

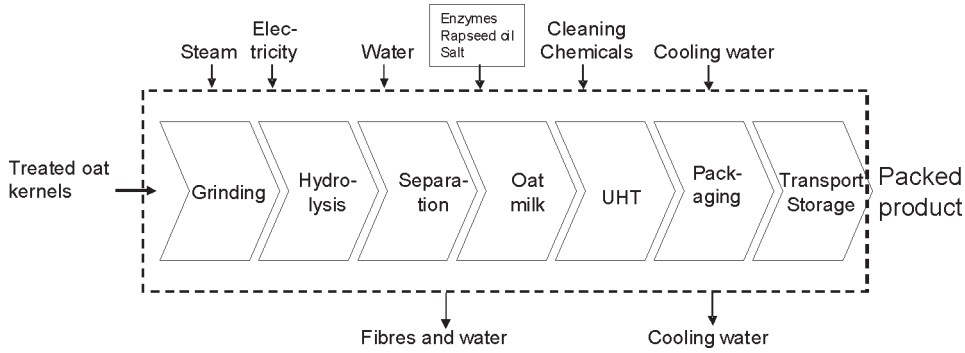

Figure 1. Oat milk production process.

The process is simple and natural. Oat kernels and water are mixed and hydrolyzed. Several natural enzymes produce a milk-like consistency and keep some insoluble fibre intact in the product. Thus the product consists of water and oats; in some products, rapeseed (canola) oil is added to give a total fat content of 1.5%.

Why oats? The nutrient content of oats[5] is good. The balance between carbohydrates, protein and fat corresponds well with human needs. The naturally occurring fat contains beneficial fatty acids, with a high proportion of monounsaturated fat. Of our most common cereals, oats has the best protein content. Several studies show that people who are intolerant of gluten (a protein found in wheat, rye, corn and oats) are, surprisingly, able to tolerate the type of gluten found in oats, which varies from gluten found in the other cereals.

Oats also contain beta-D-glucan, a water-soluble fibre, which clinical studies showed lower cholesterol. The US Food and Drug Administration (FDA) decided in 1997 to permit health declarations for products that contain soluble fibre derived from oats. And because oats contains no lactose, persons who are lactose intolerant can consume oat milk.

Large-scale production of cow milk was chosen to compare with oat milk. Two main types of milk are produced in Sweden: conventional and ecological. Conventional milk is usually produced on farms with an average of 140 milk cows. The farms are automated to reduce labour intensity. Production is constantly being rationalised and milk yield per cow improved. The trend is toward more concentrated diet of grain often with some non-Swedish ingredients such as soy, and less time outside for the milk cows. On average, a milk cow produces at least 9,000 kg milk per year.

5 *Öste, Rickard (2005) Mjölkfria produkter från havre. (Non Dairy Products from Oats) Svensk utsädestidskrift*

Methods and results

This study focused on sustainable properties of oat milk. The impact of oat milk on climate change, land requirements and investment capital were estimated and compared with the impact of large-scale cow milk production. Global warming potential (GWP) and life-cycle analysis (LCA) were used in the comparisons.

To compare various foods from a greenhouse perspective, proven scientific methodology should be used. An accepted method of calculating anthropogenically produced greenhouse gases is to use the GWP[6] concept. GWP estimates how much a given mass of greenhouse gas contributes to global warming. The scale is relative and converts the gas in question to carbon dioxide mass (by definition, GWP = 1). GWP is calculated for a predetermined time interval, commonly 100 years.

The present study used this expression:

kg of CO_2 eqv = x kg CO_2*1 + y kg CH_4*23 + z kg N_2O*298

To determine the impact of a specific product on the environment, accumulated amounts of substances, gases, particles and consumed energy are calculated from cradle to grave; see Figure 2:

Figure 2. Cradle-to-grave accumulations.

ISO 14040 and ISO 14044 (2006) list guidelines for performing LCA, the method most commonly used to calculate environmental impact. In this study, only part of the life cycle for oat and cow milk - from cradle to storage - was used in LCA; see Figure 3.

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6 The Intergovernmental Panel on Climate Change (IPCC) determined generally accepted values for GWP, which changed slightly between 1996 and 2001. See the IPCC's 2001 Third Assessment Report for an exact definition of how GWP is calculated.

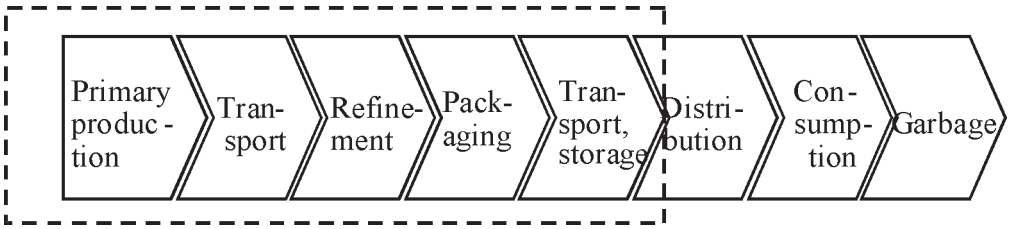

Figure 3. Cradle-to-storage portion of life cycle.

Functional unit, fu, is a term used in LCA studies to quantify performance of a product system. It is a reference unit. This study defined fu as "from cradle to 1,000 1-litre cartons (Tetra Pak) of each product, transported to storage near the production facility".

Oat milk produced by a novel Swedish method was compared with Swedish cow milk produced by conventional means. GWP and LCA calculated (a) number of kg CO2 equivalents produced per fu, (b) number of km2 needed per fu and (c) capital investment requirements (USD) per fu. Findings were interpolated to explore the consequences of producing oat milk or cow milk for 20 million schoolchildren.

A literature search for LCA data on oat and cow milk was undertaken. No adequate LCA studies on oat milk were found, so preliminary LCA estimates were made. But many Swedish LCA studies on cow milk were available, some as part of doctoral theses. Preliminary calculations found significant differences between the two beverages.

The next step was to select the best possible method for estimating LCA of Swedish oat milk. An LCA study that conforms to scientific, evidence-based principles is time consuming and costly.

Two students of technology, as part of their master's thesis of food technology, performed an LCA on Swedish oat milk following methodological guidelines in ISO 14044. Among other environmental impacts, the students calculated number of kg of CO2 equivalents produced from cradle to grave per 1 fu oat milk. Two supervisors were chosen, one (doctoral dissertation on LCA) from the Swedish University of Agricultural Sciences, and one (PhD) from Lund University, Faculty of Engineering, Department of Applied Nutrition.

The students collected data and listed the substances needed to produce x kg of oats per hectare at a specific farm in mid-Sweden: amount of diesel consumed in soil treatment and harvesting, amount of seed needed for sowing, amount, transports and type of fertilisers, amount of N2O and other substances that leach out of the soil, amount of pesticides needed and so on. The students also listed all transport,

energy and process requirements at the mill; transport to the oat milk factory; and energy and material balances for the Oatly process. Consumption data were obtained from the company's computerised Enterprise Resource Planning (ERP) system. An LCA for the cartons was made in part by the students, in part by Tetra Pak.

Thus the various kinds of energy used and materials needed for direct production and indirect consumption were collected and normalised to determine production needs for 1 fu of oat milk. For instance, 1 fu of oat milk requires steam corresponding to about 400 kWh of fossil gas. This number was obtained from company process data in the EPR system. Commonly accepted conversion factors were used to convert this energy to emission quantities. All other data were converted in a similar manner to emission data per fu of particular compounds. The various gases were summed according to the GWP concept, and a quantity for climate impact was calculated.

The numbers calculated by the students were compared with recently published data in the scientific literature. If emission data were to be representative for a farming region, not just one farm, the GWP numbers needed to be corrected by a factor of about 1.5. Production plant numbers were OK.

Land requirements for producing 1 fu of cow milk were estimated based on cow milk data in the literature: 1,400 m2/fu. But because crop yield varies with type of soil, amount of rain, climate and so on, land requirements for producing 1 fu of oat milk were estimated at 550 m2/fu (4,000 kg oats per hectare).

To compare the investment capital needed for turnkey plants, real numbers from the newly built production plant for the oat milk production process were used. This plant was dimensioned to produce 50 million litres a year. Investment capital requirements were estimated for the typical, highly automated cow milk farm in Sweden defined in 6.2. The comparison excluded capital requirements for dairies, even though a dairy is necessary to produce 1fu of packaged cow milk. Figure 4 summarises findings:

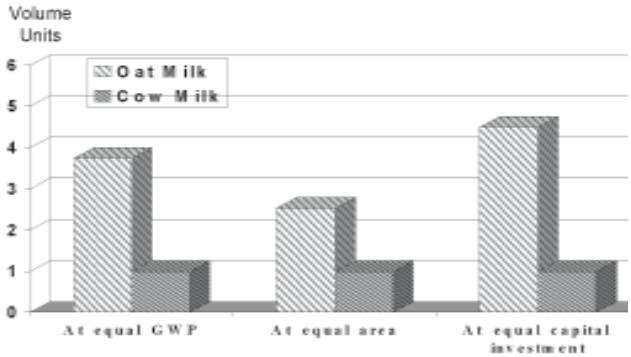

Figure 4. Oat versus cow milk.

This diagram illustrates volumes of oat milk that are produced, compared to 1 unit volume of cow milk, when GWP, production land and investment capital are equal. Compared to cow milk, oat milk volumes are about

(a) 3.7 time higher when GWP is equal.

(b) 2.5 time higher when production land is equal.

(c) 4.5 times higher when capital investment is equal.

The potential for improving oat milk production process is very good. Estimates show that if the fossil gas that is used today for steam production is replaced in a process that uses the entire oat kernel and husk to produce the oat milk and the steam required in the process, 6 times more oat milk than cow milk could be realistically produced at equal GWP load.

Figure 5 helps explain why so much more oat milk than cow milk can be produced at equal GWP load:

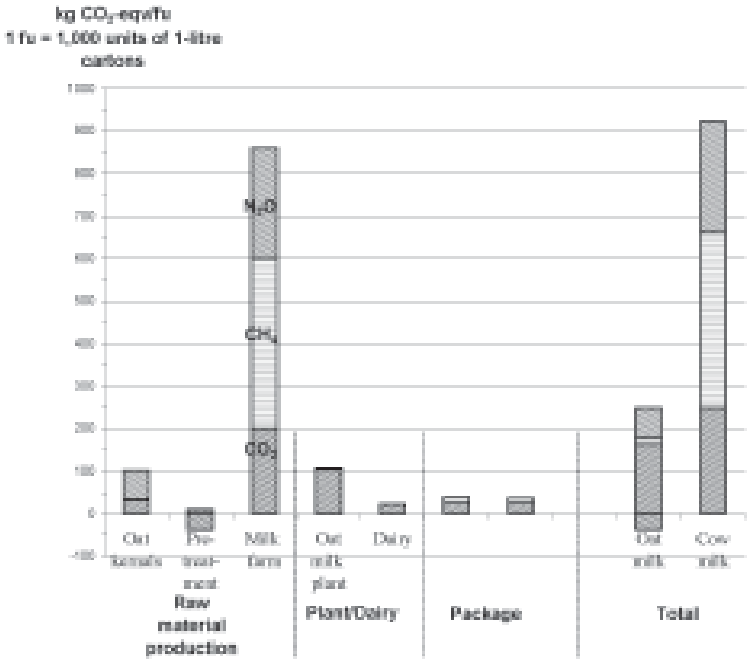

Figure 5. Why much more oat milk can be produced.

Cow milk production depends entirely on how cows digest cellulose fibres. A Swedish milk cow produces about 100 to 130 kg of methane[7] annually, mostly through anaerobic fermentation in their rumen. Cows are partly fed with concentrated diet of grain, soy and other supplements to produce more milk. Rational crop production using nitrogen-phosphorous-potassium (NPK) fertilisers

increases CO2 and N2O emissions. The feed chain for cow feed in conventional milk production is complex and has a great impact on the environment. Altogether it adds up to that 1 litre of milk at the farm gate emits at least 0.86 kg CO2 equivalents[8].

LCA calculations presuppose specific conditions and are thus difficult to apply generally. Production of oats and milk vary. LCA numbers for milk are of high quality - thanks to the many articles that have been published on the subject. LCA numbers for oat milk are uncertain because they are based on few published LCA calculations.

Because of the uncertainty in the LCA calculations, this article most likely overestimated climate impact for oat milk and underestimated the same for cow milk. For example, figures for oat milk processing do not include secondary use, such as use of bi-products for heating and animal feed. So emission data could possibly be reduced.

The fu for oat milk is not equivalent to the fu for cow milk because the oat milk undergoes ultra-high-temperature (UHT) treatment while the cow milk is only pasteurised milk, a less energy demanding process. The cartons are also slightly different.

Because the oat-kernel-to-oat-milk process studied in this article is new and only one LCA calculation has currently been made, other errors may exist.

Large-scale effects

What is the effect of these findings on a societal level? Suppose Indian authorities let 20 million schoolchildren drink 0.25 litres of oat milk and 20 million schoolchildren drink 0.25 litres of cow milk a day, 200 days a year. This corresponds to annual production of about 1 million m3 oat/cow milk. If nutritional effects are similar, what are the consequences of such a decision? Due to lack of data that are valid for India, Swedish numbers and prerequisites were scaled up to simulate the effect in India.

According to Figure 6, about 250 kton of CO2 equivalents (the blue line) are produced through oat milk consumption, 910 kton (the red line) through cow milk consumption. The dotted green line is the difference. The y axis indicates the number of cars driven 15,000 km/year and emitting 0.15 kg CO2 per km that corresponds to kton CO2 equivalents.

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7 www-mat21.slu.se/publikation/pdf/Hdj8s26-27.pdf, http://www.telegraph.co.uk/news/newstopics/howaboutthat/2274995/Cow-farts-collected-in-plastic-tank-for-global-warming-study.html. (The Argentine researchers discovered methane from cows accounts for more than 30% of the country's total greenhouse emissions. Guillermo Berra, a researcher at the National Institute of Agricultural Technology, said every cow produces between 800 to 1,000 litres of emissions every day.

8 SIK-studie. Klimatpåverkan av tio ekologiska livsmedel. June 2007. "Maten och Miljön, - LCA av sju livsmedel", 2002.

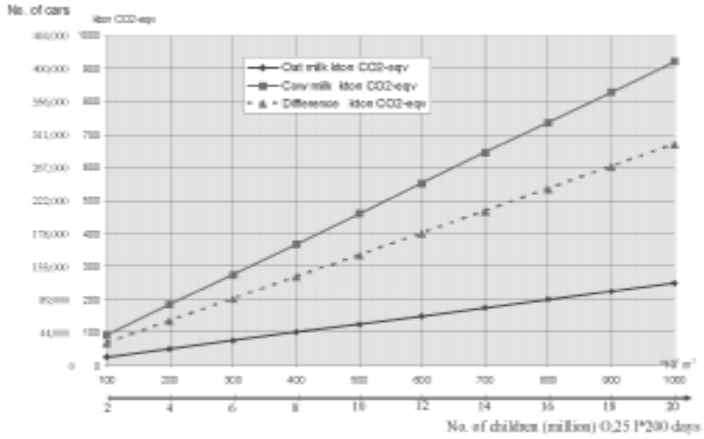

Figure 6. Variation and effects on GWP.

If the 20 million children drink oat milk, roughly 300,000 more cars can each drive 15,000 km a year than if the children drink cow milk. After optimisation of the Oatly production process, savings would correspond to about 500,000 cars.

In Figure 7, the authorities liberated a land area of about 30 x 30 km2 for other crop production. Since rational/industrially produced milks are being compared, the quality of this land can be assumed to be good[9] .

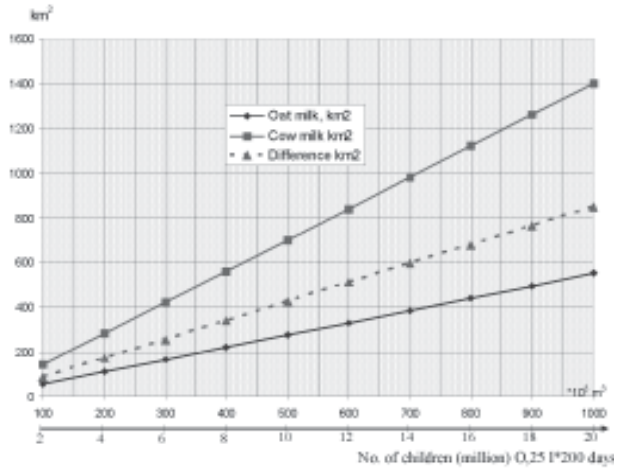

Figure 7. Land requirements.

9. *http://www.fao.org/ag/magazine/0612sp1.htm. "Grazing occupies 26 percent of the Earth's terrestrial surface, while feed crop production requires about a third of all arable land. Expansion of grazing land for livestock is a key factor in deforestation, especially in Latin America: some 70 percent of previously forested land in the Amazon is used as pasture, and feed crops cover a large part of the remainder. About 70 percent of all grazing land in dry areas is considered degraded, mostly because of overgrazing, compaction and erosion attributable to livestock activity".*

7.3. Investment capital needs

Figure 8 illustrates that oat milk investments are about USD 500 million and cow milk investments about USD 2,000 million. Conservatively, savings are about USD 1.5 billion. Costs for collection and distribution of cow milk (such as dairies) were not included.

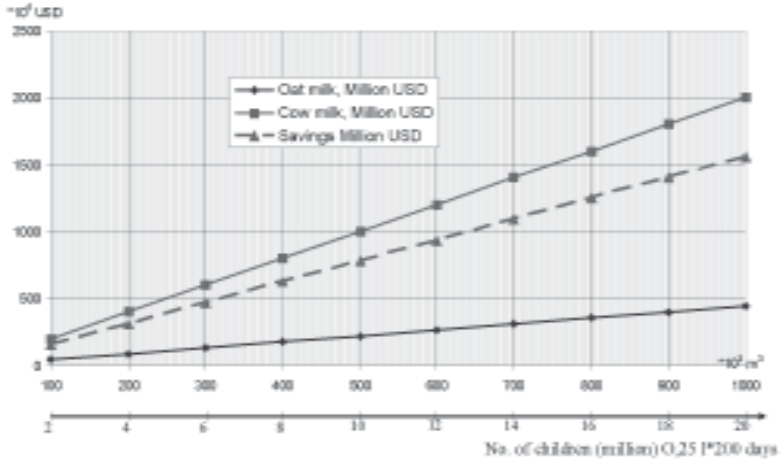

Figure 8. Investment capital rquirements.

Conclusions

Clearly, food produced for human use has a serious impact on climate change. Foods, such as cow milk, are a large part of this impact. And large-scale milk production is expanding rapidly worldwide. So foods that supplement milk as a nutritionally healthy beverage with sustainable environmental properties are of great interest.

Oat milk that is produced directly from the oat kernel by modern methods could be one answer. Preliminary oat milk LCA estimates show that the product meets environmental requirements concerning climate change. And compared with large-scale cow milk production, resource need (land and capital investment requirements) for oat milk production is lower.

The main obstacles to oat milk are cultural and habitual factors. Cow milk is regarded as a superior beverage, especially for growing kids, by most people around the world. Can oat milk compete with cow milk from a nutritional standpoint? The answer to this question is studied in a school intervention study with oat milk in China. Results are expected during 2010.

The ideas presented here are a realistic alternative, because oat milk is being produced in Sweden and sold under commercial conditions on a market that is open for competition.

A NON-DAIRY MILK FROM OATS - SUSTAINABLE UTILISATION OF PLANT BIOMASS FOR HUMAN CONSUMPTION

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Oats (*Avena sativa*) is traditionally grown and consumed by humans in the northern regions and countries of the northern hemisphere, such as Europe, Russia, and Canada. It is also grown in China, and in northern India, primarily for feed production. It is found in the southern hemisphere as well, in particular in the countries further south, such as Australia, New Zeeland, Argentina and Chile. Further north, i.e. Bolivia and Venezuela oats is grown as well, but at a higher altitude.

The macronutrient composition of oat makes it very suitable for human consumption. The proportions of protein, fat and carbohydrates are close to the overall recommendations for intake of the energy giving nutrients. In addition, oats contain dietary fibres. The beta-glucans, a significant part of the water-soluble dietary fibres of oats, have been in focus among nutritional and food scientist and food producers for some time. They are believed to be responsible for the cholesterol lowering effect of oats and oat bran, a fact endorsed by FDA in the US and by the Swedish authorities on health claims. Further, beta-glucans are viscous fibres that may slow down intestinal uptake of carbohydrates (lower GI).

Through relatively new processing techniques new non-dairy liquid products from oats have been successfully developed and introduced in the Swedish and international market. They increase the opportunity to consume oats and oat components, and may thus significantly contribute to a healthy living, thereby reducing the risk of diet related diseases. The patented processing procedure includes enzymatic "fermentation" of starch into low-molecular weight compounds

that gives the "oat milk" a mild, sweet taste attractive to many consumers. The oat milk also forms a base for developing other types of milk free dairy products such as cooking creams and ice cream. The possibility to ferment oat milk is currently investigated. For many uses, oat milk should be an attractive alternative to cow's milk with, compared on an equal volume base, a cheaper infrastructure for production, much less land use and lower environmental impact.

What is oats?

Oat (*Avena sativa*) is a grain that thrives in cold climates. Although its health properties for humans are unique among grains, its primary use worldwide is animal feed, known to be particularly good for horses. Human consumption consists primarily of porridge and more or less processed in breakfast cereals, predominantly in North America and Northern Europe. The best quality grains in the Northern Hemisphere are grown in Scandinavia, North America and Canada. It is also grown in some parts of Asia, i.e. in China. In the Southern Hemisphere, notable amounts of oats are grown particularly in Australia but also in New Zealand and Argentina (1).

The nutritional composition of oats is exceptional. Oats contain a higher percentage of protein with superior amino acid balance in comparison to other cereals. The lipids are highly unsaturated and contain substantial amounts of essential fatty acids. Oats are also a rich source of antioxidants as well as a number of essential vitamins and minerals, such as vitamin E and folic acid. Further, oats contains dietary fibres, including water-soluble beta-glucans (1,2).

Contrary to wheat, barley and rye, oat is now on the verge of being officially recognised as safe for individuals with gluten intolerance. This is most likely due to the fact that oat proteins have a structure different from those in other cereals (1). This observation will further increase the usefulness of oat products (3).

Health potential of oats

In the US, FDA has made a ruling on food labelling of health claims relating oats consumption and reduced risk of heart disease, which was based on a thorough review made by FDA (4). In short FDA allows health claims to be made on nutritionally balanced food products made from oats or oat bran that give 0.75 g beta-glucans per serving. Recently, the health claim has been extended to also include concentrated beta-glucan preparation from oats.

Other potential benefits of oat consumption include positive effects of polar lipids, which constitute almost 10% of the total lipids in oats. It has been found that these lipids, at least in combination with some other fatty acids, convey a feeling of satiety (5).

Potentially beneficial health effects may origin from the avenanthramides, a

group of oat specific substituted N-cinnamoylanthranilic acids, antioxidant compounds present in oats that may have anti-inflammatory effects (6).

Non-dairy oat milk technology

Milk is one of the important foods of man, and it is used as a healthy drink or as raw material for the production of dairy food such as yoghurt, cream, ice cream and more. Still, the ability of many humans to enjoy these products is limited for a number of reasons. Lactose intolerance is the reduced ability of humans to digest milk sugar (lactose). Although most often described as intolerance, this is in fact the normal condition for most grown-up humans worldwide, making the ability to digest lactose the exception ('lactase persistence'). A low intestinal level of lactase limits the amount of lactose in the diet that can be conveniently tolerated.

Milk protein allergy affects about 2% of children 0-4 years of age and put a strict limitation to the use of milk products for these categories. Total exclusion of milk protein containing products is often a necessity. For a family having a milk allergic child, soy-containing products is not a good alternative, since about 30% of the afflicted children would then develop soy protein allergy (8).

Further, some religious concerns (i.e. Jewish 'Kosher food', Coptic orthodox church) also restrict the use of cow's milk based dairy products as a component in the diet.

In order to obtain a health promoting non-dairy alternative that could satisfy the need of those not being able to consume cows milk, a technology to manufacture a milk-like product from oats was developed (9). The composition of the obtained product is given in the table. In comparison with other non-dairy milk products, the product is well balanced with respect to the proportions of macronutrients, and it is also containing dietary fibre, which is a limit nutrient in particular in many European and North American diets.

Table: Basic nutrients in milk substitutes and raw material as compared to cow's milk and recommendations for humans

1 Within parenthesis: variety Mathilda
1 With added oil or eventually with Mathilda as raw material in the oat milk manufacture
1 With added oil

Health effects of non-dairy oat milk products

We have shown in clinical studies (10,11) that liquid oat products produced according to the developed non-dairy technology (9) retain the blood cholesterol lowering properties of oats and oat bran. Further we have found that this liquid oat base may be used as an efficient base in the manufacture of VLCD-products (Very Low Caloric Diet; 12). Also, some fermented non-dairy oat products were found to possess cholesterol-lowering properties (13).

The results show that the non-dairy 'oat milk' technology produce well tasting, healthy alternatives to dairy products that may be consumed as milk substitutes or as functional foods with clinically proven health effects.

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BIOGAS - VERSATILE RENEWABLE BIO ENERGY

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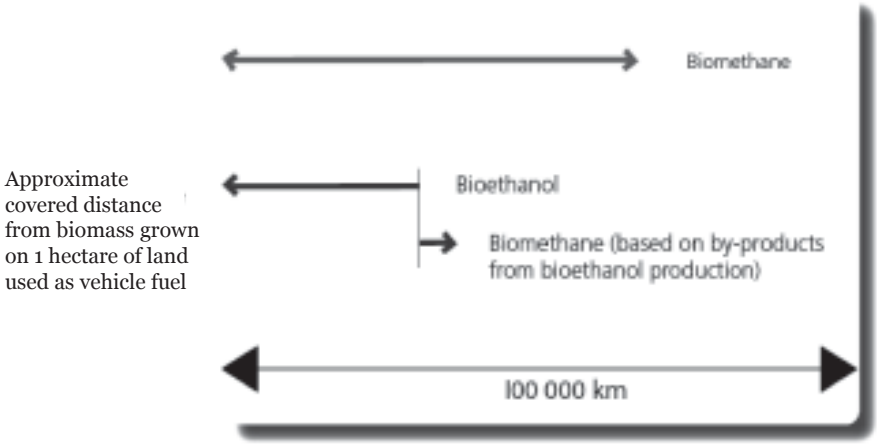
The need to markedly reduce consumption of fossil fuels has placed renewable alternatives in focus. Among bio based renewable vehicle-fuels two are completely dominating the debate - ethanol and biodiesel. However, when making an analysis of efficiency and environmental effects, it would certainly be smart to also include biogas in the discussion.

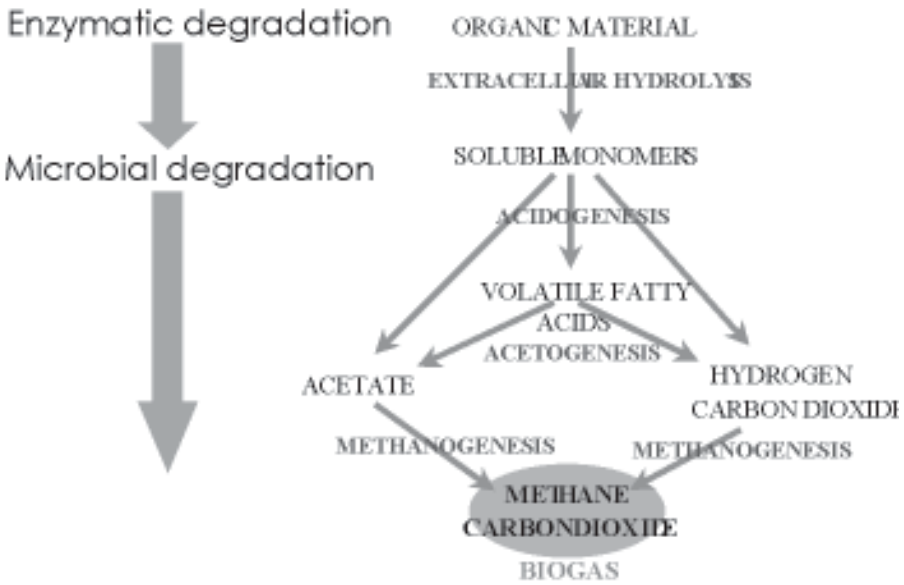
From the figure below it is clearly seen that when biogas is used as a vehicle fuel it is superior to ethanol, at least when calculated the distance one can drive on the crop harvested from one hectare of agricultural land in northern Europe.



Furthermore, biogas can be produced from almost any biomass, and this leads to utilization of waste biomass as raw material for production of biogas. Municipal solid waste, manure and sludge from wastewater treatment plants are the main resources used for biogas production until now. However, uses of special crops, so called energy crops, are starting to attract more interest.

When biomass is converted into biogas, three products are formed: methane, carbon dioxide and a solid residue which can be utilized as a bio fertilizer. All these three products may be used. The gaseous products are often not separated since biogas (the mixture between methane and carbon dioxide) is used without further separation. However, biogas as a vehicle fuel demands upgrading of the gas. Removal of carbon dioxide is done using different methods, leaving an enriched methane fraction behind. When the methane content is 96 % (vol/vol) or higher, it is regarded as being of vehicle fuel quality. This step in the production of vehicle fuel is one of the more costly. We are developing a process based on use of enzyme technology.

The anaerobic digestion when biomass in converted into biogas and a residue is catalyzed by a consortium of microbes. The process is complicated and different steps might be rate limiting under different phases of the digestion process. Since the process is complicated, it has constituted a real challenge to monitor and control it. By an efficient control, it might be possible to improve process stability and productivity.



We have demonstrated that productivity can be improved by as much as 100 % and the process stability and process documentation are markedly improved.

A limiting factor that now needs to be addressed is hydrolysis of biomass. Cellulosic materials have so far been resistant to enzymatic hydrolysis. Even if some hydrolysis has taken place, the efficiency is not good enough for building an efficient process on such hydrolysis.

In our department we carry out research concerning a more efficient utilization of biomass, both for chemicals and bio energy production. Furthermore, biogas upgrading and monitoring and control of the anaerobic digestion are two other areas where our interest is focused.

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SUSTAINABLE UTILIZATION OF INDIAN TROPICAL PLANTS FOR MEDICINAL/AESTHETIC/RELIGIOUS/SPIRITUAL/ OTHER PURPOSES BASED ON TRADITIONAL KNOWLEDGE (TK)

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Tropical plants of Indian origin include species which are used mainly as food, nutritive support, medicine, fiber, shelter, clothing etc., for essential basic needs, followed by the utility of some species as aesthetics, for spiritual/religious needs, based on the existing traditional systems. Since time immemorial, these requirements were met from wild, harvested by gatherers. With agri-horticultural interventions, cultivation practices came into existence for those species needed for food and nutrition, followed by those needed for fiber, clothing etc., by certain farming communities. With the intervention of trade linked to agriculture and horticulture, these communities were attracted by the profits of intense commercial farming of species used for other than food and nutrition. This diversification has led to the use of plant species in the tropics, either directly from wild ecosystems (unsustainable) or from specific agro-ecosystems through agri-horticultural interventions (sustainable).

Indian trees and plants have been treated with a tremendous amount of religious fervor for devotional and sentimental reasons, as life forms and integral part of a family unit. Plants and trees are associated with Indian mythology, history etc., and referred to in the epics with several anecdotes. Gupta, in her book published in 2001 on 'Plant Myths and Traditions in India' has described 45 species of tropical/ sub-tropical plants with their taxonomic names along with myths and stories associated with each one of them, as well as their usage and traditions unique to each of the species in the Indian ecosystems.In the foregoing analysis, sustainable use of Indian tropical plants for medicinal, aesthetic, religions and spiritual needs

based on TK, an attempt is made to categorically evaluate the extent of sustainability, particularly in today's context of biodiversity utilization in the Indian sub-continent.

Indian tropical fruit species

The Indian gooseberry, Emblica officianalis, commonly known, as 'Amalaka' is one of the most important ancient traditional fruit species. This is a sacred tree worshipped by Hindus on certain auspicious days and is known to have been credited with magical properties by tribal communities. Besides several mythological anecdotes, the plant has a great medicinal value, which is reported to be perceived best when planted on the southern part of a dwelling. Aegle marmelos, commonly known as 'Bilva or 'Bael' is considered as a sacred tree with trifoliate leaves, said to resemble the 'trishul' emblem of lord Shiva, denoting creation, preservation and destruction. The leaf pattern is also reported to represent the 3 eyes of lord Shiva. The tree is often referred to in the Indian mythology. The fruit is highly medicinal and is reported to cure diseases related to skin, GI track and purifies blood. Planting is required to be done on the northern side of the dwelling. There are several examples of fruit trees documented in mythology and epics to have bearing on physical, mental and spiritual health. Traditional Knowledge derived from the ancient scriptures written on leaves, primary information collected from tribal communities and Vaids practicing traditional medicine constitute some of the sources are being used by the modern systems for validation and documentation in the form of digital libraries. This has also brought to focus, the importance of such documented information available in the form of literature for use by the scientific community for sustainable non-native use of fruit species.

Secondary market interests for diversified diets, better health and foods to improve nutrition have considerably strengthened the need for sustainable non-native use of fruits by the modern consumer. Quite a few of them besides being nutritionally rich are also of great medicinal value. Many of them besides being a reservoir of vital minerals and vitamins are also known to have therapeutic value. Fruits like grape (Draksha) and pomegranate (Kuchaphala) due to high antioxidant activity in them have a role in lowering blood pressure. The antioxidant compound resveratrol found in grapes skin (and thus in red wine) is good for cardiovascular health. Pomegranates also have a very high antioxidant activity, offering brain and memory protection. Research has shown that regular intake of pomegranate juice helps lowering the risk of arteriosclerosis. It is also reported to have cancer-preventive properties specifically against lung and prostate cancer.Many tropical fruit species are reported to contain anthocyanidins, a group of naturally occurring antioxidants which have previously been proven to have chemo preventive properties. A new study indicates that these compounds can also selectively kill leukemia cells in culture without discernible toxicity against healthy cells. Many

fruits also contain pectin, a compound that confer anti-cancer properties.

Juice extracted from Morinda citrifolia,(Noni) grown throughout the Indian subcontinent also known as Beach Mulberry, has high levels of many vitamins, most of them seem to diminish during processing leaving mainly vitamin C. A preliminary study indicated that citrus juices enabled more of green tea's unique antioxidants to be retained after simulated digestion, making the lemon-tea even healthier than previously thought. Using a model simulating gastric and small-intestinal digestion, it has been found that citrus juice enabled more catechins to be available in the intestines for absorption. Catechins displayed health-promoting qualities and may be responsible for some of green tea's reported health benefits like reduced risk of cancer, heart attack and stroke. Citrus juice increased recovered catechin levels by more than five times. Ascorbic acid or vitamin C, used to increase shelf life in ready-to-drink products, increased recovered levels of the two most abundant catechins by six and thirteen-folds, respectively.

Nutrigenomics is a nutritional approach that relates to genetic makeup, and hence ones' predisposition to certain chronic diseases. If a diet plan considering fruits can be designed based on an individual's genetic profile, the risks of chronic diseases could be prevented. Most people are not yet ready to embrace this concept. Information on what fruits one can eat to reduce risk factors, rather than getting a list of fruits one must avoid may be useful for ascertaining the impact of sustainability. One needs to benefit from eating more fruits rather than popping pills.

Indian Ornamantals

Medicines have been prepared with flowers since ancient times. In Ayurveda there was a whole treatise on 'Pushpa-Ayurveda', which has unfortunately been lost. Flowers are used for therapeutic purposes chiefly in two ways: one for their fragrance, called Aroma-therapy which utilizes the essential oils extracted from flowers; the other developed by Edward Bach, called 'flower remedies' which uses the essence of the flower in water. Bach made and used 38 flower remedies from flowers in the British countryside. But now people all over the world are preparing remedies from indigenous flowers. There are the Australian Bush essences, American flower remedies and the Indian Aditi-Himalayan flower remedies. Those working with these essences were pioneers and have mostly been intuitively guided to their use since the 1870's. Edward Bach left his lucrative medical practice to discover these flower essences in the British countryside. Others, all over the world have been using this approach to come in contact with the indigenous plants and use their flowers for healing.

Ornamental plants of tropical Indian origin are well known and popular for their versatile use as aesthetic, religious and spiritual commodities. For example,

Lotus (Padma) an aquatic nymphaceous plant, Nelumbo nucifera, having solitary flowers about 8-15 cm across, usually projecting above water with leaves spread above the water surface with rose pink to white color and fragrant finds extensive use during DURGA PUJA festival by the local Hindu communities. Flowers are also used in indigenous system of medicine. The ripe seeds are edible and highly nutritious. Of these, the lotus has been mentioned in the ancient Sanskrit scripture of the Vedic times. Kalidasa also made mention of the lotus in his play Shakuntala. The poet Asvaghosa (A.D.100) also mentions the lotus in his Buddha Charita. There is no sustainable production of this commodity in India through organized farming practices.

Important flowers native to India which are under cultivation in different parts of the world are orchids, rhododendrons, musk rose (Rosa moschata), begonia, balsam (Impatiens balsamina), globe amaranth (Gomphrena globosa), gloriosa lily (Gloriosa superba), foxtail lily (Eremerus himalicus), primula (Primula denticulata P.rosea), lotus (Nelumbo nucifera), water lily (Nymphae spp.), clematis (Clematis montana- a climber) and the wild tulip of the Himalayas (Tulipa stellata and T.aitchisonii). Among the tree species, the Night Jasmine, which is commonly known as Parijata, has significant importance in the Hindu religion, particularly in Matsya Purana. The tree is considered as a 'Kalpavriksha'. This tree is also called as 'Tree of Sorrow' with the taxonomic name as Nyctanthes arbor-tristis referring to the night flowering habit of the tree. There are several mythological anecdotes referring to this tree in the epics. The flowers are easily harvested by shaking the tree for making garlands and used on religious occasions. Its leaves are antibilious and expectorant, used in rheumatism and fevers. Decoction prepared from the leaves is used in the treatment of sciatica. It is also known to have laxative, diaphoretic, diuretic and de-worming properties. Powdered seeds are used in scalp infections. According to Dr. M. S. Randhawa, the flowering trees were commonly grown in the gardens in the Hindu-Buddhist periods and the native annual herbaceous plants were perhaps not cultivated. A revisit is perhaps needed in the context of their versatile utility in modern times, for their sustainable use beyond their conventional utility!

Indian tropical plants & their medicinal use:

As has already been mentioned in the earlier sections, Indian tropical plants have an immense potential for medicinal use. There are several reports already published and adequately reviewed elsewhere, which is well documented. An attempt is made to do a SWOT analysis.

Strengths: Indian subcontinent is rich in biodiversity; existence of 2 hotspots of biodiversity (Western Ghats and the North East) ; 30% species endemic, has a rich TK base etc.

Weakness: Majority of species harvested from wild, to meet 95% of Industry's requirement for product development; Rapid increase in RET species category, lack of agri-horticultural interventions for development of cultivation practices; Lack of well defined in situ PHM leading to over extraction, etc.,

Opportunities: Scope to develop cultivation practices, support eco-restoration and enrichment of forest gene pool; Augment in situ diversity at species level;Develop well defined and sustainable in situ PHM strategies as a stop gap arrangement till cultivation practices are developed through agri-horticultural interventions. Support JFM programs and organic farming; Identification of local and export markets for products, through assessment of demand and supply position etc.,Scope for biotech intervention.

Threats: Increase in tropical plant extinction rates ; Constraints in developed cultivation practices; Changes in land use and ceiling restriction; Lack of appropriate agro technology; Issues related to conflict, biopiracy of species or their extracts and related loss of TK to other nationalities, occurrence of natural calamities, etc.

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PRODUCTION OF CHEMICALS AND POLYMERS FROM RENEWABLE FEEDSTOCKS USING INDUSTRIAL BIOTECHNOLOGY

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Fossil resources constitute the major feedstocks for fulfilling the current demands for chemicals, materials and energy. There is however an increasing concern about depletion of these non-renewable resources on one hand and on the other about the environmental damage resulting from the non-biodegradable products and the processes used for their production. This has led to a growing interest in shifting the raw material base of the industry to renewable biological feedstock that would potentially result in biodegradable products and a reduction in greenhouse effect.

Industrial biotechnology is considered to be a potentially important tool in facilitating the paradigm shift from fossil to bio-based production. It relies on the use of whole cells or enzymes as reagents or catalysts in processes based on fermentation or biocatalysis. Industrial biotechnology offers a potentially cleaner and more energy-efficient means of production than chemical processes, and is also naturally adapted to processing renewable feedstocks.

The research programme, Greenchem, based at Lund University, Sweden, focuses on development and application of sustainable biotechnology based processes for production of environment-friendly chemicals from renewable feedstocks. The different product groups of interest are targeted for applications in environment-friendly surface coatings, lubricants and biosurfactants. Biocatalysis forms the main theme of the processes for which novel and robust biocatalysts are obtained by exploring natural microbial diversity of extreme environments and by applying mutagenesis. The biocatalytic processes are run in a solvent-free medium.

The new processes and products are evaluated from a technical/economical and environmental point of view, e.g. by doing life cycle analysis. A proper choice of the renewable raw material has been seen to be important in achieving the desired environmental advantages over the fossil based resources.

In another project, a moderately halophilic microorganism is used for the production of a biopolyester, polyhydroxybutyrate (PHB) at high concentrations from different renewable feedstocks. PHB resembles the common petrochemical-based synthetic thermoplastics, polyethylene and polypropylene, with respect to mechanical properties, but differs in being biodegradable, biocompatible and non-toxic.

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REFLECTIONS ON SUSTAINABLE UTILIZATION OF PLANT BIOMASS FOR PRODUCING MANURES AS PART OF ORGANIC AGRICULTURAL PRACTICES

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Organic agricultural practice is an age old phenomenon. The essentials and importance of organic farming has been discussed by various authors (Gahukar, 1993; Gupta, 2004; Kler et al., 2001; Lockeretz et al., 1981; Prasad, 2005; Ramesh et al., 2005; Reganold et al., 2001; Shiva et al., 2004) [1-8].. However, the scientific explanation of how it works is not fully appreciated in academic circles whereas it could be easily explained with nutrient recycling and biomass conversions. Taking a cue from forest ecosystems which are independent in maintaining the ecological balance without any human intervention we should emulate and understand the processes going on and try to simulate such processes in our agricultural fields also. So what is happening in a forest? Are we adding any chemical fertilizers and pesticides? Is there any need of farming interventions in the forest. For example do they require any watering, ploughing, seeding, etc. Without any human intervention if the processes could continue relentlessly it is mainly because of nutrient recycling. Nutrient recycling is simply conversion of organic content into inorganic elemental form. Who does it? The microbes such as fungi, bacteria, microfauna (protozoans and nematodes), mesofauna (springtails and mites) and macrofauna (millipedes, isopods, earthworms, and other burrowing animals). There are a number of reviews and other articles available on nutrient recycling and it is carried out by the above mentioned organisms (Alongi, 1994; Attiwill and Adams, 1993; Cromack and Caldwell, 1992; Dighton, 1995; Fell and Master, 1980; Hattenschwiler et al., 2005; Wicklow and Carroll, 1981) [9-15].. The physical processes of nutrient recycling is

mainly carried out by the release of a battery of degradative enzymes by different microbes (mostly extracellularly) that degrade polymers such as carbohydrates (cellulases, hemicellulases and lignolytic enzymes); proteins (proteases) and lipids (lipases) into monomers and finally into elemental form thus making the nutrients in the readily available inorganic form to the plants. In the case of faunal organisms, however, it is ingestion, release of enzymes intracellularly and passing through an alimentary canal system before finally releasing the digested litter as excreta which is rich in nutrients. One of the advantages of organic agriculture is leaving the natural processes of nutrient recycling to take place in an agriculture field by adding enough organic material so that the nutrients are released slowly thus making the nutrients available to the plants throughout the year.

Where do we find the organic source? The answer is whatever biomass that is available as waste from the previous crop could be recycled without wasting anything in it. Mulching alone can bring out nutrient recycled and over a period of time the same makes all the nutrients available for the next set of crop growing. If any human intervention is required there are well established practices that can speed up the process of degradation. These are aerobic and anaerobic composting techniques including that of vermicomposting, NADEP- composting, farmyard and green manures. Now the question is whether it is possible to recycle all the biomass that is in the polymeric form to elemental form without any loss. There could be loss but it would be negligible if the biomass is trapped properly within the unit area, recycled and applied judiciously and uniformly. Going by physical laws i.e. "the energy can neither be created nor be destroyed but can only be changed from one state of energy to another state" or chemical laws that "mass of the reactants and products would be same" the biomass in a unit area can be recycled as per the original biomass perennially. Not to depend on subsidies or other freebies the farmers should consider the available biomass of their village as their real wealth. In other words banking on biomass is equal to "biomass banking". In this connection what we require is an "Integrated Biomass Management" as one of the strategies of sustainable agriculture (Sarma, 2008a)[16].

The impact of conversion to organic agriculture on yield has been assessed and the indications are that (i) In intensive farming systems, organic agriculture decreases yield; the range depends on the intensity of external input use before conversion (Stanhill, 1990; Wynen, 1994; Halberg and Kristensen, 1997)[17-19]; (ii) In the so-called green revolution areas (irrigated lands), conversion to organic agriculture usually leads to almost identical yields (Rajendran et al., 2000; Kler et al., 2002)[20,21] (iii) In traditional rain-fed agriculture (with low external inputs), organic agriculture has shown the potential to increase yields (Huang et al., 1993 ; Sing et al., 2001) (Vide Ramesh et al., 2005)[6,22,23]. In addition to this a number of studies also have shown that under drought conditions, crops in organic

agriculture systems produce significantly higher yields than comparable conventional agricultural crops (Stanhill, 1990; Dormaar et al., 1988)[17,24] often more than conventional crops (Wynen, 1994; Lockeretz et al., 1981; Pettersen et al., 1999)[4,18,25] by 7-90% (as quoted in Ramesh et al., 2005)[6].

One of the concerns of organic farming has been that the yields are 10-15% less than chemical farming produce in the case of intensive farming systems as mentioned above. However this situation is often found in the initial years of conversion to organic farming method from an erstwhile chemical farm fields. To compensate any such low yields the farmers could resort to multiple cropping which would provide different other farm produce also in addition to the main crop (Shiva et al., 2004; Sarma, 2008b)[8,26]. One of the advantages of multiple cropping is that it could provide additional income from various other crops in an unit area, increases agrobiodiversity (Shiva et al., 2004)[8] and also sequesters carbon dioxide more efficiently if a few trees are also planted thus reducing the green house gases and global warming (Sarma, 2008b)[26]. In fact such tree plantation along the boundary or intermittently would also provide carbon credits to the farmers.

If organic farming has to succeed then it should compete with chemical farming by offering the products at lower prices than at higher prices and this is not only possible but also it is very simple. Organic agriculture has to be taken as a routine practice for maintaining ecological balance and as a method which is safe. If organic farmers become greedy and put a higher price for their produce then, only, those who are rich can purchase and it becomes a fashion for a few to resort to organic produce. Selling organic produce at higher prices is a retrograde step and would be detrimental for organic movement itself. Hence the next achievement and focus should be on to bring down the prices of organic produce to lesser than the chemical farming produce.

Where to find organic material free of cost? The answer is plenty of plant biomass that is available on the roadsides in the form of weeds could be used as the raw material for composting or mulching. This biomass (from weeds) should be considered as invaluable and the same should be applied in the agricultural fields. However care should be taken to remove the biomass before flowering or make sure that the seeds are not carried on to the actual crop area. This is to avoid weeds growing in the crop area. Then the waste becomes wealth. Here only human labor is involved and there is no investment. No one is going to ask us as to why you are removing the biomass of the weeds. Further farmers should follow the theory of "nothing is waste". Even if a crop fails due to one reason or the other the farmers should not get panicky. Instead they should try to get something out of the crop failure. This could be in the form of converting the biomass of the affected crop into charcoal briquettes, compost, mushrooms, eco-friendly paper from the fiber or any other such value added products. There should be a trading of biomass.

The standing (living) or dead and decomposing plant biomass could be converted into different types of organic manures for sustainable utilization of the biomass as part of organic agricultural practices. Though farmers have their own traditional practices of organic cultivation of crops, often the methods of production of manures, field application of manures, science and logic behind how organic manures work and cost benefit analysis of organic manures are elusive to many farmers and the common man as well, in terms of knowledge or information reaching them. In the present paper in addition to presenting own ideas, attempt is made to briefly review and concisely bring out reflections, based on available literature, on some aspects of processes that take place in biodegradation and proper utilization of plant biomass for the preparation of organic manures and their sustainable utilization for agricultural purposes. In addition to the above methods available for conversion of organic matter into different types of composts and their usage also in urban backyards, small households would be elaborated during the conference.

Key words: Nutrient recycling, litter degradation, Integrated biomass management, biomass banking, organic agriculture, multiple cropping, agrobiodiversity, composting

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THE FOOD VS. FUEL DEBATE IN THE GLOBAL AND INDIAN CONTEXT

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In the industrial age, fossil fuel energy has been widely used to generate food. In the 21st century we are witnessing a reversal of the process whereby large-scale conversion of food for producing oil or biofuels for our machines is taking place. We are 'growing oil from soil.' Two main types of first generation liquid biofuels are Ethanol and Biodiesel. Ethanol is carbohydrate-derived: Produced from sugar (sugarcane, sugar beet tubers, sweet sorghum, etc) and from starches (such as corn, wheat and cassava). Whereas biodiesel is lipid-derived, being produced mainly from vegetable oil through the process of transesterification. Essentially, we are displacing land required for food production to produce liquid fuel, in both cases of ethanol and biodiesel. This paper is an attempt to holistically analyze the current and future potential impact of biofuel production on global food security, with a special emphasis on India. Alternatives, strategies and policies are also discussed.

METHODOLOGY

The methodology used is as follows. Hard data on actual consumption of various first generation feedstocks for biofuel production was collected. Then field-stock yield assumptions for land-use estimates have been studied. The extent of land alienation required for various levels of biofuel production was then assessed. This assessment is based on current consumption of gasoline and diesel and the replacement levels being proposed in blending policies evolved by governments. There is a specific focus on the Indian policy and its likely impact on food self-

sufficiency. Latest international studies by multilateral organizations like FAO and World Bank have been documented to gather factual evidence. A futuristic long-term post-fossil fuel scenario has also been attempted. While doing so, the potential and efficiency of emerging second generation technologies to mitigate food-insecurity have been studied. Based on that, new technology and policy options, as well as strategies have been elaborated.

DISCUSSION

Global Scenario: Several studies published in 2008 by reputed multilateral organizations under the UN-Brettonwoods umbrella have highlighted the strong linkage between biofuel production and galloping food prices. First and foremost evidence comes from a recent study by the F.A.O.

The production of 1st generation biofuels distorts food markets in three ways:

Diverts land / grain away from food for producing fuel e.g.

One-third of the corn grown in USA is now used to produce ethanol.

50% of the vegetable oil in the EU is diverted for production of biodiesel.

The lucrative biofuel industry has increasingly encouraged farmers to divert land to biofuel crops.

It is a myth that biofuel crops are grown on wastelands.

Diversion of grains and the resultant shortages have fuelled financial speculation in grains, driving up food prices higher and higher.

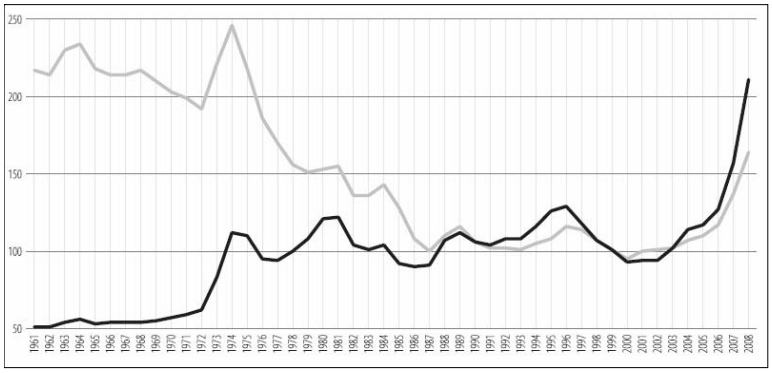


Figure: Extended Annual FAO Food Price Index 1998 - 2000=100

The figure above shows the following important pointers. Since 2006, the average annual growth rate of food prices has been 15%, a historic high. In the first three months of 2008, international nominal prices of all major food commodities reached their highest levels in nearly 50 years. Prices in real terms were highest in nearly 30 years. The FAO food price index rose, on average 8% in 2006 and 24% in 2007. In the first quarter of 2008, the index rose 53% compared to the first-quarter

of 2007. Vegetable oil prices on an average increased by more than 97% during the same period, signalling its strongest links to biodiesel production. This was followed by food grains (87%) and dairy products (58%). In short, the cereals and oilseeds sector are the worst affected because of increased demand from the biofuel industry. There is also a strengthening of linkages among different agricultural commodity markets (i.e. grains, oilseeds and livestock products) and others, such as those of fossil fuels, biofuel and financial instruments. This is not to forget some marginal supply-side issues like weather related production shortfalls or financial problems like the decline of the dollar. A World Bank study titled "A Note on Rising Food Prices" authored by Donald Mitchell was completed in April 2008. Mitchell is not an anti-biofuel campaigner, but an economist with 30 years experience and specialization in commodity markets. In sum, the report argued that the drive for biofuels by American and European Governments has pushed up food prices by 75%. Rising demand from China and India, weather related production shortfalls (Australia), higher energy and fertilizer prices, the decline of the dollar, etc... all together contributed to only 25% of the increase in food prices.

A feed-stock based analysis of second generation technology (currently not commercialized) shows that even though there may not be diversion of food, it would also put great pressure on land required to produce food. This is considered in view of the increasing population and diversion of land for other non-agricultural uses. However, alternative strategies and policies could be more effective. Production of biodiesel from algae is one good example, whereby land requirements could be significantly reduced. Decentralized rural biomass production though innovative agronomic practices can also help generate economic activity, employment and incomes in rural areas, without jeopardizing food security.

Indian Context: The Government of India has just announced a "National Policy on Biofuels". The key features are:

" 20% blending of biofuels - both ethanol (with gasoline) and biodiesel (with diesel) - by 2017

" Blending levels prescribed for bio-diesel are recommendatory in the near term

Existing 5% blending of ethanol has been raised to 10% from October 2008

Biofuels brought under the ambit of "declared goods" to facilitate unrestricted movement within and outside the states

The strategy and approach of the policy states:

"The focus for development of biofuels in India will be to utilize waste and degraded forest and non-forest lands only.....Therefore, the issue of Fuel Vs. Food Security is not relevant in the Indian Context..."

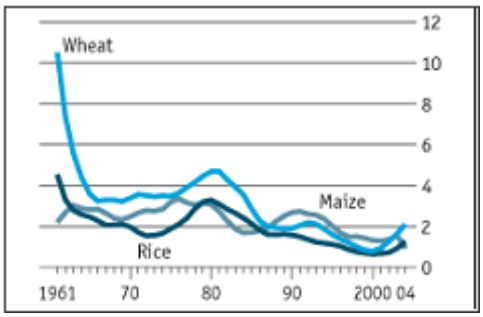
"Cultivators, farmers, landless labourers, etc... will be encouraged to undertake plantations that provide the feedstock ... corporates will also be enabled to undertake plantations through contract farming...."

In the section on 'Interventions and Enabling Mechanisms' it is stated:

"Plantations.... will be taken up on government / community wasteland, degraded or fallow land in forest and non-forest areas. Contract farming on private wasteland could also be taken up... plantations on agricultural lands will be discouraged..."

Currently, we produce about 1 million tonnes of fuel ethanol in India. This is sufficient to achieve 10% blending. But for 20% blending in 2017-18, we would require 3.87 million tonnes of fuel ethanol. Average sugarcane yield in India is 66.8 tonnes per hectare. One tonne of sugarcane yields 73 litres of ethanol. So one hectare of sugarcane gives 4926 litres of ethanol. For meeting the 3.87 million tonnes of ethanol requirement in 2017 for 20% blending, 1.07 million hectare land will have to be exclusively diverted to ethanol production.

Since biodiesel crops are proposed to be produced from wastelands, let us examine how much "cultivable" wasteland is actually available. The most optimistic figure would be around 20 million hectares of 'cultivable' wasteland. The current yield level from rainfed Jatropha / Pongamia is around 1-2 tonnes/ha. Even assuming 2 tonnes/ha production, 20 million hectares can give only 40 million tonnes of oil seeds. At 35% oil content (Jatropha) 40 million tonnes of oil seeds will give 14 million tonnes of biodiesel (1 million tonnes of biodiesel requires 1.42 million hectares of land). Which means for 22 million tonnes of biofuel required around 2020 (20% blending), we need 31.24 million hectares of land which is much more than the available wasteland. So even for 20% blending of ethanol (1.7 million hectares of agricultural land) and biodiesel (11.24 million hectares of agricultural land, if all 20 million hectares of wasteland is considered cultivable) alienation of agricultural land would become necessary to the tune of 12.31 million hectares. Whereas, every year we would need to produce 5 to 6 million tonnes of additional foodgrains to meet the needs of our increasing population. Alienation of land is



Diminishing Returns
Crop yields in developing countries
Annual Average growth rate, %

Source: World Bank

particularly dangerous in an era of climate change and diminishing returns from agriculture (as would be seen from the above figure).

The arable land area in India has reached a peak of around 140 million hectares. Our annual foodgrain production has stagnated around 200 million tonnes (plus or minus 10-15 million tonnes). By 2020, our population is projected to be 130 crore. Then our foodgrain requirement will increase substantially. Required annual average increase in foodgrains would be 5-6 million tonnes. Increased production of marine and livestock products is also difficult. Water woes, climate change, environmental destruction, soil erosion, etc., threaten to adversely affect food production. Any further agricultural land alienation for biofuels is suicidal, especially since land is already being diverted for many other non-agricultural purposes.

Besides the land diverted for commercial crops, agricultural land and resources are also being diverted for other purposes like:

" About 20 percent of the paddy lands in peninsular India are diverted for commercial aquaculture.

" Land diverted for industrialization, housing, roads and highways. The recent SEZs only have diverted about 65,000 hectares of land, and threaten to divert more.

" Land used for entertainment and tourism (hotels, airports and golf courses).

" Land lost to other large infrastructural projects like dams.

" Land diverted for increasing production of grain for livestock and beverages like beer.

" Diversion of irrigation water for non-farm use in all the above areas.

FINDINGS / RESULTS

The following are the results of the analysis:

Biofuel production using first generation technologies have already significantly impacted food prices.

Even though second generation technologies, (when commercialized) may not divert food to produce fuel, they will divert land to produce biomass. So land-use scenarios have to be developed on a country-to-country basis. Such land use scenarios (in the context of first and second generation technologies) have been developed for U.S.A. and the European Union.

A 5% displacement of gasoline with ethanol in the EU requires about 5% of available cropland to produce ethanol while in the U.S. 8% is required.

A 5% displacement of diesel with biodiesel requires 15% of EU cropland, and 13% in the U.S. (land requirement for biodiesel in higher because average yields per hectare of cropland are considerably lower than for ethanol).

Land requirement to achieve 5% displacement of both gasoline and diesel would require 20% of the cropland in the EU and 21% in the U.S.

Alternative strategies like algae-based biodiesel production need to be studied in greater detail.

CONCLUSIONS

Maximum possible production of biofuels using first and second generation technologies in the most optimistic scenario would be 20% of the current petrol and diesel consumption.

A biofuel-based long-term transportation policy means food insecurity. Alternative routes of transportation energy to be evolved.

However, alternative strategies like algae-derived biodiesel or decentralized rural-oriented production possible by evolving age-old agronomic practices (like fence-planting) can help rural electrification, employment generation, etc.

Biodiesel policies should give priority not to endanger global food security.

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SOLID STATE FERMENTATION FOR THE PRODUCTION OF COMMERCIALLY IMPORTANT METABOLITES

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Solid state fermentation (SSF), defined as a fermentation process occurring in the absence or near-absence of free water, employing a natural substrate or an inert substrate used as solid support (Pandey et al., 2000) is amongst important techniques employed in biotechnology. Hence in recent years, there is an increasing interest in adopting SSF as an alternative to submerged fermentation because of several advantages such as concentrated product yield, cheaper substrate requirement, lower energy consumption, less wastewater production, lesser chances of contamination and eco-friendly as it resolves the problem of solid waste disposal. The last two decades have witnessed an unprecedented increase in interest in SSF for the development of bioprocesses such as bioremediation and biodegradation of hazardous compounds; biological detoxification of agro-industrial residues; biotransformation of crops and crop-residues for nutritional enrichment; biopulping; and production of value-added products such as biologically active secondary metabolites, including antibiotics, alkaloids, plant growth factors; production of enzymes, organic acids, biopesticides, bioherbicides, biosurfactants, biofuel, and aroma compounds. In the recent past, SSF has gained importance for the production of several high value low volume products like antibiotics (Balakrishnan and Pandey, 1996). Achieving high titers of enzymes and organic acids by SSF with fungi has been successful (Lonsane et al., 1985).

Considering the commercial importance in international market and advantages of SSF, fermentative production and downstream processing of four different biomolecules viz. Cyclosporin A (CyA), compactin, glutaminase and cephamycin C from different microbial sources was undertaken. Studies proceeded with evaluation of the effect of different fermentation parameters in SSF such as selection of solid substrate, initial moisture content, supplementation of salts, additional carbon and nitrogen sources as well as the inoculum age and size on production. The optimization of media constituents and environmental factors (pH, temperature) using different methods such as one factor-at-a-time and statistical approach viz. orthogonal array (Taguchi), response surface methodology (RSM) was undertaken.

METHODS

Five gram samples of substrate in total (single substrate or in combination) were placed in 250 ml Erlenmeyer flasks and distilled water added in order to produce the required initial moisture content. The flasks were then autoclaved for 20 min at 121°C/15 psi. After cooling the flasks to 29 2°C, seed culture was added, the contents in the flask thoroughly mixed, and then the flasks were incubated at 25 2°C.

Different agro-industrial residues were screened for the maximum production of selected biomolecules. Effect of hydrolysis of starchy substrates such as wheat bran, rice bran, millet flour etc. was evaluated for maximum production of CyA. Various combinations of substrates were also examined for the increased production. In order to study the effect of moisture content on production, it was varied between 55 % and 80 % by adding distilled water before autoclaving.

Various carbon sources including monosaccharides as glucose and fructose, disachharides as sucrose and maltose, and complex carbon sources as maltodextrin, starch and glycerol were assessed as additional carbon source for the production. Different inorganic and organic nitrogen sources were evaluated as additional nitrogen source for production selected metabolites. Various preculture studies were also performed to find optimum slant age, culture age and inoculum size for the maximum production.

The selected fermentation parameters were further optimized by different statistical methods as orthogonal array method and response surface methodology (RSM). Effect of various amino acids on cephamycin C production was also studied.

The fermentation was carried at 25 2°C for 9 days, 7 days and 6 days for maximum production of CyA, compactin and cephamycin C, respectively. Glutaminase fermentation was carried at 30 3°C for 48 h.

RESULTS AND DISCUSSION

Cottonseed meal supported maximum cephamycin C of 10.50 1.04 mg/gds by using S. clavuligerus NT4. Supplementation with ammonium oxalate (0.5 %) gave a maximum yield (15.34 0.87 mg/gds) of cephamycin C. The maximum production of cephamycin C obtained using the RSM optimized medium was 21.68 0.76 (mg/gds) with 6.27g of CSM; 0.244% of KH2PO4; 0.08% of ammonium oxalate; 3.68 ml of inoculum size; and 76.37 % of moisture content. The maximum production of cephamycin C obtained using the optimized amino acid combination was 27.41 ± 0.65 (mg/gds). The optimized combination consisted of L-lysine hydrochloride 3.86 %, valine 0.84 %, L-cystine 0.1 % and DL-methionine 1.5 % (Bussari et al., 2008).

A combination of hydrolyzed wheat bran flour and coconut oil cake (1:1) at 70 % initial moisture content supported maximum production of 3872 156 mg CyA/kg substrate as compared to 792 33 mg/kg substrate before optimization by using T. inflatum MTCC 557. Further, supplementation of salts, glycerol (1 % w/w) and ammonium sulphate (1 % w/w) increased the production of CyA to 5454 ± 75 mg/kg substrate. Inoculation of 5 g solid substrate with 6 ml of 72 h old seed culture resulted in maximum production of 6480 95 mg CyA/kg substrate (Survase et al., 2008).

A combination of oat meal and wheat bran (1:1) gave glutaminase production of 0.614 units/gds with artificial sea water as moistening agent (pH 8.1) using Zygosacchromyces rouxii. A central composite design of RSM was employed to investigate effects of four variables, viz. moisture content, glucose, corn steep liquor and glutamine on production of glutaminase. A 4-fold increase in enzyme production (2.93 units/gds) was obtained.

Compactin production by Penicillium brevicompactum WA 2315 was studied by single factor optimization for improved compactin production. Combination of wheat bran and groundnut oil cake (1:1) gave maximum compactin yield of 736 ug/gds. Di-ammonium hydrogen phosphate as additional nitrogen source supported maximum compactin production. Subsequently, levels of supplement components were studied statistically using Taguchi orthogonal array (L25-orthogonal array). Glycerol was the most significant contributor to compactin production. The optimal supplement composition suggested by MINITAB for compactin production by P. brevicompactum WA 2315 contained (in % w/v) glycerol 16, magnesium sulphate 0.75, glucose 11, (NH4)2HPO4 2.3, KH2PO4 2.0 and maltose 5, resulted in a compactin production of 771 ug/gds (microgram/gram of dry substrate). Subsequent studies resulted in further improvement of compactin yield by varying the pH of the supplement solution and an initial pH 7.5 resulted in a compactin yield of 815 ug/gds at initial moisture content of 58 % (Shaligram et al., 2008).

CONCLUSIONS

The widespread availability of agro-industrial residues coupled with the simplicity of solid-state fermentation makes the manufacture of value-added bio-molecules an attractive commercial proposition. Problems could arise in scale-up but could be tackled effectively by using appropriate techniques. The advantages of solid state fermentation far outweigh the problems and deserve a look by the entrepreneurs and manufacturers of bio-molecules.

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Keywords: Solid state fermentation, Cyclosporin A (CyA), compactin, glutaminase, Cephamycin C

RESEARCH AND DEVELOPMENT IN FOOD SCIENCE AND BIOTECHNOLOGY FOR THE SUSTAINABLE DEVELOPMENT OF KERALA

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The FAO has defined food security as reaching a complete package of foodgrains, pulses, vegetables, fruits, milk and non-vegetarian items like eggs, meat etc in sufficient quantity to people to sustain their physical, mental and intellectual health. In that sense, a not-too-small section of the Kerala population, including those with economic ability, do not enjoy food security. Even if we consider only rice, the staple food of Keralies, we were not self-sufficient in the recent past. There were paddy fields practically everywhere in the State. Today more than fifty per cent of the paddy fields have disappeared. The major factors affecting the food security of the state are reduced yield due to poor fertility of the soil, demand for land for non-agricultural purposes, high wages, high cost of living, changing food habits, health problems, and a fragile land mass.

In Kerala research and devedlopment in Biotechnology need to be given special emphasis as it can do a lot of things for producing more food from less space. Biotechnological tools including rDNA technology can really contribute to enhance food security of the state, but when it comes to the question of sustainable development the introduction of GM crops and GM foods need to be discussed in depth (Gaskell et al, 2004, Toke, 2004). Reseachers must be able to tell the consumers that the GM food from engineeed crops are absolutely safe to them. Since the GM food is still under a cloud the emphasis must be to apply biotechnology for the production of eco friendly biopesticides, bioinsecticides, biofertilizers etc. Being a state which is well known for its biological resources, Kerala need to take steps to enhance research and development for the proper utilization of the available

resources (Srivastava, 2003). The state is known for the poduction of many important food crops, spices, fruits and vegetables but many of these poduces are not properly processed and utilised because of the lack as a sound technological platform. Hence the state should give priority to utilize the available land resources by developing improved varieties tolerant to biotic and abiotic stresses and value addition, preservation and processing of the available food materials.

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ADVANCED RESEARCH AND HIGHER EDUCATION IN PLANT BIOTECHNOLOGY FOR SUSTAINABLE UTILISATION OF PLANT BIO MASS OF KERALA

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Biotechnological interventions hold great promise for sustainable utilization of the plant biomass of Kerala. Priority areas suitable to our agro-climatic and social environment have to be identified. It is essential that meaningful multi-institutional programmes for biotechnological interventions are initiated and centres of excellence, established. Also, it is important to develop human resource in biotechnology. Biotechnology offers immense career opportunities in India and abroad. However, competent manpower, essential to realize its potential often lacks. This necessitates introduction of high standard biotechnology courses and improvement of the quality of biotechnology education. Although there are several educational institutions, offering undergraduate and post graduate courses in biotechnology, very often they are not equipped with the basic infrastructural facilities and competent manpower. Students lack opportunities for hands on experience in the various techniques of biotechnology. This affects their confidence to do independent research. The knowledge level and competence of the students are seriously hampered by lack of expertise among faculty members. The communication skill of the students, very often, is far below acceptable standards. This condition has to change, to produce competent manpower with sufficient exposure to practical and theoretical aspects of biotechnology. This is essential to generate manpower to offer leadership for the biotechnology revolution in India. It would be advantageous to identify students with high caliber and aptitude, at the plus two level itself. Being an interdisciplinary field, higher education in biotechnology does not necessarily call for a prior degree in the same subject. Hence

it is quite appropriate to start integrated courses wherein the students are exposed to all aspects of basic and applied biotechnology. This can generate suitable manpower for the growing biotechnology industry. The conduct of the course in multi institutional mode is advisable, as it will facilitate the pooling and utilization of available expertise and facilities. Such courses should cover areas of basic biology, cell biology, molecular biology, genetics, physics, organic chemistry, biochemistry, mathematics, statistics, computer science, genomics, proteomics, immunology, enzyme technology, computational biology, medical biotechnology, agricultural biotechnology, industrial biotechnology, bioinformatics, food biotechnology, microbial biotechnology, environmental biotechnology, biosafety, bioethics and IPR. Sufficient exposure should be given for developing skills for communication, management and personality development. Establishment of a state level coordination committee is essential to bring about desirable progress in research, development, teaching and extension of biotechnology in Kerala. Effective policy decisions are also essential. ■

SUSTAINABLE UTILIZATION OF KITHUL (FISHTAIL PALM) IN SRI LANKA

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Kithul (*Caryota urens*) is a native tree in tropical Asian continent and it is grown in small pockets of wet and intermediate wet zone of Sri Lanka. This palm is capable of storing large volumes of Carbohydrates, which are converted to sugars. Tapping the inflorescence enables the collection of the exudates sap which has about 8-15% sugar. As a cottage industry kithul sap is concentrated to a thick syrup and to a solid form which are commonly referred to as treacle and Jaggery respectively. Traditionally this sap is also naturally fermented and consumed by villagers as sweet toddy (alcoholic beverage). According to the Sri Lanka standard specifications for treacle the total sugar content should be more than 65%. During the process of preparation of kithul treacle, there is a tendency for the manufacture to add cane sugar to obtain a higher yield. Due to this adulteration, quality of product is affected and the original kithul flavour is masked.

Industrial Technology Institute (ITI) has launched a project to upgrade this industry by introducing scientific methods for enhancing the yield of sap and to prepare a range of kithul based products to meet internal quality standards. With the assistance of the Ministry of Rural Industries, ITI has set up a central processing unit at Rogesengama, Kothmale where farmers bring their sap to the centre to be processed. Two steam-jacketed kettles fitted with a boiler, are used for concentration of the sap in this centre. Treacle in bottled form, jaggery in slab form and a range of novel products such as non-alcoholic kithul drink in bottles, kithul jelly in cups and kithul jam are formulated and introduced to this centre by ITI.

MATERIALS AND METHODS

2.1Chemical and Sensory Analysis

Five market samples of kithul treacle were randomly collected and tested for chemical parameters such as brix value (total soluble solids), pH value, acidity, reducing sugars and total sugars .. According to the work done by the Industrial Technology Institute, the ratio of reducing sugars to total sugars (0.1 - 0.2) was found to be a useful parameter to detect whether kithul treacle is adulterated with cane sugar. Sensory parameters such as colour, consistency, taste & flavour and overall acceptability of three treacle samples were also done. These parameters were compared with those of pure kithul treacle made at the above centre. pH value of treacle samples were measured using micro processor based pH tester while the total soluble solids (Brix value) was determined using Atago Hand Refractormeter. Acidity was determined by titrating with 0.1 M Sodium Hydroxide and Phenoptheline as an indicator. Reducing sugars were determined by Lane & Eynon method. Total sugars were determined after converting the non-reducing sugars to reducing sugars followed by Fehlins tritration. Adulteration was checked by calculating the ratio between reducing sugars to total sugars. Sensory analysis was carried out in two batches (three samples in each batch) using twenty-trained panelist.

Presently the kithul-processing centre is producing about five hundred bottles (750 ml) of treacle a month and jaggery on request and supply for distribution by an agent in Colombo. ITI continues to keep a constant check on the hygienic standards of the centre, and the product quality, based on the above parameters.

2.2 Preparation of Kithul based products in the processing centre

2.2.1 Bottled kithul treacle

Kithul sap which is brought to the centre by farmers is accepted after checking the quality (brix and pH). Fifty liters of sap is added to the steam-jacketed kettle after straining and concentrated to a brix value of 68° -70°. Then it is transferred to the filling unit and it is bottled hot to sterilized bottles and sealed.

2.2.2 Preparation of Kithul Jaggery

Unfermented kithul sap is concentrated by heating and at the final stage with low heat, it is stirred to facilitate to make the crystals. Finally the thick mass is transferred to a flat mold to get cubes (1cm x 1cm x 1cm) or 250g / 500g slabs.

2.2.3 Preparation of unfermented Kithul Beverage

Unfermented kithul sap is filtered and heated to boiling for few minutes. Brix value is adjusted to 10%- 14%, and pH level is brought down to 3.5 - 4 and filled into sterilized containers. The shelf life of this product is more than 6 months.

2.2.4 Preparation of Kithul Jelly

Unfermented kithul sap is mixed with natural jellying argent such as carageenen, agar - agar or any other (less than 0.5%).This is hot filled into bottles and sterilized.. Shelf life of this product is more than 6 months

2.2.5 Preparation of Kithul Jam

Acidified unfermented sap is heated and required amount of pectin is added to thicken the jam and filled in to sterilized bottles .

RESULTS AND DISCUSSION

Table-1 Results of chemical analysis of treacle samples

Sample No. Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Brix value	72.0	69.0	68.2	67.2	67.0	64.4
pH value	4.09 at 25.9 °C	4.21 at 26.3 °C	4.53 at 25.9 °C	4.95 at 28.9 °C	4.65 at 26.7 °C	4.75 at 27.1 °C
Acidity %	0.21	0.2	0.19	0.17	0.18	0.18
Reducing Sugars %	24.034	23.29	13.04	6.85	8.05	5.93
Total Sugars %	71.15	68.43	68.05	67.97	66.78	64.02
RS/TS	0.33	0.34	0.19	0.1	0.12	0.09

According to the results, brix value of samples varied between 64.4 - 72.0 and pH value varied between 4.09 to 4.95, acidity was between 0.17% - 0.21% and amount of reducing sugars varied between 5.93% - 24.03%. Amount of total sugars varied between 64.02% - 71.15%. There was a relationship between chemical and sensory parameters, and according to the results, 50% of samples were not within the required ratio (0.1 - 0.2) of reducing sugars to total sugars.

Results of sensory analysis of treacle samples-

Sample No Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Colour	7.30	7.40	7.10	7.20	7.40	6.95
Consistency	6.00	6.30	6.65	7.30	7.15	5.60
Taste & Flavour	4.60	7.05	7.25	7.10	6.75	5.15
Overall acceptability	5.10	7.02	7.15	7.15	6.95	5.30

Such samples could be adulterated with cane sugar. According to the results of the sensory evaluation, there was no difference in colour at 5% level of significance. However taste & flavour, overall acceptability and consistency were different in samples.

CONCLUSION

Kithul (Fish tail palm) which is presently not utilized to its full potential could be developed into a money earning, lucrative industry by introducing scientific methods and quality control. The study shows that there is adulteration in same samples of kithul treacle when compared with the authentic sample prepared in the processing centre. The need for such central processing centres is evident if this industry is going to reach sustainable export market. The novel products such as beverage, jelly and jam introduced by ITI could be popularized for the local market as natural organic foods for the local and export market. Jaggery in slab from also could be popularized as a alternative for chocolate and as an accompaniment for tea when packed in moisture proof packaging material.

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THE INTEGRATION EFFICIENCIES OF NATURAL FARMING IN HARMONY WITH THE ECOSYSTEM.

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Nature has its own way of doing a balancing act and this is best seen under natural farming. He most Current and broad concept of sustainable agriculture is one that includes a significant element of "quality of life" (Flora, 1990; Ikerd, 1993). Agriculture systems purposefully disrupt natural systems, in an ecological sense, through patterns of human intervention. The increased consumption pattern of pesticides and chemicals has led to changes in soil bacterial population, (Jayashree and Vasudevan 2007). Agriculture promoted by artificial inputs such as chemical fertilizers leaves behind carcinogenic residues in the food grown and kills natural microbe (Singh, 1991). Persistence of these pesticides in soil is influenced by many factors such as soil reaction, leaching, and organic matter, adsorption by soil clay and soil micro organisms, Organisms at the top of the food chain are most adversely affected as these pollutants accumulate in maximum quantity in them through a process of biomagnifications Hence Natural farming is a boon to farmers, meeting the goals of sustainable Agricultural system.

MATERIALS AND METHODS

Background and history of Natural farming Kollegal, Karnataka

I Mr. Kailashmurthy is the author of this paper and a Natural farmer, took to agriculture in my free time and started cultivating land given to me by my in-laws. Like other farmers I too stared practicing modern farming in 1984 by applying tones of chemical fertilizers and pesticides. Of course the yield was more, but later I found that the soil fertility decreased and the crop poisoned. In due course the

disease causing insects developed resistance to pesticides and the yield and soil fertility gradually diminished. Then I decided to put an end to the use of chemical fertilizers and pesticides and opted for zero input farming. Inspired by Ramon Magsaysay award winner and natural farming pioneer Masonob Fukuwoka I started natural farming in 1998 and has successfully been able to cultivate paddy crop and other horticultural crops using local seeds, less water and sunlight only under natural conditions. My results have proved all the agricultural scientists who claim that yields are directly related to use of hybrid varieties, chemical fertilizers and pest control techniques. I have neither used hybrid seeds nor fertilizers but have succeeded in getting yield more than the farmers who have grown paddy using modern techniques and chemicals. I have even raised a paddy crop quite successfully, getting a yield of 25to 30 quintals per acre, which varies according to the climatic conditions).

Faunal diversity in natural farming: Earthworms, Dung Beetles and Termites are found in large numbers. Many indigenous snake species, Birds, Butterflies, Spiders, bees are present which shows the richness of biodiversity in the farm and sustainability of Life forms.

Microbial biomass : Microbial biomass is used as primary indicator of biological activity. The greatest microbial differences are nearly always found in the upper 30cm of soil. The microbial load is high in the farm soil showing rich diversity. In the natural farm soil, in the out of the total biological count, there are 50% fungus, 20% yeast, algae and protozoa and only 10% are organisms like earthworms, nematodes, arthropods, mollusk and others. There are about 2 to 5 tons Insects per hector; 6.5-ton earthworms per hector and 0.5 tons microorganism per hector. (Anderson, New Scientist,6d1 oct. 1983). In Natural farming at Doddinduvadi various organisms like *Nocardia, Streptomycetes, Penicillium', Fusarium, Thermomonospora, Trichoderma, Myrothecium Clostridium, Thiobacillus sp, Azotobacter, Rhizopus, Monotospora Phytopthera, Mortiella, B. Megaterium var. phosphaticum and Pseudomonas* was documented which was high in number in the farm which bring about various transformation in soil like I Sulfur, NPK, Carbon, Iron and manganese transformation important in maintaining the soil fertility, were observed by Nandini et al., 2008.

A visit to my farm by the scientific community:

"Foreigners and experts in natural farming are frequent visitors to my farm. The mini forest in a dry terrain is being treated as a research laboratory where nothing is added from outside or anything removed from it." Green crops flourish on their own sweet will, one nourishing or controlling the other without tilling, manure, and pesticides. A Team of Researchers Ms Anupama ,Mr.khayum Ms.Pavithra, Ms SucharitaTandon, Mr. Kumar,Mr.Durgesh.R,Mr. Aboud S Jumbe,

And Technical staff Mr. Keerthi Kumar C.K, under the guidance of Dr.N.Nandini reader and Principal investigator. Visited my farm and had done extensive research on the soil biodiversity and they have estimated the amount of carbon stored in woody trees there by mitigating global warming and climate change. A work shop conducted on 30.8.08 for scientist, Farmers Agriculturist and leaders brought out the importance of natural farming in sustainable ecosystem.

A visit to the farm by Indian Institute of Horticulture Research experts (IIHR) On 18th of November 2008, a team of Horticulture Research Experts visited the farm and analysed the ecosystem and are going to give a report on the sustainability of this farm.

RESULT AND DISCUSSION

Agriculture is a fundamental component of the natural resources on which rests not only the quality of human life but also its very existence .If efforts to create a sustainable agriculture are successful, farmers will profit and society in general will benefit in many ways. The total carbon sequestration in this natural farming including all the tree species like; Tectona grandis, Silver oak, Mangifera indica, Rose wood, Neem, Areca nut etc was found to be 1085.556 tones in 6.5 acres at present. This is the result of only the woodytrees. Estimaton of Carbon sink by other plants like Lianes, herbs, shrubs; Microbes and soil were not calculated. If every farmer who can afford to change his land into natural farm we can mitigate global warming and the climate change and retain our soil fertility increasing the bi9mass (Nandini, 2008).Ramesh, 2008 in his report says that. this Method of farming can be emulated by others, which will contribute towards amelioration of the environment. As 33.33% of the land area should be under forest cover in order to conserve the environment; this type-of farming will supply all the benefits of forests in addition to producing sustainable food crops. All the food crops being grown here are free from pests and diseases. The soil structure and texture are excellent compared to the adjacent soil, which is gravelly. Since no chemicals are applied this system contributes all the benefits of a forest ecosystem. This System acts like a forest ecosystem by sequestering carbon dioxide, supporting. biodiversity of both floras, some fauna, recharging of ground water, checking soil erosion, releasing oxygen and maintaining a microclimate like a patch or natural forest. In this patch of farm he observed different types of birds, insects, small mammals and reptiles. Gurubasavaraju, 2008 say that about 110 varieties of plants (edible and medicinal) grow under natural conditions and they are rich in nutrition and are highly medicinal and is looking forward to educate the Ayurvedic students. By tagging the plants for identification and utilization for research. According to Nanjaiah, 2008, the experiment carried out on horticultural crops in this farm under natural farming is highly appreciable and feels it can be extendable to other crops.

Radha Kale 2008 feels that this natural farm at Dodinduvadi provides necessary, favorable environment for Earthworms. Shivanandappa 2008 has the opinion that the food crops grown here in the natural farm is free from all pesticides and chemical fertilizers residues. According to Sidappaji 2008 Biological control is well balanced in the farm, as the pesticides are not used in the farm. The objective of Zero cultivation is to improve the soil fertility, mitigate global climate change, to improve the air quality, to conserve the plant biodiversity, soil flora and fauna, to propagate sustainable farming methods for food security and to protect Mother Earth from Hazardous Chemicals.

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Key words : Natural farming, sequestering, microclimate, flora, and fauna, Biodiversity.

DEVELOPMENT OF PROCESSES FOR PREPARATION OF SHELF STABLE PRODUCTS FROM 'BITTERLESS' KINNOW JUICE

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India had emerged as the second largest producer of fruits in the world with an annual production of 47.7 MMT, accounting for about 10% of the world's fruit production (www.tradeindia.com, www.india.nic.in). Amongst fruits, the current production of citrus fruits is around 3.8 MMT. Kinnow mandarin is one of the major citrus fruit crops of India and the national production is in tune of over 0.4 MMT (Express News, 2008). Hybrid of Citrus nobilis and Citrus delicosa, kinnow fruit is juicy and its fresh juice is nutritive, has thirst quenching properties and refreshing flavor, though it has a short shelf life (Premi et al., 1996). Presently, about 95% of the production goes for fresh fruit market. The availability of large quantities of kinnow over a short period of time (December to February) poses problems for efficient marketing and utilization; thus wastage of kinnow fruits is over 30% of the total national produce. Kinnow has great potential for packed juice market, estimated to be worth 2000 Million INR by 2010 (The Tribune, 2006). However, processing of kinnow juice faces formidable problems due to delayed bitterness caused by limonin, thereby significantly affecting its consumer acceptability (Kamaljeet, 2002; Jagjiwan Deep, 2001; Premi et al., 1995; Hasegawa, and Maeir, 1983). Biotechnological and physico-chemical approaches to debitter kinnow juice have met with incomplete and variable success (Joshi et al., 1997; Puri et al., 1996). Thus processing of the juice, by and large, is still a challenge. In the present study, attempts were directed exclusively on preventive approach for controlling bitterness via a patented method and then the bitterless juice thus obtained was processed into kinnow squash, kinnow Ready-to-serve/ready to drink

(RTS/RTD) beverages, frozen & refrigerated kinnow juice concentrates (Kansal, 2003 & 2007).

MATERIALS AND METHODS

Fresh and fully ripened kinnow fruits were procured from the local market in Patiala and Bangalore in the months from December to April. The bitterless kinnow juice was extracted as per the patented method (Title of patent: A process for the manufacture of bitterless kinnow juice; International Classification: A23L 1/068, Published on August 3, 2007 vide Application No. 60/DEL/2003 through NRDC, New Delhi for TIET, Patiala), pasteurized (In-bottle, 950C for 3 minutes, preserved with KMS, @ 350 ppm) and then stored in sterile glass bottles. It was monitored for period of 7 days and only after the limonin content (Vaks and Lifshitz, 1981) in juice was found to be below threshold level (?4ppm), it was then processed as per FPO specifications into kinnow squash, kinnow RTS/RTD beverage and frozen & refrigerated kinnow juice concentrates (FJC & RJC) as shown in Fig 1, 2 and 3, respectively. Three months shelf stability studies for the products were conducted by keeping kinnow squash in glass bottles at ambient and refrigerated temperature (AT & RT), kinnow RTS/RTD beverage at refrigerated temperature in polyethylene tetraphthate (PET) and glass bottles, and kinnow juice concentrates in glass bottles at frozen and refrigeration temperature (FT & RT). Kinnow juice and all processed products were analyzed for pH, Total Soluble solids (TSS), ascorbic acid content and titratable acidity (%TA) using standard methods as prescribed in AOAC (1984) and Ranganna (1998). Microbial counts namely total plate count (TPC), yeast and molds count and total coliform count were enumerated according to methods described in APHA (1982). Consumer acceptability profile was deduced via sensory evaluation as described by Ranganna (1998).

RESULTS AND DISCUSSION

Kinnow juice: The juice extracted by the modified method of juice extraction was found to be shelf stable for more than 3 months under refrigerated conditions with a marginal rise of 2-3 ppm Limonin. pH, %TA, TSS, ascorbic acid were found to remain stable. TPC and yeast & molds were found to be much below the permissible limits with no coliform till end of storage period.

Kinnow Squash: The prepared squashes were kept at two different temperatures viz. ambient (120C-300C) and refrigerated (40C-60C) and were found to be stable for over a period of 3 months. During storage, pH remained in similar range of 3.58-3.44; TSS between 38-42 and 43.6-43; %TA between 0.49 to 0.35 and 0.44; and as expected, the ascorbic acid content was found to slightly decrease during the storage (14.4-12mg/100ml and 14.4-13.2mg/100ml) respectively for squashes stored at AT & RT, indicating relatively wider changes in parameters for squash stored at AT. Importantly, it was noticed that the limonin content of the squash

kept at both the temperatures increased by 1-2 ppm, but remained below the threshold level (4-5ppm) during the entire storage period. Microbiological examination of kinnow squashes revealed that coliform was found to be absent in the squashes throughout the period of investigation. The yeast and mold count appeared after 31days and TPC after 56 days of storage in case of squash stored at AT. Organoleptic evaluation carried out on every 7th day of storage showed that the kinnow squash thus prepared was quite acceptable till the end of the storage period.

Kinnow RTS beverage: Kinnow RTS beverage stored in glass and PET bottles at 4-60C were analyzed on every fourth day of storage. Similar values of pH, TSS, %TA and ascorbic acid were obtained: pH 4.07-4.02, TSS 16.6-16.0, %TA 0.38-0.28 and ascorbic acid 17.34-12 respectively. Limonin content in beverage was found to remain below threshold and was unaffected by type of packaging material used. As is seen in kinnow squash, slight increase in the level of limonin was found initially in case of kinnow RTS/RTD beverage (2-4ppm) that remained stable thereafter. Mrobiological examination revealed that during the entire storage period no coliforms could be enumerated. Yeast and mold was also not found in RTS stored in both type of packaging material till 45 days. Incidentally, TPC was found after 20 days of storage in case of beverage stored in glass bottles that could be attributed to contamination due to water, but was undetectable in beverage stored in PET bottles.

Kinnow juice concentrate: In the two types of concentrates viz. FJC (stored at -30C to -80C) and RJC (stored at 40C to 60C); pH, TSS, %TA and ascorbic acid content were found to be nearly same during the entire storage period of 2 months. The values were found to be in range of 4.5 - 4.37 (pH), 40-420Brix (TSS), 0.56-0.51% (TSS) for frozen concentrate and 4.5-4.37 (pH), 40-42 (TSS), 0.56-0.51 (%TA) for refrigerated concentrate. Ascorbic acid content of the two products was found to decrease from 28.2 to 19.3 mg/100ml, thus confirming that certain significant loss of ascorbic acid occurred during storage. Limonin content of the products were found to range between 3.3-4.2 ppm. The condensate thus obtained was also analyzed for pH, TSS, %TA and ascorbic acid. pH was found to be 4.02; while TSS, %TA & ascorbic acid were almost negligible, while limonin content was found to be 2.3ppm. Microbiological examination of the two concentrates revealed no observable growth in TVC till 4 & 3 weeks of storage respectively in frozen and refrigerated juice concentrate. One colony of coliforms was reported only in RJC after 1 month of storage, and yeast and mold remained absent till 36 days in same. No coliform or yeast and mold counts were observed in FJC till end of storage period.

Sensory evaluation of all the products was suggestive of appreciable organoleptic appeal obtained in terms of taste and overall acceptability. Little lower scores for appearance were obtained as no external addition of color and flavor was made.

CONCLUSION

Preventive approach of controlling bitterness development by checking formation of limonin in mid and late season kinnow fruits led to bitterless juice that was processed into consumers relished products namely kinnow squash, kinnow RTS/RTD beverage, frozen and refrigerated kinnow juice concentrates. The products were found to shelf stable for 3 months and beyond in terms of physicochemical attributes, acceptable microbiological counts and quite appreciable sensory scores. Scale up studies for such processing are underway to utilize the huge potential of kinnow fruits production in the country for processing juice as aseptically packed juice, juice based products and blended kinnow wine.

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Key words:

Kinnow mandarins, delayed bitterness, limonin, juice extraction, bitterless kinnow juice, kinnow squash, kinnow RTS/RTD beverage, juice concentrate, blended kinnow wine.

RECYCLING BIOMASS FOR NUTRIENT ECONOMY IN COCONUT AND ARECANUT BASED DIVERSIFIED CROPPING SYSTEMS

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Homestead farming system, unique to Kerala because of the regions' limited land resources, is highly intensive and diverse with a variety of crops, mainly plantation based. In perennial crop based diversified homestead farms, many intercrops are grown beneath the tree canopy, which if managed properly, represents a profitable and environmentally stable land-use system. Plantation based multispecies cropping systems add a lot of biomass to the soil in the form of leaf shedding, pruning etc. resulting in addition of nutrients to the system (Nath et al., 2008). If the available biomass is fully utilized, it can meet the requirement of a major portion of chemical fertilizers. Hence, a field investigation was undertaken in farmers' fields to ascertain the savings in fertilizer use that could be achieved through the recycling of biomass generated in the predominant arecanut and coconut based diversified cropping systems of Kerala.

MATERIALS AND METHODS

The investigation was carried out in farms spread across sixteen panchayaths of Mannarkkadu and Sreekrishnapuram blocks of Palakkad District for a period of two years extending from July 2005 to June 2007. The soil type of the site is laterite and acidic. Nineteen cropping systems, most commonly adopted by the farmers of the region, were selected from the Integrated Farming System plots spread across different panchayats. The nineteen systems can be broadly classified into arecanut based systems (8 numbers) and coconut based systems (11 numbers). Description of the different systems and plant population of the components are given in Table

1. Out of the total biomass generated, though a large quantity was consumed or sold, substantial quantity was recycled in the system itself.

Table 1. System description: Population of the components

No.	Systems	Plant population per ha
1	A	(A) = 1111
2	A+B	(A) = 1111 ; (B) = 1111
3	A+B+C	(A) = 1111; (B) = 1111; (C) = 2666
4	A+P	(A) = 1111; (P) = 1111
5	A+P+Cf	(A) = 1371; (P) = 1371 (Cf) = 1230
6	A+V (Type 1) Vanilla trailed on *Gliricidia* and Areca	(A) = 1111; (V) = 4524
7	A+V (Type 2) Vanilla trailed on rubber tyre tied between areca	(A) = 1111; (V) =1111
8	A+V (Type 3) Vanilla trailed on *Gliricidia* only	(A) = 1371; (V) = 1371
9	Ct	(Ct) = 123
10	Ct+A+P	(Ct) = 123; (A) = 1111; (P) = 1234
11	Ct+A+P+B	(Ct) = 167 ; (A) = 1000, (P) = 167 ; (B) = 1500
12	Ct+A+P+N	(Ct) = 69; (A)= 1111; (P) = 69; (N) = 69
13	Ct+A+P+N+V (Systematic planting)	(Ct) = 129; (A) = 657; (P) =129; (N) =129; (V) = 1371
14	Ct+A+P+N+V (Mixed planting)	(Ct) = 139; (A) = 2500; (P) =816; (N) =139; (V) = 2500
15	Ct+A+P+V	(Ct) = 69; (A)= 555; (P) = 69; (V) = 4444
16	Ct+P+B+N young	(Ct) = 69; (P) = 69; (B) = 1111; (N) = 69
17	Ct+P+Co	(Ct) = 92 ; (P) = 92; (Co) = 555
18	Ct+P+N	(Ct) = 167; (P) = 167; (N) = 167
19	Ct+P+V	(Ct) = 159; (P) = 318; (V) = 2380

Ct: Coconut; A: Arecanut; P: Pepper; B: Banana; N: Nutmeg; Co: Cocoa; V: Vanilla, C: Colocasia; Cf: Coffee

The quantity of biomass recycled and hence the quantum of nutrients that could be recycled within the system was assessed. This was examined to determine the fraction of nutrient requirement (based on recommendation in the Package of Practices Recommendations, KAU) of the systems that can be met by recycling crop residues generated from the system. It was observed that the common practice among farmers was to recycle only 75% of the coconut leaf. Hence, such a situation was considered for the study. The total quantity of crop residues recycled back into the system after the harvest of the crops was recorded periodically. Samples of these crop residues were taken, oven dried at 700C, powdered and chemically analysed for their nitrogen, phosphorus and potassium contents following standard analytical methods (Jackson 1973). The biomass produced by each crop/tree component was multiplied with their respective nutrient contents to estimate the nutrient addition by crop residues into the system and expressed in kg/ year.

RESULTS

The quantum of biomass recycled in the different systems and the nutrients thereby available is presented in Table 2.

Systems	Nutrient requirement as per POP recommendation (kg/ha)			Biomass recycled (kg DW/ha)	Recycled nutrients (kg/ha) (**if 75 % coconut leaf recycled**)			% of nutrient requirement available through recycling		
	N	P	K		N	P	K	N	P	K
A	244.42	111.10	288.86	6222.00	104.53	9.04	11.72	42.77	8.14	4.06
A+B	566.61	294.42	733.26	12000.00	211.33	30.90	173.94	37.30	10.49	23.72
A+B+C	581.11	300.33	749.10	12000.00	211.33	30.90	173.94	36.37	10.29	23.22
A+P	411.07	222.20	566.61	6311.00	105.82	9.15	11.88	25.74	4.12	2.10
A+P+Cf	640.11	373.83	832.05	9719.00	165.89	14.50	18.44	25.92	3.88	2.22
A+V-Type 1	844.50	137.10	356.46	14365.00	238.07	16.37	223.44	28.19	11.94	62.68
A+V-Type 2	377.74	111.10	288.86	6222.00	104.53	9.04	11.72	27.67	8.14	4.06
A+V-Type 3	466.14	137.10	356.46	11106.00	185.21	14.24	103.59	39.73	10.39	29.06
Ct	66.42	33.21	108.24	14706.00	126.84	15.35	66.30	190.96	46.23	61.26
Ct+A+P	495.94	267.71	705.60	19733.00	224.68	23.09	73.67	45.30	8.63	10.44
Ct+A+P+B	770.23	409.29	1048.71	30337.36	391.55	55.16	308.95	50.84	13.48	29.46
Ct+A+P+N	333.43	157.33	380.63	14313.52	175.21	17.51	46.83	52.55	11.13	12.30
Ct+A+P+N+V (Sole vanilla)	475.47	152.13	342.39	22170.00	229.71	25.08	114.87	48.31	16.49	33.55
Ct+A+P+N+V (Mixed)	1130.86	410.83	1004.12	27959.00	365.19	34.95	89.91	32.29	8.51	8.95
Ct+A+P+V	702.99	81.03	222.27	10616.52	147.91	11.74	105.25	21.04	14.49	47.35
Ct+P+B+N (Y)	411.20	229.55	536.17	13175.52	172.64	29.53	196.42	41.99	12.87	36.63
Ct+P+Co	174.48	78.44	259.36	9988.36	105.08	14.31	39.24	60.23	18.25	15.13
Ct+P+N	215.43	111.89	222.11	18539.00	166.62	19.81	82.86	77.34	17.71	37.31
Ct+P+V	419.16	74.73	219.42	17792.00	172.13	18.20	116.10	41.07	24.36	52.91

A: Arecanut; B: Banana; Co: Cocoa; Ct: Coconut; Cf: Coffee; C: Colocasia; N: Nutmeg; P: Pepper; V: Vanilla

Table 2. Percentage of nutrient requirement of system met from residues recycled within the system

Arecanut based systems: A minimum of 25 % of the N requirement can be unquestionably met through recycled waste in arecanut based systems. If banana is a component, upto 35 % of N requirement will be satisfied by recycling. Nearly, 5-10 % of the P requirement is also available through recycling. In arecanut based systems with banana, nearly 20 % of the K requirement will be available from the residues. Similarly in areca based systems where large population of vanilla is trailed on gliricidia and arecanut (Arecanut+Vanilla-Type 1), even upto 60 % of the K requirement can be met through recycling.

Coconut based systems: Except for the coconut+arecanut+ pepper+nutmeg+vanilla (mixed) and coconut+arecanut+pepper+vanilla systems, where N requirement is very high, in all other systems 40 % of the N requirement

can be made available through recycling. 10-15 % of the P requirement can also be met through the crop residues recycled. In coconut based systems with banana, 30 % of the K requirement is satisfied by recycling. Also, when vanilla is trailed on gliricidia and more of gliricidia loppings are recycled, substantial quantities of K requirement (upto 50 %) can be met eg. Coconut+Pepper+Vanilla (trailed on gliridicia).

DISCUSSION & CONCLUSION

It can be inferred that, a substantial quantity of N (25 % in arecanut based systems and even upto 50 % in coconut based systems) can be met through recycling. However, only 8-15 % of the P requirement can be met from recycled crop residues. A major part of the P requirement should be supplied through fertilizers based on soil reserves/available P status only. In most coconut and arecanut based systems, especially in those with banana and gliricidia (as support for vanilla and leaf loppings copiously recycled), though 25 % (in arecanut based systems) and 30 % (in coconut based systems) of the K requirement can be met through recycling of residues generated in the system, inorganic fertilizer addition is needed. Hence, depending on the system, savings of 30-50 % N, 5-15 % P and 30 % K can be achieved by recycling crops residues generated in the coconut and arecanut based systems of Mannarkkad and Sreekrishnapuram. The present practice is to fertilize individual crops in a system based on the fertilizer recommendations standardized for each crop. However, in diversified arecanut and coconut based systems, recycling of biomass generated will help reduce the quantum of inorganic fertilizers, lead to enhanced soil health, better economy and long term sustainability.

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Keywords: Arecanut, biomass, coconut, crop residue, nutrients, recycling

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PROCESS DEVELOPMENT FOR THE OPTIMAL UTILIZATION OF CONVENTIONAL AND UNCONVENTIONAL PLANT WASTE

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INTRODUCTION

Food industry, agricultural farms, market yard and kitchen are the sources of ever increasing plant byproducts and or waste. The improper and inadequate disposal of which not only is responsible for the increasing environmental pollution and the related health problems of the population at large, but also results in the loss of nutrients/ biologically active chemicals present in them. There is a need for proper management and processing to overcome both the problems i.e. converting these byproducts/ residual waste into commercial products (dietary supplements. value added and health promoting products). The concept of drugs of natural origin, either prepared from a biological material or nutrient exploitation, in the recent times has gained preference over the synthetic ones giving birth to the terms like phytochemicals, phytonutrients, designer or functional foods and nutraceuticals. Hence, for more than a decade my interest has been on the concept of process development for optimal utilization of bioactive rich waste of plant / animal origin.

Oil seed residues, fruit and vegetable pomace, marine ,market yard and dairy industry waste are all nutrient rich left over that have negligible or poor utilization by humans and as animal feed or even as manure. It is the poor eating quality (color, flavor, texture, taste) that is responsible for reducing the acceptability. So, also is the nutritional quality (availability of nutrients, digestibility) affected due to concentrating of the anti- nutritional factors. Various processing techniques ; heat treatments, fermentation, sprouting, and even irradiation have been exploited

to reduce the antinutrient effect or else extract the molecule of interest. Thus the attempts are towards the preparation of a product that can be either directly consumed or indirectly. This paper presents comparative data of the processing effects on only one of the byproducts of the food industry.

Key Words : Unconventional, food waste, by-product, plant biomass.

Methodology

Sample : Oil seed residues; Karanja , safflower and soy bean (MACS-13).

Processing : 1. Heat treatments - both dry (roasting, Microwave) and wet (autoclaving).
2. Sprouting - 24h, 48h, 72h.
3. Fermentation - 10h, 20h, 30h.
4. Irradiation (gamma) - 1 ,5, 10 & 50 K.Gy

Analysis : Proximate composition and anti- nutrients (phenolics, phytataes, inhibitors, haemagglutinins and cyanogens) by standard methods, before and after various treatments.

Nutritional Evaluation : a) In-vitro digestibility and b) In- vivo animal studies

Indirect process : Protein isolate preparation and the factors affecting.

Results Overall data indicated an improvement in the oil seed residues by all the given treatments to variable extent, both in the eating as well as the nutritional quality. The reduction in the anti-nutritional factors paralled with the increased availability of some nutrients It was confirmed by the results of in-vitro digestibility and in-vivo animal studies. Similarly, the effect of various treatments was seen on the protein isolates w.r.t. quantity and phsico-chemical characteristics. Though the results were encouraging more studies required, are in progress. So, also presence of other bioactive molecules (anti-oxidants), their mechanism of action and physiological significance are being looked for.

CONCLUSION

Plant waste on processing can be optimally utilized catering to the ever increasing demand due to population explosion, preventing malnutrition and promoting healthy living (exploited for the control of various diseases). Thus, cost-effective process development is the need of the day for the production of biologically functional molecules (supplemental products, nutrients, nutraceuticals, and even color and flavor compounds) or functional foods with no side effects (natural origin). This, thus is likely to provide better utilization. prospects , market value and eco-friendly disposal of by-products / waste from both, conventional, and unconventional sources.

FLORAL BIOLOGY STUDIES IN *JATROPHA CURCAS*

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Jatropha (*Jatropha curcas*; family : Euphorbiaceae; subfamily: crotonoideae; 2n=22) commonly known as Physic Nut / Purging Nut is a perennial shrub well adapted to arid and semi-arid regions (Heller,1996). The oil from Jatropha seeds is an important source of biodiesel. Besides being an important biofuel crop, Jatropha can form an important component of silviculture and has medicinal / therapeutic uses too.

The knowledge of floral biology is a prerequisite for genetic improvement of any crop through conventional breeding. Despite the extensive Jatropha planting programmes world wide little efforts have been made for its genetic improvement. Earlier studies made on the floral biology of Jatropha (Solomon Raju and Ezradanam, 2002 and Bhattacharaya, Ashoke et al. 2005), concentrate mainly on insect foraging behavior on Jatropha and little attention is paid to development of suitable hybridization technique. The present study mainly describes the flower morphology, phenology of flowering, pollen stigma maturation, fruiting behaviour comparison of selfing methods, comparison of geitonogamy and xenogamy and a suitable crossing technique, which can be directly used in conventional Jatropha breeding program aimed at improvement of important economic traits.

MATERIAL AND METHODS

i)Study Site

The study was conducted in 2006 and 2007 at Anand Agricultural University, Anand during October to February (normal flowering period of Jatropha).

ii) Inflorescence and Floral morphology:

Inflorescences on each selected plant were carefully observed for its type, position on the plants, opening of flowers in the inflorescence, anthesis, etc

iii) Female : Male ratio

Inflorescences of appropriate stage (just before opening of flowers) were tagged for counting the number of male and female flowers.

iv) Flowering Phenology

100 inflorescences (before flower opening) from healthy growing plants were selected and tagged from the jatropha plantation for this study. As the inflorescences started blooming (flower opening started), all the opened male flowers were counted and removed daily. The number of opened females flowers were also counted daily, but were not removed. A coloured thread was tied at the base of the female flowers to avoid counting of the same female flower again.

v) Pollen : Ovule ratio

The pollen grains were counted from both the upper tier and the lower tier of stamens of the male flowers separately. Based on the pollen production from both tiers of stamens the total pollen production per flower was calculated. The pollen ovule ratio was determined by dividing the number of pollen grain per male flower by the number of ovules per female flower which is normally three.

vi) Pollen viability and germination studies

The pollen grains were stained with acetocarmine (1%) to test the pollen viability. After staining the pollen grains were observed under a compound microscope. The number of stained and unstained pollen grains were counted and percent pollen viability was calculated, considering the stained pollen grains as viable. Different concentrations of sucrose, sucrose along with boric acid, calcium nitrate, casein hydrolysate, with and without pretreatment with hexane were used to study the pollen grain germination and the pollens were observed for germination for four consecutive days.

vii) Stigma receptivity:

To study the stigma receptivity approximately 125 inflorescences (25 each for pollination on 1st, 2nd, 3rd, 4th and 5th day) from healthy growing plants were selected and tagged (indicating pollination day) before flower opening. All male flowers were removed from the inflorescences and these inflorescences were then bagged to avoid natural pollination. Flowers were marked with threads to count days after opening in separate inflorescences and pollinations were carried out only once in all cases. Number of fruits set was recorded from each of these selected inflorescences separately and per cent fruit set was calculated, which indicated stigma receptivity (%).

viii) Fruiting behaviour:

Natural fruit set rate was studied using 436 female flowers from 47 inflorescence of 39 plants.

a) Comparison of selfing methods :

For comparison of selfing methods viz,. only bagging and bagging of the intact inflorescences with manual pollination (selfing), selected inflorescences were bagged till all male flowers withered and the stigma of female flowers dried completely. Alternatively, inflorescences were opened daily and opened male flowers from the same inflorescence or other inflorescence of the same plant / genotype were used for pollination. This comparison was attempted in 4 genotypes viz. SKN Big, Urulikanchan, Chhatrapati and Hansraj.

b) Comparison of geitonogamy / xenogamy:

153 flowers, from 26 plants were used for geitonogamy (pollination of the female flower with the pollen grains of same plant/ same genotype) and 183 female flowers, from 35 plants were used for xenogamy (pollination of the female flower with the pollen grains of a different plant/ different genotype) by pollination on the first day of flower opening. Bagging of inflorescence was done before flower opening and after pollination to ensure xenogamy or geitonogamy.

RESULTS AND DISCUSSION:

i) Inflorescence and flower morphology

In Jatropha curcas the inflorescences are borne terminally on branches. Flowers in the inflorescence are produced in a racemose pattern with dichasial/ biparous cyme pattern. Jatropha curcas is monoecious, however, the flowers are unisexual and male and female flowers are found in the same inflorescence. Normally the inflorescence produced a central female flower surrounded by a group of male flowers. In some cases, the position, where female flower are expected, were found substituted by male flowers. Also only male flowers are produced in a few inflorescences (sometimes). The inflorescence takes about 1 to 1½ month from the initiation of floral bud to complete opening of the flower. The male and female flowers can be distinguished from each other only 10-15 days before flower opening.

FLOWER MORPHOLOGY

(a) Male Flowers: Male flowers are small, odourless and tray shaped; sepals and petals are 5 each and free; petals are connivent at the flower base forming short tube, stamens are ten, diadelphous arranged in 2 tiers, lower having all five stamens free, while in upper tier all united. Anthers and pollen grains are yellow, anthers are dithecous and dorsifixed. These observations are in concurrence to earlier studies (Solomon Raju and Ezradanam, 2002).

(b) Female flowers: Female flowers / buds are relatively bigger than the male flowers / buds. Sepals and petals are relatively large and petals form a small tube. Ovary is tricarpellary, with 3 styles and 3 stigmas being bifurcated. The flowers were found opening in synchrony with male flowers. The unpollinated / unfertilized flowers fall off while the pollinated ones remain in place. Sepals and petals of fertilized flower gradually enlarge and the growing fruit reaches its full size by 90 days.

ii) Female Male Ratio: 0 - 24 female flowers and 15 - 275 male flowers were observed in the inflorescences. The female: male ratio ranged from 1:5.88 to 1:53 with an average of 1:17.56.

iii) Flowering Phenology: Once the blooming started, flower opening was continuous; Flowering duration ranged from 6 to 19 days with an average of 13.24 days; Male & female flowers both bloomed on first day of blooming.; More no. of female flowers bloomed than male flowers on 1st day of blooming. Female flowers opened from the 1st to 7th day with a maximum frequency on 2nd day, while, the male flowers opened from 1st to 17th day with a maximum frequency on 9th day.

iv) Pollen Ovule ratio (P/O ratio) : P/O ratios: indicator of breeding systems (Solomon Raju and Ezradanam, 2002). The average pollen production in the lower tier in the stamen was 360, while in upper tier of the stamen it was 370. Thus, the total pollen production per flower was 3650. The pollen ovule ratio was 21365:1.

v) Pollen viability and germination studies: 85 % of the pollens were stained indicating good pollen viability in Jatropha curcas. All the artificial germination media tried for pollen germination failed to show any germination, which is indicative of complex growth media requirement for pollen germination.

vi) Stigma Receptivity: Stigma receptivity was found maximum on 1st day of flower opening (82.9 % fruit set). However, it remained receptive on 2nd, 3rd and 4th day of flower opening with 66.7 %, 78.9 % and 41.1 % fruit set, respectively. Stigma found completely withered on 5th day.

vii) Fruiting behaviour: Natural fruit set varied from 37.5% to 100% with an average of 87.61%.

a) Comparison of Selfing methods

Hand pollination gave higher seed set as compared to selfing in all 4 genotypes.

However, differences were significant in SKN Big, Hansraj & Urulikanchan only.

b) Comparison of Geitonogamy and Xenogamy

Both the systems are functional in Jatropha curcas, xenogamy being pre dominant one with 49.18 % fruit set as compared to geitonogamy (40.52 % fruit set).

CONCLUSION:

Jatropha curcas is a monoecious perennial shrub with continuous flowering in hot and humid weather. However, effective flowering leading to matured seed in during September to February. Female flowers are usually larger in size and centrally located in the dichasial racemose inflorescence. Both flower sexes open synchronously in the inflorescences. Pollination of the female buds on the day it opens is most appropriate time for pollination. Pollen viability is good, however, pollen germination requires complex nutrients.

Based on this study a crossing technique is suggested for hybridization programs which includes preparation of female buds at appropriate stage, preparation of male buds, crossing time and best season for crossing.

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SUSTAINABLE UTILIZATION OF ORGANIC WASTES FOR ENHANCING THE PRODUCTIVITY OF RICE CROP IN SODIC SOIL

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INTRODUCTION

The use of inorganic amendments like gypsum, phlosphogypsum, iron pyrites or elemental S for the reclamation of sodic soils has been in vogue for the past several years. Continuous use of inorganic fertilizers, pesticides and fungicides cause environmental pollution thereby affecting the soil fertility on a long-term basis. For maintaining optimum productivity of the land and building up of soil fertility, the use of organic manures needs no emphasis. Due to non-availability of organic manures like farm manures, green and green leaf manures in sufficient quantities, the recycling of organic wastes and industrial by-products plays a vital role in improving soil fertility. Considering the importance of organic additives in sustainable agriculture, the sugar industry byproducts like pressmud and distillery spentwash that are rich in organic and inorganic nutrients can serve as suitable raw materials for the production of organic manure viz., biocompost. Preparation of biocompost based on the principles of solid-state fermentation ensures complete abatement of pollution through zero discharge. The present investigation was conducted to study the effect of biocompost on fertility status of the soil and yield of rice crop.

Keywords: Organic additives, biocompost, soil fertility status, sustainable agriculture.

MATERIALS AND METHODS

Field experiments were conducted during September - December 2005 and

January - April 2006 to study the effect of incorporation of biocompost on lowland rice. The experimental soil was clayey loam with pH 9.3, EC 0.82 dsm-1 and 218, 14 and 315 kg of available N, P and K per ha respectively. The experiments were carried out in Randomized Block Design with four treatments viz., M1-Control, M2-FYM @ 12.5 t ha -1, M3 - GLM @ 6.25 t ha -1 and M4-Biocompost @3 t ha-1. Each treatment was replicated four times. Rice varieties Co 43 and IR 50 were used as test crops in 2005 and 2006 respectively.

The different sources of organic manures were incorporated in the respective plots and allowed for decomposition keeping 1 cm of water column 15 days before planting of rice seedlings. The recommended fertilizer schedule of 150:50:50 kg N, P2O5, K2O ha-1 and 120: 38: 38 kg N, P2O5, K2O ha-1 were kept constant for all the treatments for the long and short duration varieties respectively. The characteristics of biocompost used in this study is presented in Table1. Soil samples drawn from each plot after harvest were analyzed for available N, P and K by using standard procedures (Jackson, 1973). Microbial assay was done adopting plate dilution technique (Waksman and Fred, 1922). Yield attributes of rice crop viz., panicles m-2, filled grains per panicle, 1000 grain weight were recorded for the corresponding treatments. The yield of grain and straw were recorded individually from the net harvested area and the results were expressed on dry weight basis in kg ha-1.

RESULTS

The data on the available N P and K status of the soil as influenced by different organic manures are presented in Table 2. Biocompost application @ 3 t ha-1 recorded the highest values of soil available N of 244.20 and 230.10 kg ha-1, available P of 28.15 and 24.60 kg ha-1 and available K of 355.0 and 320.70 kg ha-1 in 2005 and 2006 respectively.

The population of bacteria, fungi and actinomycetes observed at maximum tillering stage of rice are presented in Table 3. The dominant microbial species found in the rice rhizosphere is chemoheterotrophs (Bhattacharya et al. 2005) and the addition of organic manures influenced these species of microbes thus contributing to an increase in microbial population over the control. Among the different sources of organic manures, biocompost application @ 3 t ha-1 recoded the maximum bacteria, fungi and actinomycetes population of 21.82 and 21.95 x105, 4.60 and 4.75 x 104 and 3.47 and 3.62 x 104 per gram of oven dry soil in 2005 and 2006 respectively. Traces of reducing and non reducing sugars left in the spentwash and pressmud might have served as ready energy source for the growth and multiplication of microbes. The bacterial population was influenced to a greater extent than the fungi and actinomycetes.

The data on yield attributes viz., number of panicles m-2, filled grains per panicle, 1000 grain weight and yield are presented in Table 4.All the treatments were found to significantly influence the yield attributes and yield over control in both the seasons. Biocompost @ 3 t ha-1 (M4) recorded the highest number of panicles / m2 (310.5 and 270.0 in 2005 and 2006 respectively), filled grains per panicle (150.4 and 135.6) and maximum 1000 grain weight (25.0 and 24.0 g) in 2005 and 2006 respectively. Application of biocompost @ 3 t ha-1 recorded the maximum grain yield of 5.60 and 5.35 t ha-1 in 2005 and 2006 respectively. The grain yield of rice was increased by nearly 30% over control in both the seasons.

DISCUSSION

Biocompost as an organic manure contain plant nutrients which are released into soil solution upon its decomposition. By virtue of its higher N analysis, biocompost contributes a higher quantity of N supplement thus increasing the available N content of the soil. The increase in available P status was due to appreciable P content of biocompost and also due to the solubilization effect of organic acids on insoluble form of phosphates. Potassium was supplied directly in large quantities by the compost thus enhancing the availability of K in soil. Arcia et al., (2002) has expressed similar views with the use of filter cake pressmud. The overall improvement in soil physical, chemical and biological environment through biocompost application had favoured the release of more nutrients from the native forms of the soil thus increasing the soil fertility status.

Biocompost application resulted in increased mineralization of nitrogen by virtue of lower C: N ratio (12:1). During aerobic digestion a considerable amount of protein nitrogen must have been mineralized to ammoniacal form thus increasing the N uptake. This could have been the reason for significant increase in the yield attributes and yield of rice crop. The pressmud based organic manure is rich in plant growth stimulants and enriched with beneficial microflora. These characteristics along with higher nutrient content, lower C: N ratio and well decomposed nature of biocompost contributed its superiority in rice grain yield compared to other sources. Similar results were reported by Angayarkanni and Ravichandran (2002) with bio-digested pressmud application in ADT 36 rice crop.

CONCLUSIONS

The results of the field experiments indicated that among the different organic manures used, application of biocompost @ 3 t ha-1 enhanced available nutrient contents and microbial population of the soil thus increasing the overall soil fertility status. Under improved soil conditions, this treatment registered the highest values for yield attributes viz., number of panicles m-2, number of filled grains per panicle, 1000 grain weight and grain yield. Thus the nutrient rich biocompost can be

effectively introduced as an ecofriendly component in the integrated nutrient management systems to enhance the soil fertility status and achieve sustainability in crop production.

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Table. 1. Characteristics of Organic Manure (Biocompost)

Parameters	***Values (in percentage)***
Moisture	30
Total organic mater	40 - 45
Organic carbon	23 – 26
Total Nitrogen	1.7 - 2.5
Total Phosphorus	1.0 - 1.5
Calcium (Ca)	2.0 - 4.0
Magnesium (Mg)	1.5 - 2.0
Sulphur (as SO_4)	2.0 - 3.0
Iron	0.1 - 0.5
Zinc	50 – 100 ppm
Manganese	150 - 500 ppm
Copper	30 - 50 ppm
Boron	3 - 5 ppm
C : N ration	Between 10 : 1 and 20 :1
pH	7.0 – 8.0

Table 2. Effect of different organic sources on soil available N P and K (kg ha-1)

(Mean of four replications)

Treatments / Manures	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	2005	2006	2005	2006	2005	2006
M_1 – Control	191.50	180.25	18.50	16.63	295.60	277.50
M_2 – FYM @ 12.5 t ha^{-1}	225.65	208.00	24.60	20.80	321.80	293.65
M_3 – GLM @ 6.25 t ha^{-1}	236.00	227.60	28.15	24.60	340.00	305.00
M_4–Biocompost @3t ha^{-1}	244.20	230.10	27.35	22.00	355.00	320.70
CD (5%)	**7.56**	**10.18**	**0.40**	**1.66**	**3.45**	**4.58**

Table 3. Microbial population (per gram of oven dry soil) as influenced by organic manures.

(Mean of four replications)

Treatments /Manures	Bacteria (10^5)		Fungi (10^4)		Actinomycetes (10^5)	
	2005	2006	2005	2006	2005	2006
M_1 – Control	16.70	16.15	1.50	1.45	1.90	1.75
M_2 – FYM @ 12.5 t ha^{-1}	21.50	19.89	3.66	3.50	2.84	2.58
M_3 – GLM @ 6.25 t ha^{-1}	20.25	19.50	3.20	3.35	2.63	2.50
M_4–Biocompost @3t ha^{-1}	21.82	21.95	4.60	4.75	3.47	3.62
CD (5%)	**0.28**	**0.24**	**0.26**	**0.28**	**0.20**	**0.15**

Table 4. Yield attributes of rice crop as influenced by various organic sources

Treatments/Manures	Panicles per m^2		Filled grains per panicle		1000 grain weight (g)		Grain Yield t ha^{-1}	
	2005	2006	2005	2006	2005	2006	2005	2006
M_1 – Control	225.5	234.0	124.0	105.8	24.50	20.0	3.90	3.70
M_2 – FYM @ 12.5 t ha^{-1}	265.4	230.5	135.0	118.6	24.60	22.0	4.30	4.00
M_3 – GLM @ 6.25 t ha^{-1}	275.0	240.4	139.6	120.0	24.70	22.0	4.65	4.40
M_4–Biocompost @3t ha^{-1}	310.5	270.0	150.4	135.6	25.0	24.0	5.60	5.35
CD (5%)	**0.52**	**0.68**	**0.32**	**0.14**	**0.28**	**0.33**	**0.29**	**0.26**

A STATUS REPORT OF AROGYAPACHA

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Arogyapacha -Trchopus zeylanicus, 'the herb of health' are founds in the thick forest of the Agasthiyar hills in south Kerala. It was first brought to the notice of the scientific community by Dr.N.Pushpangadhan in 1987.He was leading a team of scientists and researches from the All India coordinated research project on etheno botany (AICRPE) to Agasthiyar hills. Kani tribals, who accompanied as guides offered the fruit to the exhausted scientists during the trip. It gave their tired bodies a flash of energy and vitality. After a great deal of persuation, the tribals revealed the identity of the sacred plant.

The rare and endangered plant named arogyapacha meaning health plant is biologically termed as trchopus zeylanicus. , is a rare, herbaceous, perennial wild plant found in Malaya peninsular and Kerala. This scarce floral resources is endemic and restricted to a few pockets deep inside the thickly forest of Agasthiyar hills though it has also been reported from an isolated pocket in Karnataka forest

The plant belongs to the family Trichopodaceae. It is a rhizomatous perennial herb. The leaves are solitary triangular oval in shape. The fruit is trilocular blackish violet or deep reddish brown in colour with three ridges. The habitat includes moist deciduous vegetation (shady places near stream).It is slow in natural multiplication and thrive only in the forest, its natural habitat.

Arogyapacha is considered as the health food of 21st century. It has entered modern pharmacopoeia as a safe, antistress, antifatigue, appetite promoting and

restorative herbal tonic for people in all age groups. It boosts the immune system, and produces a state of non-specific increased resistance to disease. It could hold the key to a cure for the dreaded AIDS and an herbal aphrodisiac and health promoting drug. It prevents the attack of AIDS virus to a great extent. By preventing its multiplication inside the body and it increases the functioning ability of blood and thus increasing the life span.

Arogyapacha could be developed as a cheaper alternative to the Korean sinsing, the medicinal plant with immunity enhancing properties, growing mainly in China and South Korea. But unlike sensing; it is free from steroidal effects which holds out a promise for sportsmen helping them to extend the frontiers of human physical excellence.

Only the extracted compounds or the plant extracts in combination with other potent ayurvedic medicines could be developed as medicine. According to Kanis, all parts of the plant from root to leaves are useful for making medicine. But normally they avoid using any part other than the fruit. This is only because soon there will be no more arogyapacha plant if they start using the whole plant.

It has been confirmed that arogyapacha belongs to svathahita (health promoting) group of drugs. It could indeed be the divine varahi which was considered the ultimate health tonic by Sushruta, the father of Ayurveda. According top Kanis their ancestors learned the health boosting powers of the herb directly from saint Agasthya, the founder of siddha system of medicine centuries ago.

After isolating the herb's rejuvenating properties TBGRI-Tropical Botanical Garden and Research Institute (government funded body) developed a traditional drug formula containing 15% arogyapacha. They scientifically tested its toxicity and efficiency and named it as Jeevani.

Arogyapacha cannot be grown in our houses since it grows only under specific conditions in specific regions and in association with specific wild flora. Unless urgent steps were taken to prevent the vandalism arogyapacha would become extinct deriving us of its miraculous medicinal powers.

The study indicates that certain plant species were seen in association with arogyapacha. Trees species like Hopea Parviflora, Terminalia Paniculata were seen in regions where these plants are plenty. Shrubs like Drasena Terriflora are also seen in association. The arogyapacha was seen healthier and with greater number of leaves with the association of these plants. These plants help in holding the soil, increasing the moisture content or increasing the humus etc. From the studies, it was in regions where luxuriant growth of reeds is seen even though other conditions are satisfied. Presence of water bodies may also have a direct influence on the growth of arogyapacha.

During the study conducted, a numbers of chordate and non-chordate animals were identified. The dominating species were millipedes which are humus loving. Other animals include arthropods, leaches, snails ants etc. The reptilian and amphibian fauna were also rich in this area.

STUDY AREA

LOCATION

Neyyar Wild life Sanctuary is situated in the extreme southern tip of Kerala state, 30km away from Thiruvananthapuram, the capital city. This area was notified as a Wild life Sanctuary in 1958 for the purpose of protecting, propagating and developing wild life and its environment. The sanctuary is located between 8030' and 8038' north latitude and 7708' and 77017' east longitude covering an area of 128 km2.The flora and fauna of this sanctuary exhibiting a high degree of diversity due to varied climatic and topographic condition. It abodes substantial natural forest ranging from mountain subtropical forest to tropical evergreen formation. The sanctuary presents the endemic flora and fauna of diverse variety and complexity and makes it an ideal gene pool.

CLIMATE OF THE AREA

The climate is moderately hot and humid. The temperature varies from 16oC to 35oC .The high hills are cooler and drier than the foot hills and valleys. The maximum mean temperature during the hottest month of March is about 35oC and that during the coldest month of January is about 16oC.the mean annual rainfall is about 2800mm from both south west(May-July) and northeast(Oct-Nov) monsoons.

CONCLUSION

From the present investigation it can be concluded that the amount of solar radiation, canopy and certain faunal association have got a direct influence on the growth of arogyapacha.

a. Light penetration

It was found that lesser number of arogyapacha was seen in region where there was high amount of light penetration.i.e. % occurrence of Arogyapacha*(1/ amount of light penetration)

b. Canopy It was noted that rich growth of arogyapacha were seen in the region where canopy is thick. i.e. % occurrence of arogyapacha*canopy

c. Associated flora

Tree species like Hopea Parviflora and, Terminalia Paniculata, shrubs like Drasena terriflora, Curculigo are seen in association with arogyapacha.

i.e. % of occurrence of arogyapacha*certain flora like Hopea, terminalia, Drasena

d. Soil quality

The presence of high moisture content and organic matter favors the growth of arogyapacha.

Considering the economic importance of arogyapacha and owing to the present status report of this endemic medicinal plant species, it can be summarized that a habitat management of this plant is essential for future generation.

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SUSTAINABLE UTILISATION OF FARM WASTE AS MANURE - A METHOD FOR COMPOSTING OF RAINFED PEARL MILLET STRAW

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Population explosion, generate lot of solid wastes. The composting is one of the eco-friendly and cheap methods of recycling solid wastes. The continuous use of large quantities of chemical fertilizers in intensive cropping systems results in various adversities and unfavourable soil conditions (Parr et al., 1986). So, the usage of sustainable sources of nutrients becomes necessary. Composting is a process in which the complex organic substances are converted into carbon dioxide, water, mineral constituents and biostable organic compound known as humus. Composting leads to the conservation of nutrients, destruction of pathogens and enrichment of soil fertility. Generally, it takes six to seven months to obtain good, finished compost from agricultural wastes and one of the important research is to reduce the period of composting of agricultural residues through rapid composting. Pearl millet is extensively cultivated in poor fertile and water-deficit soils, mostly with low and erratic rainfall. India is the largest producers of pearl millet in the world. Hence, one experiment was conducted to fasten the composting of rainfed pearlmillet straw with different combination of microorganisms at Regional Research Station, Aruppukottai, Tamil Nadu Agricultural University.

METHODS

One composting experiment was carried out by pit method. Treatments fixed were five, each replicated four times.

Treatment details

T1 - Pearl millet straw + cowdung + *Bacillus sp.*+ *Pseudomonas sp* .

T2 - Pearl millet straw + cowdung + *Trichoderma sp.*+ *Pleurotus sp* .

T3 - Pearl millet straw + cowdung + *Streptomyces sp* .

T4 - Pearl millet straw + cowdung + mixed microbial inoculum .

T5 - Pearl millet straw + cowdung (control).

Composting of pearl millet straw was carried out with the cultures isolated during mesophilic and thermophilic stages of composting from the compost pits.

Mixed microbial inoculum consists of *Bacillus sp.*, *Pseudomonas sp.*, *Trichoderma sp.*, *Pleurotus sp.* and *Streptomyces sp.*

The pearl millet straw was chopped into bits of 10 to 15 cm length. One hundred kilograms of straw on wet weight basis was added for each treatment which was then sprayed with water to maintain the moisture content of 50 to 55%. Cultures of different organisms were inoculated at 1% level two times at fortnightly interval, Accurately 10kg of fresh cowdung was prepared as slurry by mixing with 10 litres of water and sprinkled over each heap. Every fortnight, all the compost heaps were turned upside down. The samples were collected from the composting pits regularly for its analysis. The statistical analysis of data was carried out by completely randomized block design.

RESULTS

During the composting process, the pH reduced and sustained in neutral condition. C: N ratio of the compost was gradually reduced from 81.37 to less than 20 during 105 days of composting. Due to increase in total nitrogen and reduction in organic carbon content, the C: N ratio reduced. C: N ratio during 90th day ranged from 14.84 to 25.84. C: N ratio of the treatments applied with fungi (T2) and the mixed microbial inoculum applied treatment T4 were less than 20 (17.63 and 17.25 respectively) during 75th day itself (Table 1). The pH was also stabilized and even after incubation pH was 7.05 and 7.02 in treatments T2 and T4. Hence, the treatments T2 and T4 can be assessed as matured, during 75th day. Cation Exchange Capacity was more than

60 C mol (p+) kg -1. Final CN/ Initial CN ratio was less than 0.4.

Total nutrients content were significantly different from the control. Total nitrogen varied from 1.07 to 1.22%. Total phosphorus content of compost ranged from 0.12 to 0.21%. Total potassium content of compost ranged from 1.64 to 2.13% (Table 2).

DISCUSSION

Rapid composting is to reduce the time taken for complete maturity of compost. Wide C:N ratio and higher amounts of resistant constituents like lignin are responsible for the slow degradation of cereal residues (Bharadwaj and Gaur, 1985). In rainfed pearl millet straw composting, the treatments T2 and T4 matured on 75th day, as the treatments T2 and T4 were inoculated with Pleurotus sajor-caju and Trichoderma viride. Inoculation of lignin degrading fungi along with cellulose decomposing fungi deserves its application in disposing of cereal residues by rapid composting (Nandi et al., 2000). According to Singh and Amberger (1998), wheat straw compost enriched with nitrogen, molasses and rock phosphate should be used only after 120 days of decomposition for sustainable crop production.

CONCLUSION

For the quick composting of rainfed pearlmillet straw, the combination of organisms Trichoderma sp and Pleurotus sp could be used along with 10% of cowdung. Maintenance of moisture content of 50-55% is very much essential for the survival of decomposing organisms. Turning of composting materials may be carried out once in fortnight to make it aerobic. The fully matured, good quality compost can be obtained within 75 (seventy five) days.

Table 1: Determination of maturity of the compost

Treatments	Tests conducted (75th day of composting)					Tests conducted (90th day of composting)				
	pH		CEC	C:N ratio	Final CN/ Initial CN ratio	pH		CEC	C:N ratio	Final CN/ Initial CN ratio
	Before Incubation	After incubation	Cmol (p+) kg^{-1}			Before Incubation	After incubation	Cmol (p+) kg^{-1}		
T_1	7.41	6.74	58.5	20.44	0.25	7.34	7.10	61.5	18.84	0.23
T_2	7.78	7.05	60.7	17.63	0.22	7.37	7.19	63.5	15.40	0.19
T_3	7.62	6.71	59.2	20.10	0.25	7.43	7.06	62.0	19.00	0.23
T_4	7.44	7.02	61.0	17.25	0.21	7.31	7.22	64.2	14.84	0.18
T_5	7.05	6.69	52.8	33.89	0.42	7.01	6.73	58.7	25.84	0.32

Table 2: Nutrient content of the matured pearl millet straw compost

Treatments	Total N (%)	Total P (%)	Total K (%)	Organic carbon (%)	C:N ratio
T_1	1.17	0.16	1.91	20.17	17.24
T_2	1.20	0.18	2.11	17.85	14.88
T_3	1.14	0.15	1.86	21.39	18.76
T_4	1.22	0.21	2.13	17.89	14.66
T_5	1.07	0.12	1.64	21.35	19.95
SED	0.02	0.004	0.04	0.32	0.27
CD (.05)	0.04	0.01	0.09	0.68	0.59

T1 = T5 + Bacterial culture. T2 = T5 + Fungal culture. T3 = T5 + Actinomycetes culture. T4 = T5 + Mixed microbial inoculum. T5 = Pearl millet straw + cowdung (control).

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VERMICOMPOSTING - A SUSTAINABLE METHOD OF SOLID WASTE MANAGEMENT

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Vermicomposting is a biotechnological process of composting aided by earthworm. The final product obtained is known as vermicompost which is a finely divided peat like material with excellent structure, porosity, aeration, drainage and moisture holding capacity. A study on industrial solid waste management through Vermitechnology and its effect on crop cultivation were carried out at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai.

The crop chosen for cultivation was Abelmoschus esculentus (L.) Moench Var. Arka anamika which is one of the most familiar annual tropical vegetable grown extensively through out the year in India. India is the largest producer of bhendi in the world. Its adaptability to a wide range of growing conditions makes it popular among vegetable growers. In India, the area under okra is 3.60 lakhs hectares producing 3.5 mt of fruits.

(Key words: Composting, earthworms, Abelmoschus esculentus)

MATERIALS

The experiment on vermicomposting of industrial waste like pressmud, paper mill sludge and vegetative tannery waste was conducted by using earthworm namely Eudrillus eugenie. at Agricultural College and Research Institute, Madurai by collecting the wastes from Sakthi Sugar Industries limited, Padmathur, TNPL, Karur and Sea Lord Leather Factory, Dindigul respectively. The vermicompost obtained was utilized for further research. The field experiment was conducted at the Orchard

of the department of Horticulture, Agricultural College and Research Institute, Madurai. The field experiment was conducted by Randomized block Design with nine treatments and three replications.

Treatments details

T1-Control,

T2-50% RDF*,

T3-100% RDF*,

T4-Vermicompost of Pressmud @ 5 t ha-1,

T5-Vermicompost of Papermill sludge @ 5 t ha-1 ,

T6-Vermicompost of Vegetative tannery @ 5 t ha-1,

T7-Vermicompost of Pressmud + 50% RDF*,

T8-Vermicompost of Papermill sludge + 50% RDF*,

T9-Vermicompost of vegetative tannery + 50% RDF*

*RDF - Recommended Dose of Fertilizers.

The yield of fruits per plot and the dry matter yield was also recorded and statistically scrutinized.

RESULTS

The results indicated that the nutrients content of the vermicompost produced from press mud was superior to all others. The N content of vermicompost produced from press mud, paper mill sludge and vegetative tannery was 2.0, 1.15 and 0.23 % respectively. The P content of vermicompost produced from press mud, paper mill sludge and vegetative tannery was 0.72, 0.52 and 0.47 % respectively. The total K content of vemicompost produced from press mud, paper mill sludge and vegetative tannery was 1.29, 0.96 and 0.79 % respectively (Table 1).

Parameter	Press mud	Papermill	Vege.tannery
pH	7.4	7.7	7.4
EC (dsm^{-1})	1.45	1.55	4.36
Organic carbon (%)	12.3	24.2	8.07
Total N (%)	2.0	1.15	0.226
Total P (%)	0.72	0.52	0.47
Total K (%)	1.29	0.96	0.79
Total Ca (%)	2.29	0.95	0.92
Total Mg(%)	0.82	0.52	0.51

Table 1. Major and secondary nutrient content of industrial solid wastes based vermicompost

Treatments	Yield		Dry matter yield (g/pl$^{-1)}$
	Kg Plot^{-1}	Ton ha^{-1}	
T1	2.33	5.83	38.2
T2	3.12	7.11	51.78
T3	4.4	11.0	66.2
T4	3.77	9.42	62.25
T5	3.43	8.58	53.93
T6	3.27	7.25	53.39
T7	5.2	13.0	71.47
T8	4.5	11.25	70.99
T9	3.9	9.75	64.16
SEd	0.0140	0.0375	0.1761
CD(0.05)	0.0296	0.0794	0.373

Table 2. Influence of vermicompost on yield of bhendi var. Arka anamika

The fruit yield of bhendi variety Arka anamika was significantly influenced by the application of vermicompost of industrial wastes. The result revealed that the yield of bhendi fruit ranged from 2.33 to 5.2 kg/plot and 5.83 to 13.0 t/ha respectively. The highest value was recorded in the treatment that received press mud vermicompost @5 t ha-1 in combination with 50% RDF followed paper mill sludge vermicompost @ 5 t ha-1 with 50%RDF. The lowest value was recorded in the control (Table 2). Among the three vermicompost, the press mud vermicompost has greater influence on soil available nutrients, uptake, yield and quality of bhendi.

DISCUSSION

The total N content was found to be maximum in pressmud vermicompost. This may be attributed to higher N content of pressmud compared to other organic wastes as reported by Jeyabal and Kuppsamy, 2001. The total P content was recorded maximum in press mud vemicompost than other wastes. The variations in total P content due to the influence of different species of worms were also reported by Sailaja Kumari and Ushakumari (2000).

The press mud vermicompost with 50 % RDF recorded higher number of fruit per plant and fresh weight per fruit. It is due to the application of organic manure with inorganic fertilizers. Similar findings were reported in Bhendi by Gupta and

Rao (1979), Pandey and Singh (1979) in French bean.

CONCLUSION

The study revealed that vermicomposting is an efficient, eco-friendly approach for recycling of industrial solid wastes. The application of press mud vermicompost in combination with 50 % recommended dose of fertilizer was found to be the best combination for increasing soil available nutrients, yield, and quality of bhendi and maintaining soil health quality and sustainability.

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NUTRITIONAL IMPORTANCE OF OUTER COVER OF *TERMINALIA CATAPPA* FRUIT

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Terminalia catappa is a large tropical tree from the family combretaceae. Commonly known as Indian almond, tropical almond and wild almond. It is widely planted as an ornamental tree and for shade in parks, along road side as well as in home gardens due to

its pagoda form (Lex, Barry 2006). Its fruits are drupe-like in which outer fleshy part (exocarp or skin and mesocarp or flesh, soft followed by fibrous portion) surrounds the shell (woody coat) of hardened endocarp with a kernel (edible nut) inside (Edward, Dennis 1994). These fruits resemble closely with the fruits of Rosaceae family; plum, apricot, peach and cherry which similarly have succulent fleshly part attached to hard shell and in some cases even an edible nut inside the shell. Despite the easy cultivation and growth (does not require specific conditions) of the plant, consumption of the abundantly produced fruit is restricted only to small pockets of India and other countries. The difficulty in breaking pericarp (unavailability of easy method of extracting the kernel) is the limiting factor. Moreover, the size of the nut in proportion to the whole fruit being extremely small (1-2%) is not felt worth the efforts for its removal. Largely, the fruit is considered as waste and thus is thrown. Surprisingly, the thick fleshy outer cover (exo and mesocarp) of the ripe fruit has been found to be eaten by birds as well as children and even adults in certain parts of the globe, enjoying the astringent sweet taste, raw or processed, either out of curiosity or due to easy availability (without any cost) and no harmful effects. This has generated an interest in investigating the nutritional potential of the outer cover surrounding the endocarp which can act as

a cost effective nutrient source to cater to the demand of the malnourished and low-socio-economic class in particular through supplemental effect. At the same time will help solve the waste disposal problem, preventing environmental pollution.

Key words: Terminalia catappa fruit, proximate composition, fleshy coat, Phytochemical.

MATERIALS AND METHODS

The proximate composition and phytochemicals (nonenzymatic antioxidants) in the two different varieties and at different stages of development of the fruit were analyzed with standard available methods; estimation of moisture, ash and fiber by AOAC (1990) and crude protein, fat and total carbohydrates by sadasivam (2005). Caloric value per 100g edible portion was calculated according to the system of Atwater, namely Kcal= (3.36 X %protein) + (3.60 X %total carbohydrates) + (8.37 X %fat) (Merrill and Watt 1973). Beta carotene was estimated from fresh sample by using method described by AACC (14-50, 1995). Experimental method described by Sadasivam (1987) was used to measure Vitamin C content of the fresh sample. All estimations were carried in triplicate.

RESULTS

The proximate composition of outer flesh of the two varieties of tropical almond has shown changes in the content of nutrients at different stages of development within and between them. The protein concentration was higher in red variety than in the yellow one which contains more carbohydrates than the red variety. It is a good source of antioxidant vitamins , beta-carotene and ascorbic acid in particular. Fat, fiber and ash content were comparably same in both varieties. . Nutrient content increased with ripening of the fruits. Overall; the analysis suggests this source to be nutritionally quite comparable to other like fruits.

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EFFECT OF LONG-TERM MANURE FERTILIZER ADDITION ON RICE YIELD, SULPHUR UPTAKE AND AVAILABLE SULPHUR STATUS UNDER RICE MONOCULTURE IN TYPIC HAPLUSTALF

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Modern intensive farming has resulted in higher demand for fertilizer because of removal of all the essential plant nutrients. Most of our attention has been restricted to N, P and K. The report on the deficiency of secondary and micronutrients are increasingly appearing particularly from intensively cropped regions. Sulphur nutrition to crops has not been fully realized during the past mainly because of the fact that S deficiency was not a serious problem. Recently in S nutrition to crops has increased dramatically. Response studies on S have been done on various crops under various Agro climatic conditions. The long term application of manure fertilizer schedules on rice monoculture on yield, S availability and S uptake in lacking. Keeping these points in view the present investigation was taken up.

MATERIALS AND METHODS

A permanent manurial experiment with rice monoculture is in operation since 1975 at the Agricultural College and Research Institute, Madurai, Tamil Nadu to evaluate the long - term effects of different manure fertilizer schedules on the properties and fertility status of the soil and rice yield. The treatment structure followed are four main plot treatments involving manures and eight sub plot treatments involving N, P and K fertilizers in split plot design (Main plots : M1- control, M2 - FYM 12.5 t ha-1 ; M3 - Green leaf manure 12.5 t ha-1 and M4 - Urban compost (UC) 12.5 t ha-1, sub plot S1 - control, S2 - N alone, S3 - P alone, S4 - K alone, S5 - N+P, S6 - N+K, S7 - P+K, S8 - N+P+K). Nitrogen, P and K are applied at the rates of 120, 60 and 60 Kg ha-1 respectively in the form of Urea, single super

phosphate and MOP according to the treatments. The present study was conducted on 44th and 45th rice crop.

RESULTS AND DISCUSSION

Effect of manure fertilizer schedule on rice grain yield

Application of manures significantly influenced the grain yield and it ranged from 3264 to 5045 Kg ha-1. The highest grain yield of 5045 Kg ha-1 was registered with the application of green leaf manure followed by 4816 Kg ha-1 by the application of urban compost (Table 1). The green manuring and its positive effect on rice grain yield was reported by Swarup (1986) and Panda and Sahoo (1989). Similarly application of chemical fertilizer also significantly influenced the grain yield and the highest grain yield of 5003 Kg ha-1 was recorded with the application of N, P and K followed by application of N and P. Similar to the individual effect, the combined application of manures with chemical fertilizer also significantly influenced the grain yield. The highest grain yield of 5773 Kg ha-1 was registered with the incorporation of green leaf manure in conjoint with N, P and K.

Effect of manure - fertilizer treatments on uptake of S by rice crop

Application of manure - fertilizer schedules significantly influenced the uptake of S by the rice crop. As regard the organic manures, the highest uptake of S was registered with the incorporation of green leaf manure (35.7 Kg ha-1) followed by urban compost (34.1 Kg ha-1) (Table 2). Deikmann etal. (1996) noticed that addition of green manure increased the S content. Regarding the fertilizer schedules, the highest S uptake was registered with the application of NPK followed by incorporation of N and P. Higher S content in rice grain due to the application of SSP was reported by Manchendra etal. (1993). The combined application of manure and fertilizer also significantly influenced the uptake of S by the rice crop. The highest uptake of S was recorded with the application green leaf manure with N, P and K.

Effect of manure fertilizer schedules on available S status

In the case of manurial treatments the available S status ranged from 15.5 to 39.3 Kg ha-1 and the highest status of available S was noticed in the treatments receiving urban compost (39.3 Kg ha-1) followed by green leaf manure (38.8 Kg ha-1) (Table 3). The increase in available S status due to the addition of cattle manure was reported by Chae and Krouse (1986) who attributed the appreciable increase in the labile S status to the influence of organic manure by chelating the cations like Fe3+ andAl3+. With regard to the fertilizer schedule, the available S status ranged from 20.5 to 46.5 Kg ha-1. Misra (1996) reported that continuous application of recommended dose of NPK with S for rice has raised the available S status three times more as compared to the treatments without S.

CONCLUSION

Long-term application of organic manures in conjoint with chemical fertilizer influence the grain yield, S uptake and S availability to the rice crop. Among the various organic sources green leaf manure performed better in influencing the grain yield and S uptake by the rice crop. Thus integration of organic sources conjoint with the chemical fertilizer has become inevitable to sustain the rice yield and fertility status of the soil.

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Table 1. Effect of manure - fertilizer schedules on rice grain yield (Kg ha-1)

Treatments	M_1	M_2	M_3	M_4	Mean
S_1	2800	4050	4500	4300	3913
S_2	3430	4680	5250	4900	4565
S_3	3000	4255	4600	4600	4114
S_4	2850	4100	4420	4405	3943
S_5	3630	4785	5500	5210	4779
S_6	3500	4980	5450	5025	4738
S_7	3200	4330	4870	4750	4288
S_8	3700	5180	5773	5360	5003
Mean	3264	4545	5045	4816	4418

SED	CD (p = 0.05)	
M	50.4	101
S	71.3	143
M x S	100.5	NS

Table 2. Effect of manure - fertilizer schedules on S uptake by the rice crop (Kg ha-1)

Treatments	M_1	M_2	M_3	M_4	Mean
S_1	7.2	23.8	27.7	27.3	21.5
S_2	8.6	26.8	34.3	30.5	24.5
S_3	20.0	33.5	41.6	35.3	32.6
S_4	7.4	22.8	28.7	29.8	21.2
S_5	23.0	38.4	41.8	38.6	35.5
S_6	9.6	30.4	35.5	32.5	26.8
S_7	21.3	36.2	37.5	38.3	23.4
S_8	23.1	39.2	44.0	40.2	36.6
Mean	15.1	31.1	35.7	34.1	

SED		CD (p = 0.05)
S	0.22	0.40
M	0.42	0.80
S x M	0.86	1.80

Table 3. Effect of manure - fertilizer schedule on available S status (Kg ha-1)

Treatments	M_1	M_2	M_3	M_4	Mean
S_1	8.2	24.5	28.2	35.6	24.1
S_2	5.4	26.0	25.0	25.4	20.5
S_3	24.6	46.4	52.0	44.4	41.9
S_4	8.0	23.5	33.8	32.6	24.5
S_5	22.0	52.4	42.0	45.0	40.4
S_6	7.6	22.8	23.0	27.8	20.3
S_7	25.0	51.8	57.8	51.4	46.5
S_8	22.8	46.5	52.5	48.4	42.6
Mean	15.5	36.7	38.8	39.3	

SED		CD (p = 0.05)
M	0.21	0.40
S	0.30	0.60
MxS	0.59	1.2

ORGANIC MANURE APPLICATION FOR CONTINUOUS CROP PRODUCTION IN IRRIGATED RICE ECOSYSTEM

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Rice system is a dominant system in Tamil Nadu covering nearly sixty per cent of the total cropped area. This wide scale adoption of rice - rice system has ushered an increase in agricultural production, but this intensive system over a period of time has set declining trend in yield, and resulted in deterioration of soil productivity even with optimum use of fertilizes. Therefore the apparent contradiction of our necessity for nutritional security on one hand and environmental sustainability on the other makes it inevitable to resort to the organic or eco-farming system as it appears to be a possible option to meet both these objectives In view of these considerations, a study was taken up in a Permanent Manurial Experiment to assess the influences of organic manures and fertilizers on soil properties and yield in irrigated rice ecosystem.

MATERIALS AND METHODS

A permanent material experiment in rice-rice cropping system was established in 1971 on sandy, loam soil (Typic Haplustalfs) at Agricultural College & Research Institute, Madurai, Tamil Nadu, 9504 north latitude, 7800 East longitude and 147 on above sealovel. Initial soil characteristics of the experimental silos were, pH 7.2 (1:2 soil / water suspension) electrical conductivity 0.27 dsm-1 (1:2 soil/water suspension), organic carbon - 0.61%, available 258 t ha-1 Cu, Zn respectively. The study consists of four main plot treatments involving manures and eight sub plot treatments involving N,P and K through fertilizers, replicating each treatment twice in split plot design.

The organic manures of FYM, GLM, and UC are applied at the rate of 12.5 t ha-1. All these manures are applied according to the treatments and incorporated into the soil one week prior to planting. N, P and K are applied at the rates of 120, 60 and 60 kg ha-1 respectively in the form of urea, super phosphate and muriate of potash according to the treatments. The entire dose of P is applied basally and N and K are applied in three equal splits - 1/3 as basal, 1/3 at active tillering stage and 1/3 at panicle initiation stage of the crop. Two field experiments were conducted in the existing Permanent aManurial Experiment with ADT 36 rice as test crop.

Treatment Details

Main Plot

M1 - Control (No Manure)

M2 - FYM -12.5t ha-1

M3 _-GLM -12.5t ha-1

M4 - Urban compost -12.5t ha-1

Sub Plot

F1 - Control (No N,P,K)

F2 - N alone

F3 - P alone

F4- K alone

F5 - N + P

F6 - N + K

F7 - P + K

F8 - N + P +K

Soil Properties

Soil reaction ranged between 6.6 in FYM treatment to 7.2 in unmanured control. Soil reaction was lower in the treatments that received manures and electrical conductivity of the soil ranged between 0.27 dS m-1 in unmanured control and 0.31 dS m-1 in urban compost treatments and it ranged from 0.27 to 0.33 dS m-1 among the NPK treatments. soil salinity has not changed significantly due to different manure - fertilizer schedules.

Cation exchange capacity of the soil ranged between 24.3 cmol (p+) kg-1 in FYM treatment.Organic carbon content ranged between 0.75% in unmanured control and 1.33% in UC treatments. Organic carbon content was higher in the treatments that received manures than in unmanured control.

Yields of rice crop

The grain yield ranged from 4.2 t ha-1 in unmanured control to 5.4 t ha-1 in FYM treatment. The results showed that among the manuorial treatments, significantly higher yields were recorded in the treatments that received one of the manures than in the unmanured control, recording the highest yield in the FYM treatment. Though the highest yield of 6.3 t ha-1 was recorded in the NPK treatment, the yields recorded in N(6.2 t ha-1) NK (5.8 t ha-1) and NP (5.5 t ha-1) treatments were on par with this yield. The results from the experiments at the Broadbalk field (Rothamsted) continuing for more than 150 years have also shown the significant positive effects of FYM on crop growth (Nambiar, 1994).

The straw yield ranged between 8.0 t ha-1 in control and 10.7 t ha-1 in the FYM treatments among the manorial treatments and among the fertilizer schedules it ranged from 7.0 t ha-1 in control to 12.4 t ha-1 in NPK treatment. The results on the rice straw yield reflected similar trends as in grain yield. straw yield was significantly higher in the treatments receiving one of the manures and N irrespective of the application of P and K.

The total dry matter yield of the rice crop ranged from 12.2 t ha-1 in control to 16.1 t ha-1 in the FYM treatment and among the fertilizer schedules in ranged between 10.9 t ha-1 in control and 18.5 t ha-1 in NPK treatment. Total dry matter yields in the treatments that received either FYM, urban compost or GLM were significantly higher than the total dry matter yield in the unmanured control.

DISCUSSION

The reduction in pH in the manured plot may be attributed to the release of organic acids from manures which in turn would have reduced the pH by releasing treatments. Similar results were reported by Dekamedhi and De Datta (1995) who attributed lower pH in manurial treatments to the CO2 and organic acids production by the organic manures during their decomposition. The CEC was significantly higher in the treatments that received manures and this may be attributed to the higher CEC of the humus in these treatments as evidenced by the higher organic carbon content. This may be attributed to the contribution of organic matter through humus formation Similar results were reported by Udayasoorian (1983). The higher organic carbon content is due to the contribution of organic matter through humus formation by the addition of manures. Patnaik et al. (1989) reported build-up of organic carbon in the LTFE, Bhubaneswar and Hyderabad where rice-rice crop

sequence was followed.

The higher grain yields in the treatments receiving organic manures may be attributed to the overall positive influences of the manures on the properties and fertility status of the soil. Significantly lower yields were recorded in treatments without N due to poor vegetative growth in the absence of N. The results showing that the grain yields in the treatments receiving NPK and N alone were on par indicates that there is no response for P and K application.

CONCLUSION

The results have shown that the integrated use of organic manures and inorganic fertilizers could be recommended to improve the properties and fertility status of the soil and to maximize the soil productivity. The results showing that the grain yields in the treatments receiving NPK and N alone were on par indicates that there is a possibility to effect a saving in the inputs of P and K in soils with sufficient status of these nutrients without reduction in the grain yield.

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CHARACTERIZATION AND PARTIAL PURIFICATION OF ACID PHOSPHATASE FROM THE LEAVES OF *EUPATORIUM ODORATUM*

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Acid phosphatase is a phosphatase, a type of enzyme, used to free attached phosphate groups from other molecules during digestion. It is basically a phospho homo esterase. Acid phosphatases (ortho phosphoric-mono ester phospho hydrolase) are widely distributed plants and animals. Many researchers purified and characterized acid phosphatases from tubers, plant roots. Acid phosphatase seemed to be involved in the solubilisation of macromolecular organic phosphatase in soils which can then utilized by plants (Panara and Antonielli 1990).

Phosphatase enzymes are also used by soil microorganisms to access organically bound phosphate nutrients. An assay on the rates of activity of these enzymes may be used to ascertain biological demand for phosphates in the soil. (Yenigun and Guvenilir, 2003) Major other applications include DNA profiling, semen detection test, mycorrhizal studies, plant nutrition, and criminology. Organic P sources can be utilized by the plant after they are hydrolyzed by phosphatase (Gilbert and Knight 1999). Agro forestry species with high acid phosphatase activities can mobilize and utilize organic P in the soil (George et al., 2002).

Fifty two plants were screened for detecting the presence of acid phosphatase in their leaves, out of which 4 plants showed maximum activity. Among them Eupatorium odoratum was selected because of the ease of availability. The present study attempts to characterize and partially purify acid phosphatase from the leaves of Eupatorium odoratum

MATERIALS AND METHODS

1. Screening of plants for acid phosphatase

About 52 species of plants were screened for the presence of acid phosphatase and enzyme activity was expressed in terms of OD (Lowry et al., 1954)

2. Preparation of plant extract

Twenty grams of plant tissue was weighed and were ground using a chilled mortar and pistle along with 25ml of 50 mM of citrate buffer. Homogenate was filtered through four layered cheese cloth and the filtrate was collected in a measuring cylinder. Then the filtrate was centrifuged at 10000 rpm for 10 minutes at 4 ^{o}C. The supernatant was assayed for the presence of acid phosphatase activity and it was stored under refrigerated condition.

3. Acid phosphatase assay, determination of protein and specific activity.

Phosphatase assay was done as per Lowry et al., 1954. Protein content of the sample was quantified according to the method of Lowry et al., 1951. Specific activity of enzyme was calculated using the equation; Specific activity = enzyme activity/ protein content

4. Partial purification of acid phosphatase

The crude enzyme extract was adjusted to 30%, 60% & 100 % $(NH_4)_2SO_4$ saturation sequentially by adding solid $(NH_4)_2SO_4$. After each step of ammonium sulphate addition, solution was stirred well and kept for one hour at 4 ^{o}C for complete precipitation. Later the solution was centrifuged at 10000 rpm for 10 minutes at 4 ^{o} C. The collected pellet was dissolved in 2 ml of ice cold citrate buffer (pH 5.3).

5. Determination of optimum pH and temperature.

The optimum pH for acid phosphatase activity was determined by using the following buffers:-

For pH 3, 4, 5, 6 citrate buffer and pH 7, 8 phosphate buffer. The temperature sensitivity assay was performed by varying the incubation temperature from 15°c to 55°c and the respective enzyme activity is recorded.

6. Histochemical localization

Histochemical localization of acid phosphatase in leaves of Eupatorium odoratum was performed as follows, free hand sections were prepared and incubated in 3 ml of substrate solution and then in 9.5 ml NaOH for few minutes. After incubation sections were washed with distilled water and observed under light microscope. The control sections were incubated in distilled water.

RESULTS AND DISCUSSION

The enzymatic activity of all fifty two plants were screened for the presence of the enzyme acid phosphatase. Among the 52 plants screened Allamanda cathartica, Bougainvillae, spectabilis, Adathoda beddomei and Eupatorium odoratum showed maximum enzymatic activity and for the present study Eupatorium odoratum was selected because of the ease of availability. As per Lowry's method, enzyme activity was found to be 0.08 units and 1 g of tissue was found to contain 1.25 mg protein. Then the specific activity was calculated as 0.07units/mg. During partial isolation procedure most of the enzyme was found to be precipitated at 30% (NH4)2SO4 concentration.

Sl. No.	Ammonium sulphate concentration (%)	Enzyme activity (units)
1.	10	0.01
2.	20	0.03
3.	30	0.05
4.	40	0.01
5.	50	0.01
6.	60	00
7.	70	00
8.	80	00
9.	90	00
10.	100	00

Table 1: Enzyme activity at different ammonium sulphate concentration

The optimum pH was found to be 5 for acid phosphatase from the leaves of Eupatorium odoratum. The acid phosphatase isolated from Lupinus luteus cotyledons showed an optimum pH of 5. (Agate 1997).

Sl.No.	pH	Enzyme activity (units)
1.	3.0	-
2.	4.0	0.3
3.	5.0	0.4
4.	6.0	0.3
5.	7.0	-
6.	8.0	-

Table 2: Enzyme activity at different pH

The optimum temperature was found to be 45°C. 35°C also showed reduced activity. Phosphatase from cassava leaves was found to have an optimum temperature of 60°C (Tham et al., 2006).

Sl No.	Temperature (°C)	Enzyme activity (units)
1.	15	-
2.	25	-
3.	35	0.4
4.	45	0.5
5.	55	-
6.	65	-

Table: 3 Enzyme activity at different temperatures

Histochemical localisation studies showed that acid phosphatase is mainly located in the phloem cells.

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STATUS REPORT ON THE EBONY-A CASE STUDY

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Forest and environment have profound impact on the socio-economic life of the people of the country, particulary in areas where people have to depend greatly on forest for their livelihood. Ecology and economy rarely goes together. This fact has placed the ecology of the planet in the present state. Several hundred thousand floral and faunal species had been extinguished so far. The present environmental condition is not rendered a safe habitat for still more species. An environment in which animals and plants become extinct is not safe for the human beings either. In this context trees like ebony, sandalwood etc., which have economic importance and are under threat need special attention.

The present work was to prepare a status report of Ebony in the Peppara Wild life sanctuary. The main objective behind the study was habitat management of Ebony. For the preparation of status report, quadrat sampling method was adopted and the percentage of Ebony in the prescribed area was calculated.

EBONY -THE ROYAL TIMBER

Ebony - *Diospyrous ebenum*, popularly known as "Karimaram" is considered as one among the royal timbers. It is seen frequent in semi evergreen to evergreen forest of Western Ghats. It is a very rare tree in Travancore and hence got the name royal timber. The tree, Diospyrous ebenum belongs to the family ebenaceae.

Ebony is a tree, which occasionally attains a height of 20 m and about 40 cm in diameter. Its distribution is sporadic in semi evergreen forest, available in limited quantities. Its timber is heavy fine textured jet-black ornamental wood of first class,

strong and durable. It is used for constructional purposes, carving and cabinetwork and for making walking sticks, mathematical and engineering instruments and handicrafts.

The true ebony is a tree of dry region and has only been found in Travancore. It is a large evergreen tree with dense leafy head and sometimes attains a height of 80 feet and diameter of 2¼ inch. It occurs also in the Deccan and in Ceylon. Under favorable circumstances the trees attain a total girth of 14 feet in Ceylon and the largest log of ebony, with the sapwood, removed, seen by brown was 7 feet. According to the same observer the proportion of black wood to the gross volume of the trees examined varies from 14 to 35, an average of less than a quarter. The rate of growth is slow as the following figure shows.

A tree probably reaches a girth of 18 inch at 25 years, 36 inch at 75 years, 54 inch at 135 years, 72 inch at 200 years.

Ebony prefers a rocky well drained soil and is found chiefly in company with other species of Diospyros. It is never found to be gregarious. Seedlings are shade enduring but require to have the cover removed when they are established .

There is large export of this tree to China from Ceylon for the purpose of making chopsticks, opium pipes and carved works. About 300 tons a year are shipped from that island.

STUDY AREA

Peppara wildlife sanctuary is located in Western Ghats, about 50 km north-east of the capital city, Trivandrum. The sanctuary is in the catchment area of Peppara dam constructed across the river Karamana and commissioned during 1983, to augment drinking water to Trivandrum city and sub urban area. The area was declared as a wildlife sanctuary considering the importance of preserving the climatic balance, floral and faunal resources. The sanctuary is situated in Western Ghats in Nedumangad taluk of Trivandrum district and lies between 80 7' and 770 1.7' East Longitude.

The habitat in the reserve can be broadly classified as wet evergreen, semievergreen, moist deciduous, grass land and reed breaks. There is about 5 sq.kms of wet evergreen forests, 5 sq. kms of semi evergreen forests, 25 sq. kms of moist deciduous forests, 5 sq. kms each of grass lands and reed breaks and 3 sq. kms of other montane type forests and rocky out crops put together and 5 sq.km of water spread area.

METHODOLOGY

The vegetation or plant community of the given site was analyzed by the following method.

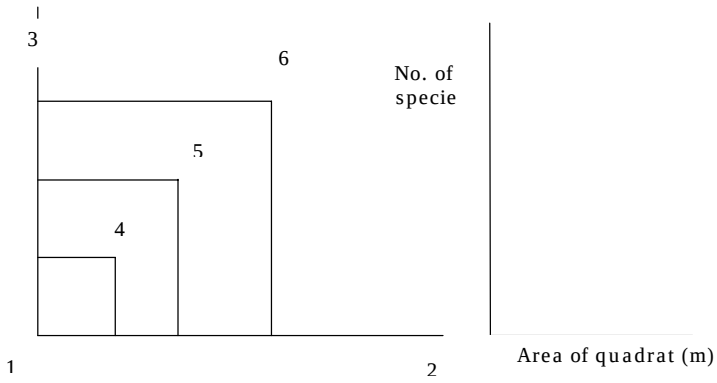
Quadrat method

It is a technique, which is used when only a part of large area is sampled. On the basis of this information the total population of the area is estimated. The quadrat method is used to measure the population density of organism, such as plant plankton, earth worms, insects and also blood cells in the blood. A quadrat is a sample unit or plot, which is in area of a definite size. In shape it may be rectangular, square or circular. The size of the quadrat is determined according to the characteristics of the community. The richer the flora the larger or more numerous the quadrates must be. To sample forest trees the fifth area plot is a popular size but it may be too large if trees are numerous or if many species are involved. Smaller quadrates are used to study shrubs and under storey trees. Quadrates are often labeled according to uses of data derived from them. In list quadrates organism found in the area are listed by name. In list count quadrates, in addition to listing out the species, numerical counts of individuals of each species are also made estimating the abundance and density. This method is widely used in forest survey work.

In the present investigation, we not only studied the species present but also their relative importance in the community as shown by their distribution, abundance and association ship. Since it is not possible to count and measure every plant in a large area, modern sampling methods, which give valued results, have been used. The size, number and distribution of samples to be taken in an area was decided upon before hand in order to make sure that the sampling is representative, typifying the study area as a whole. The size of the sample or the number and size of the sample plots (quadrates) or all three of these may be increased. The following procedures were used in determining the number of quadrates that will be necessary for adequate sampling. The quadrates used to sample the plants in a community are of such dimensions that all the species which occur in that community are fully represented.

A point was selected at random in the study area and fixed a stake at this point. Put in another stake at about 10 m (or less if the study area is a small one) from the first. A third stake was fixed at right angle to the second at equal distance. A rope was passed around the three stakes to make figure. 'L', as showed in the bottom. Using a fourth stake and a rope, a 2×2 m square was marked at the angle of the 'L'. The number of species of plants in it was counted. The size of the square was doubled. Each count of the number of species (y axis) against the size of the square (quadrate) in 'x' axis was recorded. It was observed that the curve obtained flattened out at a certain point. This point represents the minimal size of the quadrate necessary to sample that area. The curve is known as the species area curve. The size of the quadrate depends on the type of vegetation present in the area. Large

quadrats are needed to sample trees, while herbs and shrubs could be adequately sampled with smaller quadrats. If a separate tally for the species number of the trees, herbs and shrubs is made, it will be possible to arrive at suitable quadrat size for each of these structural types of vegetation. In the present study, we have selected 25×25m quadrat for trees and 5×5m quadrat for shrubs and herbs.



CONCLUSION

The total number of Ebony in the present study area of 100.4 hectares is only 22 out of 31023 other trees. The present investigation revealed the presence of this particular species as rare (present in 1-20% of sample per unit). This shows the drastic decrease of the valuable timber, Ebony. So it is very urgent to take necessary actions to mitigate the current threat and save this endangered tree species.

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ORGANOGENESIS OF *SOLANUM NIGRUM* USING *OSCILLATORIA FOREAUI* EXTRACTS

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Cyanobacteria or Blue-Green algae are the most predominant photosynthetic prokaryotic microorganisms that produce a wide array of substances. These include antibiotics, algicides, toxins, pharmaceuticals, biofertilizers and plant growth regulators (Metting and Pyne, 1986). Among the plant growth regulators, gibberellin, auxin, cytokinin, ethylene, abscissic acid and jasmonic acid have been detected in cyanobacteria (Gupta and Agarwal, 1973; Stirk et al, 1996; Ordog and Pulz, 1996). Plant regeneration from somatic cells can be accomplished through two morphogenic pathways; somatic embryogenesis and organogenesis (adventitious shoots and roots). The pathways of regeneration depend on the media and the material used. Many substances such as organic additives, plant hormones as well as amino acids have been added to culture media to enhance plant regeneration. Cyanobacterial biomass extract have been observed to strongly promote somatic embryogenesis (Wake, 1992). Extract of Plectonema sp. stimulated somatic embryogenesis and somatic embryo development in Sandal wood (Santalum album) (Bapat, 1996). The present study aimed to reveal the effect of extracellular products (EP) and biomass water extract (BWE) of Oscillatoria foreaui for regeneration of Solanum nigrum.

METHODS

Algal Culture: Cyanobacteria, Oscillatoria foreaui was obtained from culture collection centre, CAS in Botany, University of Madras. Axenic culture of Oscillatoria foreaui was grown in BG11 medium (Rippka et al, 1979), photoperiod 12hrs light,

45µmol photon × m-2seg-1 27± 1?C. Biomass derived from this culture has been tested as a source of growth regulators for organogenesis of Solanum nigrum with different treatments.

Obtaining Cyanobacterial products (EP & BWE): After 30 days of growth, the biomass was separated from the culture medium by centrifugation at 10,000g at 5?C. The fresh biomass was homogenized with acid wash sand (1g biomass/3g acid wash acid), and extracted with sterile distilled water (1g fresh biomass/ 5ml distilled water). After centrifugation, the supernatant BWE was obtained. The culture medium contained the extracellular products (EP). BWE and EP were sterilized by ultra filtration (0.22µm).

Tissue Culture Media: Treatments I - 8ml MS + 2ml D.H2O (control); II -8ml MS + 2ml D.H2O + NAA + BAP; III - 8ml + 2ml BWE; IV -8ml MS + 2ml EP. The commercial growth regulators BAP, NAA were taken in the concentration of 0.5mgL?1 and 2mgL?1.

Invitro cultures: Explants (leaves, stem and nodal region) were inoculated aseptically on culture medium of various combinations and were incubated at 25±2?C under 16hrs photoperiod.

RESULTS

Cyanobacteria produces bioactive compounds including plant growth regulators which accelerate the production of number of agronomical interesting plants. Earlier regeneration is the primary goal of Invitro studies and the number of days taken for root and multiple shoots were recorded. After 40days, the number of regenerated shoots, leaves and roots were measured.

Treatment III (MS+BWE) showed positive effect of elongated shoot induction with rooting (9g of fresh weight). Shoot proliferation was more intense in treatment IV (MS+EP) compared to treatment II.

DISCUSSION

Complex nutritive mixtures have been added to plant tissue culture media in the past decades. But in our study, naturally available algae (Oscillatoria foreaui) extract was used to determine their role and it compared with normally used BAP, NAA. BWE & EP are natural substrates which can be used as better alternative to BAP & NAA in the MS medium for shoot and root induction. Interestingly, we also observed better proliferation of roots and shoots in BWE compared to treatment II which might be due to the production of growth regulators like auxin and cytokinin. Tremendous growth of roots and shoots in short period indicates that MS with cyanobacterial EP and BWE also be used for improvement of invitro culture media of economically important crops. Further in-depth research is still required to determine the specific substances in EP and BWE as well its mode of action.

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USE OF WATER LETTUCE (*PISTIA STRATIOTES* L.) LEAF EXTRACT AS A GROWTH MEDIUM FOR CULTURING MICROORGANISMS

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Pistia stratiotes is a freshwater invasive weed found throughout the tropics and subtropics. It is a free-floating plant that is capable of forming dense mats on the surfaces of lakes, ponds, rivers and other bodies of water. The present study reports the use of P. stratiotes leaf extract as a growth medium for culturing microorganisms for the first time. Escherichia coli MTCC 1652 was successfully cultured in the fresh and boiled leaf extracts at a pH range of 5 to 7.

INTRODUCTION

Water lettuce (*Pistia stratiotes* L., Araceae) is considered as the third aquatic weed of world importance (Barreto et al., 2000), and it can inflict a severe impact on the environment and economy of infested areas. The use of floating macrophytes for wastewater treatment is recognized (Brix 1997) as a favourable breeding ground for Mansonia mosquitoes (Kengne et al., 2003). Pistia biomass is used for ethanol production (Mishima et al., 2008) and reports were also there for fungicidal property (Premkumar & Shyamsundar 2005). P. stratiotes removes organic and inorganic nutrients as it grows and spreads in the waters and is also used as feed for pigs and rodents. The carbohydrate and protein composition of P. stratiotes were brought out by Dewanji 1993 & Mishima et al., 2008. The clear insight of the compositions of P.stratiotes leaf biomass prompted to exploit it as a substrate to grow microorganisms and this is the first report in this regard.

MATERIALS AND METHODS

1. Biological materials

Fresh P. stratiotes were collected from Cherthala which is in Alappuzha District and its fresh leaves were harvested. The leaves were washed manually using tap water. Escherichia coli MTCC 1652 was used as the test organism for culturing in the new medium.

2. Preparation of leaf extracts from P. stratiotes

Two kinds of extracts were prepared. First fresh leaf extracts were prepared by crushing 100 grams of fresh leaf tissues of P. stratiotes ground with 150 ml of distilled water and then the second type was prepared by boiling leaf extract by taking 200g fresh leaves chopped into small pieces and boiled with 300 ml of distilled water. Both the extracts were filtered using filter paper and both the extracts were used for growing microbes separately.

3. Preparation of media

The fresh and boiled extracts having pH 6 and 5.5 were adjusted to 5 and 7 were also used. 2% agar was added to solidify the medium. The medium was autoclaved and dispersed into sterilized petri plates and allowed to settle. No other growth supplements were added in support microbial growth. After settling, the E. coli was streaked on the solidified agar plate and is kept for incubation at 37 oC for 24 hours.

RESULTS AND DISCUSSION

The fresh P. stratiotes collected contained 96 % water. The pH of fresh extract was 6 and that of boiled extract was 5.5. All the P. stratiotes leaf extract medium solidified with in 30 minutes. The test organism E. coli grown rapidly after 24 hours of incubation (shown in figures 1- 4) even though it was not supplemented with other carbon, nitrogen or protein sources. But during the course of the study a contaminant fungi is grown very well in two petri dishes of pH 5 and 7 of fresh leaf extracts. This clearly indicates that this medium can also support fungal growth irrespective of anti fungal agents present as reported by Premkumar & Shyamsundar 2005.

Maximum bacterial growth was observed in both the fresh and boiled extracts of pH 7. P. stratiotes leaf extracts contain glucose, carbohydrate polymers (Mishima et al., 2008), protein and its amino acid compositions of leaf proteins (Dewanji 1993) are given in tables 1-3 and these constituents present in the leaf extracts contributed for the growth of microorganisms.

Sugars	In % of sugar equivalent
Glucose	19.5
Mannose / Galactose / Xylose	5.0
Carbohydrate polymers	
Cellulose	16.5
Hemicellulose	17.3
Starch	6.4

Table: - 1. Main sugar and carbohydrate polymer compositions of P. stratiotes (Mishima et al., 2008).

Nitrogen %	8.2
Crude fat %	14.4
Crude fiber %	1.5
Ash %	5.8
Calorific value kcal/g	3.6
β-carotene μg/g	653.7
Total polyphenols %	1.3
In vitro digestibility %	80.7

Table: - 2. Composition of Leaf protein (dry weight basis) from P. stratiotes (Dewanji 1993).

Amino acids	Gram of amino acid per 100 g of recovered amino acid
Lysine	7.04
Hietidine	2.88
Arginine	6.31
Aspartic acid	9.62
Threonine	4.76
Serine	4.84
Glutamic acid	13.44
Proline	5.04
Glycine	5.74
Alanine	6.34
Valine	6.73
Methionine	1.10
Isoleucine	5.96
Leucine	9.82
Tyrosine	4.60
Phenylalanine	5.96

Table: - 3. Amino acid composition of leaf proteins from P. stratiotes

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SOME BIOACTIVITY STUDIES ON UNDERUTILIZED PALMYRAH PRODUCTS

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Palmyrah (*Borassus flabellifer Linn.*) belongs to Family Palmae and is distributed widely in the tropics. In Sri Lanka palmyrah can be found over an area of 70, 000 ha in the dry zone, mainly in the North and North Western and Eastern regions. Its uses can be basically categorized as edible and non edible. Non edible uses are similar to coconut and each and every vegetative part has some proven use. The traditional edible uses include sweet toddy, treacle and jaggery from sweet toddy obtained by the sap of the inflorescence, flour from the tuber and the fruit pulp which are used in food preparations following various processing techniques. Both the flour made from the tuber and the fruit pulp are vastly underutilized. One reason for underutilization of the fruit pulp is its characteristic bitter taste which limits the use to non indigenous populations. The bitter taste is due to a steroidal glycoside (Flabelliferin II). There are many flabelliferins present in both the palmyrah flour and fruit pulp. Some have been studied in detail and have been found to inhibit growth of some bacterial cultures, inhibit Na-K ATPase pump inhibiting uptake of glucose in the intestine and lower serum cholesterol levels. The present study looks in detail into some bioactivities namely anti-microbial activity of fruit pulp and cytotoxicity and mosquito-larvaecidal activity of falbelliferins in the flour which could result in increased utilization of both flour and pulp.

METHODS:

Palmyrah fruit pulp

Antimicrobial effect: This is caused by Flabelliferin triglyceride FB whose structure is known. Fruit pulp from Palmyrah development Board was used. The flabelliferins were purified following extraction with methanol and by partitioning into petroleum ether (60o-80oC) to remove carotenoids. The dried EtOH fraction was extracted into acetone to remove sugars. The EtOH extract was then subjected to a dry cellulose column, MPLC to give mainly Flabelliferin B and chromatotron to remove bound UV active carotenoids phytoene and phytofluene and finally purified by preparative TLC and re-crystallization. Thus isolated FB was used for Bauer Kirby method and nephalometry for determination of antibacterial activity.

A series of animal experiments were carried out to determine the local and systemic effect of FB before application on human wounds. Wounds were created on either side of the vertebra of Wistar rats (n=8). The 2 wounds on each rat were applied with FB and distilled water for 4 days respectively. Parameters related to wound healing and toxicity symptoms were studied. A rat eye test and a rabbit eye test were carried out for toxicity testing. One eye was treated with 25 l of a 18mg/mL FB solution once in the rats while the other eye was treated with saline. In rabbits the test eye was treated with 50 L portion of 57.7mg/mL FB solution twice a day for 5 consecutive days. Any change in the eyes or behaviour was observed.

Any allergic or hypersensitivity to FB was tested on humans by placing a tissue containing 50 l FB from a 74 mg/mL solution and saline as the control. A 2% ointment of FB with UV active binder was mixed with soft paraffin was made and gauze was impregnated with 2-3g and covered with aluminium foil. Patients with foot ulcers without subcutaneous involvement were selected. Tests were treated with FB and controls with normal hospital treatment. Patients were observed 2-3 times a week and data on wound measurement, photographs and wound swabs for microbiological assays were collected.

Palmyrah flour:

Dengue (Aedes albopictus) mosquito larvaecidal activity: Crude methanolic extracts of palmyrah flour was tested on moulting state 3 and 4 for larvaecidal activity. The extract was then extracted with a series of solvents of which only methanolic extractive was active. Using MPLC and preparative TLC separations of the methanolic extract an active compound was isolated and structure determined using bioactive directed separation. Effect on other mosquito larval species and aquatic species were also tested.

Cytotoxic effect: The MPLC separation from the above resulted, by serendipity, in a saponin which crystallized with water, MeOH and EtOAc solvent

mixture. The compound was used for testing cytotoxic activity of ICR cancer cells (melanoma cell line). Cytotoxicity and growth were observed after 24hrs.

RESULTS AND DISCUSSION:

Palmyrah fruit pulp:

The antimicrobial falbelliferin (FB) of palmyrah fruit pulp was found to have a UV active binder attached. This complex had higher antimicrobial activity than the pure glycoside both with equi-molar and equal weight basis against E. coli ATCC 25922 (Table 1).

Table 1. Inhibition zones of FB with and without active binder

Animal experiments indicated no significant difference in the wound healing rates of rat wounds indicating that the test had not caused adverse reactions. Other than the increased initial blinking immediately after introducing the extract in to the eye no other toxicity symptoms were noticed for 4 days or 3 days following termination of the experiment. The rabbits did not indicate any toxicity during the 5 days or following the experiment. Human allergic reactions indicated negative allergic reactions to the ointment.

The non ulcerous wound healing rates were in subjects (n=) expressed as percentage decline on the wound surface area per week compared to the initial state. The rate of wound healing of the test group showed an average healing rate of 27.7% per week in comparison to control which had only a 17.5% rate. The wound healing rates were not statistically significant due to the large individual variation in the rates of wound healing in subjects. Wound healing was considered to be clinically significant with no adverse effects being observed. In addition a wound cleansing effect of the test ointment was also observed.

Palmyrah flour

One steroidal glycoside (sitosterol triglyceride) was lethal to dengue mosquito Aedes albopictous and Aedes aegypti at a LC50 ranging from 60mg/L to 75.8 mg/L. The mechanism of action was found to be physical layering of the compound on the surface of water preventing the larvae with short siphons from reaching air. This was confirmed by the fact that other mosquito larvae with long siphons being

unaffected. However, the compound was found to be lethal to gill and lung breathing fish.

The cytotoxic activity of a flabelliferrin (spyrostane tetraglycoside) was proven with a melanoma cells at a concentration of 100ug/mL.

CONCLUSIONS:

" The complex (sitosterol triglyceride (FB) +UV active binder) isolated from palmyrah fruit pulp on application to human non ulcerous wounds indicated this to be as good as the hospital treatment indicating that this could be a new generation of antibiotic for the future.

" The larvaecidal steroidal glycoside with a beta sitosterol moiety and a linear Glc.Rha.Rha moiety has limited application and could be used to prevent indoor larval breeding or to prevent larvae breeding in places where other beneficial organisms do not frequent.

" The cytotoxic effect of the tetraglycoside proves its potential as a cancer drug. However, further studies are needed before a final conclusion is reached.

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A COMPARATIVE STUDY ON THE ANTIOXIDANT POTENTIAL OF THE EXTRACTS OF A FEW MAJOR SPICES.

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Spice trade between countries has largely determined the histories of nations. In recent years there has been increased awareness about the detrimental effects of synthetic food supplements/ additives and the search for natural alternatives in plants has intensified. Spices have been treasured for ages not only for the flavor and aroma they impart to food, but also have been valued by traditional systems of medicine and 'kitchen remedies' for their nutraceutical/ therapeutic effects. Most of these properties are attributed to their unique secondary metabolites - the essential oils and oleoresins, as also some of their primary metabolites. The various phytochemicals include flavonoids, terpenoid, lignans, sulfides, polyphenolics, carotenoids, coumarins, saponins, plant sterols, curcumins, phthalides.

For an aerobic organism, oxygen is a double-edged sword, since though essential for aerobic life processes, 5% or more of the inhaled oxygen is converted to reactive oxygen species (ROS). Cellular antioxidant enzymes and free-radical scavengers normally protect the cells from the damaging effects of ROS, but when the dynamic equilibrium is upset pathological conditions result from the oxidative damage to the cellular macromolecules.

The objective of this study is to scientifically validate the nutraceutical property of spices; in specific it's potential to scavenge free oxygen radicals, viz., its antioxidant potential, as also to compare the major spices, black pepper, ginger, turmeric and cinnamon.

MATERIALS & METHODS

Materials: The spices used for the study were black pepper (Piper nigrum) berries (variety 'Thevam'), turmeric (Curcuma longa) rhizomes ('Alleppey Supreme'), ginger (Zingiber officinale) rhizomes ('Rejatha') all harvested in January-February 2008, and cinnamon (Cinnamomum verum) bark ('Nithyashree') harvested in October 2007.

Extracts: The spices were processed to produce essential oil, aqueous extracts and ethanol extracts. Essential oil was extracted by hydro distillation using Clevenger type apparatus for 3 hours. The oil was dried over anhydrous sodium sulphate and stored at 4oC until analysis. The yield of the oil is computed as % (volume/weight). Aqueous and ethanol extracts were prepared by boiling the spices in the respective solvents twice, pooling the filtrates and concentrating the filtrates in a rotary flash evaporator to a concentration of 0.01 g/ml before the in vitro assay for antioxidant potential. Mean of three replications for each treatment are reported in this study.

Assays for antioxidant potential: The antioxidant potential of the above spice extracts was studied using the following methods:

" The total antioxidant capacity by the phosphomolybdenum method was estimated as per the method of Prieto et al. (1999) and expressed as mmoles ascorbic acid equivalents/ml for essential oils and mmoles ascorbic acid equivalents/g sample for water and ethanol extracts

" 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity was estimated using the method of Braca et al. (2001) and expressed as % over control

" Fe(III) to Fe(II) reducing activity was estimated by the method described by Oyaizu (1986) and expressed as mmoles ascorbic acid equivalents/ml for essential oils and mmoles ascorbic acid equivalents/g sample for water and ethanol extracts

These assays were also carried out on the synthetic food preservatives Butylated hydroxy toluene (BHT) and Butylated hydroxy anisole (BHA), both at 0.0001 g/ml ethanol (the concentration at which these are normally used for foods).

The total phenol content of the extracts was also estimated by the method of Singleton et al. (1999), and expressed as mg gallic acid equivalents/ml for essential oils and mg gallic acid equivalents/g sample for water and ethanol extracts; to look for any correlation between the antioxidant potential and phenol contents.

Chemoprofiling of the essential oil was done using GC-MS, to identify the predominant compounds in the volatile fraction of the spices. The analysis was performed on a Shimadzu (GC-2010) gas chromatograph equipped with QP 2010 mass spectrometer. RTX-5 column (30 m x 0.25 µm; film thickness 0.25 µm) was used. For turmeric oil alone carbowax column was used. Helium was used as the carrier gas at a flow rate of 1.67 ml/min; 0.1µl of the sample was injected. The

injection port was maintained at 250oC; detector at 220oC; oven temperature was programmed as follows: 60oC for 5 minutes, up to 110oC @ 5oC/ min, up to 200oC @ 3oC/min and up to 220oC @ 5oC/ min. The split ratio was 1:40 and ionization energy was 70 eV. The constituents of the oil were identified by a comparison of the retention indices with those reported in literature (Adams, 1989; Gianni et al., 2005; Tava et al., 2007 and Formisano et al., 2007) by matching the mass spectral data with those stored in NIST and Wiley libraries.

RESULTS & DISCUSSION

The yield of the essential oil in the spices varied considerably; in black pepper it was 3.3%, ginger 1.7%, turmeric 3.3% and cinnamon 0.6%. Table 1 gives the data on the total antioxidant capacity of the spice extracts, as determined by the phosphomolybdenum method. The total antioxidant capacity was found to be greater in the water extracts of black pepper and ginger, followed by the ethanol extract of cinnamon. The essential oil of cinnamon and synthetic food preservatives, BHA and BHT, showed no detectable antioxidant capacity. The DPPH radical scavenging activity (Table 2) was least in the water extracts of the spices; among the spices, cinnamon and ginger had equally high activity. Greater activity was especially noticed in the essential oils of cinnamon, ginger and turmeric and ethanol extracts of black pepper and ginger. The Fe(III) to Fe(II) reducing activity (Table 3) was maximal in the ethanol extracts of all the four spices studied - twice that of water extract and four times that of the essential oils - exceeding that of BHA and BHT; and cinnamon demonstrated more than twice Fe(III) to Fe(II) reducing activity compared to the other three spices. As expected, ethanol extracted the most phenols as is shown in Table 4, 3.5 times that of the water extracts; and of the spices, the maximum total phenol content was reported in cinnamon. The total phenol content and the Fe(III) to Fe(II) reducing activity were highly correlated (0.93), though this was not true of the total antioxidant capacity as estimated by the phosphomolybdenum method and DPPH radical scavenging activity.

Table 1. Total antioxidant potential capacity of the extracts of black pepper, ginger, turmeric and cinnamon

Samples	Essential oil (mmoles ascorbic acid equivalents/ ml)	Water extract (mmoles ascorbic acid equivalents/ g)	Ethanol extract (mmoles ascorbic acid equivalents/g)
Spices			
Black pepper	8.30	443.67	119.08
Ginger	12.41	369.56	44.74
Turmeric	16.37	23.70	161.23
Cinnamon	0.87	145.76	244.43

Food preservatives	(mmoles ascorbic acid equivalent/g sample)
BHA	0.05
BHT	0.01

p=0.00; CV=5.29%; CD (5%) for extracts=5.91; CD (5%) for spices=6.80

Table 2. DPPH radical scavenging activity (% over control) of the extracts of black pepper, ginger, turmeric and cinnamon

Samples	Essential oil	Water extract	Ethanol extract
Spices			
Black pepper	13.19	0.08	75.00
Ginger	88.19	47.92	78.47
Turmeric	71.97	61.11	28.47
Cinnamon	103.47	53.47	65.28

Food preservatives	(mmoles ascorbic acid equivalent/g sample)
BHA	76.39
BHT	75.00

p=0.00; CV=6.57%; CD (5%) for extracts=3.17; CD (5%) for spices=3.67

Table 3. Fe(III) to Fe(II) reducing activity of the extracts of black pepper, ginger, turmeric and cinnamon

Samples	Essential oil (mmoles ascorbic acid equivalents/ ml)	Water extract (mmoles ascorbic acid equivalents/ g)	Ethanol extract (mmoles ascorbic acid equivalents/g)
Spices			
Black pepper	12.04	87.57	92.67
Ginger	17.29	63.66	110.55
Turmeric	16.26	45.99	153.51
Cinnamon	37.50	131.99	289.78

Food preservatives (0.0001 g/ml)	(mmoles ascorbic acid equivalent/g sample)
BHA	52.60
BHT	36.22

p=0.00; CV=14.31%; CD (5%) for extracts=10.60; CD (5%) for spices=12.30

Table 4. Total phenol content of the extracts of black pepper, ginger, turmeric and cinnamon

Samples	Essential oil (mg gallic acid equivalents/ ml)	Water extract (mg gallic acid equivalents/ g)	Ethanol extract (mg gallic acid equivalents/g)
Spices			
Black pepper	9.26	100.12	93.57
Ginger	8.96	49.21	115.57
Turmeric	6.05	31.41	447.49
Cinnamon	52.81	164.47	559.53

p=0.00; CV=4.88%; CD (5%) for extracts=5.62; CD (5%) for spices=6.50

The chemical profile of essential oils revealed that major compounds in the four spices are:

Black pepper: D-Limonene (20.7%), Caryophyllene (18%), Sabinene (12%), ?-3-Carene (11%), ?- Pinene (6.5%) and ?-Pinene (10%)

Ginger: Zingiberene (23.5%), Farnesene (13.8%), Citral (8.4%), ?-Sesquiphellandrene (9.2%), Camphene (6.8%), Z-Citral (5.5%), ?-Curcumene (5.4%), ?-phellandrene (3.7%), 1,8-Cineole (3.2%)

Turmeric: Turmerone (38%), Curlone (22%), Ar-Turmerone (17.8%), l-Phellandrene (6%), 1,8-Cineole (3.4%), Zingiberene (2.1%),

Cinnamon: Cinnamaldehyde (66.7%), t-Caryophyllene (9%), Benzyl benzoate (4.5%), Linalool (3.3%), Cinnamyl acetate (2.2%)

The safety of the use of the most commonly used antioxidants, the synthetic phenols such as BHA and BHT is a matter of concern. Therefore natural sources of polyphenols and alkaloids, which are abundant in the secondary metabolites of the spices under the present study, are promising alternatives, as the results suggest that most of the spice extracts are better antioxidants. It is already known that the antioxidant activity of plant extracts containing polyphenols is due to their ability to act as hydrogen atom or electron donors and thus to capture free radicals. While the Fe(III) reduction is often used as an indicator of electron donor activity, in DPPH radical scavenging test hydrogen atoms are also involved (Hinneburg et al., 2006). Of the several compounds that make up the essential oil volatile fraction, the antioxidant activity is attributed to not only the major constituents but also to the mixture of minor constituents or to synergy among them (Abdalla & Roozen, 1999). Cinnamaldehyde the major fraction of cinnamon essential oil, is a known antioxidant (Sivakumar et al., 2006), as also that of piperine (Mittal and Gupta, 2000). The major component in ethanol fraction of turmeric is the curcuminoids,

whose structure is very similar to diarylheptanoids. The hydroxyl (in the para position) and phenol groups, as well as the ?-diketone moiety (H atom donation activity) are attributed with the antioxidant activity of curcuminoids (Masuda et al., 1999; Iwakami et al., 1986; Kim & Kim, 2001).

CONCLUSION

The total antioxidant capacity was greater in the water extracts of black pepper and ginger, followed by the ethanol extract of cinnamon. Cinnamon and ginger had equally high DPPH radical scavenging activity. The Fe(III) to Fe(II) reducing activity was more in cinnamon, as also in the ethanol extracts of all the four spices, exceeding that of BHA and BHT. Ethanol extracts and cinnamon had the most phenols. Of the spices tested, cinnamon with the highest total phenolic content, also had the greater antioxidant potential as measured by the DPPH radical scavenging ability and the Fe(III) to Fe(II) reducing activity. The total phenol content and the Fe(III) to Fe(II) reducing activity were highly correlated (0.93). All the four spices studied are promising alternatives to BHA and BHT.

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UTILIZATION OF ALGAL BIOMASS FOR COLOUR REMOVAL, pH CORRECTION AND SLUDGE REDUCTION IN DYEING EFFLUENT

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Phycoremediation may be defined in a broad sense as the use of macro algae or micro algae for the removal or biotransformation of pollutants, including nutrients and xenobiotics from wastewater and CO2 from waste air (Olguín, 2003). Microalgae play an important role during the tertiary treatment of domestic wastewater in maturation ponds or the treatment of small-middle-scale municipal wastewater in facultative or aerobic ponds (Aziz and Ng, 1993; Abeliovich, 1986; Mara and Pearson, 1986; Oswald, 1988, 1995). Micro algae enhance the removal of nutrients, heavy metals and pathogens and furnish O2 to heterotrophic aerobic bacteria to mineralize organic pollutants, using in turn the CO2 released from bacterial respiration . Photosynthetic aeration is therefore especially interesting to reduce operation costs and limit the risks for pollutant volatilization under mechanical aeration and recent studies have shown that microalgae can indeed support the aerobic degradation of various hazardous contaminants (Mun˜ oz et al., 2004).

Phycoremediation potentials of micro algae:

The mechanisms involved in micro algal nutrient removal from industrial wastewater are similar than that from domestic wastewater treatment. Algae-based treatment is especially interesting in the case of N-containing contaminants whose biodegradation normally leads to NH4+ or NO3 _ release. (Mun˜ oz et al., 2005a, b).

Heavy metals represent an important group of hazardous contaminants often found in industrial wastewater (Kratochvil and Volesky, 1998). Microalgae can be

efficiently used to remove these (Can˜ izares- Villanueva, 2000). Microalgae can biodegrade hazardous organic pollutants. Micro algal species have been successfully used for the treatment of olive oil mill wastewater and paper industry wastewater (Abeliovich and Weisman, 1978; Narro, 1987). Lima et al. (2003) reported - nitrophenol removal by a consortium of micro algae.

Phycoremediation of industrial effluents: Conventional treatment: Dyeing industries conventionally treat their effluent by using lot of chemicals. Highly alkaline effluent is neutralized using acid and the residual dyes are bleached using bleaching chemicals. The sludge is precipitated using a number of chemicals and the resultant sludge is dried and stored as hazardous solid waste waiting for land fill to dispose them. The liquid effluent is either discharged or sent to R/O plant for recycling. The R/O reject is again evaporated using SEPs (solar evaporation ponds). The resultant sludge is again stored as hazardous solid waste. The problems caused by effluent disposal in and around Tiruppur area are well known.

Present study: The present investigation deals with the study of Phycoremediation potentials of micro algae to effectively treat effluent from SUNTEX Processing Mills, a textile dyeing industry situated near Chennai. After successful laboratory trials, field level trials using pilot slope tanks were conducted.

METHODS

Micro algae: Micro algae employed in the present study were obtained from the culture collection of Vivekananda Institute of Algal technology (VIAT), Chennai. The micro algae were maintained in CFTRI medium (Venkataraman and Becker, 1985). Physico- chemical parameters were analyzed following Standard Methods (APHA, 2000). UV-VIS Spectrometer (Shimadzu UV-1650PC) was used for studying dye removal efficiency of micro algae.

Slope Tank: The pilot slopping pond was constructed in RCC and was designed as with a dimension of 2.68 m (L) x 2.38 m (W) x 0.64 m (Depth) with a sloping angle of the evaporating surface at 450. The dimension of the slopped area was 6.5 m2. The holding capacity of the tank was 4000 L. The flow rate of the effluent was at 1800 LPH. The plant was run during the day for about 9.5 hrs.

RESULTS

Isolation and screening of micro algae for remediation potentials

Samples collected from different sites of ETP at SUNTEX Processing mills were analyzed for the presence of micro algae. By employing standard isolation procedures micro algae were isolated and maintained in the culture collection. Micro algae were screened for their remediation potentials. Based on the laboratory trials a few micro algae were selected for field trials.

Field Trials employing Pilot Slope tanks: Field trials using slope tank with 2

KL of culture of Chlorococcum humicola, developed in modified CFTRI medium were conducted. To the culture raw effluent was added @ 100 L per day (as the evaporation rate was also 100 L /day). Various physic-chemical parameters including TDS, pH, BOD and COD were analyzed on daily basis. Final analysis was done after charging the slope tank with 6660 L of raw effluent

DISCUSSION

After repeated running of the plant the following results were obtained:

The micro algae selected could tolerate and grow very well in the raw effluent. Algal growth corrected the pH and removed colour, odour and sludge and reduced BOD and COD. Conventional treatment process employs chemicals to achieve this. Algal technology has achieved this without using any expensive and toxic chemicals. The industry saves lot of money on chemicals. Since there is significant reduction in sludge (80%, which can be improved during scaling up) the pollution problem caused is prevented. The remaining water can either be evaporated using SEPs or send to R/O plant for recycling. R/O reject can also be recycled to algal treatment plant and treated to prevent sludge formation.

A comparison of algal treatment with conventional treatment

The raw effluent loaded into the treatment plant was darkly coloured due to dyes and highly alkaline (pH 11.4) with a high TDS (Total Dissolved Solids - 6800 mg/L) The effluent treated with conventional chemical treatment had a pH of around 9.6 and a TDS of 10,280 mg/L, which was much higher than the raw effluent due to usage of chemicals for treatment, and sludge formation was 100%. The effluent treated with algal technology had a pH of 9.5, the TDS was reduced to 5700 mg/L and there was excellent colour removal. The most significant achievement was, there was 80% reduction in sludge formation which could be improved when scaled-up

CONCLUSION

The scaling up process is on now. There is also an attempt to treat the dye bath effluent separately using the algal technology. The excess algal biomass settling in the treatment tank is being dried for possible use as fuel for the boilers at SUNTEX. When scaled Phycoremediation technology is going to help the industry to save money, reduce sludge and most importantly the environment is saved.

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CONSERVATION AND SUSTAINABLE PRODUCTION OF MEDICINAL PLANTS THROUGH OIL PALM BASED CROPPING SYSTEM

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Oil palm (Elaeis guineensis Jacq.) is now a rapidly expanding plantation crop being grown for prosperity, poverty alleviation, sustainability, eco-friendliness and co-generation (Rethinam 1998). Presently majority of the oil palm plantations in India are maintained as monocrop resulting in huge wastage of natural resources. The agro climatic conditions in India provide an ideal habitat for the natural growth of a variety of medicinal plants, majority of which are shade tolerant, occurring as under storey in forests. Ever increasing population coupled with diminishing forest resources, progressive demand of raw material both for indigenous industries as well as export and unrestricted exploitation of crude drugs from natural resources without proper measure of conservation have led to a situation where at least 120 medicinal plant species have been officially classified as endangered (Jain,1987).This calls for urgent measures for conservation of such species along with cultivation for sustained supply to the growing herbal industry. Introduction and integration of medicinal plants into the oil palm based cropping system is a suitable proposition for efficient resource utilization and conservation and sustainable production of commercially important medicinal plant species.

METHODS

The field experiment was conducted at Kulathupuzha oil palm estate, Kerala, India, during the period from October 1999 to September 2002. The estate is situated 90 5' N latitude and 760 8' E longitude, 100 - 300 m above mean sea level and

comprises of palms of age group ranging from 4 to 15 years. In the field experiment ten commercially important species of medicinal plants were screened for their adaptability as intercrop in oil palm plantations of various age group. The medicinal plants were grown in the interspaces of oil palms under four shade situations viz., shade condition prevailing under palms below five years age (young), between five and eleven years age (medium) and above eleven years (mature) and also in the adjacent open area for comparison. The experiment was laid out in split plot design with three replications. The medicinal plants selected for the study were Adhatoda beddomei (Malabar nut), Alpinia calcarata (Lesser galangal), Asparagus racemosus (Asparagus), Coleus zeylanicus (Hribera), Kaempferia galanga (Galanga), Plumbago rosea (Rosy leadwort), Pogostemon patchouli (Patchouli), Piper longum (Long pepper), Solanum incanum (Medicinal solanum) and Strobilanthes haenianus (Medicinal strobilanthes). Photosynthetically active radiation (PAR) in the interspaces of oil palms was measured using the steady state porometer (?T) and expressed in µmol m-2 s-1. The per plant yield in Rupee equivalent and the economics of cultivation was worked out for each species.

RESULTS AND DISCUSSION

Light Interception in the plantation

The pattern of distribution of solar energy indicated that there was considerable variation in the interception of sunlight by palm canopies of different age groups. Compared to open condition there was a sharp decline in PAR values under young palms (42 % of open), which again tended to be lower under medium palms (19 %). Under mature palms there was a slight increase in PAR values (22 %). The data showed that the shade intensity under middle-aged palms is the highest.

Table 1. PAR in the interspaces of oil palm of various age groups

Shade condition	PAR (• mol m^{-2} sec^{-1})	% of open
Open	1756	100
Young	737	42
Medium	334	19
Mature	386	22

Performance of medicinal plants under different shade levels

Among the four shade levels, the condition under young palms was found to be the most ideal for the growth and yield of the medicinal plant species under evaluation (Table 2). Moderate light transmission and decreased root competition may be the reason for the better performance of the medicinal plant species under this situation. However the yield from plants grown under open conditions was on

par with that obtained under medium and mature palms. Hence growing of these plants in the interspaces of medium and mature oil palms is also beneficial for getting reasonable additional income from these plantations. Shelton et al. (1987) stressed that the level of shade is the most significant factor determining the output from intercrop grown in plantations.

Table 2. Mean yield/plant of medicinal plants in rupee equivalent under different oil palm canopy shade levels

Treatment	Yield (Rs)
Shade condition	
Open	0.40
Young	0.43
Medium	0.39
Mature	0.39
CD 0. 05	0.011

Economic analysis of intercropping system revealed that the performance of five species viz., Adhatoda, Alpinia, Kaempferia, Strobilanthes and Asparagus were superior under the different oil palm canopy shade conditions (Table 3) because a net profit and higher benefit cost ratio was recorded only for these five species. Accordingly these five species were identified as profitable intercrops in an oil palm based cropping system and among them, Kaempferia galanga was the most profitable species.

Table 3: Economic analysis of intercropping medicinal plants in oil palm plantations

Treatments	Net profit ha^{-1} (Rs)				BCR			
	Open	Young	Medium	Mature	Open	Young	Medium	Mature
Adhatoda	1297	1442	1214	549	1.02	1.03	1.03	1.01
Alpinia	17551	13120	7375	9373	1.18	1.24	1.13	1.17
Solanum	-13146	-4022	-5559	-7594	0.32	0.6	0.45	0.25
Coleus	-10796	-782	-2678	-3548	0.47	0.93	0.75	0.66
Kaempferia	47630	28218	19506	21711	1.47	1.51	1.35	1.39
Strobilanthes	6134	7991	6154	4914	1.11	1.25	1.19	1.15
Plumbago	-9042	-954	-1667	-3003	0.8	0.96	0.93	0.88
Patchouli	-18193	-7010	-12955	-12779	0.61	0.73	0.49	0.5
Asparagus	2382	4499	2490	1724	1.08	1.28	1.16	1.11
Piper	-37671	-22083	-22909	-24400	0.15	0.11	0.08	0.02

Note: Medicinal plant population in open condition - 1,33,333
Medicinal plant population / ha of oil palm plantation - 74,926

CONCLUSION

The results of the present study confirmed the feasibility of intercropping five medicinal plant species viz., Adhatoda, Alpinia, Kaempferia, Strobilanthes and Asparagus in young, medium and mature plantations. Thus, oil palm based medicinal plant intercropping system appears to be an effective and potential agro forestry system conserving the valuable medicinal plant wealth, at the same time fetching some additional income to the farming community without compromising the productivity of the main crop. Eventually this could become a very good eco-restoration programme which could be effectively utilized for developing some kind of sustainable medicinal plant management.

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DIRECT TRANSESTERIFICATION OF *NELUMBO NUCIFERA* TRIGLYCERIDES FOR BIODIESEL PRODUCTION : OPTIMISATION STUDIES

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The use of edible vegetable oils and animal fats for biodiesel production has recently been of great concern because they compete with food materials. As the demand for vegetable oils for food has increased tremendously in recent years, it is impossible to justify the use of these oils for fuel use purposes such as biodiesel production. (Chhetri et al., 2008). The biodiesel is an alternative to reduced CO2 and sustainable use of bioresources. Moreover, the fuel will reduce country over dependence on imported petro-diesel (Korbitz, 2005). Hence, detailed screening process of all available virgin or plant and animal origin coming up with some restrictions. The cheapest feedstock available is the key factor for a low cost biodiesel. The recent focus is to find oil-bearing plants that produce non-edible oils as the feedstock for biodiesel production. Biodiesel obtained from neat vegetable oil is costly compared to the petroleum diesel fuel (Issariyakul et al., 2006). Recently, a lipase-catalyzed esterification of various kinds of vegetable oils using an organic solvent or a solvent free system was studied by environmental friendly process (Park et al., 2007). Research has recently indicated that the lipids contained in sewage sludge are a potential feedstock for biodiesel (Dufreche et al., 2007). Researchers are also developing microalgae that produce oils, which can be converted to biodiesel (Demirbas, 2007). Much effort has been devoted to develop new biodiesel production processes by using cheaper feedstock (Wang et al., 2007). The present study concentrates on screening untapped natural resources like the lipids present in aquatic plant leaves for the production of biodiesel.

MATERIALS AND METHODS

Fresh and mature leaves of Water hyacinth (Eichhornea crassipes), Lotus (Nelumbo nucifera), Lily (Nymphaea nouchali) and White Lotus (Nymphaea lotus) were collected from water bodies of Kanchipuram. The triglycerides from all the collected samples were extracted and estimated using the procedure described by Ribeiro and Eastridge (2006). The triglycerides obtained from leaves were pre-treated before the reaction to remove free fatty acids and water contaminants by the method of Naik et al., (2007). Fatty acid methyl esters (biodiesel) were produced from the pretreated triglyceride through a transesterification process (Frohlich and Rice, 2003). The upper fatty acid methyl ester (biodiesel) layer was washed twice with equal volume of water and ester layer was dried at 70°C under vacuum. Optimization studies were carried out using the method described by Oliveira et al., (2008). Effect of different solvents on biodiesel yield was studied. The effect of alkali concentration on the yield of biodiesel was also studied by varying the concentration ranging from 1 % to 2% with 0.1% increments. The transesterification reactions were also carried out to determine the optimum reaction time (30, 60, 90, 120 and 150 minutes). The biodiesel production was further optimized for reaction temperature by carrying out transesterification process at various temperatures like 500C, 550C, 600C, 650C, 700C and at room temperature (~280C). The physical and mechanical properties of biodiesel produced in the present study were determined at Industrial Testing & Analytical Laboratory (ITA lab, Paris, Chennai-1). The parameters studied were cetane number, flash point, pour point and fire point, density and viscosity.

RESULTS

Fresh and mature leaves were collected and the triglycerides from all the collected samples were extracted. Based on the quantity of triglycerides, lotus (Nelumbo nucifera) leaves, which had maximum triglyceride content (40%), were selected for biodiesel production and optimization studies. Fatty acid methyl esters - biodiesel was produced from the pretreated triglyceride paste using a transesterification process. From 40 grams of triglyceride, 24.15 grams (60.37%) of fatty acid methyl ester was obtained. Biodiesel yield was studied by using methanol, ethanol, butanol and propanol as solvents for biodiesel production. Among these solvents, methanol gave the higher yield (60.37%). Ethanol, Butanol and Propanol yielded 58.50%, 54.05% and 56.83% respectively. The effect of alkali concentration on the yield of biodiesel was studied by varying the concentration, ranging from 1 % to 2% with 0.1% increments. The maximum fatty acid methyl ester production, 26.34 grams (65.85%), was observed at 1.5%. The transesterification reactions were carried out at different time durations (30, 60, 90, 120 and 150 minutes). The maximum biodiesel yield was noticed at the reaction

time of 120 minutes. The biodiesel production was further optimized for reaction temperature by carrying out trans-esterification at various temperatures. It indicated that the optimum temperature for the reaction was 650C. The physical and mechanical properties of biodiesel produced in the present study were analysed at Industrial Testing & Analytical Laboratory, Chennai-1. The cetane number of biodiesel produced in the present study was found to be 51. The flash point, pour point and fire point were 230C, less than -140C and 250C respectively. The density was 912 Kg/m3 and viscosity was 2.23 mm2/S.

DISCUSSION

Aquatic plant leaves are the most promising source for biodiesel production because of availability, rich lipid levels and ease of fatty acid extraction. Lotus leaves was found to have 40% triglyceride content. The fatty acid methyl esters produced from lotus by transesterification process was found to 65.5% and overall biodiesel production was comparable with the results reported by Ganesapillai et al., (2007). Trans-esterification requires 3 mol of alcohol for each mole of triglyceride to produce 1 mol of glycerol and mol of methyl esters. Methanol ensures that the reaction is driven in the direction of methyl esters, i.e. towards biodiesel (Fukuda et al., 2001). The present results also showed that methanol as a solvent, which enhanced the biodiesel yield (60.37%). The maximum fatty acid methyl ester production, 26.34 grams (65.85%), was observed when using the alkali concentration of 1.5%. Transesterification is catalyzed by 1% alkali was reported by Meher et al., in 2006. The results revealed that, there was a considerable increase of reaction time when the reaction temperature was at 650C. Fukuda et al., (2001) reported that alkali-catalyzed transesterification is carried out at approximately 60°C for 90 min to complete. The value observed in the present study was 120 minutes. The values observed in the present study are in accordance with the previous findings (Ganesapillai et al., 2007). However, the flash point and fire point of previous study were 1620C, 1700C respectively, which are very high values when compared to the present study (230C & 250C). The physical and chemical properties of biodiesel were compared with that of methanol to make sure that the liquid obtained after the trans-esterification is indeed biodiesel not the methanol originally added to the reaction mixture. Since the Cetane number of lotus leaf biodiesel is 51 and that of methanol is 0, it was confirmed that the lotus leaf triglycerides are successfully converted in to biodiesel. In essence, the comparison showed that the lotus leaf biodiesel produced in the present work is like diesel in all-physical properties except the burning properties. The properties of biodiesel satisfy ASTM standards in terms of Cetane number, which is characteristic of diesel like fuels (45-58), Pour point, viscosity and density. Further study needed to ascertain the burning properties of lotus leaf biodiesel.

Table.1 Comparison of properties biodiesel with petrodiesel and jatropha biodiesel

Properties	Biodiesel	Petro-Diesel#	Jatropha Biodiesel*	ASTM STD#	Remarks
Cetane number	51	47	50	Min 45	Measure of the combustion quality of diesel fuel during compression ignition.
Flash point (^{0}C)	23	>62	170	Min 38	Lowest temperature at which fuel can form an ignitable mixture in air.
Pour point (^{0}C)	Below - 14	- 6	N.A	N.A	Lowest temperature up to which fuel will flow.
Fire point (^{0}C)	25	45	N.A	Min 42	Temperature at which fuel will continue to burn.
Density (Kg/m^3)	912	822	880	Min 800	The measure of the relative "heaviness" of fuel with a constant volume.
Kinematic Viscosity (mm^2/S)	2.23	2.73	5.65	2.0 – 7.5	An internal property of a fluid that offers resistance to flow.

(Ganesapillai et al., 2007)

*(Chhetri et al., 2008)

N.A - Not available

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