



AGRI MIRROR FUTURE INDIA

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CONVENIENT FOODS: EMERGING SECTOR IN FRUIT AND VEGETABLE PROCESSING INDUSTRY

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ABSTRACT

The human lifestyle has undergone a lot of changes in the last couple of decades. A busy life, time constraints, and the efforts needed to face them persuade us to switch over to ready-made goods and services. The same scenario also applies to the food we consume leading to the development of convenient food. Convenient foods are foods that require little preparation or may even only require heating and are ready to eat (RTE) in less than five minutes.

Keywords: Canning, Osmo-dehydration, Freezing, Instant mixes, minimally processed products

Introduction

With the increasing awareness and influence of western culture, there is a visible shift in food consumption patterns among urban families. Indian households today welcome food with convenience in cooking and purchasing. Ready meals are gaining acceptance primarily from the younger generation and are becoming a part of their day-to-day life. Convenient (convenience) foods require little preparation. Some convenient foods only require heating and are RTE (Fig.1) in less than five minutes ex. The majority of convenient foods are processed foods. They are healthy foods but are usually more expensive than less prepared fresh fruits and vegetables. According to Capps *et al.*, (1983) convenient foods are “fully prepared or partially prepared food items where some or all of the preparation time, culinary skills, or energy inputs are provided by the food processor–distributor rather than in the homemaker’s kitchen”. Brunner *et al.* (2010) defined convenient food products as “those that help consumers minimize time as well as physical and mental effort required for food preparation, consumption and clean-up”.

Urbanization, growing western cultural influence, a rise in per capita income and a busier lifestyle are the major growth factors for convenient foods in India. Further, India’s demographic advantage of youth being the majority of the population in India and increased female participation in the workforce and general economic growth has resulted in many ‘cash rich, time poor’ consumers contributing to the growth and acceptance of convenient foods in India (MOFPI, 2017). A substantial increase in the number of single-person and small households has boosted the demand for single servings, smaller pack sizes and convenient foods.

Background

Canned food was the first convenient food developed in the 19th century, primarily for military use, and became more popular during World War I. Experience in World War II contributed to the development of frozen food industry. Modern convenient foods had their beginnings in the United States during the period after World War II. Many of these products had their origins in military-developed foods designed for storage longevity and ease of preparation on the battlefield.



Figure 1. Ready-to-cook, Ready-to-eat and minimally processed products

Levels of convenience

- ✚ Basic – Canned, frozen, and dried foods with one or very few ingredients; instant potatoes and frozen juice concentrates.
- ✚ Complex – Have several ingredients with more time-saving processing; these often cost more than homemade products (ready-to-use frosting, frozen waffles and frozen entrees).
- ✚ Manufactured – Cannot be made at home, relatively expensive because of its production technology (carbonated beverages, instant breakfast, and RTE cereals).

Classification

Convenient foods can be classified into three types (Fig. 1).

- ❖ Foods that offer convenience to consumers
 - Ready to cook products
 - Ready-to-use products
- ❖ Foods that offer convenience to both consumers and manufacturers
 - Minimally processed products

I. READY TO COOK PRODUCTS

a. Frozen vegetables

The principle of freezing includes prevention of microbial growth and retardation of food enzymes. It has the best nutrient, flavour and texture retention. Since food remains microbiologically safe during freezing, its shelf life is determined by chemical and physical changes occurring during storage. Good quality vegetables are 'prepared' and blanched



according to the nature of the commodity. The blanched produce is subjected to IQF (Individual Quick Freezing).

b. Canned vegetables

Method of preserving food in which the food contents are thermally processed and sealed in an air tight container. Canned vegetables are peeled or cut and are ready-to-cook products. They do not require refrigerated storage if unopened and enable safe and affordable vegetables. Vegetables after 'preparation' are blanched, filled in 1 to 2% brine and subjected to the canning process which involves the double seaming process and cooling.

c. Dehydrated vegetables

Dehydration preserves foods by removing moisture from food to prevent decay and spoilage. The water content of properly dehydrated food varies from 5 to 25 per cent depending on the food. They have a unique texture and flavour and are dried until they are brittle. They are best used as ingredients for soups, sauces, stuffing and stews.

d. RTC instant mixes

Kerala agricultural university has standardized RTC instant mixes where adjuncts are added additionally so that time for preparation is further reduced. RTC dehydrated banana blossoms were formulated from Nendran, Rasakadali and Palayankodan with food adjuncts like coconut, cumin, red chilli, salt, turmeric, and garlic. Three RTC Jackfruit instant mixes which are specific curry formulations of Kerala like avial, koottu and olath mix were standardized. RTC instant olath mix of ivy gourd was standardized and contains adjuncts like crushed red chilli, onion, garlic, turmeric powder and curry leaves in the ratio 2:10:5:1:5.

II. READY-TO-USE PRODUCTS

a. RTS beverages

RTS beverages are easily digestible, highly refreshing, thirst-quenching, appetizing and nutritionally superior. It contains at least 10% fruit juice, 10% total soluble solid and 0.3% acid and is not diluted before serving with convenience in usage.

b. Frozen fruits

Frozen fruits act as a convenient alternative to fresh produce. The process of preparation of frozen fruits is similar to the case of vegetables. Frozen fruits are to be thawed at room temperature in their original package before usage to preserve quality and nutritive value. Frozen fruits can be directly consumed or can be used for product preparation. Processed products made from fruits are indistinguishable from those made from fresh fruits.

c. Canned fruits and curried vegetables

The process used for canning fruits is the same as that of vegetables except that sugar syrup is used in the canning of fruits. Instead of brining, pasteurization is adopted in fruit as opposed to sterilization in vegetables. Canned curried vegetables are considered a ready-to-use



product. Preparation is similar to that of canning vegetables. Vegetables are 'prepared' and curry is made with little water and filled with 2% brine. Sealed cans are processed at 115°C for 40-75 minutes.

d. Boil-in-bag “ready food”

Boil-in-bag ready food is a type of canned food where tin cans are replaced by retortable pouches. Retort pouches are heat sealable packages which can be dropped into boiling water for a predetermined period to reconstitute the food material.

e. Osmo-dehydrated fruits

Osmo-dehydrated fruits are unique, tasty and nutritious and can be consumed without reconstitution. Unlike vegetables, they are not dehydrated to the point of brittleness and should contain 10-15% moisture content. It is an advanced dehydration technique which consists of partial removal of moisture from plant tissue by immersing it in a hypertonic solution of sugar or salt before dehydration

f. Fruit juice concentrate

A fruit juice from which water has been mostly removed by heating or freezing is known as concentrate. They contain pure juice with at least 32% total soluble solids. They have reduced weight and bulk compared to other beverages.

g. Spray dried powders

Spray drying is the transformation a liquid or slurry to dry powder. It offers convenience in terms of reduced volume or weight, reduced packaging, easier handling and transportation and a longer shelf life.

III. MINIMALLY PROCESSED PRODUCTS

Minimally Processed (MP) products involve minimum processing which includes washing, sorting, trimming, cutting, slicing etc. It keeps the product fresh without losing nutritional quality and promotes extended shelf life. It is acceptable to consumers because of its convenience, uniform pieces, reduced preparation time, labour cost and storage space. MP's are fruits or vegetables that have been peeled and cut into 100% usable product that is packaged to offer consumers high nutrition, convenience and flavour while still maintaining freshness (IFPA, 2004). Protocol for any fresh cut fruit or vegetable includes surface sanitization of the whole commodities, preliminary preparations like removal of inedible portions, cutting into pieces of required sizes, pretreatment of cut pieces, air drying, packaging and storage.

Advantages

Convenient foods offer many advantages, including less time for planning meals, grocery shopping, and preparing food, as well as fewer leftovers (with single-portion foods) and easier cleanup. They can also provide options for those who do not like to cook, have limited cooking skills or ability, or have poor or no kitchen facilities. Storage of convenient foods is easy as they can be stacked up anywhere and can also help better utilization of the space available. Convenient



food helps save labour in the terms of purchasing, pre-cleaning, pre-preparation and post-preparation cleaning.

Disadvantages

Processed convenience foods generally have low nutritional quality, high in sodium, fat and added sugars compared to fresh foods. Day-to-day use of these foods leads to new lifestyle diseases like diabetes, high blood pressure, obesity, heart attacks, etc.

Conclusion

Convenient food is the result of modern technological advances in the field of food processing and preservation. There has been tremendous growth in the convenient food industry in the last decade. It is a better alternative for consumers who seek easy-to-prepare and easily consumable food that suits their busy lifestyles. Novel processing technologies like minimal processing are to be promoted for the growth and development of the processing industry.

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MILLETS - THE NUTRITION HUB FOR ALL

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Introduction

“India is honored to be at the forefront of popularizing Millets. Millet consumption furthers nutrition, food security and welfare of farmers”

-Honorable PM Narendra Modi

Millets, being grown in more than 130 countries, have been considered an integral part of the diet of over half a billion people across Asia and Africa for centuries. In India, Millets were among the first crops to be domesticated. In addition to many health benefits, millets are also good for the environment with low water & input requirement. Recognizing the enormous potential of Millets to generate livelihoods, increase farmers' income and ensure food & nutritional security worldwide, the Government of India (GoI) has prioritized Millets. In April 2018, Millets were rebranded as “Nutri Cereals”, followed by the year 2018 being declared as the National Year of Millets, aiming at more extensive promotion and demand generation.

History and Cultivation of Millets

There is evidence of the cultivation of millets in the Korean peninsula around 3500 B.C. In India, millets have been mentioned in Yajurveda Texts. Millet was extensively cultivated till around 50 years back. But due to the Western development model, India has neglected its traditional wisdom. Millets are cited as too primitive and coarse grains. It was looked at only as the food of rural people or ancestors. Besides that, the Green revolution had a negative impact on the production of millet. Before Green Revolution, the millets are 40 percent of total grain production. India produces 170 lakh tons of millet. The global average yield is 1,229 Kg per hectare, while the average yield of millets in India is 1,239 kg per ha.

Millets and its types

S. No.	Common Name	Colour
1.	Sorghum/Jowar	Brown, deep red
2.	Peral millet/Bajra	White, yellow
3.	Ragi/Finger millet	Red to purple
4.	Tenai/Foxtail millet	White, yellow, red, brown, black
5.	Pani Varagu/Proso millet	White, cream, yellow, orange, red, brown and black



S. No.	Common Name	Colour
6.	Varagu/Kodo millet	pinkish
7.	Kudhiraivali/Barnyard millet	White-creamish
8.	Samai/Little millet	Off-white, creamish
9.	Browntop millet	Greenish with brown colour at the top

Source: India Science, Technology & Innovation, 2023



Sorghum



Pearl millet



finger millet



Foxtail millet



Proso millet



Banyard millet

Millet cultivation in India

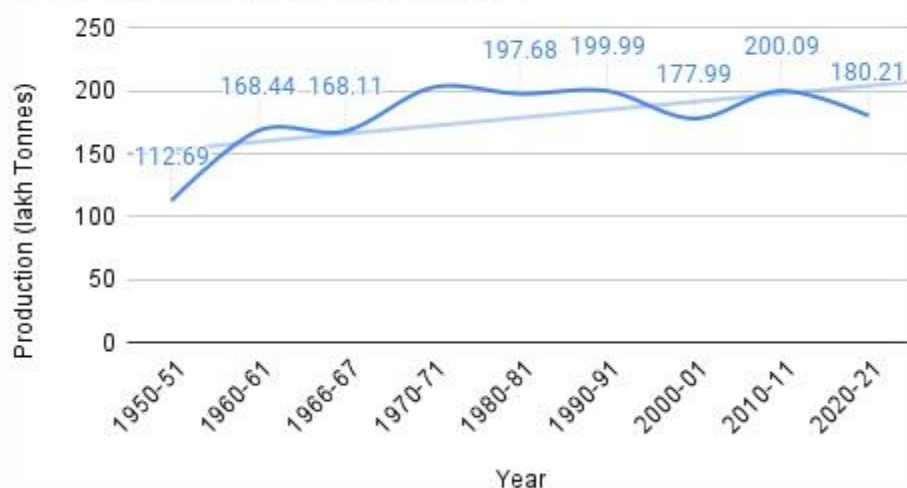
In India, Jowar and Bajra are grown in most states like Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, and Tamil Nadu, except North East states, Himachal Pradesh and Jammu and Kashmir. Both can be grown as Kharif (July - November) and Rabi (October – February) crops. Traditional varieties of these crops are available in India. They exhibit a wide range of variations concerning duration and quality. They can be grown as sole crops, intercrop, and mixed crops. The crop duration varies from 90 -120 days. The mixed cropping of Jowar-Arhar and Jowar with other pulses and even Bajra and other cereals could be done. The crop rotation of mung followed by Jowar improves soil fertility. Bajra can also be grown as a mixed crop.

Finger millet (Ragi) is an important cereal of Karnataka. It grows as summer and Rabi crops in Southern India but mainly as a Kharif crop in Northern India. It can grow in alkaline soil with a pH as high as 11. The duration of the Ragi crop is 135 days. It grows as the sole crop in Southern India and Orissa, as a mixed crop with Jowar, Bajra, Oilseed, and Pulses, and as an off-season crop in rice fallow. Foxtail (Italian) millet can grow under tropical and temperate conditions. It grows



throughout the year in Southern India. The duration of the crop is 80-100 days. The Little millet and Barnyard millet are also produced under rainfed conditions. Both can withstand drought and waterlogging conditions. Proso, Kodo, and Browntop millets are highly drought resistant. Browntop has the shortest duration of 70-75 days among all millets.

Production Trends of Millets in India



Source: Millet Network India, 2023

Millets are also grown in irrigated conditions. One to two ploughing is enough for the cultivation of millets. The seed rate for sowing varies from millet to millet. 3 to 4 rain is sufficient to grow these crops. The sowing is done through seed drill or dribbling. Nitrogenous fertilisers or phosphatic fertilisers are required in small quantities. There is a minimum or no requirement for pesticides. The panicles contain grains, and the stalk and leaves are utilised as fodder for animals.

Role of Millets in Sustainable Development Goal 2

Sustainable Development Goal 2 aims to achieve "zero hunger". It is one of the 17 Sustainable Development Goals established by the UN in 2015. The official wording is: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture. A profound change in the global food and agricultural system is needed to nourish today's 800 million people. It can be possible by focusing on millet production. Nearly 40 per cent of the global land surface is dry land. Millets are the most suitable crop for dry land agriculture.

International Year of Millets 2023: Initiatives taken and proposed activities:

The Indian government had suggested to the United Nations for declaring the year 2023 as the International Year of Millets (IYOM). India got the support of 72 other countries, on 5th March 2021, United Nations General Assembly (UNGA) declared 2023 as the International Year of Millets.

The initiative of the Indian government is of celebrating IYOM 2023, it is done by making the population aware of the millet benefits and increasing the acceptability of the value added of millet across the country and world.



The international year of millet gives a thriving opportunity to

1. Increase the contribution of millet to food security.
2. Increase the global production of millets
3. Ensuring efficient processing, transport, storage, and consumption.
4. Sustainable production and quality of millet with the involvement of the stakeholder.

Millets and Health

Millets are rich in non-starchy polysaccharides, fibre, and low glycemic index, which controls blood sugar levels, and are the ideal grain for diabetic patients. The soluble fibre and millet protein help to improve gut health and reduce cholesterol levels. Millets are gluten-free grains, a viable choice for people with celiac disease. Ragi is an excellent source of calcium and is suitable for bone health, blood vessels, muscular contraction, and nerve function. Kodo millet is rich in iron. It purifies the blood, reduces hypertension, and regulates the body's immune system. Foxtail millet keeps neurons (brain cells) healthy. Little millet is good for the thyroid. Because of the goodness of nutrients, these are termed Nutri cereals. These should be part of the daily diet, and each millet should be consumed in a week on a rotational basis. Bajra is best to eat in winter and Jowar in summer. Barnyard millet is usually eaten during religious fasts and is suitable for liver health. Browntop millet has anti-cancerous properties. Kutki, Sama, and Kagni can be substituted for rice.

These are coarse grains, so prior soaking of 6 to 8 hours before cooking is required. Traditional millet recipes like millet roti and millet khichdi already exist on the regional level. Besides that, many innovative recipes like millet dosa, millet idli, pancakes, millet bread, waffles, crispy crumbs in the salad, and cookies are developing professionally in hotels, bakeries, and also at home. New ideas to improve its palatability and acceptability by all age groups will end the hidden hunger and can fulfill the goal of zero hunger. Millet farming can play a crucial role in sustainable agriculture and make farmers prosperous.

Conclusion

Millets are water saving, drought tolerant crops. Therefore they must be viewed as climate change compliant crops. Like Ragi, other millet crops also have to be supplied to the people through Public Distribution System. This enhances the livelihood of the millet growers as well as improves the health of the rural people. The initiatives taken for the development and improvement of the millet farmers have to be highly monitored to get good quality produce.

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CHAWKI REARING CENTER (CRS'S)

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Introduction

Young age silkworm rearing generally called as chawki rearing has become a vital cog in the sericulture industry. Silkworm larval stage from hatching to cocoon spinning is of about 23-24 days duration, which is clearly differentiated in to five instars by four moults. The stage from hatching up to the end of second moult covering the first two instars is considered as the young age or chawki stage.

Chawki rearing refers to the rearing of young silkworms under controlled micro climate. The process of chawki rearing may be compared to the establishment of nursery in horticulture and plantation crops. The purpose of chawki rearing is to grow quality silkworms under disease free environment, to reduce the cost and silkworm rearing duration with famers, and to improve the cocoon quality and productivity.



Chawki worms

Robust and healthy worms ultimately produce quality cocoons. In the developed silk producing countries like China, Korea and Japan, the farmers (95%) receive silkworm as chawki worms. The young age silkworms are referred as Chawki (India), Kego (hairy silkworms in Japan) and Ants (China). The basic requirements for successful commercial chawki rearing centre (CRC) are suitable rearing house for chawki rearing with required rearing appliances, well maintained and irrigated exclusive chawki mulberry garden and well trained man power.

Commercial Chawki Rearing Centres

A commercial Chawki Rearing Model was established at CSRTI, Mysore with the capacity to brush 1, 60, 000 dfls (disease-free-layings) per annum @ 5000 dfls per batch for 32 batches in



a year. After testing this model successfully for 2 years, the same model has been popularized in major silk growing areas of the country.

Silkworms not reared properly in younger stage are prone to diseases leading to losses or even crop failure. Facilities for maintenance of required temperature and humidity, supply of suitable leaves and appropriate handling of delicate worms, demand technical skills which may not be available with all rearers. Further, small scale silkworm rearers cannot afford the equipments necessary to provide the ideal condition for young age worms. In order to overcome the difficulties, commercial chawki rearing centers are must. As the farmers have now realized the advantages of buying chawki worms, there is more scope for entrepreneurs to set exclusive chawki rearing centers in prominent sericulture areas.



Commercial chawki rearing centre

Essentials for Commercial Chawki Rearing Centres

- Commercial chawki rearing centre requires separate chawki irrigated mulberry garden, chawki rearing house with essential rearing equipments and above all trained / skilled manpower with rearing experience for scientific chawki rearing.
- Silkworm eggs have to be procured from grainages and also mulberry garden of about 120 to 150 acres owned by 80 to 100 sericulturists is essential around the chawki rearing center.

Suitable location for CRC

- Select a place closer to the cluster of villages with large number of rearers.
- The choice of location shall also take into an account to tie up with reputed grainage for sourcing quality eggs.
- The location shall be conducive in terms of isolation being at a safe distance from a commercial rearing house.
- It would be better to avoid vicinity of factories.
- Choice of location shall also take into account the access and road links to the service area.

Characteristics of Chawki Silkworms

- High growth rate, only 6% of total mulberry leaf is consumed up to III moult



- Body water content is very low in newborn larvae and increases rapidly up to II instar
- Needs succulent mulberry leaves with high moisture content
- Need quality nutrition through mulberry leaf/artificial diet
- Resistant to high temperature and high humidity
- Weak against pesticides, chemicals, gases and susceptible to diseases

Chawki certification for CRC

The supply of disease free quality chawki worms is a basic pre-requisite for the production of bivoltine silk. Chawki certification is essential and usually given during 2nd moult before supply of the chawki worms to farmers. Chawki certification consists of the following four tests: Quantification of missing larvae; Quantification of larval uniformity; Assessment of larval growth; Health status of the larvae.

FORMAT OF CHAWKI CERTIFICATE			
Name of the CRC:		Address:	
Date of Brushing:		Hatching %:	
Source of dfls:		Lot No. :	
Breed/Hybrid:		No. of dfls:	
Stage of Larvae:		No. of trays kept/100 dfls :	
Chawki Certification System		Norms	Observation
Assessment	Missing Larvae	< 5%	✓
	Larval Uniformity [under sized larvae]	<15%	✓
	Growth of larvae (wt./100 larvae)	3.4 - 3.8 g (BV) 2.2 - 2.6 g (CB)	✓ ✓
Visual & Microscopic Examination	Grasserie	Free	✓
	Examination	Free	✓
	Muscardine	Free	✓
	Pebrine	Free	✓
REMARKS: BATCH IS FIT FOR DISTRIBUTION			
Date: XX-XX-XX		XXXXXX Signature Name & Designation:	



Advantages of Commercial Chawki Rearing Centre

- Raising of healthy and robust young age worms, which ensure stabilization of cocoon crop and increase cocoon yield.
- Producing uniform and healthy silkworm larvae and cocoon.
- Reducing the chances of contamination and spread of diseases.
- Proper incubation of eggs leads to good hatching.
- During rearing, there is reduction in missing percentage of larvae and hence the crop yield is increased.
- Prevention of crop loss and cocoon crop stabilization
- Higher profits



MORINGA: A MIRACLE TREE FOR SUSTAINABLE AGRICULTURE

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In agriculture chemical fertilizers used most frequently than organic fertilizers. This is mainly because their result is faster and plants absorb and utilize them quicker. This lead too many issues for environment and human health such as ground water contamination, soil erosion and degradation issues, chemical residue in food and other. Hence there is a need to protect environment by promoting organic agriculture. In this one of the option is to use of organic products to improve yield and quality of the agriculture produce. Moringa leaf extract as foliar spray is can be used (bio stimulant) to improve the quantity and quality of the produce.

Moringa leaves are source of vitamins, carotenoids, anti-oxidant substances and trace elements (Michaul *et al.*, 2008) and rich in mineral elements P, Ca, K, Mg, Fe, Cu, Zn & Mn (Merwad, 2018) Moringa leaves good source of gibberellins, cytokinin, IAA and zeatin (Lathif and Mohamed, 2016). Unuigbo *et al.* (2015) noticed that, moringa leaves contain zeatin *i.e.* plant growth hormone. By using moringa leaf extract yields of soybean, maize and coffee can be improved by 25-30%. Moringa leaf extract is used as an effective plant growth hormone to enhance seed germination, improving yield and growth in plants (Phiri, 2010). Because of having antioxidant compounds like zeatin, ascorbic acid, phenolic flavonoids, vitamin E and minerals in moringa leaves, it can be used to enhance the metabolism of plants and overcoming plants from environmental stress (Lathif & Mohamed, 2016).

Manzor *et al.* (2015) the concentration of 5% leaf extract (MLE) and root extracts significantly increased growth and reduced aphid infestation in wheat crop, as well as improved leaf area index, total dry matter, growth rate, spike numbers, and the total yield. Moringa leaf extract is also used as a growth promotor in seed germination of many cereal crops like sorghum, rice, wheat & maize (Chattha *et al.*, 2018). Mathew (2016) found that growth and yield of pepper increased with the spray of 5% concentration of moringa leaf extract. Higher protein content and fresh pod weight in pea plants was recorded with foliar application of 4% moringa leaf extract (Merwad, 2018). Moringa seed extract can be a useful source of antimicrobial property (Ali *et al.*, 2004) Moringa leaf extract can be used as a safe and effective insecticide against weevil (Tshimenga *et al.*, 2018). Foliar application with moringa leaf extract improves the immune system of plants against some parts and diseases (Makkar & Becker, 1996)

Moringa leaf, seed or root extract can be used as a part of organic farming to improve human health as well as ecological balance.



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NANO HERBICIDES – AN INNOVATIVE APPROACH IN WEED MANAGEMENT

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Weeds are the major biotic constraint in Agriculture. The economic loss due to weeds about USD 11 billion was estimated in 10 major crops in India (Gharde *et al.*, 2018) weeds also impair product quality and environment hazards. Herbicides are one of the most effective tools to control weeds. Herbicides account for 47.5% of overall yearly pesticide use of 2 million tonnes. Herbicides shown a negative impact on the environment *i.e.* soil, water pollution which target the other organisms. Because of continuous use of same herbicides or same family herbicides or same mode of action made the weeds resistant to herbicide. Weeds acquired resistance to 164 different herbicides. Hence to turnout the present situation we need to depend on the new tool *i.e.* nanotechnology.

Nanotechnology is the science and technology of tiny things. The materials that are less than 100nm in size. It is a new scientific approach that includes the use of materials and equipment capable of using physical and chemical proportion of a substance at molecular levels to explore the biological and material worlds in nano meter scale and use it in various carriers from medical to agriculture.

Different nano formulations in weed management.

Nano encapsulation: It is a membrane controlled method in which herbicides are coated with any semi permeable membrane, which could be organic or inorganic Eg: Chitosan, poly ethylene, poly propylene. Herbicides can be encapsulated with nano particles to increase their efficacy by focusing at the unique receptor of specific weed after entering into the root system and inhibiting glycolysis, starving them death.

Nano carrier: It is used to decrease the environmental impact of herbicides, specially reducing herbicide non target toxicity Eg: Alginate and starch. Chitosan / Tripoly phosphate nano particles (NP's) with paraquat herbicide were less hazardous to crops and safe to use in weed management (Grillo *et al.* 2014)

Nano emulsion: Nano emulsion are used to improve the delivery of active herbicidal substances. Nano emulsion droplets are typically 20-200 nm in size. The nano emulsion of pretilachlor micro emulsion and monolithic dispersion was found to be much superior in managing *Echinochloa crusgalli* compared to the commercially available formulation (Kumar *et al.*, 2016).

Nano biosensors: Nano Biosensors can be used as a tool for detection of enzyme inhibiting herbicide. The herbicide metsulfuron methyl (an acetoacetate synthase inhibitors) was detected in the solid using a novel nano-bio sensor based on atomic force microscopy (Da Silva *et al.*, 2013)



Advantages:

- Minimize environmental pollution
- Enhanced soil herbicide residues mitigation.
- Safety to the microbiota in the soil.
- Enhanced efficacy of herbicides.

Disadvantages:

- Inhibition of seed germination
- Nano particles can easily enter the human body through skin.
- High production cost of nano particles.

Brindha *et al.* (2017) reported that the presence of higher amount of starch (142 mg g^{-1}) phenol in the control treatment inhibited germination of tubers and no germination (0) was recorded. Whereas, the ZnO treated tubers at the rate of 1500 mg kg^{-1} registered lower content of starch (102 mg g^{-1}) phenol (60 mg g^{-1}) and higher percent of germination (80 Percent), ZnO nanoparticles acts as a powerhouse of electron donor possessing ability to degrade organic and inorganic compounds present in the tubers and thus starving the tubers which results in the germination of the tubers.

Pradeesh Kumar and Chinnamuthu *et al.* (2017) proved that nano encapsulated pendimethalin using solvent evaporation method released the herbicide over a period of 40 days under controlled conditions. Through outer covering and porous nature of polymer determine the release pattern of encapsulated herbicide. When irrigation is applied to the field the entrapped herbicide inside the carrier is slowly released and the left over herbicide inside the carrier will be released during the subsequent irrigations. Which helps in controlling the germination of weeds over the entire crop growing period and also the biosafety the germination of weeds for longer period and also the biosafety studies proved that nano encapsulated pendimethalin by solvent evaporation was non toxic to earth worms.

Weed control efficiency with pretilachlor emulsion 450 g ha^{-1} was highest when compared to pretilachlor @ 600 g ha^{-1} which proves that pretilachlor micro emulsion is superior to Pretilachlor (Kumar *et al.*, 2016). Vimalraj *et al.* (2018) reported that application of nano particle herbicide combination significantly influenced the plant height of black gram.

Conclusion: Nano herbicide shown the effective weed control as well as it reduced the herbicide residue in the soil. However, Need to study the nano herbicides on long term basis in different situations.

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