

Value addition to coconut - opportunities and challenges

● Jagadeesh K. Mannekote** and Satish V. Kailas*

**Centre for Emerging Technologies, Jain Global Campus, Jain University, Jakkasandra-562112, Karnataka, India

*Department of Mechanical Engineering, Indian Institute of Science, Bangalore-560012, Karnataka, India

Coconut palm is a versatile crop found in most of the countries located in and around the equatorial region. It is less susceptible to abnormal climatic conditions and grows even in severely depleted soil. Coconut palm referred to as Kalpavriksha has been traditionally cultivated in India from ancient time. The three states Kerala, Tamil Nadu and Karnataka account for about 85 per cent of the Coconut in the country.

Coconut tree with its capacious biomass is an alternative source of renewable energy. The midribs of leaves are useful in making brooms, fish traps and baskets. The husk yields fiber which itself is made into hundreds of products. The pith is a soil conditioner and also acts as a rooting medium. The coconut shell is used as a fuel besides it also acts as a starting material for shell powder, shell charcoal, activated carbon, utility articles and attractive show pieces. Coconut shell powder finds extensive uses in plywood and laminated board industries, as filler in synthetic resin glues, mosquito coils and Agarbathy industries. Activated Carbon is a non graphite form of carbon widely used in the purification of water, bleaching of vegetable oils and also in gas masks.

Coconut is a food as well as an oil seed crop. Tender Coconut is used as a nutritious health drink. The water of mature nut is the starting material for value added products such as vinegar, jelly and wine. The kernel is an important constituent of the diet in many countries. Coconut oil cake, the residue left over after the extraction of oil is a good cattle feed. Coconut oil is used as important food ingredient. Coconut oil is used as hair oil and also as skin care body oil. It is an important source of C12-C18 fatty acids highly desired by the oleo chemical industry. Neera is sweet sap tapped from unopened spadix of the coconut palm is a delicious health drink, rich in carbohydrates. It is also raw material for many value added products like palm syrup, palm jaggery and palm sugar.



In India coconut crop economy is mainly linked with fresh coconut or copra, as over 40% of the total nuts produced are consumed in the form of either fresh or tender nuts and about 50% of the nuts are converted into copra and consumed as coconut meal and coconut oil. Very small proportion is consumed as desiccated coconut and other products. It is evident that despite of the multitude opportunities for product diversification, value of coconut in India is regarded mostly in terms of copra or coconut oil. It is necessary to delink this dependency by means of developing and popularizing more value added products.

Coconut oil – a raw material for lubricant application

Most of the lubricants which are in use today are derived from petroleum. These products being non biodegradable are cause of concern as they are contaminating the flora and fauna. Growing environment

awareness and stringent regulations in the recent past have renewed interest in environment friendly lubricants. Coconut oil has good oxidative resistance in comparison to other vegetable oils due to the presence of high content of saturated fatty acids. In addition, coconut by virtue of its inherent properties has huge potential as a raw material in total loss lubricant applications such as metal working fluids (MWF) and greases.

Green Cutting Fluid (GCF)-Coconut oil based Metal Working Fluid

Metal Working Fluids (MWF) are used in various machining operations to lubricate and cool the tool and work piece. It is also used to flush away the chips generated during the machining process. Traditionally MWFs are prepared using mineral oil derived from the crude petroleum. MWFs also have biocides as functional additives in their formulations and due to this machine operator are facing increased risk of respiratory and skin disorders. Petroleum itself is known for causing irreversible damage to the environment. Further, these products would be unsustainable. In order to overcome these problems several countries have enforced environmental legislations making MWF formulators to abide by these rules.

Several studies have been done in the past and MWF formulations have been developed using the vegetable oils. Those formulations are unsustainable as the conventional additives which are carcinogenic in nature are used. A product is sustainable only if it is derived from renewable sources, biodegradable, non toxic and should be completely replenishable. Thus toxicity and biodegradability testing of base oils, additives and final product is essential to term a product as sustainable. Since coconut oil is a renewable source and completely biodegradable, it would be ideal choice for MWFs and greases.

The present work is significant in terms of sustainability as it gives an overview of how coconut oil based MWF called "Green Cutting Fluid" is developed. The product is unique as the base oil (coconut oil) and the other constituents of the formulations such as emulsifiers and additives are non toxic to aquatic life and benign to environment. The overall process and key findings of this process are discussed in briefly.

Selection of emulsifiers and additives and evaluation of stability

Commercially available food grade emulsifiers (E-1, E-2 and E-3) were selected for this purpose and their final composition was adjusted to get the required Hydrophilic lyphophilic balance (HLB) value of coconut oil. Further the ratio of oil to emulsifier was also adjusted to get small particle size and extended stability.

Toxicity testing of emulsifiers and additives

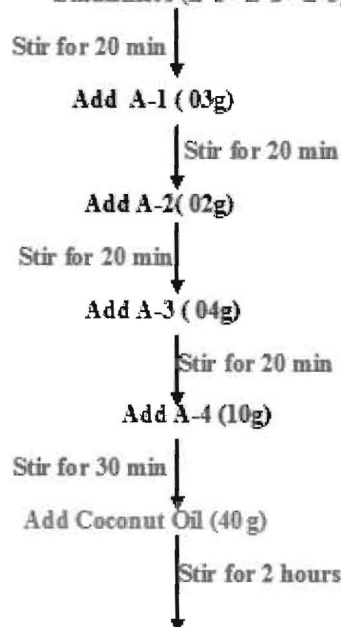
Aquatic toxicity of each ingredient and the final

formulation was carried out as per OECD 203 method. Fishes which were pre-acclimatized to the testing condition were used in experiments. Concentration of test substance was increased at the geometric series of 2.2 and seven fishes were exposed to test substances for

Sample Details	Toxicity level (LC ₅₀) In mg/L
Coconut oil	>2342.56
E-1	>1064.8
E-2	>1064.8
E-3	>1064.8
A-1	>1064.8
A-2	>1064.8
A-3	>1064.8
A-4	>1064.8
GCF	>1064.8
MWF	<100

Table - 1

Figure - 1 Emulsifiers (E-1+ E-2+ E-3) – 40 g



Store the formulation mixture at room temperature.

Dilute the formulation mixture in 1:20 ratio with deionized water and use for machining processes.

(Where E-1, E-2 and E-3 are emulsifiers and A-1, A-2, A-3 and A-4 are the additives used for preparing the GCF)

96 hours. Dissolved oxygen and PH were monitored throughout test duration. Mortality of fishes was recorded at an interval of 24 hours for four days. The studies have shown that coconut oil, emulsifiers and additives used in GCF formulation were found to be non toxic even at 1000 ppm. Whereas the conventional MWF formulation found to be highly toxic well below 100 ppm concentration as shown in the Table 1.

Green cutting fluid formulation and Optimization of formulation

The emulsifiers and additives which were found to be nontoxic in the fish toxicity test were used in GCF formulation. The schematic representation of process is shown in Figure 1

Cytotoxicity and fish embryo tests

The *in vitro* cytotoxicity of cutting fluid samples was evaluated by MTT assay. The studies have revealed that GCF does not have any toxic effect even at a concentration of 50 µg/ml even after 24 hrs, where as MWF showed significant reduction in cell viability with in 2hours. These results clearly indicate the toxicity of commercial cutting fluids in human keratinocyte cell lines.

Zebra fish free from externally visible diseases and pharmaceutical treatments aged from 6 to 24 months were used for egg production. The 24 hours post fertilization embryos were used for testing. In two replicates for each test concentration, 10 embryos were transferred per well into a 24-well plates having test concentration of 1 µg/L, 10 µg/L, and 100 µg/L and incubated at 26°C. The embryos were inspected at 24, 48, 72 and 96 hours of exposure equivalent to 48, 72, 96 and 120 hours respectively. The studies have revealed that the LC50 value for GCF after 120 hours was estimated to be 100 µg/L compared to < 1 µg/L. for MWF clearly indicating that MWF is highly toxic to the fish embryos where as GCF is relatively non-toxic.

Machining performance of cutting fluids on mild steel

The performance of cutting fluids was evaluated by

means of turning and drilling experiments. Commercial grade AISI 1018 mild steel cylindrical rod of diameter 25mm was used as work piece for turning experiments and Turning experiments were performed in a lathe equipped with a 3-axis dynamometer to measure tangential force, feed force and radial force. Experimental results for turning have shown that GCF has performed better than MWF

It is evident with the above results that coconut oil based metal working fluid is a sustainable product. It was found to be non toxic to aquatic species and benign to environment.

Conclusion

Despite of having opportunities for product diversification, value of coconut in India is regarded mostly in terms of its potential to produce oil due to lack of awareness and low efficacy of transfer of technology. There should be a proper mechanism to procure and convert surplus coconut into value added products, which will strengthen the coconut economy of the country.

Coconut oil derived Oleo chemicals offer great value addition to coconut oil. Coconut oil holds tremendous potential in lubricant sector especially as MWF and grease which not only add value addition but also helps to abide by the edicts of environmental regulations.

A completely sustainable coconut oil based metal working fluid "Green Cutting Fluid" has been developed. The cytotoxicity, fish toxicity and fish embryo tests have shown that GCF is non toxic to aquatic species and benign to environment. The turning and drill dynamometer tests have shown that the performance of GCF was comparable to conventional metal cutting fluids.

Acknowledgement

The authors JKM and SVK wishes to acknowledge the contribution of Sathwik Chatra K.R., Rakesh S., Suvin P.S. and Prof. Dipshikha Chakravorty of Indian Institute of Science for their contribution in realizing this work. ■



CDB Regional Office at Patna

CDB opened a new Regional Office at Patna by converting the State Center office of the Board. Regional Office Patna will look after the activities of Bihar, Jharkhand and Chhattisgarh. Board is already having Regional Offices at Tamilnadu, Karnataka and Assam.