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Determination of Optimum Spawn Quantity for Maximum Yield of Pleurotussajorcaju cultivated on Agro Waste

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ABSTRACT

Mushroom cultivation is one of the promising areas of food and agricultural microbiology. Mushrooms are an excellent food source and addition to any diet or menu. Beyond tasting great, mushrooms are also a very nutritious addition to any cuisine. Mushrooms are by and large high in protein and dietary fiber while being low in fat, cholesterol, and carbohydrates. In the present study the optimum spawn quantity of mushroom *Pleurotussajorcaju* is investigated. The auxiliary objective of the present research is to explore the potential to convert agricultural waste into nutritionally and pharmaceutically useful metabolites. Optimum spawn requirement for 3 kilograms of agricultural and office waste substrate was determined. Different types of substrates were tested for obtaining the yield of *Pleurotussajorcaju*. Carton & paper was found to be a better substrate as compared to wheat straw in terms of time of mushroom pinhead body appearance. It was found that ten per cent or more spawn quantity was optimum for better yield of mushroom. It is also concluded the and standardized that ten per cent spawn on the basis of the dry weight of substrate was required for maximum yield of mushroom *P. sajorcaju*.

Keyword: Mushroom, *Pleurotussajorcaju*, Neutraceuticals, Spawn, Antioxidant activities, Agricultural wastes, Office waste, Wheat Straw

INTRODUCTION

Growing mushrooms is a popular activity all over the world since it produces nutraceuticals and is utilised as a wholesome food source. India is a country with a large agricultural sector, and this sector forms the backbone of the Indian economy. A million tonnes of agricultural trash are produced in India together with important crops. India generates over 600 million tonnes of agricultural waste each year, most of which is burned on-site or allowed to organically decay (Manjit Singh, ICAR, 2011).Mushroom growing is a bioconversion strategy that is suitable for managing agricultural and agro-industrial leftovers (Chang and Miles, 1992). Therefore, if we use trash in mushroom culture, we may turn agricultural waste into a useful item and also solve the landfill problem. India can create 3 million tonnes of mushrooms and roughly 15 million tonnes of compost by diverting just 1% of agro-waste towards mushroom growing (Manjit Singh, ICAR 2011). Therefore, mushroom farming benefits both the local economy and the economy of India. India raises four to five important mushroom species: Button mushroom (*Agaricusspp*), Oyster

mushroom (*Pleurotus),* Paddy straw mushroom (*Volvariella),*Milky (*Calocybe indica*) and Shiitake (*Lentinula edodes).*

Only the kinds Button and Oyster, which account for about 9 per cent of all Indian production, are grown in Gujarat. As a result, India's mushroom production is gradually but steadily rising. Here is a graph showing the increase in production.

Unique characters of *Pleurotusspp* are:

(1) The Wide Range of Substrates: Unlike other species, oyster mushrooms may easily grow on any cellulose or lignin substrate.

(2) Do not need elaborate controlled conditions: Oyster mushrooms are subtropical mushrooms and may grow at temperatures between 20 and 30 °C and humidity levels between 80 and 90%. By retaining humidity, we can grow it while the temperature rises. As a result, oysters grow best in the winter, and the climate in India is better for oyster mushrooms.

(3) Species Varieties: Oyster mushrooms come in a variety of hues, including white, pink, yellow, light brown, and others. The species of mushroom and the surrounding environment have a significant impact on the colour of the mushroom.

(4) Higher Biological efficiency : In general, productivity is higher than that of other mushrooms, and one can obtain the highest yield.

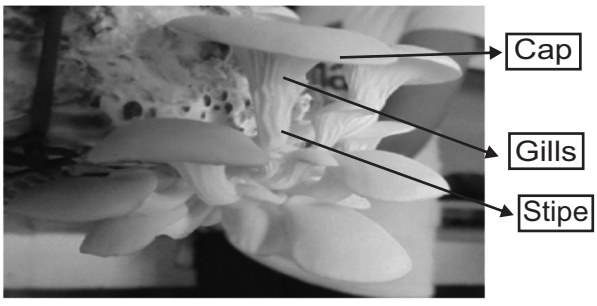


Fig 1: Mushroom *Pleurotussajor-caju*

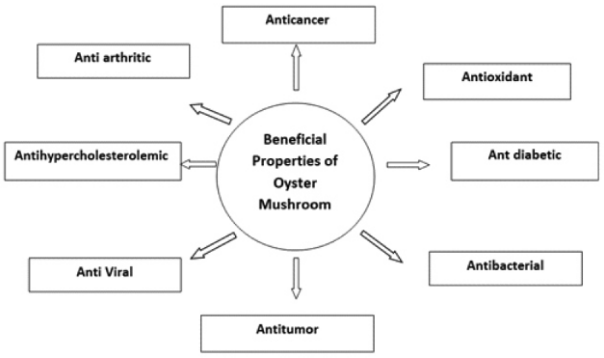


Fig 2: Applications of Oyster Mushroom

Objective :

Determination of optimum spawn quantity for maximum yield of *P. sajorcaju* cultivated on agro waste.

MATERIALS AND METHODS

(1) Experimental site :

The Department of Life Science at Bhakta Kavi Narsinh Mehta University and the Department of Plant Pathology at Junagadh Agricultural University carried out the cultivation and laboratory experiments.

(2) Experimental duration:

The experimental work has been done for total 6 months in winter-early summer season.

(3) Experimental materials:

The experiments were conducted on *Pleurotussajorcaju*. Wheat straw and coconut husk used as substrates and sorghum seed were used as spawn.

A . Preparation of pure culture of *P. sajorcaju* :

Because it has a good source of carbohydrates and has an acidic pH, which both support fungal growth, Potato Dextrose Agar was chosen as the medium. In the laminar air flow, inoculation was performed by slicing tiny sections of the

mushroom tissues from cap to base using a sterile blade. The inner area of the junction between the stalk and the pileus was sampled for tissues. A small piece was inserted into petri dish. Plates were incubated at 25° C or room temperature. After 5 to 6 days, the white mycelia fully covered the plate. Microscopic structure of fungi was observed with the help of lactophenol blue stain in 10x and 45x. Fungal growth was transferred into PDA slant and preserved in the refrigerator.

B. Preparation of master and mother spawn bags :

In simple words, spawn is grains covered with mushroom mycelium & used as propagating material by a grower. A pure culture of *P sajorcaju,* sorghum seeds, Chloramphenicol antibiotic capsules, $CaCO_3$ powder, plastics bags, cotton plugs etc were utilized for the said preparation.

Good quality of sorghum seeds (around 5 kg) were taken and washed it with water thoroughly. Seeds were taken in the vessel and sufficient amount of water was added and the antibiotic capsule was added (1 capsule was added per 1 kg of grain) Then, grains were boiled until they became soften but did not split apart. After it cooled down, excess water was removed and seeds were spread over the cotton cloth. Again antibiotic was added to prevent contamination. $CaCO_3$ was mixed with grains for maintaining the pH. After proper mixing, plastic bags were filled with grains and mouths of bags were plugged with non absorbent cotton and pipe. All bags were autoclaved at 121° C, 15 psi. A pure culture of fungi was inoculated inside the laminar air flow, and bags were incubated in walking chamber.

C. Preparation of mother spawn bags:

The mother culture underwent the same process. Grain that had been boiled was combined with an antibiotic and CaCO3. Following the preparation and autoclaving of the bags, inoculation was created by transferring grains from the master bag to the new bag. With the aid of the sterile spatula, approximately 5gm of master spawn grains were injected in mother spawn bags inside the laminar air flow. In the walking chamber, all of the bags were incubated. The experiment was conducted using bags that were completely coated in mycelia after a few days of growth.

D. Cultivation of Mushroom *P. sajorcaju*:

3 steps were followed for cultivating the mushroom on different substrate and determination of optimum spawn quantity for its maximum yield.

i. Substrate preparation
ii. Preparation of mushroom bags
iii. Harvesting

i. Substrate preparation:

Separately, 8 to 9 kg each of wheat straw and coconut husk were placed in a tub and left to soak for 24 hours in water containing 50 ml of formaldehyde and 5 g of bavistin-fungicide. The saturated substrate was retrieved after 24 hours and given two more washes with plain water. After washing, any extra water was wiped away. When dealing with office garbage, small pieces of paper and carton were placed inside a plastic bag before the bag was autoclave sterilised at 121°C and 15 psi pressure. Papers and carton pieces were employed as substrates following sterilisation.

iii. Preparation of mushroom bags

In order to give the plastic bag a pleasing oval shape, the bag's end was tied with

plastic thread after being inverted. After then, bags were changed back. The substrate was then taken, the extra water was squeezed out, and the first layer of substrate was created in the bag. Hands were cleaned with alcohol before harvesting spawn. Around the edge of the bag, a layer of spawn was created. The substrate was then created in a second thick layer in the same manner. A new spawn layer was created. The substrate and spawn were formed in layers of 4 to 5, with the last layer of the substrate being made thinner than the others. To ensure there is no air within the bag, the thread was tightly tied to the bags. The bag's perforations for aeration were cut with sterilised scissors. Bags were stored in a room that had a 20 to 25 °C temperature and an 80 to 90% humidity level. Three bags of 9 to 10 kg wet substrate each weighed around 3 kg each were manufactured. Typically, 250 to 300 gm of spawn were utilised per 2.5 to 3 kg of substrate for 1 bag. 50gm, 100gm, 150gm, 200gm, and 250gm of spawn were utilised per 2 kg of dry substrate to find the ideal spawn rate. 3 replicas were made for 1 spawn treatment; meaning that total 3 bags were prepared those contain 50 gm spawn per 2.5 kg substrate. Same procedure was repeated for paper and carton in the bag and in between the layer water spraying was carried out for maintaining the moisture.

iv. Harvesting:

After 8 to 9 days, when mycelia had colonised the entire bag, the bag was opened, and the plastic was removed. To keep the substrate moist when the bag was taken off, water was sprayed twice daily. After the fruiting body had emerged, water was sprayed only on the substrate, avoiding the fruiting body itself. A mushroom is harvested when it reaches maturity by removing it from the substrate, and the fresh weight of the mushroom is recorded in a weigh scale. Mushrooms were stored in plastic bags in the refrigerator for later analysis.

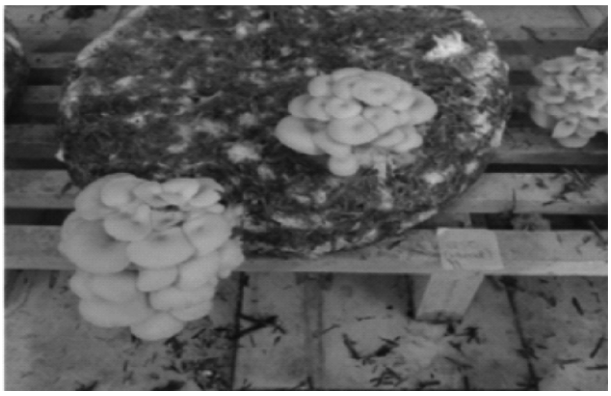
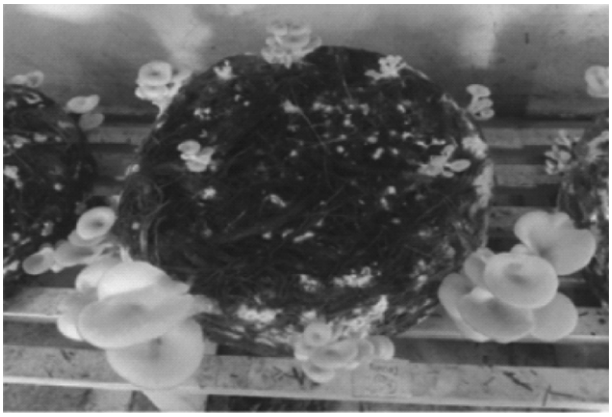


Fig 3: Mushroom harvested after maturation



Biological Efficiency (BE):

Biological efficiency means the substrate's efficiency to produce a maximum product. It is calculated by the given formula:

$$BE = \frac{\text{Total yield or total weight of mushrooms}}{\text{Total weight of dry substrate}} \times 100$$

Period between flushes:

The period between 1st harvest to 2nd time harvest is essential because it gives an idea about fungal colonization and capacity of

substrate to give best propagating medium to fungi. It can be calculated by,

$$\text{Period between flushes} = \frac{\text{Days taken for first harvest to last}}{\text{Total number of harvesting.}}$$

RESULTS AND DISCUSSION

PDA plates were used to cultivate the fungus *P. sajorcaju*. With the use of lacto phenol cotton blue stain, the microscopic structure of fungus and fungal spores was examined under 10X and 45X magnification. The outcomes were as follows:

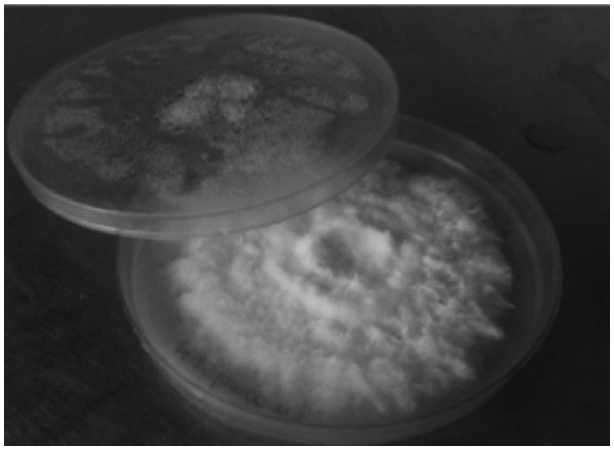


Fig 4 : Fungi *P. sajorcaju* on PDA plate

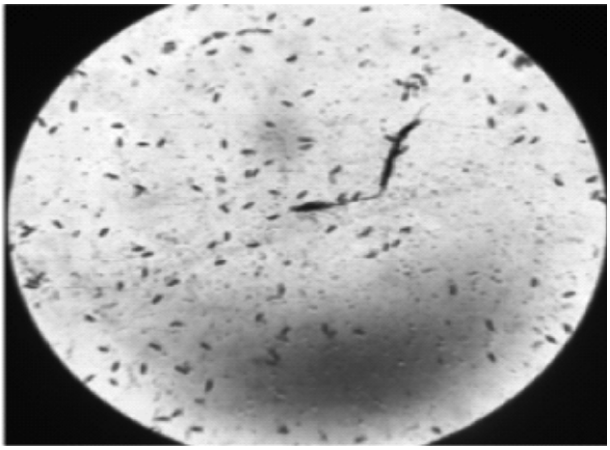


Fig 5: Basidiospores of fungi *P. sajorcaju*

Cultivation of mushroom on different agro waste substrates :

It has been noted that mushrooms may grow readily on both coconut fibres and wheat straw. Additionally, P. sajorcaju can grow on coconut husk, according to reports by Nurudeen T.A. et al. (2013) and Shubhra Shukla and A. K. Jaitly (2011).

Effect of spawn quantity on spawn run days, formation of pinhead body as well as 1st maturation.

It was shown that spawn quantity had a significant impact on mycelial growth, the fungi's time to colonise an area, the number of pinhead bodies produced per day, the days it took for pinhead bodies to become apparent, the maturity period, and the number of fruiting bodies. On wheat straw, the 250 gm spawn rate had the fastest spawn run (9 days), which was followed by the 200 gm spawn rate (14 days). The 150gm spawn took a moderate amount of time, and the 100 and 50gm spawn rates ran the slowest. Pinhead bodies first

P. sajorcaju mushroom cultivation and biochemical characterization were completed. Wheat straw and coconut husk (fibre) were used as the two different substrates for growing *P. sajorcaju*. To establish the ideal spawn quantity for the highest possible mushroom yield, multiple amounts of sorghum spawn were utilised. 50gm, 100gm, 150m, 200gm, and 250gm of spawn used per 2 kg dry substrates. It was observed that quantity of spawn, quality of spawn, quality substrates, highly affected the yield of mushrooms. Temperature, humidity and water spraying have affected the color of mushroom as well as the yield of mushroom.

showed up in 250gm spawn (over the course of 11 days), then in 200, 150, 100, and 50 gm spawn. Mature fruiting bodies developed in 250 and 200 gm spawn in less time (17,19 days respectively) whereas in 150, 100, 50 gm time was increased (22,26,37 days respectively) with a decreased quantity of spawn (Table 1)

Table 1: Effect of Spawn Rate on Spawn run days, Pinhead body Formation & Maturation

Substrate	Spawn Rate (Gm)	Spawn Run Days	Pinhead body Formation (Days)	Days taken for 1st Harvest
Wheat Straw	50	25	27	37
	100	20	21	26
	150	17	18	22
	200	14	15	19
	250	9	11	17
Coconut	50	14	15	19
	100	12	13	18
	150	10	12	17
	200	8	11	16
	250	7	9	14

Effect of different spawn quantity on total yield of mushrooms and biological efficiency of the substrates:

On a 2 kg dry weight basis, it was shown that substrates with 250 and 200gm spawn produced the maximum yield. 250 gm of spawn produced 1048 gm of 52.2% BE on wheat straw and 1037.8 gm of 51.89% BE on coconut. With less spawn available, the yield reduced. In both situations, spawn rates of 150, 100, and 50 gm resulted in subpar yield and BE. (Table 2). Additionally, it was noted that, in comparison to 150, 100, and 50, the time between 2 flushes was significantly shorter in the higher spawn rates of 250 and 200.

Table 2: Effect of Spawn Rate on Yield of mushroom and Biological Efficiency of Substrates

Substrate	Spawn Rate	between Flushes	Period Yield (gm) per 2 kg dry substrate				Biological Efficiency (%)
			1st harvest	2nd harvest	3rd harvest	Total yield	
Wheat Straw	50	12	44	32	30	106	5.3
	100	8.66	64	50	40	154	7.7
	150	7.33	90	75	55	220	11.0
	200	6.66	395	355	265.2	1015.2	50.76
	250	5.66	410	367	263	1042	52.1
		C.D.	15.73	10.82	9.25		3.91
		C.V.%	4.31	3.38	3.89		8.46
Coconut	50	6.33	44	32.5	22.5	99	4.9
	100	6	62	43	31.09	136.09	6.80

150	5.60	71	53.5	35.2	159.7	7.98
200	5.33	370	310	298.66	978.6	48.93
250	5	395	353.2	289.66	1037.8	51.89
	C.D.	7.05	7.40	5.34		4.20
	C.V.%	2.06	2.57	2.17		9.59

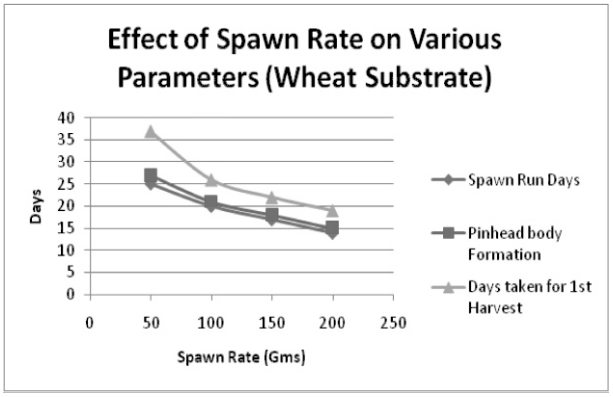


Fig 6 : Effect of Spawn Rate on Spawn Run days, Pinhead body Formation & Maturation (Wheat Straw Substrate)

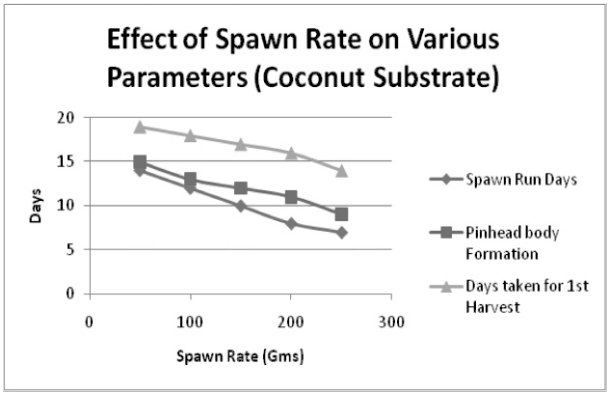


Fig 7 : Effect of Spawn Rate on Spawn Run days, Pinhead body Formation & Maturation (Coconut Substrate)

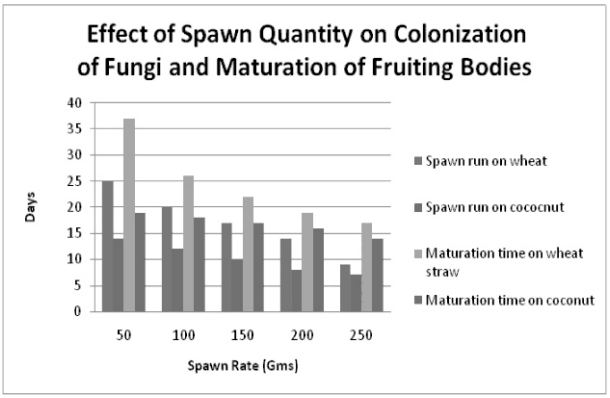


Fig 8: Effect of Spawn Quantity on Colonization of Fungi and Maturation of Fruiting Bodies

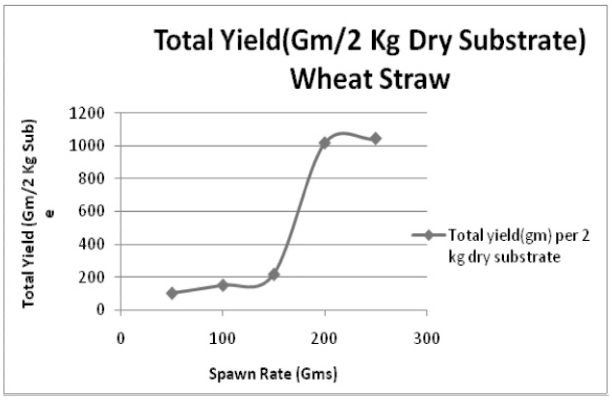


Fig 9 : Effect of Spawn Quantity on Yield of Mushroom (Wheat Straw)

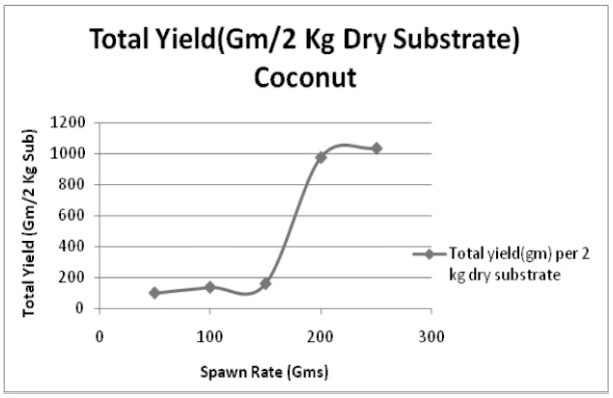


Fig 10 : Effect of Spawn Quantity on Yield of Mushroom (Coconut)

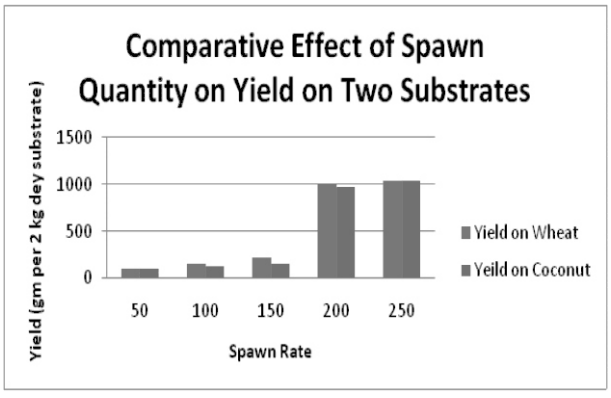


Fig 11: Effect of Spawn Quantity on Yield of Mushroom

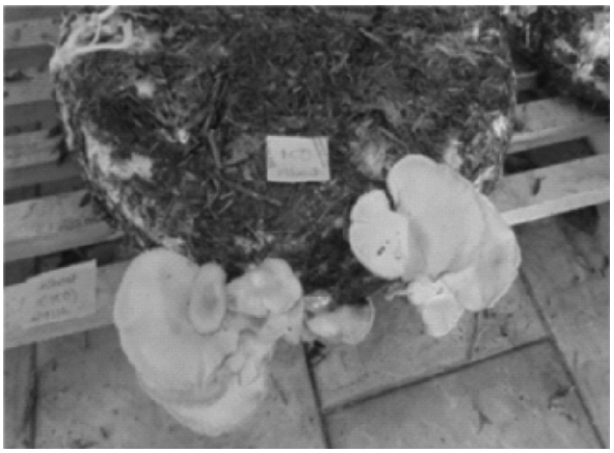


Fig 12: mature fruiting bodies in 150 gm spawn on wheat straw.

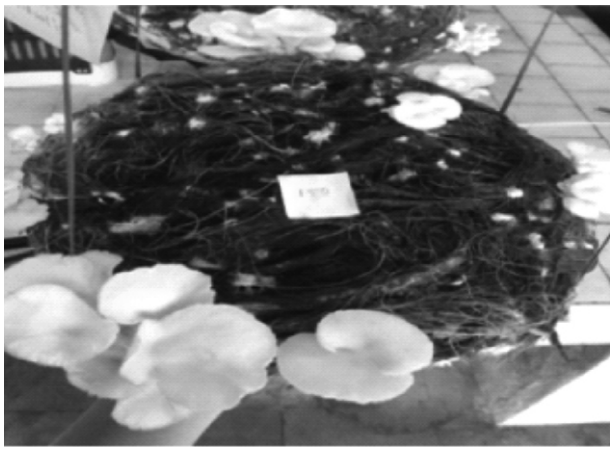


Fig 13: mature fruiting bodies in 150 gm spawn on wheat straw.

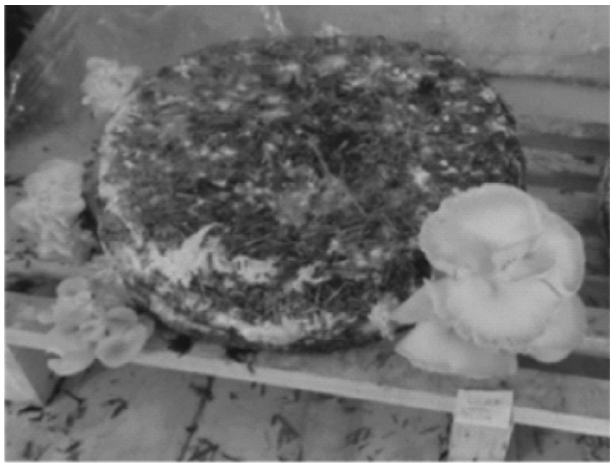


Fig 14: Pinhead bodies in 200 gm spawn on wheat straw

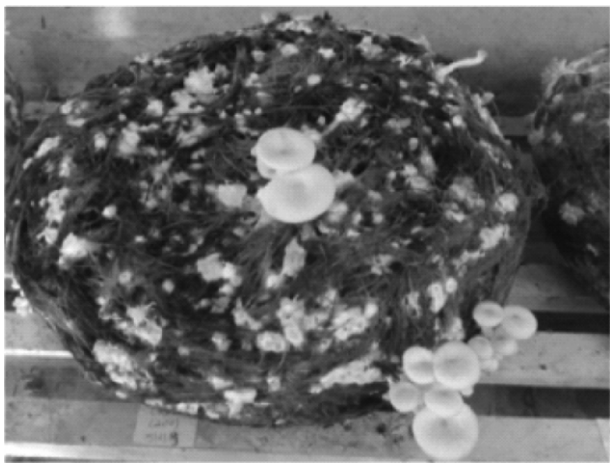


Fig 15: Pinhead bodies in 200 gm spawn on coconut husk



Fig 16: Mature fruiting bodies in 200 gm spawn on wheat straw



Fig 17 : Mature fruiting bodies in 200 gm spawn on coconut

It was found that when spawn number rose, maximum yield and BE (200 and 250 gm spawn) were attained. In increased spawn quantities (200 & 250 gm spawn), spawn run time, pinhead body appearance, and maturation were all significantly reduced. It was discovered that 10% or more spawn quantity was ideal for greater mushroom yield. The same experiment also showed that 10% spawn, based on the dry weight of the substrate, was necessary for the mushroom P. sajorcaju to produce its highest production. 10% spawn was required for oyster mushroom production, according to R.C. Upadhyay (ICAR, 2011). According to M.I.Bhatti et al. (2007), 1kg of substrate required 70gm of spawn. According to Pradeep et al. (2018), the 6% of the dry substrate spawn of bajra seed produced the best yield. They also noted that the six per cent spawn had the shortest spawn run, lasting just 15 days, and the six per cent spawn produced pinhead bodies in just 17 days. The maximum yield (540gm/1kg) with 54 per centBE came from 6% of the spawn. P. pulmonarius was grown on wheat straw by Jogindar Pal et al. (2017), who reported that 8% spawn produced the maximum yield (168.7 per 200 g dry substrate) and had an 84.33per cent BE. With a drop in spawn rate, yield and BE fell. They discovered that the 8per cent spawn had the fastest spawn run (10.50 days) and took much less time than the 6per cent, 4per cent, 2per cent, 1per cent, and 0.5 per cent spawns to form pinhead bodies and mature.

The physiological needs for oyster mushroom growing, such as steady temperature, humidity, and lighting arrangements, may vary under controlled or semi-controlled settings, explaining the discrepancy between the results published by other study workers. The response of various substrates varies in terms of how long it takes for pinheads to form, how long it takes for fruiting bodies to mature, how long it takes between flushes, how many flushes there are, and how much yield is produced. Results are much closer to those of other researchers, nevertheless.

CONCLUSION

With the addition of 10 per cent spawn on a dry weight basis of the substrate, oyster mushroom *P. sajorcaju* can grow readily on agricultural wastes such wheat straw and coconut husk at low temperature and high humidity. So, by growing mushrooms, we contribute to the local economy as well as the Indian economy by turning garbage into a useful good. Due to its excellent nutritional value (high protein, low fat, and fibre content), mushrooms are utilised as food supplements and are also beneficial for diabetic and cardiac patients. The market is flooded with natural organic items that work as antioxidants, but many of them are prohibitively expensive or difficult for everyone to access. However, the mushroom is the only product that is both an antioxidant and a meal. One of the promising fields in food microbiology, agricultural microbiology, cancer biology, gerontological sciences, and bioconversion technology is mushroom farming. Therefore, by using office and agricultural waste to produce mushrooms, we can boost the economy, reduce trash, recycle waste, and, most significantly, enhance health and make a step towards curing cancer.

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Heat Transfer Performance and Energy Analysis during Mathura Peda Manufactured in Mechanized Steam Jacketed Kettle

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ABSTRACT

India had emerged as the world's largest producer of milk with half of its production being used for the manufacture of different traditional milk products. For achieving uniform quality for the manufacture of these products on large scale, mechanization in production, standardization of process and processing conditions are inevitable. The performance of the mechanized steam jacketed kettle used in experiment was evaluated at different scraper speeds (S1=15 rpm, S2=20 rpm, S3=25 rpm) and operating steam pressures (P1=1.0 kg/cm^2, P2=1.5 kg/cm^2, P3=2.0 kg/cm^2) by adopting optimum process of the product. The rate of evaporation ranged between 7.05 to 9.96 kg water evaporation/h and U-values ranged from 345.78 to 477.72 W/m^{2}K. The values of steam consumption ranged from 15.75 to 20.84 kg/h and electrical power consumption 217 to 245 Wh under different operating conditions. The specific steam consumption of optimized product was found in the range of 2.09 to 2.26 kg steam/ kg water evaporated. The total heat losses during manufacture of *Mathura Peda* in the mechanized steam jacketed kettle ranged from 25.08 to 29.09 % of the heat input by the steam, at different steam pressures and scraper speeds.

Keyword : *Mathura Peda,* Mechanization, U-value, Steam Consumption, Energy Analysis

INTRODUCTION

India is the largest milk-producing country in the world. According to Basic Animal Husbandry Statistics, DAHD & F, GOI, India's milk production in 2019-20 was 198.4 million tons (NDDB, Anand). The conversion of liquid milk into traditional dairy products increases the longevity of milk solids. The consumption of sweets is an integral part of the Indian dietary system. Traditional dairy products have great commercial significance as they account for over 90 per cent of all dairy products consumed in the country (Aneja *et.al.*, 2002).

Traditional dairy products not only have an established market in India but also have great export potential because of the strong presence of the Indian diaspora in many parts of the world (Rao and Raju, 2003). The small-scale technology adopted by halwais for the preparation of indigenous products cannot be exploited for industrial production.

Mechanization for the manufacturing of

TIDP would give large-scale production with the best possible hygienic and economical production. It would facilitate the convenient handling of both raw material and finished products. By, mechanization, it would be possible to use the same equipment's for its multiple utilization because most of the processes in TIDPs preparation consist of the same operations *viz*. heating, cooling, mixing, straining, pressing, and so forth with a little bit of variation in their level of process parameters. The mechanization production of value-added dairy products will give the advantages like (a) economic production, (b) uniform quality, (c) hygienic production and better keeping quality, (d) scale-up production, (e) less laborious process, (f) less energy consumption, (g) better control over the process parameters to maintain standardized sensory and rheological attributes, and (h) promote exports of TIDP through small and medium entrepreneurs. It is also necessary to develop and standardize a commercial method of manufacture of *Mathura Peda*, which can be adopted at the industrial level.

MATERIALS AND METHODS

Mechanized steam jacketed hemi-spherical kettle

In the food industry, scraped surface heat exchangers (SSHEs) are often used for improved heat transfer, crystallization, freezing and other continuous methods. They're suitable for viscous, sticky, and particulate-containing materials. SSHEs are well suited for pumpable food products and they share these traits with the vast majority of packaged foods. To facilitate control over crucial manufacturing stages, heat-desiccated milk products such as *khoa, burfi, Peda, halwasan, halwa,* and others include batch-type SSHEs with conical or hemisphere-bottom kettle designs.



Fig 1: Mechanized Steam Jacketed Kettle

The SSHE principle is used to design the mechanized steam jacketed hemi spherical kettle. The obtained data was analyzed for the purpose of optimizing processing parameters and obtaining superior quality attributes of MathuraPeda in terms of its typical colour, body and texture. The highly insulated mechanized jacketed hemi spherical kettle with a volumetric size of 50 litres was used during experimentation. The kettle is made of stainless steel AISI 304. The kettle comes with all of the required attachments and mountings, including a steam pressure gauge, an air release valve, a safety valve, a steam regulating valve, a steam trap, a worm and worm wheel system for unloading hot processed products, and a lid to cover the kettle. The unit also includes a specially built scraper assembly with a Variable Frequency Drive (VFD) that allows for speed variations between 1 and 50 rpm to achieve the optimal rheological properties of the product. The scrapers are specially engineered to prevent the product from overheating and to have a higher rate of heat transfer to the desired granulations.

Table 1. Specification of mechanized system

Sr. No.	Particulars	Specification
1.	Material of construction	SS AISI 304
2.	Volume of kettle	50 liters
3.	Outer diameter of inner shell	0.500 m
4.	Inner diameter of outer shell	0.505 m
5.	Thickness of the inner shell	0.005 m
6.	Height of the inner shell (hemisphere+ cylinder)	0.450 m
7.	Effective area of heat transfer	0.3925 m2
8.	Thermal conductivity of SS AISI 304	16.2 W/m K
9.	Thickness of steam jacket (middle shell)	0.003 m

Scraper assembly of the mechanized steam jacketed kettle

A customizable Teflon scraper blade vertical circular agitator is used in the scraper assembly. The inner shell has a 30 mm diameter 304 stainless steel shaft that is connected to a 0.25 HP gear motor via motor coupling. For improved scraper assembly speed control, the motor is attached to a variable frequency drive (VFD). To provide the required clearance to fix the Teflon blades on the stainless-steel strip, a nut and bolt are used to modify them. The arrangement is such that the blades sweep the product settled both on the top of the inner shell and at the bottom of the hemispheric kettle. The scraper assembly includes an agitator stand at the bottom, as well as an agitator bush on the main shaft. A Teflon bush is attached to the shaft's bottom end. The angles of the two blades are maintained in such a way that the product does not adhere to them during rotating.

Table 2. Specifications of rotor and scraper assembly

Sr. No.	Particulars	Specification
1.	Type of Rotor	Teflon and SS
2.	Number of blades	2
3.	Material of strip to hold Teflon blade	AISI SS 304
4.	Blade material	Teflon

Drives for scraper assembly

The scraper assembly was powered by an A.C. motor (0.192 kW, 3-phase). For the experimental trials, a Variable Frequency Drive (VFD) was used to control the motor speed used to run the scraper assembly at various speeds.

Measuring and control instruments for mechanized steam jacketed kettle

For the mechanized steam jacketed kettle to operate efficiently, different parameters must be managed when the machine is in operation. During the experimental trials, the VFD (Make: Amtech Electronics (India) Ltd., model: THYFREC VT13OS, Capacity: 2 HP) was used to regulate the speed of the motor, which in turn regulated the speed of the scraper.

To control the steam supply to the mechanized steam jacketed kettle, a hand-operated needle valve was mounted in the steam pipe line. During use of the mechanized steam jacketed kettle, a Bourdon tube pressure gauge (range: 0 - 7

kg/cm^2) was mounted on the jacket to measure the steam pressure in the jacket. A pocket-sized optical temperature sensor was used to determine the product's temperature. A power analyzer (MULTISPAN, 3-Phase 4-wire power analyzer, 440-Volt) was used to measure the electrical input variables.

Energy supply for mechanized steam jacketed kettle

The scraper assembly of the system is operated by three phase electrical motor. It is supplied with three phase connections with VFD through power analyzer. The steam is generated in the boiler was supplied to the system at required pressure by regulating the steam valve.

Process parameters for mechanized productionof *Mathura Peda*

It was important to optimize processing variables in order to have mechanized output of *MathuraPeda*. To have greater control over the desired flavour, body and texture, colour and appearance of the mechanized system, process variables required to be optimized. In all of the experimental trials during the manufacture of *MathuraPeda*, the efficiency of the mechanized steam jacketed kettle was evaluated at various scraper speeds (S_1=15 rpm, S_2=20 rpm, S_3=25 rpm) and operating steam pressures (P_1=1.0 kg/cm², P_2=1.5 kg/cm², P_3=2.0 kg/cm²) with batch sizes of 10 litre milk. The study of energy analysis in terms of thermal and electrical calculation, overall heat transfer coefficient, energy input and output, energy losses and consumption were needed for the performance evaluation of the entire mechanized system.

Electrical Power Consumption

The electrical energy consumption (input voltage, current and power) of the mechanized jacketed kettle was measured by power analyzer (MULTISPAN, 3- , 4-wire power analyzer, 440 volt) and energy meter installed in the electrical circuit.

Determination of Overall Heat Transfer Coefficient

The study of heat transfer was the most important aspect for designing the machines and generating data for improving the machine's operating conditions. It also aids in the selection of scraper assembly and kettle designs. The rate of heat transfer is influenced by a number of factors (i.e., the type of metal and its thickness was also affecting heat transfer performance). Steam kettles are usually hemispherical in shape, but for traditional dairy products, a flat bottom and shallow form is preferred.

Milk has been processed in a mechanized machine kettle at a lower temperature (14-16°C). It was appropriate to provide steam in the jacket for sensible heating of milk up to its boiling point in the first stage of sensible heating. As a result, the following formula was used to calculate sensible heat Qs:

i) Sensible heating

$$Q_s = M \quad CpM \quad (Te - Ti)$$

Where,

Q_s = Sensible heat transfer, kJ

M = Mass of feed, kg

CpM = Specific heat of feed, kJ/kg ºC

Te = Evaporation temperature, ºC

Ti = Temperature of feed, ºC

ii) Latent heating

$$Q_L = E \quad L$$

Where,

Q_L = Latent heat transfer, kJ/hr

E = rate of evaporation, kg/hr

L = latent heat of evaporation, kJ/kg

As the evaporation at different stages ofmanufacture takes place at atmospheric conditions, latent heat of evaporation, (L) was taken as 2258 kJ/kg.

Total Heat transfer (Q_t) = Total sensible heat (Q_{st}) + Latent heat (Q_L)

Now, using heat flow equation,

$$Q_t = U \quad Ae \ \Delta T$$

Where,

U = Overall heat transfer co-efficient, W/m^2 ºC

Ae = Effective area of heat transfer, m^2

ΔT = Temperature difference, ºC

Thermal Energy Analysis

The mechanized system was based on mechanized steam jacketed kettle with a hemispherical bottom and scraper assembly, which was used to collect and concentrate raw materials for the manufacture of *MathuraPeda*. The concentration of the mixture was requiring different scraper speeds and steam pressures.

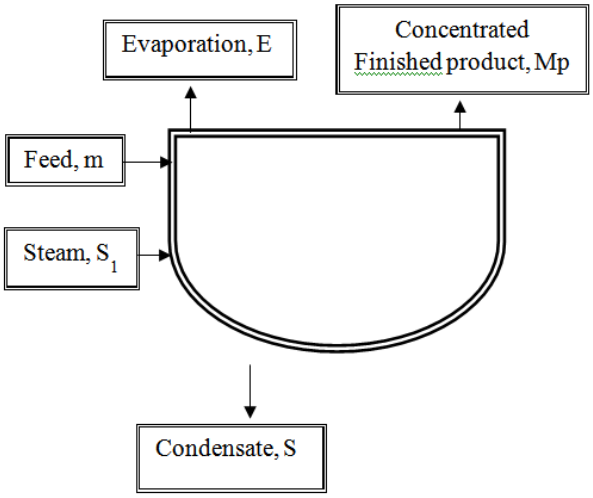


Fig 2: Block diagram of input and output energy of *Mathura Peda*manufacturing in mechanized steam jacketed kettle

Rate of heat energy input = Rate of heat energy leaving the mechanized system + Losses

$$H_f + H_s = H_c + H_e + H_p + E_1$$

$$(mf \ Cpf \ Ti) + S_1 \ (hs + x \ h_L) = (S_1 \ Cpc \ Ts) + (E \ Hv) + (mp \ Cpp \ Th) + E_1$$

Where,

H_f= heat energy of feed

H_s= heat energy of steam

H_e= heat energy of evaporation

H_c= heat energy of condensate

H_P= heat energy of product

hs = Sensible heat of steam, kJ/kg

x = Dryness fraction of steam

h_L = Latent heat of steam, kJ/kg

Cpc = Specific heat of condensate, kJ/kg C

S_1 = Quantity of steam used kg/h

Ts = Saturation temperature of condensate, C

E = Evaporation rate of water from mechanized system, kg/h

E_1 = Energy loss, kJ/h

Hv = Enthalpy of evaporated water, kJ/kg

mf = Mass of *milk* taken in kettle, kg/h

mp = Mass of *Mathura Peda* leaving the kettle, kg/h

Cpp = Specific heat of the *Mathura Peda* leaving the mechanized system, kJ/kg ºC

Th = temperature of *Mathura Peda* leaving the mechanized system, C

RESULTS AND DISCUSSION

Rate of Evaporation during manufacture of *Mathura Peda* in a mechanized steam jacketed kettle under different operating conditions

The rate of evaporation (kg water

evaporated/h) in the mechanized steam jacketed kettle during the manufacture of *Mathura Peda* at different steam pressures and scraper speeds (Table 3). During the manufacturing of *Mathura Peda*, the rate of evaporation varied from 7.05 to 9.96 kg water evaporated per hour depending on the operating conditions. According to the details in the table, the rate of evaporation increased with the increase in scraper speed and steam pressure during the manufacturing of the *Mathura Peda*, due to the covering more effective area of heat transfer and effect of turbulence.

Table 3. Rate of Evaporation and U-values during manufacturing of Mathura Peda under different operating conditions of the mechanized steamjacketed kettle

Steam Pressure kg/cm^2 (kPa)	Scraper speed (rpm)	Rate of evaporation (kg water/h)	U-value (W/m^{2}K)
1.0	15	7.05	345.78
(98.1)	20	7.32	351.09
	25	7.61	364.98
1.5	15	7.98	382.79
(147.15)	20	8.40	402.90
	25	8.63	413.90
2.0	15	9.02	432.70
(196.2)	20	9.38	449.90
	25	9.96	477.72

Overall heat transfer coefficients (U-values) of mechanized steam jacketed kettle at different operating conditions during the manufacture of *Mathura Peda*

The overall heat transfer coefficients (U-values) during the manufacture of *Mathura Peda* in the mechanized steam jacketed kettle were determined (Table 3). The sample calculation of the U-value for one set of operating variables is given in Appendices.

Table 4. U-values during manufacturing of Mathura Peda under various operating conditions

Steam Pressure kg/cm2	U - Value W/m2K			
	Scraper Speed (RPM)			Mean (P)
	S1 (15)	S2 (20)	S3 (25)	
P1	347.24	352.34	366.07	355.21
P2	384.36	403.90	415.78	401.35
P3	435.01	451.05	480.03	455.36
Mean (S)	388.87	402.43	420.63	
	SEm±	CD (0.05)	CV %	
P	0.723	2.149		
S	0.723	2.149	0.53	
P X S	1.253	3.722		

** Each value is an average of three replications*

The average U-values derived from data collected under different operating conditions during the manufacture of *Mathura Peda* in the mechanized steam jacketed kettle. At various combinations of operating parameters, such as steam pressure and scraper rpm, the U-values obtained during the manufacturing of *Mathura Peda* in a mechanized steam jacketed kettle ranged from 345.78 to 477.72 W/m^2K.

Statistical analysis of the data showed that the main effects of steam pressure (P) and scraper speed (S) during the manufacturing of *Mathura Peda* in the mechanized steam jacketed kettle were significant at a 5% level of significance. Steam pressure and scraper speed (PS) had a significant interaction effect. The U- value during the manufacture of *MathuraPeda* under various processing conditions of mechanized steam jacketed kettle (Table 4).

Increase in the level of steam pressure and scraper speed there was increase in the U-values. The higher scraper speed gave higher rate of evaporation. Similar findings on overall heat transfer coefficients have been reported during manufacturing of *Halwasan*, *Burfi* and other traditional products. (Vyas, 2011).

Thermal energy requirement

Steam consumption was in the range of 15.75 to 20.84 kg/h under different operating conditions. According to the results, steam consumption increased as steam pressure and scraper speed increased during the manufacturing of *Mathura Peda* in the mechanizedsteam jacketed kettle.

Under various operating conditions, specific steam consumption ranged from 2.09 to 2.26 kg steam/kg water evaporated. Thesteam pressure and scraper speed increased and specific steam consumption decreased as well (Table 5). Increase in the speed resulted into reduction in the specific steam consumption which may be due to intense agitation and more heat penetration in the whole mass.

Table 5. Steam consumption and specific steam consumption of *Mathura Peda* manufacturing in mechanized steam jacketed kettle

Steam Pressure kg/cm2 (kPa)	Scraper speed (rpm)	Rate of evaporation (kg water/h)	Steam consumption kg/h	Specific steam consumption (kg steam/ kg water evaporated)
1.0	15	7.05	15.75	2.23
(98.1)	20	7.32	16.07	2.20
	25	7.61	16.23	2.12
1.5	15	7.98	17.78	2.23
(147.15)	20	8.40	17.98	2.14
	25	8.63	18.08	2.10
2.0	15	9.02	20.41	2.26
(196.2)	20	9.38	20.62	2.20
	25	9.96	20.84	2.09

Table 6. Heat energy input, output and heat losses during the manufacture of *Mathura Peda*

Steam Pressure kg/cm2 (kPa)	Scraper speed (rpm)	Heat energy of feed kJ/h	Heat energy of steam kJ/h	Heat energy of condensate kJ/h	Heat energy of evaporated water kJ/h	Heat energy of product leaving kJ/h	Energy losses kJ/h	Energy losses (%)
1.0	15	573.78	37802.21	8051.31	19150.62	416.70	10757.36	28.42
(98.1)	20	595.51	38570.2	8214.89	19884.05	432.48	10634.34	27.57
	25	618.96	38954.27	8296.68	20671.80	449.51	10155.24	26.07
1.5	15	649.65	42674.49	9089.04	21676.87	471.80	12086.43	28.32
(147.15)	20	683.54	43154.52	9191.27	22817.76	496.41	11332.62	26.26
	25	701.85	43394.53	9242.39	23442.53	509.71	10901.75	25.12
2.0	15	734.65	48986.86	10433.48	24501.93	533.53	14252.57	29.09
(196.2)	20	763.18	49490.89	10540.83	25479.83	554.53	13679.16	27.64
	25	810.39	50042.92	10658.40	27055.34	588.53	12551.04	25.08

The energy components of heat input, heat output, and heat losses. This energy components are represented in hours and showed an increasing trend as steam pressure and scraper speed increased. At different steam pressures and scraper speeds, total heat losses in the mechanized steam jacketed kettle during the manufacture of Peda varied from 25.08 to 29.09 % of the heat input as steam (Table 6).

Electrical energy requirement

The electrical power consumption of the mechanized steam jacketed kettle during the manufacture of *Mathura Peda* (Table 7). These values ranged from 217 to 245 Wh depending on the operating conditions. The data indicates that the rise in electrical power consumption with the increase in scraper speed. The average power consumption during *Mathura Peda* manufacturing was 0.231 kWh. The mechanized steam jacketed kettle requires very little electrical power in comparison to the amount of thermal energy used. A similar observation has been reported by Bhadania (1998), Dhotre (2006), and Dodeja and Deep (2012) during the manufacture of *khoa* and thermal processing of dairy products.

Table 7. Electrical power consumption of the mechanized steam jacketed kettle during manufacture of Mathura Peda

Steam Pressure kg/cm2 (kPa)	Scraper speed (rpm)	Electrical power consumption Wh
1.0	15	217
(98.1)	20	228
	25	240
1.5	15	220
(147.15)	20	230
	25	242
2.0	15	224
(196.2)	20	235
	25	245

CONCLUSION

It is important to introduce mechanization on sweetmeat to address the drawbacks associated with traditional technology and make it easier to adopt at a commercial scale for large production. However, no attempt at mechanized development of *Mathura Peda* has been published.

The optimum formulation of the product, the efficiency of the mechanized steam jacketed kettle used in the experiment was evaluated at various scraper speeds (S_1=15 rpm., S_2=20 rpm., S_3=25 rpm.) and working steam pressures (P_1=1.0 kg/cm^2, P_2=1.5 kg/cm^2, P_3=2.0 kg/cm^2).

The U-values of the mechanized steam jacketed kettle at various operating conditions were calculated. The electrical energy consumption of the mechanized steam jacketed kettle was calculated using the power analyzer attached to the jacketed kettle, and the energy analysis of the mechanized jacketed kettle in terms of thermal energy was carried out using heat & mass balance equations.

The rate of evaporation ranged between 7.05 to 9.96 kg water evaporation/h during manufacturing of *Mathura Peda* at different operating conditions. The rate of evaporation increased with the increase in scraper speed and steam pressure.

The U-values of the mechanized jacketed kettle increased with increase in steam pressure and scraper speed during *Mathura Peda* making process. The range of U-values were about 345.78 to 477.72 W/m^{2}K. under various operating conditions of the mechanized jacketed kettle.

The values of steam consumption and electrical power consumption under different operating conditions during manufacture of *Mathura Peda* ranged from 15.75 to 20.84 kg/h and 217 to 245 Wh, respectively. The specific steam consumption of optimized product was found in the range of 2.09 to 2.26 kg steam/kg water evaporated.The energy components of heat input, heat output and heat losses showed increasing trend withincrease in steam pressure and scraper speed. The total heat losses during manufacture of *Mathura Peda* in the mechanized jacketed kettle ranged from 25.08 to 29.09% of the heat input by the steam, at different steam pressures and scraper speeds.

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Molecular Authentication of the Traditional Medicinal Plant *Nyctanthesarbor-tristis* (Linn.) by RAPD –DNA Fingerprinting Technique

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ABSTRACT

The RAPD (Random Amplified Polymorphic DNA) technique was employed in the present study for determination of the components in an Ayurvedic herbal medicine. The RAPD approach is appealing to a large number of scientists since, it may be implemented in a variety of settings with little effort. Most importantly, Random Amplified Polymorphic DNA analysis does not require any cloning, sequencing, or other molecular characterization of the genome in order to extract a large number of genetic markers from a small amount of DNA. Fresh leaves ofthe*Nyctanthesarbor-tristis* (Linn.) plant were gathered in the month of June in the surroundings of Solapur. Researchers used OPAB11, OPT12, OPQ15, and OPC10 4 decamer primers to conduct a RAPD study, which measures genetic variation at random. Pure and RNA-free high-molecular-weight DNA was extracted from the leaves. The DNA was amplified with repeat primers and 4PCR primers, and then analysed on agarose gels.

Keywords : *Nyctanthesarbor-tristis* (Linn.); RAPD analysis; DNA: Primer; RAPD markers

INTRODUCTION

The RAPD (Random Amplified Polymorphic DNA) technique was employed in this study for determination of the components in an Ayurvedic herbal medicine. India is home to an abundance of flora and fauna that should be protected and studied. Having access to a large genome will help us overcome the obstacles to food production caused by various biotic and abiotic stressors. Only if there is a large diversity of genes within these kinds they can be crossed successfully. Unfortunately, bio-wealth is under constant attack despite our reliance on it. Recent developments in molecular biology have laid the groundwork for the discovery of an almost infinite variety of DNA markers. DNA-based markers' value is often established by the methods employed to uncover polymorphism in DNA. The Restriction Fragment Length Polymorphism (RFLP) assay, which measures genetic diversity and creates a genetic linkage map, is currently the method of choice for a wide range of species. To identify DNA polymorphism, the Restriction Fragment Length Polymorphism (RFLP) technique uses restriction enzyme digestion and DNA hybridization, both of which take a considerable amount of time and effort. Polymerase chain reaction (PCR) technology has quickly proliferated over the past decade, allowing for the creation of a number of novel genetic assays based on the selective amplification of deoxyribonucleic acid (DNA). The high success rate and seeming ease of polymerase chain reaction (PCR) are two of the main reasons for its widespread use.

Unfortunately, Polymerase chain reaction (PCR) tests are restricted in their utility due to the requirement of DNA sequence information. The establishment of genetic markers for various purposes was aided by the realization that Polymerase chain reaction (PCR) with random primers can be employed to amplify a set of randomly dispersed loci in any genome.

Principal of Random Amplified Polymorphic DNA Methods:

Polymerase chain reaction (PCR) amplification of random portions of genomic DNA with a single primer of arbitrary nucleotide sequence yields decamer (10-nucleotide length) DNA fragments that can differentiate between genetically separate individuals, albeit not always in a reproducible manner. It employs a random order of primers to examine the ancestry of a given individual. Several of the most prevalent uses of Random Amplified Polymorphic DNA markers are reviewed, as well as their concepts, operating mechanism, characteristics, laboratory techniques, data processing and interpretation, advantages, and limitations. Many researchers are curious about the Random Amplified Polymorphic DNA method. The ability to obtain a large number of genetic markers from very little amounts of DNA without the need for cloning, sequencing, or any other type of molecular characterization of the genome of the species in question is perhaps the most important factor in the success of Random Amplified Polymorphic DNA analysis.

A complex DNA template is utilised to amplify random sequences using a single, short oligonucleotide primer that binds to many distinct loci. This indicates that the size of the amplified fragment produced by Polymerase chain reaction (PCR) is proportional to both the length and size of the primer and the genome being amplified. An underlying premise of Polymerase chain reaction (PCR) amplification is that a given DNA sequence (complementary to that of the primer) would exist in the genome on opposite DNA strands in opposite orientation at a distance that is amenable to amplification by Polymerase chain reaction (PCR). These enlarged products (up to 3.0 kb) are typically separated on agarose gels (1.5-2.0%) and ethidium bromide stained for visualization. The use of a single decamer oligonucleotide stimulates the production of many discrete DNA products and these are believed to come from separate genetic loci. The presence or absence of a specific Random Amplified Polymorphic DNA band indicates the presence or absence of polymorphisms caused by mutations or rearrangements at or between the primer binding sites[7].

Many researchers are interested in the Random Amplified Polymorphic DNA method because of how easy it is to use and how broadly it may be applied[8]. The ability to obtain a significant number of genetic markers from very little amounts of DNA without the need for cloning, sequencing, or any other type of molecular characterization of the genome of the species in question is perhaps the most important factor in the success of Random Amplified Polymorphic DNA analysis[9].

In this study, we tested how well Random Amplified Polymorphic DNA analysis worked at identifying polymorphism in*Nyctanthesarbor-tristis* (Linn.).Our primary goal was to ascertain whether or whether this strategy could be used to generate polymorphic markers in

Nyctanthesarbor-tristis (Linn.)for the purposes of genotype identification, phylogeny analysis, and the creation of a genetic map of *Nyctanthesarbor-tristis* (Linn.)

MATERIALS AND METHODS

Collection and authentication of plants

The fresh leaves parts of *Nyctanthesarbor-tristis* (Linn.) were collected from local areas of Solapur District in month of June. The collected plant materials were authenticated at P.G. Department of Botany and Research Centre D. B. F. Dayanand College of Arts and Science, Solapur, India.DNA fingerprinting of plant is performed at the Centre for DNA fingerprinting and diagnostic, Hyderabad.

Procedure

Random amplified polymorphic DNA (RAPD) analysis was performed with 4 decamer primers like OPAB11, OPT 12, OPQ 15, and OPC10.

DNA Extraction

DNA was extracted from the leaf of *Nyctanthesarbor-tristis* (Linn.) using Gsure plant mini kit and quantitated using Nanodrop. PCR was performed in 25µl reaction volumes containing 1X PCR buffer [10mM Tris HCl (pH 8.3), 50mM KCl, 1.5 mM $MgCl_2$], 200µM dNTPs, 50ng of template DNA, 5 pmol of each primer, and 5 unit of Taq polymerase (Thermo scientific). PCR conditions included an initial Denaturation step at 94°C for 5 min, followed by 40 cycles of 94°C for 1 min, 36°C for 1 min and 72°C for 2 min and a final extension at 72°C for 7 min. All amplified products were resolved in 1% agarose gels (Lonza Inc., USA) along with 1kb molecular marker (Thermo scientific). The reproducibility of the bands generated by these 04 primers was confirmed by replicating the amplification twice and if needed thrice. Only the bands showing reproducible amplification were considered for scoring and for further analysis.

The plant and DNA fingerprinting profile of*Nyctanthesarbor-tristis* (Linn.) is shown in Figure 1. Comparison of primers and DNA bands from the*Nyctanthesarbor-tristis* (Linn.) accession shown in table 1.

RESULTS AND DISCUSSION

High molecular weight DNA extracted from the leaf material was found to be pure and free of RNA. The DNA was diluted and was amplied using 4 Polymerase chain reaction (PCR) primers, repeat primers and were analysed on 1% agarose gels.



Fig.1: Image of *Nyctanthesarbor-tristis* (Linn.)

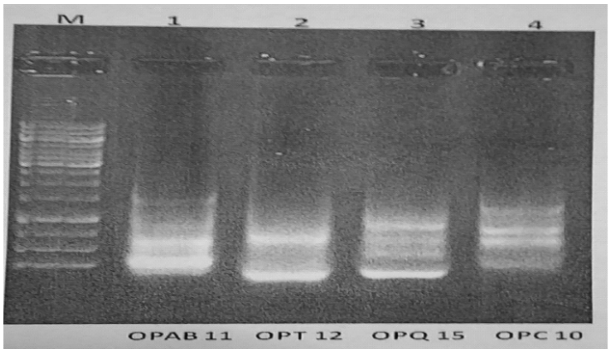


Fig.2: DNA fingerprinting profile of *Nyctanthesarbor-tristis* (Linn.) using RAPD markers.Lane 1: OPAB11, Lane 2: OPT 12, Lane 3: OPQ 15, Lane 4: OPC 10. M is the 1Kb molecular weight size standard.

Table 1: DNAfingerprinting profile of *Nyctanthesarbor-tristis* (Linn.)

Primers	Size (Base Pairs)	Primer sequence
OPAB 11	~230 ~250 ~650 ~1300	GTGCGCAATG
OPT 12	~200 ~670	GGGTGTGTAG
OPQ15	~210 ~400 ~670 ~910	GGGTAACGTA
OPC10	~250 ~670 ~850 ~1200	TGTCTGGGTG

This research shows that the Random Amplified Polymorphic DNA method may be used to successfully uncover useful DNA polymorphisms in species with extremely large genomes, such as *Nyctanthesarbor-tristis* (Linn.) Species. The high-molecular-weight DNA isolated from the leaves was found to be RNA-free and pure. Using 4 PCR primers and repeat primers, the DNA was amplified and then analysed on 1% agarose gels. The trials were repeated, and only the bands that could be replicated each time were used in the final statistical analysis. In a set of experiments using different dinucleotide repeat primers, all primers successfully produced clear bands. It's not easy to explain why Random Amplified Polymorphic DNA profile complexity is not correlated with genome size. Scientists believe that competition among priming sites in the template, rather than the total number of priming sites accessible, governs the composition of amplification products in Random Amplified Polymorphic DNA reactions. Under the relaxed annealing conditions used in the thermal cycling, primer-template mismatches are more likely to arise. Therefore, in the presence of several priming sites, competition leads to a greater proportion of initiations from perfectly matched sites and a lower total number of products. Our results show that phylogenetic analysis of species is possible through the application of Random Amplified Polymorphic DNA markers. A less biassed and more thorough dendrogram might be generated by the study of a larger number of cultivators within each species, as well as other wild relatives of cultivated *Nyctanthesarbor-tristis* (Linn.). Single sample for DNA barcoding analysis is reliable and convenient for authenticating medicinal species. Additionally; this would permit a more precise measurement of the differences in genetic makeup between different species. A more precise reconstruction of the *Nyctanthesarbor-tristis* (Linn.) Genus may be possible with the use of such an analysis and data from other cladistic methods. The use of such a method could also be useful in locating other wild*Nyctanthesarbor-tristis* (Linn.) Species that could be of use in genetic improvement efforts. DNA Barcoding method is effective utility in quality control of commercially important medicinal herbs which are adulterated. Application of these DNA barcoding techniques will help in identifying the authentic samples of herbal drugs used in herbal formulations. This also helps to identify the potent medicaments in the preparation.

CONCLUSION

This study shows that the Random Amplified Polymorphic DNA method can find useful DNA polymorphisms in large-genome species like *Nyctanthesarbor-tristis* (Linn.). High-molecular-weight leaf DNA was RNA-free and clean. DNA was amplified and analysed on 1% agarose gels

using 4 Polymerase chain reaction (PCR) and repeat primers. Only repeatable bands were employed in the statistical analysis. All dinucleotide repeat primers produced clear bands in experiments. It is hard to explain why Random Amplified Polymorphic DNA profile complexity does not correlate with genome size. According to scientists, Random Amplified Polymorphic DNA reactions, amplification products are determined by template priming site competition rather than total priming site accessibility. Thermal cycling relaxes annealing, increasing primer-template mismatches. Thus, competition between priming sites increases the proportion of perfectly matched initiations and decreases the total number of products. Random Amplified Polymorphic DNA markers allow phylogenetic analysis of*Nyctanthesarbor-tristis* (Linn.) species. Studying multiple cultivators within each species and other wild relatives of farmed*Nyctanthesarbor-tristis* (Linn.) may produce a more accurate dendrogram. This would also enable more accurate species-specific genomic measurements. Such an analysis and other cladistic methods may help reconstruct *Nyctanthesarbor-tristis* (Linn.) more precisely. This strategy could potentially help to find wild*Nyctanthesarbor-tristis* (Linn.) species for genetic improvement.

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Suggestions on Retaining Students and Increasing Enrolments in Foods and Human Nutrition (Home/ Community Science Education)

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ABSTRACT

The Corona pandemic has put focus on health and immunity like never before. It has boosted the field of nutrition, food product development and related areas. But, the field of education in foods and nutrition is struggling with the problem of low enrolment of students. To solve this, it is imperative to identify the factors causing the students to withdraw from the subject. Hence, the present study was purposely carried out with the college students and faculty members selected from home/ community science colleges/ departments of six universities in five states. The information pertaining to the causative variables behind student drop-outs and suggestions for student attraction and retention was gathered from 166 students and 51 teachers respectively. According to the students and faculties, the causes behind withdrawal from the subject were no interdisciplinary collaborations and inter-linkage with the nutrition and food organizations/NGOs/government organizations. Reforming the traditional curriculum of food science and nutrition can contribute to higher enrolment and retention as per the findings of the study. The study concluded that implementing these suggestions can aid in better enrolments. Advantage can be taken of the digital measures and tools available today to reach larger sections of the student population. Cues can be taken from the guidelines of National Education Policy 2020.

Key words: Home/ Community Science, Foods and Nutrition and Enrolment enhancement.

INTRODUCTION

The pandemic has put focus on health and immunity like never before. Boosting immunity, staying healthy, especially through natural methods has become the favorite topic of discussion for most households. Now this is a welcome change but at the same time, there has been rampant circulation of misinformation and fad practices about health, immunity and most prominently diet. There is a never before need for specialized experts in diet, nutrition, food product development and related areas. But, the field of education in foods and nutrition is struggling. Foods and nutrition, a discipline of the beautiful field of Home/community Science, has been experiencing dwindling enrolment of students for quite some time now.

Overall, the education sector of India is booming with the largest student population in the world (over 350 million). Efforts will have to be put in to ensure that this young upcoming generation gets itself involved in fields requiring most consideration. Proper direction will have to be provided to improve the enrolment in concerned subjects by addressing causative variables and suggestions for retaining them in Home/Community and Agriculture Sciences. As per the All India Survey on Higher Education (2015-16) conducted by

Ministry of Human Resource Development, Department of Higher Education (New Delhi), there are only 9970 students enrolled in higher education under home science, only 98876 students are enrolled in B.Sc. (Agriculture) as compared to 5,09,031 students in Bachelor of Sciences and 13,80,583 in Bachelor of Arts. The Gross Enrolment Ratio in higher education of Rajasthan is only 18.50 percent for females; which is sadly lower than Chandigarh (70.40%), Delhi (48.20%), Tamil Nadu (42.40%) and Himachal Pradesh (35.50%) along with other states of India.

Health and education are strongly interconnected while a healthy individual is more likely to have better education outcomes, the right education can improve the health status of the household. The government has launched various developmental programmes and Home/Community Science education contributes to maximizing its benefits to the target population via nutrition and health education, and effective dissemination of authentic information. Home/Community Science takes note of the ecological conditions of the rural families and educates them on the methods to maximize the benefits accruing from them.

According to Raghuvanshi (2018), there has been a great revolution in the field of Home/community Science. This subject which was earlier perceived as only suitable for girls, to prepare them for domestic life and motherhood, is now viewed as multi purpose programme being taken up by both girls and boys. New dimensions have been attained in its concerned departments, viz. Foods and Human Nutrition, Textiles and Apparel Design, Human Development, Resource/Home Management and Extension Education and Communication Management. This education can undoubtedly contribute to empowering the minds of young girls and boys.

Foods and Human Nutrition is a beautiful subject that deals with imparting knowledge about the significance of correct dietary practices and the underlying science. Looking at the condition of the country in terms of malnutrition and hidden hunger, the significance of nutrition education increases manifolds. This multidisciplinary subject emphasizes nutrition education, hygiene and sanitation, improvement in food quality and product development. But with the advancement in the education sector, there is a declining enrolment rate in Home/Community Sciences.

So, in order to attract more students towards Food Science and Nutrition, it is imperative to identify the factors that cause them to withdraw from the subject and also determine their idea and suggestions for retention in Home/ Community Sciences. Keeping above factors in mind, the present study was designed with the objectives:

1. To identify the causative variables for student drop-outs in Home/Community Sciences in the field of Food Science and Nutrition
2. To determine the suggestions from Home/Community Sciences students and faculty members for attracting and retaining students in the field of Food Science and Nutrition.

MATERIALS AND METHODS

The present research (conducted under the ICAR funded extramural project) was carried out purposively with the college students and teachers/ professors that were selected from Home/community Science colleges/departments from Maharani College (University of Rajasthan, Jaipur, Rajasthan), Choudhary Charan Singh Haryana Agricultural University, Hisar (Haryana), Gobind Ballabh Pant University

of Agriculture and Technology, Pantnagar (Uttarakhand), Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan), Maharaja Sayajirao University, Vadodara (Gujarat) and Avinashilingham University of Women, Coimbatore. The information pertaining to the causative variables and suggestions for their retention in Food Science and Nutrition was gathered through an online Google tool survey; some were contacted personally and others through the email-id, which led to a total of 166 students and 51 teachers/ professors. The results were coded initially and based on the frequency of the respondents they were recorded and tabulated. The percentages are calculated and presented in the result section.

RESULTS AND DISCUSSION

Deriving causes behind student drop-outs from concerned subject teachers and students

Data in Figure (1) highlights the causes that lead to student drop-outs in the Food Science and Nutrition department of Home/ Community Science colleges. The majority of the students (68.70%) reported that due to a lack of awareness about the career avenues and job prospects in the Food Science and Nutrition department, students are getting shifted to other courses. Moreover, most of the students (41.6%) also pointed out that due to a lack of exposure to experiential training, internships in industries and hospitals there is a decline in enrollment and an increase in drop-outs. Furthermore, three-fourth (76.50%) of the faculty members responded with the same cause for drop-out: that there is a lack of awareness regarding career avenues like public/ health/ community etc. Also, most of the faculty members (47.1%) believed that due to inadequate marketing of self-developed healthy products, students are dropping out of the concerned department.

Apart from the information given in figure 1, students also believed that there is no new motivation and the same traditional pattern is being followed in the syllabus. Further, there is a lack of streamlining or specialization in the particular field and no collaboration of the college with other Indian or foreign universities. Furthermore, faculties also believed that there is a lack of awareness about the entrepreneurship potential of the subject. Moreover, doctors suggest the diet charts to the patients so, the dietician suggestions remain impractical in the Indian scenario.

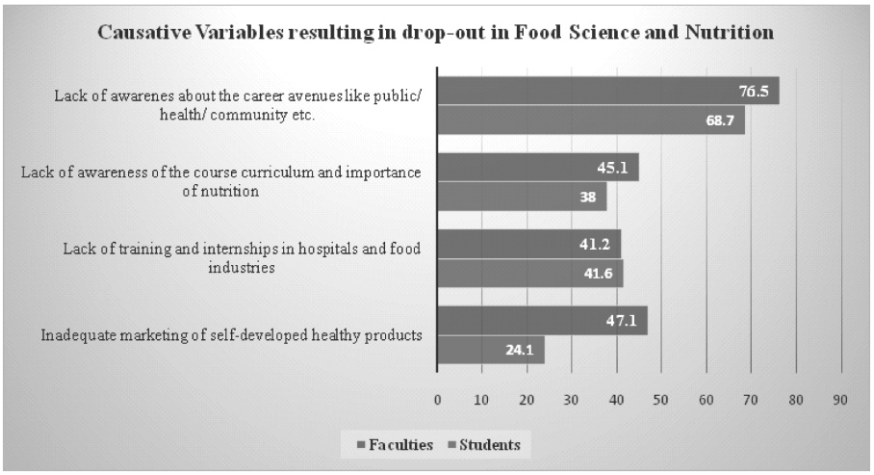


Figure 1: Causative Variables resulting in drop-out in Food Science and Nutrition

Suggestions to attract and retain the students in Food Science and Nutrition

A perusal of Figure (2) infers the suggestions collected from the students and faculty members to attract and retain the students in Food Science and Nutrition..

Data in Figure 2 showed that the majority of the students (71.7%) suggested that the University linking up with the health/ dietary/ community departments can retain the students in the concerned department. Similar results were reported from the faculties also as 78.4 per cent of them suggested that the University link up with the health/ dietary/ community departments to retain the students. This was followed by the student's suggestions as the inclusion of diplomas, certificate courses and skills to be introduced at UG level (61.4%), publicizing the self-prepared healthy food products (47.6%) and re-framing the concept of lab-to-land and vice-versa (39.8%). Results of the suggestion from faculties showed similar results.

Apart from the above mentioned suggestions, more suggestions were given by students and faculties as career related counseling and internships during the summer break should be included in the curriculum to utilize the time productively and publicizing the public health department also with the dietetic ones. Furthermore, focus on lab work for development of food products that are economic, healthy and nutritious and are meant for marketing and distribution in rural communities could also be made part of the curriculum.

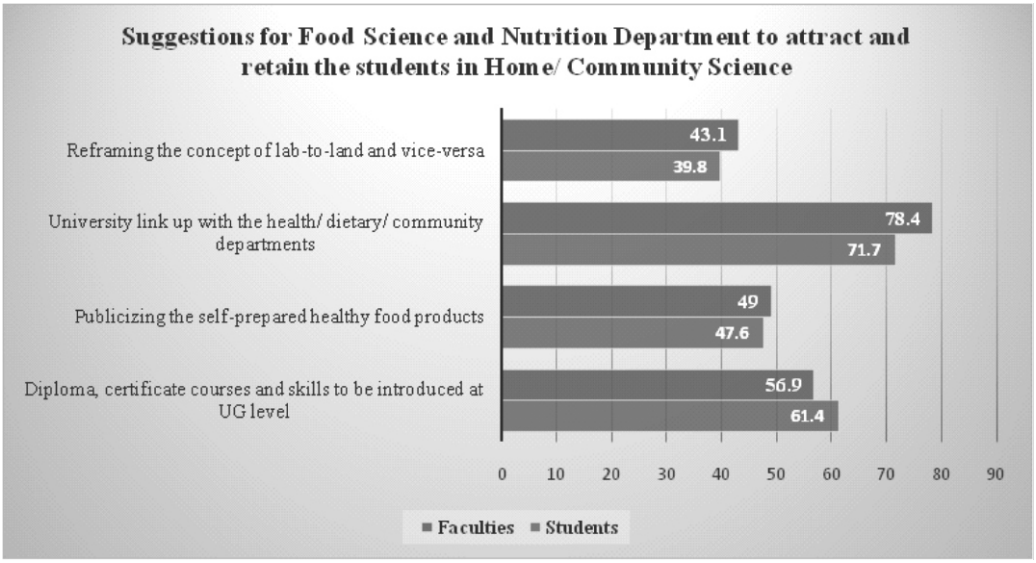


Figure 2: Suggestions for Foods and Nutrition Department to attract and retain the students in Home/ Community Science

RECOMMENDATIONS IN LINE WITH NEP, 2020

Health is a multidimensional concept that is shaped by biological, physical, psychological, social, economic, cultural and political factors. Access to basic needs like food, safe water supply, housing, sanitation and health services influences the health status of a population and these are reflected through mortality, morbidity and nutritional indicators. So, Health, Foods and Nutrition education is mandatory for the

students and there is a need to re-design the curriculum for better enrollment rates. In line with this, the National Education Policy, 2020 had crucial guidelines set by the Government of India to achieve the goal of quality education. There are various recommendations in line with NEP, 2020 policy that can be noted for upgrading the field of Foods and Nutrition:

1. Students in Foods and Nutrition should learn as per their will through holistic and multidisciplinary approach, where students can combine multi-disciplinary subjects along with integration of vocational courses, for example clinical nutrition with human development or community nutrition with extension education . The element that can be incorporated is that the students will be given 'multiple exit options' and appropriate 'certification' within their graduation degree only. For instance, Foods and Nutrition students will get certification after completing one-year, offer an advanced diploma after two-year, a Bachelor's degree after completion of 3 years and a degree indicating research intelligence by the end of the 4th year.
2. Other university linkages and inter-departmental collaborations should be encouraged to provide a better linkage, support talented students and help students grasp the concept better.
3. University/ college should create an autonomous entity to ensure appropriate integration of technology with foods and nutrition education. Thereafter, institutions will also be able to empower their faculty as well as students by streamlining lecture processes through ICT-enablement.
4. Blended learning approach should be followed and new modifications to be made in traditional classrooms. A dedicated team for developing digital infrastructure including e-content, digital library, etc. can be initiated to meet the needs of students and maximize their learning outcomes.

CONCLUSION

Every field of education needs a good quantity and quality of students in order to remain relevant and thrive. Low student enrolment and higher rates of dropouts are a problem for all five disciplines of Home/community Science education today. The study endeavoured to identify the causative factors behind low enrolments in Foods AND Nutrition science and strategies to retain the students. The most significant cause was lack of diversity of courses in the field and product development labs in the departments and universities. However, the study also found that inter-linkages with food and nutrition organizations, non-governmental organizations and revamping the traditional curriculum of food science and nutrition along with some major interdisciplinary collaborations can make a substantial impact in retaining and attracting students. Guidelines of National Education Policy 2020 can also be followed for better formulation and upgradation of Foods and Nutrition syllabi and their implementation. Advantages can be taken from the easy availability of digital tools and media to improve the enrolment rates and address the misconceptions about the subject.

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A Review on Biosynthesis Mechanism and Application of Microbially Produced Exopolysaccharide Substance (EPS)

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ABSTRACT

Recent discoveries in science increases use of microorganism and microbial products in various commercial, industrial and environmental applications. Microbial exopolysaccharide substance(EPS) are produced by bacteria, fungi and algae. Study of biosynthesis pathway for EPS production provides idea regarding composition of polymers and in-situ view to engineered pathway to get desired polymers. EPS is composed of carbohydrate, protein, uronic acids, humic substance, lipids etc. EPS can help microbes in survival against different environmental conditions. EPS released by microbial cells provides defense against harsh conditions of starvation, pH, and temperature. Due to its structure and efficient role in nature EPS can be utilize in the field of medicine, environment, food industry, cosmetic industry and agriculture.

INTRODUCTION

Microorganisms resembles natural polymers that are tightly associated with cell surface or they may be liberated into outer environment as exopolysaccharides substance(EPS) having wide variety in structural and functional aspects. Due to increasing demand of natural polymers, microorganisms are widely used for production of biopolymers. Certain carbohydrates are produced by microorganisms as extracellular polysaccharide having wide applications in food industry, pharmaceutical industry and environmental pollutant removal. These polysaccharides are produced by microorganisms as attached capsule with bacterial cell wall or liberated into the medium as ropy polysaccharide or mucus (Behare*et al.,* 2009; Broadbent *et al.*, 2003; Yang *et al.,* 2018). Exopolysaccharides are biosynthetic organic polymers secreted outside the cell responsible for binding of microbial cell and particulate material known as cohesion and when binds with substratum known as adhesion (Salama *et al.,* 2015). During environmental stress condition, certain microorganisms produce extracellular polysaccharide as a self defense which not only protects them from toxic substances and dewatering but also serves as source of carbon and energy (Patel *et al.,* 2014; Gupta & Diwan, 2017). EPS also plays important role in biofilm formation and in host pathogen interaction

(Schmid, 2018). These biopolymers resemble exemplary physiological, rheological and physio-chemical properties which makes them suitable for various clinical, industrial and environmental applications. Besides polysaccharide backbone, EPS possesses multiple structural diversifications by altering various side chains, functional groups, non-carbohydrate substitution as well as diverse bonding and linkages results in generation of different homopolysaccharides as well as heteropolysaccharide. EPS present in peripheral surface of microorganisms can defend them against infiltration of toxic metal ions. Sequestration of metal ions depends on structural and compositional makeup of EPS and due negative charge of EPS, which combines with positively charged heavy metal resulting in biosorption of heavy metals. Due to this property of EPS from last few years has been widely used in reduction of heavy metal contamination. (Gupta and Diwan, 2017).

COMPOSITION AND TYPES OF EPS

Biosynthetic polymer EPS is majorly composed of carbohydrates. Second most important component of EPS is protein which accounts for 10-60%(W/W). In matrix of EPS other molecules such as lipids, nucleic acids, uronic acids and some other inorganic materials are also found which together with carbohydrate & protein help in adhesion, aggregation, adsorption, storage and protection of microbial cell (Chen*et al.,* 2021; Salama *et al.,* 2015). Based on repeating units of monosaccharides, EPS can be classified as homopolysaccharides and heteropolysaccharides. Homopolysaccharides consist of single type of monosaccharides synthesized by anchored or secreted transglycosylases which are able to catalyze transfer of corresponding glycosyl moiety. Dextran, levan, mutan are examples of homopoly-saccharides produced by *Lactobacillus* sp., *Streptococcus* sp., *Leuconost-ocdextranicum* respectively. Heteropoly-

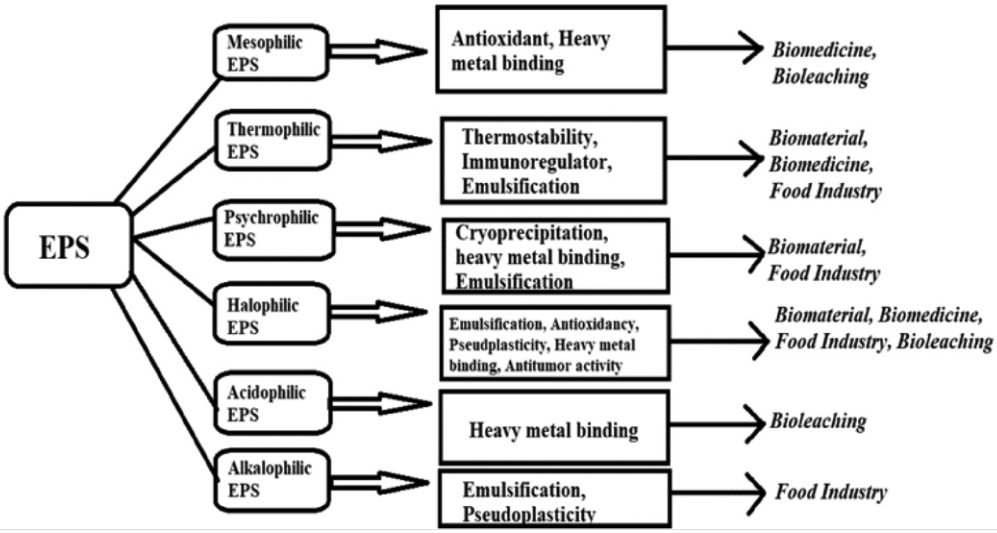


Figure 2.1: EPS secreted by different types of microorganisms and its function (Wange *t al.*, 2019)

saccharides are synthesized by repeating unit of branched and unbranched chain of different monosaccharide units majorly of glucose, galactose and minorly of rhemnose, mannose, N-acetylglu-coseamine, N-cetylglac-toseamine, glucuronic acid etc. Unlike homopoly-saccharides, heteropoly-sachharides are synthesized intracellularly at cytoplasmic membrane catalyze by glycosyl transferases which transfers sugar nucle-otide from activated donor molecules to specific acceptor molecules, thereby forming a glycosidic bond (Behare *et al.,* 2009; Nadzir *et al.,* 2021; Broadbent *et al.,* 2003).

BIOSYNTHESIS OF EPS

Exopolysaccharides are carbohydrate polymers that help organism to withstand extreme conditions. As it resist extreme environment, it offers novel microbial diversity which produces novel types of EPS (Satpute *et al.,* 2010). Biosynthesis of EPS occurs when various activated sugar monomers, derivatives of sugars such as sugar alcohol or aminated sugars make complex near the cytoplasmic membrane of cell resulting in formation of homopolysaccharidde s and heteropolysaccharides (Nichols *et al.,* 2005). Depending upon physiological condition of microbial cell, EPS can be synthesized by four general mechanisms such as Wzx/Wzy-Dependent Pathway, ABC Transporter-dependent pathway, Synthase-Dependent pathway & Extracellular Biosynthesis by Sucrase. Homopolysaccharides are generally synthesized by synthase dependent pathway and extracellular biosynthesis by sucrose protein whereas heteropolysaccharides are synthesizd by Wzx/Wzy-dependent pathway and ABC transporter-dependent pathway (Nadzir *et al.,* 2021).

3.1 Wzx/Wzy-Dependent Pathway:

The Wzx/Wzy-Dependent Pathway is a major pathway for EPS synthesis which consist of three stages: (i). synthesis of nucleotide sugars, (ii) assembly of repeating units, and (iii) polymerization and export. In first stage repeating units are constructed though appropriate transfer of monosaccharide units towards undecaprenyl phosphate (Und-P) anchored at the cytosolic side of the inner membrane. In second stage, glycosyl transferases (GTs) link more sugar units followed by its translocation across cytoplasmic membrane by Wzxflippase encoded by wzx gene. Side chain and other functional groups such as acetate, glycerol, pyruvate, succinate, sulfate will be incorporated before final polymerization event takes place, but at which stage it incorporate is still unclear. In third stage, translocated polysachharide chain undergo various modifications such as acetylation, methylation *etc*. and polymerized to polysaccharides by Wzy protein (Vuyst *et al.,* 2001; Nichols *et al.,* 2005;Wang *et al.,* 2019). Wzx gene encodes flippase protein which transfers repeating units in H^+ dependent antiporter mechanism. Different Wzx proteins lack similarity at sequence level indicated by various numbers of transmembrane sequences which conclude diverse type of wzx proteins exist. Wzx proteins are major target proteins for polysaccharide production. During the final construction of EPS, depolymerization occurs. Depending on the proteins involve

in depolymerization process, name of the pathway given as Wzx/Wzy pathway (Schmid, 2018).

3.2 ABC Transporter Dependent Pathway:

ABC Transporter dependent pathway is mainly involved in synthesis of capsular polysaccharides. Name ABC transport pathway comes from ATP Binding cassette dependent pathway in which active sugar units are transported to Und-P molecule in inner membrane of cell to form Und-PP sugar molecule by action of GTs and polymerizing enzymes located at cytoplasmic side of inner membrane. Synthesized polysaccharides are then translocated cross inner membrane by tripartite efflux pump complex (Nadzir *et al.,* 2021). Two strategies for ABC transporter dependent pathway have been identified. One is observed in *Klebsiella pneumoniae* O2a in which competition occurs between ABC transporter and assembly chain, which finalizes length of glycan chain. Second observed in *Escherichia coli* O9a in which uncoupled glycan synthesized and exported by non-reducing terminal modification of Und-P linked polymers that results in termination of chain extension. Glycan length dictated by terminator and ABC transporter recognized export signals resulting in accumulation of polysaccharides outside the inner membrane of cell (Schmid *et al.,* 2015).

3.3 Synthase-Dependent Pathway:

In contrast to ABC/Wzx-Wzy-dependent pathway, synthase based pathway synthesizes homopolysaccharides which made up of single type of monosaccharides such as glucose, maltose, galactose, *etc*. The major examples of homopoly-saccharides are bacterial cellulose or alginates. In biofilm forming bacteria, cellulose is a major polymer made up of linear beta-(1,4)-glucan. Glucose monomers are activated by assembly of cytosolic UDP followed by specific mechanism of cellulase synthase complex which includes conserved catalytic subunit BcsA (bacterial cellulose synthase subunit A) belonging to GT2 family and performed processive mechanism of polymerization after which polymers transported to outside the cell. In *Rhodobactersphaeroides*, BcsAB complex show GT activity and PILZ domain to interact with allosteric activator c-diGMP. Cellulose synthesis pathway is a highly variable and species specific (Wang *et al.,* 2019; Vuyst *et al.,* 2001). Alginate biosynthesis occurs via polymerization of GDP-mannuronic acid monomer by GT polymerase Alg8 and Alg44 which also act in polymerization. Complex of alginate biosynthesis consist of epimerases (AlgG), lyases (AlgL) and acetylases (AlgIJFX). In periplasmic complex, several extracellular alginate polymerases are present resulting in final modification of polymer characteristics (Krasteva *et al.,* 2017).

3.4 Extracellular Biosynthesis by Sucrase :

In this pathway, extracellular sucrase cleaves sucrose to monomeric unit outside cellular outer membrane. Polymerization of monomeric unit occurs by GTs forming dextran and levan with distinct branches. Molecular effect and branching effect depends on reaction condition and engineered sucrose variant. Synthesized EPSs are then realized into extracellular environment(Rehm, 2010; Patel *et al.,* 2012).

EPS PRODUCTION

Major component of EPS is carbohydrate. Hence it is required for EPS production in culture medium. During metabolism, intracellular accumulation of polysaccharides secretes exopoly-saccharide into culture medium. Microbes can produce EPS by solid state and submerge fermentation. After EPS production cultural biomass can be separated from fermentation broth followed by EPS extraction using solvents like ethanol, isopropenol, chloroform, acetone etc. In final step of EPS production, purification and drying is carried out to get pure EPS (Tabernero and Cardea, 2020; Chen *et al.,* 2021).

4.1 EPS producing microorganisms

Certain bacteria, fungi, algae can able to secrete extra polymeric substance in outer environment. Presence of various environmental factors, such as medium composition, temperature and pH greatly affects production and composition of EPS. Different environmental condition produces different kind of EPS based on specific enzymes secreted by microorganisms. These enzymes are responsible for polymerization of EPS (Behare *et al.,* 2009; Nouha *et al.,* 2017). Following tables provides idea regarding EPS produced by specific kind of microorganism.

Table 4.1: Various types of EPS produced by different types of microorganisms

Type of EPS	Micoorganisms	Reference
Dextran	*Leuconostocmesenteroides*	Broadbent *et al.*, 2003
Glucan	*Streptococcus mutans*	Broadbent *et al.*, 2003
Fructan	*Streptococcus salivarius*	Behare *et al.*, 2009
Xanthan	*Xanthomonas campestris*	Behare *et al.*, 2009
Acetan	*Acetobacter xylinum*	Behare *et al.*, 2009
Gellan	*Sphingomonaspaucimovilis*	Behare *et al.*, 2009
Alginate	*Pseudomonas aeruginosa, Azotobacter vinelandii*	Gupta and Diwan, 2017
Hyaluronan	*Pseudomonas aeruginosa, Pasteurella multocida*	Gupta and Diwan, 2017
Galactopol	*Pseudomonas oleovorans*	Gupta and Diwan, 2017
Fucopol	*Enterobacter sp.*	Gupta and Diwan, 2017
Kefiran	*Lactobacillus hilgardii, Lactobacillusrhamnosus, Lactobacillus kefir*	Nadzir *et al.*, 2021

APPLICATIONS OF EPS

Various properties of EPS such as pseudoplasticity and high viscosity make it resistant to various extremities of temperature, pH and salinity. Due to these properties EPS act as thickening, coagulating, adhesion, stabilizing and gelling agent used in various industrial and environmental applications. Novel EPS contains high uronic acid and sulfate contents in it's structural composition that increases its use in biotechnology. (Satpute *et al.,*2010).

5.1 In food industry:

EPS improves physical property of fermented products by acting as food stabilizer, viscosifier, texturizers, emulsifier

or gelling agent. Heteropolysaccharides produced from *Lactobaccilus* sp. used as food additives, function in starter culture results in safe and natural product. EPS improves rheological property, texture, stability of food material and have higher water retention power which increases demand of novel EPS producing microorganisms. Various types of EPS are used in food industry for example, incorporation of dextran in dough results in improvement of texture. Addition of softening agent glutan in dough ultimately increases specific volume and shelflife of bakery product. EPS produced by *Lactobacillus* sp. improves functioning of human gastrointestinal track and contribute to food fibre which increases it's use in food industry (Vuyst *et al.,* 2001; Behare *et al.,* 2009). Pullulan produced by *Agrobacterium* sp. have attractive rheological, thermal gelling and thickening property which increases its use in food and pharmaceutical industry. Xanthan produced by *Xanthomonas campestris*, an anionic heteroglycan which even at low concentration have pseudoplasticity and highly viscous due to which it is used as stabilizer, thickening, and suspending agent in food industry.(Seviour *et al.,*2011; Li *et al.,* 2014).

5.2 Biomedical Applications:

Increases in commercialization have some adverse effects on human life. It leads to increase in certain metabolic diseases such as cancer, heart blockage, increase in blood glucose *etc*. Microbially synthesized biomolecules such as EPS provides certain health benefits against metabolic diseases. EPS produced by *Lactobacillus* sp. exhibits health benefits to humans by lowering cholesterol, anticarcinogenic, immunomodulating activity and antitumoral effect. Anticoagulant activity of EPS produced by *Alteromonasinfernus*have similar effect like heparin, therefore used in a treatment of lipemia and arteriosclerosi. Extremophilic EPS induces apoptosis in tumor cells by coupling with specific surface receptors with less cytotoxicity, hence used as anticancer agent. In vitro study of EPS produced by thermophilic bacteria *Geobacillus* sp. TS3- 9 was found to inhibit proliferation of hepatoma carcinoma cell in dose dependent manner. Addition of non-carbohydrate functional group may increase biological activity as compared to naive EPS. Modified levan produced from halophilic organism show biocompatibility to non-tumor cells and anticancer activity in-vitro(Wang*et al.,* 2019; Jouault *et al.*, 2001). Sulfated EPS such as dextran sulfatehas antiviral activity against enveloped viruses by interfering with absorption and penetration of virus into host cell, and also inhibits viral reverse transcriptase enzyme. Immunoregulatory effect of EPS from *Bacillus licheniformis* strain B3-15, induce expression of proinflammatory cytokines such as IL-4, IL-10, IL-18 and TNF-α resulting in improvement of immune surveillance of PBMC (peripheral blood mononuclear cells) against viral infection. Due to higher activity against virus infection, antitumor activity and anticoagulant activity, use of EPS in biomedical has been increased so far (Arena *et al.,* 2009). EPS also acts as drug carrier, which enhances its use in drug delivery system. Dextran used as coating material in medical devices and surgical sealant due to its biocompatibility and adhesive property respectively (Nadzir *et al.,* 2021).

5.3 Agricultural Applications:

EPS secreted by soil *Rhizobium* sp. helps in development of symbiotic relationship with its host by various mechanisms such as root hair attachment, host specificity in nodulation, perception of nodule oncogenesis, avoid plant defense response, biofilm formation, structural recognition, control of the plant defense systems resulting in attachment of *Rhizobium* sp. on plant surface. In this symbiotic relationships plants in return get nutrients from *Rhizobium* sp. which requires for plant to grow and due to this mode of action of EPS, it is highly recommended in agriculture (Ghose and Maiti, 2016). Absorption of EPS on soil leads to precipitation and binding of soil particles results in modification of soil porosity which favors water and nutrient extraction by plants from drying soils. These properties of EPS enhance its use in agriculture (Pandit *et al.,* 2020). Due to good biocompatibility, biodegradability, and mechanical strength EPS act as good biomaterial in biomedical engineering. Mixture of gellan with hydroxyapatite and with Hyaluronic acid used in bone tissue engineering and growth, and attachment of chondrocyte in tissues respectively. Gellan along with hydroxyapatite and Hyaluronic acid used for bone tissue engineering and growth and attachment of chondrocyte respectively (Nadzir *et al.,* 2021)..

5.4 As an antioxidant

Excessive production of reactive oxygen species (ROS) and oxygen-derived free radicals may damage cells and tissues leading to metabolic diseases. Oxidative stress plays crucial role in occurrence of mutation in DNA, protein through generation of free radicals. Reportedly free radical cause severe diseases such as atherosclerosis, diabetes, several types of cancers, neurodegenerative disorders, disorders and alteration in the immune system. Antioxidants are agents which resolves oxidative stress by acting as protective agents, therapeutic agents, functional foods additives in the preservation of nutritive products. EPS act as antioxidant can neutralize effect of free radical by various mechanisms. Antioxidant molecule undergoes self oxidation leading to elimination of unpaired electrons, make it less reactive resulting in elimination of dangerous diseases. Thus, EPS shown to play crucial role by acting natural antioxidant(Tabernero & Cardea S., 2020; Li *et al.,* 2014).

5.5 In oil recovery

Microbial EPS act as emulsifying agent by forming emulsion.Emulsion is high molecular weight heteropolysaccharide protein containing repeating trisaccharide of N-acetyl -D-galactosamine, N-acetylgalactosamineuronic acid and an unidentified N-acetyl amino sugar used for cleaning of oil contaminated vessels, oil spills and microbial enhanced oil recovery(Satpute *et al.,* 2010). Certain EPS such as, scleroglucan increases the viscosity, hence the hydraulic pressure of sea water or brine is used to extract oil. Scleroglucan lubricates the drill and controls the backpressures created during drilling. In addition, scleroglucan exhibited high thermostability in drilling fluids when it was associated with polyglycols through intermolecular interactions resulting in oil recovery (Yadav *et al.,* 2014).

5.6 Heavy metal removal

Heavy metals are compounds which are having slightly higher density than water.

Trace amount of heavy metals are required for normal physiological function of living cell but same heavy metal in higher concentration harm structure of DNA and protein, disturbance in ion channels living tissues instigates bronchitis, cancer, dermatitis, hypo 1 kerotosis, livercirrohosis, mental disturbance, ulcer etc in individuals. Modern industrialization increases heavy metal discharge in environment resulting in heavy metal pollution which became major concern nowadays. Microbes and microbial component such as EPS act as good absorbing agent which increases its use in heavy metal pollution. Earlier it was thought that heavy metal have inhibitory effect on microbial cell but instead microbes develop certain metal resistant mechanism hence, it is used in heavy metal removal (Gupta & Diwan, 2017; Naveed *et al.,* 2019). Various mechanism are employed by microbial EPS to remove heavy metal that including biosorption, biomineralisation, biotransformation, sequestration etc. as shown in following figure along with its mode of action.

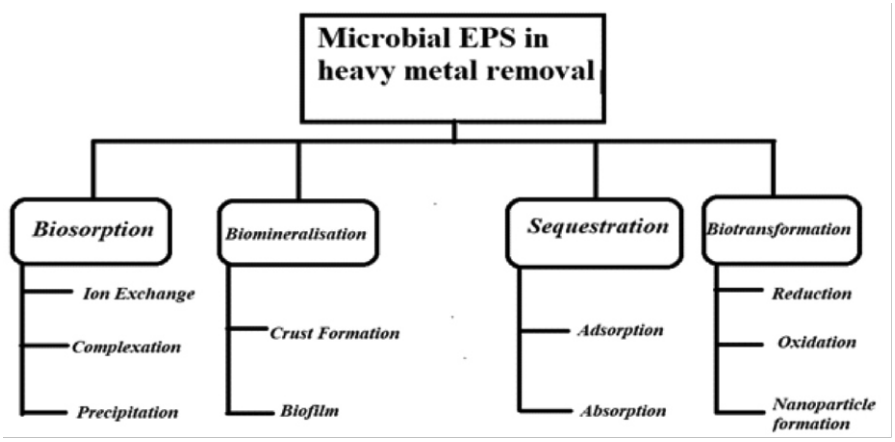


Figure 5.1: Mechanism of heavy metal removal by microbial EPS (Naveed *et al.,* 2019)

Conventional methods for heavy metal removal are cost effective and generate toxic by-products which limit its use in heavy metal removal, instead microbial EPS use as an alternative. Microbes develop protecting mechanism against infiltration of heavy metals by actively or passively interacting with them. EPS have certain properties including physisorption (*i.e.*, physical contact and electrostatic attraction), ion-exchange function, the binding sites of EPS, and chemical precipitation makes them suitable as biosorbant(Feng *et al.,* 2021).

5.6 Cosmetic industry:

Gelling and antioxidant property of EPS enhances its use in cosmetic industries. Certain microbial EPS such as glucan is used in skin care preparation, creams and protective lotions. Antioxidant property of EPS increases its use in commercial application of skins that protects against ultraviolet rays and damage caused by free radicals, therefore used in anti-aging creams. Hyaluronan is used as ingredient for enhancing collagen biosynthesis in skin cells (Sharmila *et al.,* 2014)

CONCLUSION

New microbiological researchfocuses on use of microbial product in various industries and environmental pollution control that shows remarkable effects on human life. One of major microbial biomolecules is exopolysaccharide substance(EPS) secreted by various kinds of microorganisms including bacteria, fungi, algae etc. EPS can be produced in laboratory by submerge fermentation as well as solid state fermentation. Different organism follows different pathways for secretion of EPS that will decide structural and functional composition of EPS. Microbes employed major 4 different biosynthetic pathways in making of EPS that enhances complexity in EPS structure. EPS have wide range of applications in field of food industry, cosmetic industry, biomedical, environmental and agricultural applications. Several techniques are employed to remove heavy metal contamination from environment, but they reside certain disadvantages. Instead EPS is used as it contains negative charge that makes them good sorbent agent to absorb heavy metals resulting in eco-friendly biosorption in environment. Due to gelling property of EPS, its use in cosmetic industry is increased. Reducing property of EPS makes it suitable as an antioxidant to remove oxidative species. Anti-inflammatory, anticancer, immunomodulator activity of EPS increases its use in field of medical research. EPS helps in attachment of microbes on surface and increases secretion and attachment to plant surface that enhances its application as plant growth promoting substance in agricultural field. Hence EPS become wonderful molecule for new findings and applications in field of biological sciences.

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Communication Methods used by Extension Functionaries for Transfer of Technology to Farmers

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ABSTRACT

The present study was undertaken to find out the communication methods used by extension functionaries for transfer of technology and constraints faced by them. The present study was conducted in Sardarkrushinagar Dantiwada Agricultural University jurisdiction. A sample of 100 extension functionaries was selected through purposive random sampling. Questionnaire technique was used for collecting data. Data was analysed by using frequency, percentage, mean and correlation. The findings revealed that the most used methods by extension functionaries were training, group meeting, farm and home visit, farmers - scientist interaction and farmers' visit to the centre. The most used media were telephone and whatsapp mobile app call. The major constraints faced by extension personnel were more office work, large area to cover and lack of need based and area specific technologies. Thus, the need based and appropriate technologies should be developed and send to farmers through appropriate media and methods.

Key words: Media, Extension personnel, Constraints, Telephone, Mobile app, Training

INTRODUCTION

The researchers develop user friendly, economical and practically compatible technologies in every field. There is no use of technologies developed in laboratories unless it reaches to ultimate users. Extension education plays an important role in the transfer of useful information, and technologies to the farmers in such a way that they can use it immediately. Generally, information and technologies are delivered to farmers by extension personnel by using various communication methods and media. Communication methods are the ways and means used by extension functionaries for disseminating technologies to farmers such as farm and home visit, office calls, telephone calls and SMS, social media, email, field days, demonstration, training, campaign, exhibition, farmer tours, advisory services, film shows, TV show/talk, use of leaflet, bulletin, farm magazine etc. The use of right and efficient method for transferring technologies to farmers play a very important role in adoption of innovation and practices. The wrong selection of communication method by extension functionaries is not only restricted the adoption of innovation but negatively affected the future work also. The lack of coordination and integration among farmers, extension functionaries and

researchers impede the development of rural people and agricultural production.

Thus, there is a need to find out ways and means to bridge the gap between what is known and what is practiced. To uplift the farmers and achieve a high level of production, it is not enough to develop technologies, but it is also necessary to transfer these technologies to rural people in proper way. Looking to above facts, the present investigation was undertaken to examine the "Communication methods used by extension functionaries for transfer of technology to farmers".

MATERIALS AND METHODS

Present study was conducted in Sardarkrushinagar Dantiwada Agricultural University jurisdiction. A sample of 100 extension functionaries was selected for the present study. Purposive random sampling was used for sample selection. Questionnaire method was used for data collection. Questionnaire was developed by researcher which consisted of three sections viz; background information, communication methods used by extension personnel for transfer of farm technology and problems faced by them. Data was analyzed by using frequency, percentage, mean and correlation.

RESULTS AND DISCUSSION

Demographic profile of the respondents

Demographic profile of the respondents shows that nearly half of the respondents were of age between 25-37 years (48.0%) and educated up to post graduation (53.0%) and Ph.d. (41.0%). Fifty three per cent respondents belonged to the general caste and 41 per cent respondents were from backward caste. Three fourth respondents (75%) are earning 6 to 10 lakhs per annum. Thirty two percent respondents have been working for more than 15 years whereas 11 percent respondents had job experience of 10 to15 years. Twenty one percent respondents had less than 5 years of service experience. 36 percent respondents had job experience of 6-10 years.

Regarding experience in transfer of technology, 31 percent respondents had less than five years of experience in transfer of technology to the farmers while 40 per cent had 6 to 10 years of experience in extension work. Twenty percent respondents were involved in transfer of technology to farmers from more than 15 years. Less than half of the respondents (41%) attended more than three training programmes while almost equal number of respondents attended two (20%) and three (23%) trainings respectively. Nine respondents did not attend any training yet. More than half of the respondents (53%) had nuclear family while rest (46%) had joint family with small (43%)and medium (35%) size family. It is encouraging to note that all the respondents had mobile phones and internet facility either at office or home. Majority of the respondents had computer (68%), laptop (77%) and TV (86%). Thirty per cent respondents had landline phones.

Communication Methods used by Extension Personnel for Transfer of Technology to Farmers

Data regarding communication methods used by extension personnel for transfer of technology to farmers is given in Table 1. Data show that the training was most used

method by extension personnel to transfer technology to farmers with rank first (3.09MS) which followed by group meeting (2.97 MS). The reason might be that the organisation of training is mandatory for most of extension institutes. Further training is the best method to convey detailed information to farmers. The reason for more use of group meeting might be that it is an easy way to take decision and resolve issues in a group and sending information to a group of people at the same time and being able to get their response. The findings are in accordance with the findings of *Ghanghas* (2011) who reported that the most commonly used group contact methods were group meetings and, demonstrations.

Farm and home visit was used by majority of the extension personnel (2.55 MS). These visits facilitate the extension personnel to have a better knowledge of their conditions and also build a personal relationship and bonding with them which would assist them in giving customised advice to particular farmer. Farmers - scientist interaction (2.92MS) and farmers' visit to the centre (2.87 MS) were also used frequently by extension personnel as farmers get help from scientist in solving the problems related to crop, credit, inputs etc. Demonstration (2.78 MS), *kisan goshti* (2.55 MS), field-days (2.71 MS)were often used by extension personnel for transfer of technology to farmers. Campaign (1.13 MS) was the least used method.

Similar findings are reported bySurudhi et al. (2017) that the extension functionaries frequently used telephone, office calls and farm and home visits for transferring technologies to farmers. SMS based communication was very rarely used byextension functionaries. Meetings was the frequently usedand demonstrations, farmer field school, farmer interest groups, field trips and farmer training programmes were moderately adopted group methods.

Media used by Extension Personnel for Transfer of Technology to Farmers

Data regarding media used by extension personnel for transferring technologies to

Table: 1 Distribution of respondents according to use of methods for transfer of technology to farmers. n=100

S. No.	Methods	Mean	Rank
1.	Training of farmers	3.09	I
2.	Group meetings	2.97	II
3.	Farm & home visit	2.94	III
4.	Farmer-scientist interaction	2.92	IV
5.	Farmers' visit to the centre	2.87	V
6.	Demonstrations(Result/method)	2.78	VI
7.	Field days	2.71	VII
8.	Kisangoshti	2.55	VIII
9.	Diagnostic visit	2.11	IX
10.	Exhibitions	1.94	X
11.	Farmers Fare and Krushi mahautsav	1.91	XI
12.	Exposure visit	1.86	XII
13.	Campaigns	1.13	XIII

farmers are presented in table 2. Increasing use of phones or mobile phone has changed the agricultural communication process. Extension personnel can communicate with farmers at any time through mobile. Thus, most of the extension personnel used telephone call (2.95 MS) to transfer information to farmers which followed by whatsapp (2.55 MS) and SMSs (2.11 MS). Extension functionaries sent voice messages to farmers which were easily understood by illiterate farmers too. Although literacy level is not good of the older farmers but messages sent by extension person are read by younger member of family and communicate to them.

Regarding farm literature, extension personnel used leaflet, bulletin (0.39), folder, farm magazine, booklet for transfer of technology. They expressed that they use these media as per the availability. Leaflets (2.11 MS) were used by most of extension personnel for giving precise information on any topic to farmers. Leaflets are very handy and attractive which makes them popular among farmers. It is cheaper than folders and booklets which increased its usages. Extension functionaries preferred folders (1.78MS) for giving detailed information to farmers. Bulletins (0.39MS) and farm magazines (0.28MS) were least used farm literature for transferring technologies.

Emails (0.91) were used by very few functionaries. Extension personnel used

Table: 2 Distribution of respondents according to use of media for transfer of technology to farmers n=100

S. No.	Media	Use *f* (%)	Mean	Rank
PRINT MEDIA				
1	Farm literature			
	✓ Leaflets	68	2.11	IV
	✓ Folder	59	1.78	VI
	✓ Booklet	36	0.73	X
	✓ Bulletins	13	0.39	XI
	✓ Farm Magazine	9	0.28	XII
Electronic Media				
2	Radio			
	✓ Radio talks	35	0.95	VIII
3	TV			
	✓ T.V. talks	41	1.21	VII
4	Telephone			
	✓ Calls	81	2.95	I
	✓ SMS	68	2.14	III
5	Mobile Apps			
	✓ Whatsapp	73	2.55	II
6	Internet			
	✓ emails	30	0.91	IX
7	Educational films/video show	62	1.83	V

email for official communication rather than contacting farmers.

Radio (0.95 MS) and TV (1.21MS) were less used media by extension personnel for transferring technologies. The reason for less use of TV and Radio might be that the production of programmes is not within the reach of extension personnel. The similar findings were reported by surudhi et al, (2017) and Melak and Negatu (2012), they found that television andradio were rarely used by the extension functionaries.

Educational film or video show was used by sixty two percent functionaries. Although it is liked by farmers but facilities like projector, screen, electricity etc were not available in all the villages.

Personal and Institutional Problems Faced by Extension Personnel

Data regarding personal and institutional problems faced by extension personnel is presented in table 3. It is apparent from data that more office work than technical work was reported by 87 percent respondents. The other constraints reported by the respondents were huge geographical area to cover (68%), poor economic condition of farmers(66%), scarcity of need based researches on different aspects (64%), shortage of staff (64%), less need based policy and programmes (63%). Constraints like improper interaction mechanisms (50%), and lack of co-ordination among various units (45%) restrict the extension personnel to transfer technology to farmers. Some of respondents also faced problems of vehicle (36%), funds (25%), inputs (18%) and communication facilities (12%) in transfer of technology to farmers.

Similar results are reported by Madhvan et al (2016) that constraints faced by Agricultural Assistants in transferring technologies were constraints in Input supply, administrative aspects. Additional work load which affect the routine work during natural calamities and risk in input supply were found as the most severe ones. Surudhi *et al.* (2017) reported that major

Table: 3 Distribution of respondents according to personal and institutional problems faced by extension personnel n=100

S. No.	Nature of Problem	f %
1.	More office work than technical	87
2.	Poor facilities like	
	✓ Vehicle	36
	✓ Funds	25
	✓ Lack of Staff	64
	✓ Inputs	18
	✓ communication facilities	12
3.	Less co-ordination among various units	45
4.	Shortage of appropriate researches on different aspects	64
5.	More geographical area to cover	68
6.	Inappropriate interaction mechanisms	50
7.	Poor economic condition of farmers	66
8.	Highly opinionated political interference	43
9.	Less need based policy and programmes	63

Table 4 Correlation between socio-economic characteristics of extension functionaries with communication methods and media used by them for transferring technologies to farmers n=100

S. No.	Independents Variables	Dependent variables	
		Communication methods	Communication media
		r value	r value
1.	Age	-.088	.080
2.	Education	.190	.250*
3.	Income	.104	.294**
4.	Job Experience	.068	.096
5.	Experience in transfer of technology	.042	.138
6.	Trainings attended	.344**	.140
7.	Parental Occupation	-.041	-.104
8.	Media possession	.077	.064

constraints expressed by the respondents were lack of appropriate technologies for transfer of technologies, poor infrastructure facilities and lack of input supply for programmes implementation, inadequate staff strength in respective departments and lack of proper transfer policy, lack of support from superiors and colleagues and lack of participation in programme planning.

Correlation between communication methods and media with sets of independent variables

In order to ascertain relationship if any between socio- demographic variables (age, education, income, job experience, experience in transfer of technology, trainings attended, parental occupation, media possession and communication media and methods, pearson's correlation was computed. This has been presented in Table 4. It is apparent from data that only three variables namely training attended, education and income were positively and significantly correlated with linkages used for transfer of technology to farmers by extension personnel. Age is negatively correlated with communication methods and media used by extension personnel.

CONCLUSION

On the basis of findings it can be concluded that most used methods for transferring information to farmers by extension functionaries were training, group meeting, telephone calls, farm and home visit, demonstration. Many times significant technologies could not reach to farmers due tomore office work, large coverage area, lack of staff and lack of need based appropriate researches. Thus the efforts should be made to take appropriate measures to resolve the constraints and strengthen the means and mechanism for transferring technologies sothat the rural community may not get deprived of the any technologies.

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Advantages of De-oiled Castor cake in Agriculture

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ABSTRACT

The soils of India are poor in availability of plant nutrients. As about 97 per cent of soil samples analysed were deficient in nitrogen, 83 per cent soil samples in phosphorus and 71 per cent in potash. Oil cakes are rich in fibre, protein and energy contents. Castor cake is the primary by-product generated after castor oil production from castor bean plant (*RicinuscommunisL*).In general, one tonne of castor oil production results in 2.4 tons of castor cake by-product. This is due to castor cake has a high nitrogen content and a low carbon to nitrogen ratio, and the nitrogen in castor cake can be readily mineralized and available for plant uptake once applied to soil, which makes castor cake an excellent nitrogen source for organic farming. each tonne of Castor De oiled cake contains nearly: 45 kg nitrogen (approx. 90 kg urea; 46 %N); 10 kg phosphorus (22 kg DAP; 18 % N; 46 % P_2O_5) and 10 kg potash (17 kg MOP; (60 % K_2O), close to 130 kg of fertilizers urea + DAP + MOP. The castor meal or de oiled cake are suitable for cereals, pulses, sugarcane, cotton, banana, castor, vegetables, spices, floriculture, medicinal plants, plantation crops in general and high value export-oriented crops or organic farming in particular.

Keywords : Castor cake, Deoiled cake, Nirogen, Organic farming, Integrated Nutrient Management, Soil Carbon

INTRODUCTION

Out of 118 known elements, plants require only 17 elements for their growth and development. These elements are known as essential plant nutrients. These can be grouped as: Basic nutrients (carbon, oxygen and hydrogen); Primary nutrients (nitrogen, phosphorus and potassium); Secondary nutrients calcium, magnesium and sulfur); Micro nutrients (iron, manganese, zinc, copper, boron, molybdenum, chlorine, and nickel). Primary nutrients are required in larger quantiles than the secondary nutrients. The micro nutrients are required in traces for growth and development of plants. The soils of India are poor in availability of plant nutrients. As about 97 per cent of soil samples analysed are deficient in nitrogen, 83 per cent soil samples in phosphorus and 71 per cent in potash. Close to half of the soil samples are deficient in either sulphur or micronutrients like B, Zn and Fe, etc. It is remarkable that 85 per cent of Indian soils are also deficient in organic carbon (Annonymus, 2022). The carbon play central role in balancing physical, chemical and biological properties of soil. Under this condition, it becomes necessary that the nutrient should be added very carefully. The plant nutrient addition should benefit the soil

immediately and increase nutrient reservoir on long term basis.

Looking to the food production from, India has witnessed in quantum jump in food grain production after adopted the initiatives of green revolution in the decade of 1960s. Presently, India produces around 320 million tonnes of food grains annually. That is almost 3.85 times of the production level of 1960-61. Similar trend was observed in the total fertilizer consumption. The fertilizer consumption has reached to 29.8 million tonnes in 2021-22. That is nearly 103 times to the fertilizer consumption level of 1960-61.This shows our agriculture is much dependent on externally addition of nutrients or fertilizers. The production of fertilizer nutrients is limited in India. There is a gap in fertiliser production and consumption in India. The gap is bridged through imports of fertilisers. The fertiliser import is a dent to forex reservoir of country. Last year India has imported 9.82 million tonnes of fertilizers. The gap between total fertilizer consumption in India and import of fertilizers is widening.

The ray of hope is found in use of oilmeals as nutrient source.

Organic residues are widely used as supplement to chemical fertilizers because they provide nutrition to plants, improve the physical and chemical properties of soil (Hafez, *et al.*, 2021), and promote microbial activity in soil (Shilpa shree, *et al*., 2022). Oil cakes are rich in fibre, protein and energy contents. Castor cake is the primary by-product generated after castor oil production from castor bean plant (*Ricinus communis L*). Castor oil contains around 75 to 89 per cent of ricinoleic acid, $C_{18}H_{34}O_3$, is structurally known as cis-12-hydroxyoctadeca-9-enoic acid, a 18-carbon hydroxylated fatty acid having one double bond, which makes castor oil exceptional and highly demanded on the international market (Conceicao *et al*., 2007).Therefore, castor oil has been extensively used for medical and personal care purposes (e.g., as anti-inflammatory drug), industrial applications (synthesis of coatings, paints, inks, etc.),and biodiesel production (starting material) (Deshmukh *et al.*, 2022) and also for ethanol production.

In general, one tonne of castor oil production results in 2.4 tons of castor cake by-product (Lima *et al*., 2011). India the global leader in castor production - 1.65 million tonne of castor seed and after extraction that will generate nearly 0.83 million tonne of castor meal (DOC) annually. The predominant method for castor oil extraction consists of expeller press followed by solvent extraction. The by-product of this process of is called 'cake' when only the expeller press is used and 'meal' or de-oiled castor cake when the solvent extraction is used. The castor cake contains about 10-12 per cent oil while the castor meal or de-oiled cake contains hardly 0.5 per cent oil (Fig 1). Amino acid profile of castor cake is given in Table 1.

The castor cake contains around 98 per cent dry matter, with nearly 25 per cent soluble carbohydrates. The amino acid profile of castor cake is closely related to the soybean. However, the castor cake is deficient in certain indispensable amino acids like iso-leucine, tryptophan, lysine. Besides this the castor cake also contains around 72 ppm iron, 8.08 ppm manganese, 5.33 ppm copper, and cobalt 1.64 ppm (Annongu and Joseph, 2008).

Table 1: Amino acid profile of castor cake

Amino acid, g/16gN	Castor cake	Soybean
Lysine	4.11	6.30
Histidine	1.38	2.70
Arginine	8.00	8.10
Aspartic acid	6.42	11.80
Threonine	3.00	3.90
Serine	2.13	5.20
Glutamic acid	13.19	17.90
Proline	2.76	5.90
Glycine	0.56	4.40
Alanine	3.96	4.30
Cystine	0.53	1.60
Valine	5.46	5.10
Methionine	2.06	1.60
Iso-leucine	3.09	7.90
Leucine	5.90	5.10
Tryptophan	-	1.30

Although, castor cake is rich source of protein (~35%) (Anandan *et al*., 2005) could not suitable to use as animal feed due to presence of toxins and allergens. The ricin, is protein, consisted of two chains (A and B) bonded by a single disulfide bond. Chain A is a ribosome-inactivating enzyme of 32 kDa, whereas chain B is a galactose/ N-acetylgalactosamine-binding lectin of 34 kDa. Both chains are required for the high toxicity of ricin and inhibition of protein assimilation in cells. Castor DOC contains is toxic to animals because it contains a toxic protein ricin varied from 1 to 5 per cent (Shah *et al.*, 2014; Mondal *et al*., 2019); another reason for not use of ricin as feed is due to presence of ricinine ($C_8H_8N_2O_2$) or 3-cyano-4-methoxy-*N*-methyl-2-pyridone belongs to the group of piperidine alkaloids, content varies but contains 2.3–32.9 g/kg in leaves, 2.4 g/kg in stems, 3 g/kg in roots and 0.43–7.0 g/kg in seeds (Leite *et al*., 2005; Xu *et al*., 2007; Wen *et al*., 2008; Cazal *et al*., 2009).In addition, deoiled cake also contains Ricinus Communis Agglutinin (RCA). RCA is a tetrameric protein with stronger agglutinating properties than ricin but is less toxic (Lord *et al*., 1994; Bigalke and Rummel, 2005). Together these compounds make up around 5% of the total protein in the mature seeds. Therefore, not suitable for animal feed unless detoxified fully. Instead of feeding livestock, castor cake is more recommended to be used as an organic fertilizer (Lima *et al*., 2011; Patel *et al*., 2016; Severino *et al*., 2012).

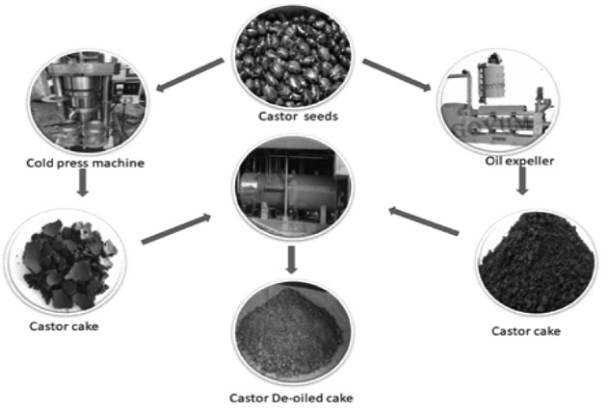


Fig 1: Systematic diagram of production of Castor DCO from castor seeds

The composition and nutritional availability of oil cakes widely vary based on the quality of the seed, method of oil extraction, storage parameters, etc. This is due to castor cake has a high nitrogen content and a low carbon to nitrogen ratio, and the nitrogen in castor cake can be readily mineralized and available for plant uptake once applied to soil, which makes castor cake an excellent nitrogen source for organic farming (Kulkarni *et al*., 2018). Castor cake are also inhibiting the nitrification process. Therefore, increasing nitrogen usage by the crop. Applying organic fertilizers to soils for improving soil quality and crop growth is a promising practice for sustainable agriculture. Castor

cake has dual agricultural benefits of organic fertilizers and pesticides seem to synergistically support plant growth and prevent plant diseases (Ning *et al*., 2017).

Specifications of Castor de-oiled cake: As per The Fertiliser (Inorganic, Organic or Mixed) Control Order, (1985), the non-edible de-oiled cake fertiliser is defined as "The substance obtained as residue after oil extraction (by expeller and/or through solvent extraction) from crushed seeds of nonedible oilseeds (Such as Castor, Neem, Karanj, Mahua and Jatropha for use in soil as fertiliser" (Biofertilizers and Organic Fertilizers in Fertilizer (Control) Order, 1985) (Table 2).

Table 2: Specifications of Castor de-oiled cake

Parameters	Castor DOC	Remarks
Moisture % (by weight)	12	Maximum
Ash content % (by weight)	15	Maximum
Total Organic Carbon % (by weight)	25	Minimum
Total Nitrogen (as N) % (by weight)	4.5	Minimum
Total Phosphorus (as P2O5) % (by weight)	1.0	Minimum
Total Potash (as K2O) % (by weight)	1.0	Minimum
pH	6.8-8.0	
Conductivity (as dSm-1)	4	Maximum

Roughly, each tonne of Castor De oiled cake contains nearly: 45 kg nitrogen (approx. 90 kg urea 46 %N); 10 kg phosphorus (22 kg DAP 18 % N, 46 % P_2O_5) and 10 kg potash (17 kg MOP (60 % K_2O), close to 130 kg of fertilizers urea+ DAP+MOP.The N content of de-oiled cake mineralize rapidly. On decomposition, enzymes, hormones, antioxidants, vitamins and plant growth promoting substancesare produced.

The castor cake is being used as source of nutrients in many areas of India, the scientific study on integration of castor cake with chemical fertilisers was conducted by many researchers (Table 3).

Table 3: Selected references for integrated use of castor cake for crop production.

State	Crop	Location/District	Dose of Castor DOC	Reference
Andhra Pradesh	Papaya Nursery management	Anantharajupeta, YSR	10 g /nursery bag	Lakshmi Devi *et al.*, 2020
Delhi	Sunflower-maize	Delhi	50 % of RDN	Yadav *et al.*, 2007.
Karnataka	Rice	Raichur, Dhadesugoor	0.5t/ha	Ramesha *et al.*, 2017
Maharashtra	Rice	Kolhapur	25 % of RDN	Sharma *et al.*, 2016
Punjab	Maize	Ludhiana	33 % RDN	Patidar *et al.*, 2018
Rajasthan	Potato	Bikaner	3 t /ha	Meena and Gupta (1996)
Tamil Nadu	Greengram	Tiruchirappalli	0.5 t/ha	Kalaiyarasi *et. al.*, 2019
Tamil Nadu	Medicinal COLEUS	Sirukalathur, Ariyalur	2 t/ha	Muruganandam *et. al.*, 2021

Gujarat being the topmost castor producing state in India having most of castor oil extracting units located in Gujarat, the availability of castor cake, therefore, the research on different crops has been conducted and farmers are using castor cake in their field (Table 4).

Table 4 : Selected references for integrated use of castor cake for crop production in Gujarat.

Crop	Location/District	Soil Type	Dose of Castor DOC	Reference
Groundnut	Dantiwada-Banaskantha	Loamy sand	1.0 t/ha	Bhutadiya *et al.*, 2019
Custard apple	Anand	Loamy sand	4.0 kg/plant (11 yr old plant)	Jangid, *et al.*, 2021
Pearl millet	Navsari	Clayey	2 t/ha	Barad, *et al.*, 2017
Coriander	Dantiwada-Banaskantha	Loamy sand	0.5 t/ha	Nisarata 2022
Potato	Deesa-Banaskantha	Loamy sand	50 % of RDN	Kanbi and Bhatanagar (2005)
Garlic	Danti-Umbharat, Navsari	Clayey	50 % of RDN	Joshi *et al.*, 2019
Sugarcane	Navsari	Clayey	1t/ha	Patel *et al.*, 2009
Sorghum	Anand	Loamy sand	25 % of RDN	Yadav P.C., Sadhu A.C., Swarnkar P.K. 2007
Ashwagandha	Anand	sandy loam	2.5 t/ha	Jat *et al.*, 2021
Kalmegh	Anand	sandy loam		Basak, *et.al.*, 2020
Chrysanthemum	Junagadh	Medium black	0.88t/ha	Palagani, *et. al.*, 2013
Cotton	Junagadh	Medium black	0.5 t/ha	Vekaria, *et.al.*, 2022
Cowpea	Dantiwada-Banaskantha	Loamy sand	50 % of RDN	Birla and Patel, 2022
Blackgram	Devgadh Baria, Dahod	sandy loam	0.12 t/ha	Patel *et. al.*, 2022
Chickpea	Anand	sandy loam	0.5 t/ha	Shulka *et al.*, 2013
Wheat- forage cowpea	Anand	sandy loam	25 % of RDN	Suryawanshi, *et al.*, 2019
Tobacco	Anand	sandy loam	0.2 t/ha	Patel, *et. al.*, 2018

Recommendations based on national centre for organic and natural farming:

Castor cake could be a suitable source of nutrients under organic farming. Many researchers have studied the suitability of castor DOC under organic farming (Table 5) Fig 2.

National Centre for Organic Farming (NCOF) is a nodal organization for promotion of organic farming under INM Division, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India under Soil Health Management component of National Mission on Sustainable

Table 5 : Selected references for use of castor cake for crop production under organic farming.

Crop	State	District	Soil type	Reference
Field bean	Karnataka	Shivamogga	sandy loam	Shilpashree, *et al.*, 2022
Fenugreek	Gujarat	Dantieada	Loamy sand	Malav, *et. al.*, 2018
Onion	Gujarat	Navsari	Clayey	Naik, *et. al.*, 2014
Cotton	Maharashtra	Akola	Vertisol	Khuspure 2018

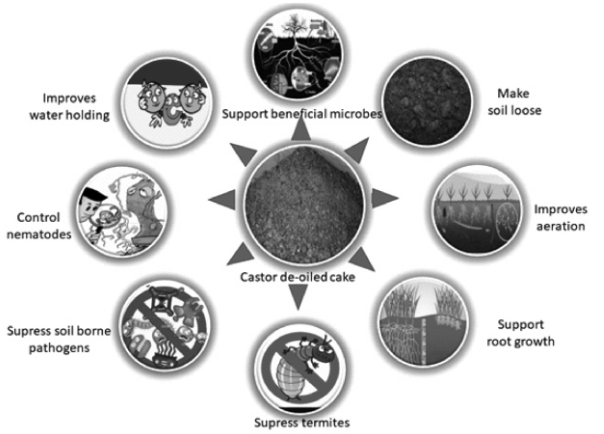


Fig 2: Use of castor cake for crop production

Agriculture. The package of practices under organic farming are provided on the website of the organization. Castor cake are promoted to use for nutrient management or disease management or nematode control. For nutrient management it is crop and location (state) specific (Table 6). For nematode control under organic farming practices, soil application of 1 t /ha of castor cake is recommended in Gujarat for Garlic and Blackgram and in Kerala for Okra crop. Soil application of castor cake (0.5 t/ha) along with *Trichodermavirdi* is recommended to control Sclerotium Stem rot of Groundnut in Andhra Pradesh and Cotton wilt in Gujarat. Wheat weevil/ termites could be controlled by application of 1 t castor cake 2-3 days before sowing of wheat.

Table 6: Nutrient management under organic farming suggested by NCOF

State	Crop	Dose of castor DOC	Crop	Dose of castor cake
Gujarat	Field crop		Horticultural crop/ plantation corps	0.2 -0.75 kg/plant
	Groundnut/ Sugarcane/ Potato/ Maize/ Moong bean/ Pegion pea/ Castor/Sesame	1 t/ha	Rose /Custard apple/ Guava /Banana	
	Paddy/ Kalmegh/ Jivanti (Dodi)	2 t/ha	Mango / Pomegranate	2 - 5 kg/ plant
Madhya Pradesh	Wheat	0.3 -0.5 t/ha		
Tamil Nadu	Rice	0.1-0.2t /ha		
Odisha	Turmeric	2 t/ha		

(SOURCE: https://ncof.dacnet.nic.in/Package of Practices accessed on 06.03.23)

In different states the castor cake has been recommended as package of practices. In Punjab, soil application of castor cake @ 0.5 t /ha for onion and 1.5 t /ha for wheat and maize is recommended. In Andhra Pradesh for turmeric, application of 0.5 t/ha and for onion (Mananandi District) 2.5 t/ha castor cake is recommended.

Speedy nitrogen mineralization: The carbon to nitrogen ratio (C:N) is one of the most important factors affecting the decomposing rate of an organic material. The optimum C:N ratio for a material to be used for compost is in the range of 25–30 and different materials can be mixed in order to reach an adequate ratio (Kumar et al., 2010). Castor husks are comparatively poor in N (1.86%) but rich in K (4.50%), while castor meal is rich in N (7.54%), but poor in K (0.66%).

Phosphorus management: Low phosphorus (P) use efficiency necessitates the high rate of P fertilizer application to achieve the desired crop yield. Castor cake may be alternative of costly inorganic P fertilizer. The application of castor cake promotes the phosphorus uptake. The difference occurred due to higher microbial biomass P and alkaline phosphatase activity due to application of castor cake (Basak, 2023).

Suitable for rainfed and salt affected soils: Castor can be grown easily in non-productive lands especially in rainfed area and in sodic land of subtropical and tropical locations that require low inputs. It can prevent desertification and erosion in marginal lands if grown there. It has capacity to tolerate salinity stress (Berman and Wiesman, 2011). Adequate nutritional supplementation with nitrogen (N) may be an alternative to mitigate the harmful effects of salinity in plants mainly when provided as organic inputs. These N sources act on the osmotic regulation, ion compartmentation, and biosynthesis of osmoprotectants. The accumulation of osmoprotectants, such as sugars, proteins, and some amino acids, results in osmotic adjustment, reducing the water potential of cells and maintaining the water uptake even in soils with low water potential, as saline soils. In addition, these osmoprotectants can also scavenge reactive oxygen species and stabilize proteins and membranes, being important molecules for salt stress tolerance (Singh *et al*., 2019). Application deoiled cake up to 5 t ha^{-1} could mitigated the effects of moderate saline stress upto 3 dSm^{-1} in basil. In addition, CBC induced osmoregulation under saline conditions, as shown by the increase in free amino acids, proteins, proline, glycine-betaine, and sugars.

Effect on microbial population: Soil health and productivity is directly related to soil microflora as it is an intimate part of soil organic matter and supports growth and development of different crops in many ways. The microorganisms present in the rhizosphere environment around the roots influence the plant growth and crop yield. The castor DOC resulted in higher production of root exudates and increasing the beneficial microbial population in rhizosphere of pulses (Table 7). The microbial population was maximum during the 60 days after sowing(Shilpashree, *et al*., 2022).

Promotes soil mycorrhiza: Castor cake application favours the growth of myccorhizal in the root rhizosphere. The favorable effect of addition on soil properties by the application of castor cake favour increased colonization by

Table 7: Influence of deoiled castor cake on soil microorganism population

Microflora	Bacteria (No. × 105)			Fungi (No. × 104)			Actinomycetes (No. × 103)			N-fixers (No. × 103)			PSM (No. × 103)		
Initial	5.67			2.33			3.00			3.67			4.33		
Treatments	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	60 DAS	At DAS	30 Harvest	60 DAS	At DAS	30 Harvest	60 DAS	At DAS	30 Harvest
Control	11.00	27.00	19.00	3.00	6.00	4.67	5.67	18.33	6.33	5.00	17.00	14.00	7.67	9.33	2.67
Castor cake	15.00	32.67	24.67	6.00	10.33	7.67	8.33	24.00	10.00	13.33	22.67	19.00	10.33	12.33	7.00
CD	2.73	1.35	1.32	1.64	1.35	1.22	1.15	1.30	0.73	1.17	0.93	0.95	0.90	1.41	1.02

Crop: Field bean; Initial soil pH: 6.45; OC % 0.40; Avail N; P2O5:; K2O: 140:30:140 kg/ha
Castor cake N 4.3 %, P 1.8 % and K 1.3 %

*DAS- Day after sowing

mycorrhiza. When brinjal seedlings were transplanted in castor cake amended soil, the nematode population densities both in soil and root significantly reduced and plant growth parameters were increased. Favourable effect was observed by castor cake amendment on the growth of *G. fasciculatum* in the rhizosphere of brinjal plant. The combined effect of colonization of *G. fasciculatum* on roots and castor cake amendment in the soil was responsible for the significant reduction of M. incognita infestation on transplanted brinjal plants (Jothi *et al*., 2005).

Supporting nursery management: Castor cake can sever a suitable potting mixing material for nursery raising. Castor deoiled cake can be used as a potential, effective, cheaper and non-polluting organic source of nitrogen and other growth promoting substances. It was found that the growth characters of papaya seedlings raised in the potting mixture enriched with castor cake, *T.harzianum* and A.M Fungi exhibited enhanced shoot length, stem girth, petiole length, petiole diameter, number of leaves, SCMR values, vigour index and leaf area or a vigorous healthy seedlings for quicker germination and for production of healthy robust seedlings in just 45 days. Many researchers reported that using bio-fertilizers in addition to organic fertilizer led to improvement of vegetative growth and productivity of castor (Patel *et al*., 2010).

Disease control: Ricin inhibits protein synthesis by acting mainly on eukaryotic ribosomes. So, fungi are more susceptible to it than bacteria. (Rashmi *et al*., 2019). Deoiled castor cake was found effective in controlling several soil borne diseases. Soil application of castor-cake enriched *Trichoderma* (isolate T-170) at 50kg/ha (Trichoderma multiplied on sorghum grains and mixed with 50 kg castor-cake) + intercropping with maize (3:1 ratio) + gypsum at 500kg/ha at flowering + foliar application of Chlorothalonil effectively controlled collar rot, stem rot, early leaf spot and late leaf spot. *Trichoderma* isolate NRCG T12 enriched with castor-cake effectively controlled collar and stem rots, *A. flavus* infection and *aflatoxin* contamination. Annonymus, 2009.

Insect pest control: Castor cake, owing to its biochemical produced during the process of decomposition has reported to control *Agrotisipsilon* (Potato cutworm)

when applied to the soil @ 2.5 q/ha (Manendra, 2016).

Nematode control : Use of castor cakes @ 1 tonne/ha has been found to reduce root-knot nematode damage in vegetables and groundnut (Khan *et al*, 2010). Their combinations with seed treatment of carbosulfan (25 DS) @ 3% a.i. (w/w) further improved efficacy in reducing the nematode population and enhancing the yield significantly. Castor deoiled cake suppress pathogenic nematodes because during decomposition volatile compounds (VOC) like phenol, 4-methylphenol, γ-decalactone, and skatole are produced. VOCs produced after the incorporation of castor bean cake in the soil resulted in immobility (>97.3%) and death (>96.9%) of *M. incognita* second-stage juveniles and reduction in *M. incognita* egg-hatch (>74.3%) (Pedroso *et al*., 2019).

Challenge for use of castor cake is the time of application : Following De-oiled cake application to soil, a temporary toxic effect is occasionally observed for some days because of rapid mineralization, leading to the release of excessive N in the soil; however, the toxicity eases after 1-2 weeks (Lima, *et al*., 2011, McKeon, *et. al*., 2013). Higher dose of application or close contact with seed, reduce seedling emergence, impair plant growth, and even cause plant death could observe Roberto *et. al*., 2011; also high concentrations of ricinine is poisonous to earthworms in soil (Liu *et. al*., 2021). The de oiled cake should be applied at least three weeks before sowing of wheat and the field must be kept moist for the degradation of toxicants. This also helps to liberate phosphorus to the plants (Gupta *et al*., 2004).

CONCLUSION

Castor meals are good source of nutrients especially nitrogen, phosphorus, potassium and micronutrients. The meals also act as soil conditioner. They improve soil fertility. Castor meals have ability to control disease and pest considerably. The castor meal or de oiled cake suitable for cereals, pulses, sugarcane, cotton, banana, castor, vegetables, spices, floriculture, medicinal plants, plantation crops in general and high value export-oriented crops or organic farming in particular.

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