WOMEN FRIENDLY TECHNOLOGIES IN TROPICAL TUBER CROPS

भाकृअनुप-केन्द्रीय कन्द फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

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From the Director

Indian agriculture is as diverse and vibrant as the nation itself, deeply rooted in its history, culture and economy. India's agricultural sector is a tapestry of traditional practices, modern technologies and socioeconomic complexities. We are living in an era of innovations but it's true potential can be realized only when innovations are gender neutral. The technological outputs should also cater to the diverse needs and priorities of all individuals irrespective of gender. In this pursuit, the concept of women-friendly technologies emerges as a beacon of progress and equality. The integration of women-friendly technologies in agriculture represents a pivotal shift in our approach to innovation. In this direction, the Institute has developed women friendly technologies with an aim to enhance the participation of women in tuber crops cultivation thereby reducing their ergonomic issues and drudgery. The voice of the farm women is marginalized in the technology industry but ICAR-CTCRI fosters an environment where the technologies thrive not in exclusion but in diversity. As we embark on this journey towards a technological landscape, our scientists and staff remain steadfast in their approach and commitment to uplift the women living in the last mile of the country by handholding them with the truly women friendly innovations. I feel proud and delighted to publish this technical bulletin for promoting economic development and social empowerment of the women in our country who hold the means for the welfare of the country.

28 February 2025

G. Byju
Director

1. Introduction

Preamble

The ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) was established during the Third Five Year Plan for intensification of research on tuber crops (other than potato). The Institute started functioning in July 1963 with its headquarters at Sreekariyam, Thiruvananthapuram, Kerala. It has one Regional Station at Bhubaneswar, Odisha. The All India Co-ordinated Research Project on Tuber Crops (AICRP TC) was started at ICAR-CTCRI in 1968 for testing and popularizing the location specific tuber crop technologies in various parts of the country. It has presently 21 Centres including ICAR-CTCRI HQ and Regional Station. The Institute is also one of the centres of the All India Co-ordinated Research Project on Pre and Post-Harvest Technology.

The ICAR-CTCRI is conducting basic, applied and strategic research on 15 mandated tropical tuber crops. The vision of the Institute is utilising root and tubers for ensuring better health, wealth generation and inclusive growth. It functions with a mission to integrate root and tuber crops as sustainable farming system components to ensure food and nutritional security of the nation and livelihood improvement of rural population. It has a broad mandate which includes basic, strategic and applied research on genetic resource management, crop improvement, sustainable production and utilization of tropical tuber crops and to co-ordinate research and validation of technologies through AICRP on Tuber Crops.

Mandate crops of ICAR-CTCRI

The Institute has made significant contributions during the last 61 years of service to the nation which led to the development of 77 improved varieties, crop production practices including organic farming and good agricultural practices, protocols for quality planting material production, pest and disease management packages, value added food and industrial products and ICT tools including crop growth models and decision support systems. Considering due recognition to women and to address their needs, the Institute has developed several women friendly technologies which help women to adopt these technologies thereby reducing their drudgery and increasing their farm income.

Women in agriculture in India

Agriculture employs a significantly higher percentage of the labour force globally. Given that farming employs a substantial portion of the rural population, it is a vital industry for the economy. Agriculture not only feeds the nation, but also gives the rural population a means of subsistence. Almost all agricultural operations involve women, with the exception of those that need labour-intensive tasks. Their involvement is particularly noticeable in post-harvest processing and value addition activities. Crop production and post-harvest technologies are undergoing significant developments in India. Previously seen as a traditional profession, agriculture has evolved into a business. This is mostly because worldwide markets have opened up, and majority of the agricultural products are exported to other nations, indirectly increasing our foreign exchange. In this age of mechanization, women's role in agriculture cannot be undervalued, and they should be included in this technological transformation. Technology should be planned and developed so that women are not left behind; rather, women should be included in this mechanization process and given the chance to join the modern world. When creating new technologies and drafting laws, women should be given the credit they deserve and their demands should be taken into account. Reforms must be implemented to support women's holistic development, enabling socioeconomic circumstances and the security of their health.

Women friendly technologies

'Women-friendly technologies empower women by enhancing their participation in agriculture by reducing drudgery and enable them to participate in agrifood systems without any compromise'

India is witnessing technological revolution in the recent past. Research and development organizations are introducing new technologies that are more advantageous than those that are already in use. Agriculture sector is supported with

much technological advancement. Women must lead the way in this technology age as they perform half of the agricultural operations. Every time a new technology is invented, women's role should be given equal priority. The main goal of agricultural technology development is to boost productivity and output while cutting down on labour, reduce drudgery and saving time. Every technology that is created should be technically sound, ecologically safe, and economically feasible. Women have less access to technologies, and this is due to multiple factors, including their educational background, cultural norms, family structure and psychological hurdles. The primary criteria that encourage women to adopt technologies are affordability, simplicity, ease of use and less complexity. Women are naturally at the back end to use new technologies; this worry may stem from a lack of self-assurance. Women's labour burden in farming can be lessened by investments that provide them access to labour-saving technologies, as in plantation agriculture and agro-processing they put in longer hours. A larger degree of change in agricultural settings is being brought about by technologies. Women-friendly agriculture seeks to address gender disparities and promote gender equality in agriculture by ensuring that women have equal access to resources, opportunities and decision-making power. By promoting women-friendly agriculture, societies can unlock the full potential of women farmers, improve food security and nutrition and contribute to more inclusive and sustainable agricultural development.

Features of women friendly technologies

- **Design machinery based on ergonomics:** Due importance is to be given to the capacity and strength of the women in handling the machineries, the size, shape and weight of devices and equipment is to be designed accordingly. The machineries should include adjustable features to accommodate a wide range of individuals who can handle them.
- **Women centric decision:** Women's needs, interests and obstacles are understood through their involvement in the design process. The necessity of conducting usability tests on various female groups is to be done in order to obtain input on product design.
- **Safety and security:** Make sure that personal security features and privacy protection are in place to reduce the possibility of accidents.
- **Gender-inclusive design:** Designing technology and equipment that reflects the diverse needs and use of all users with gender neutrality.
- **Operational efficiency:** The operational efficiency of the technology need to be high

and this should support to empower women to use technology effectively, particularly those women who are underprivileged.

Benefits of women friendly technologies

i. Reduces the level of drudgery faced by women
ii. Conserve energy and fuel
iii. Boosts the productivity of man- machine system
iv. Increase input utilization efficiency
v. Make field operations timely
vi. Saves input costs and reduced labour
vii. Better quality of work and produce
viii. Improves the standard of living of the farm women

Strategies for technology development and promotion

The machineries are to be designed using anthropometric and strength data of women workers and also based on the need of the women. Proper trainings to the women on various improved equipments are to be provided so that they can operate them properly and safely. Keeping this in view, to use the technology effectively and to develop their own small-scale enterprises the farm women are given training at the Techno Incubation Centre facility of the Institute to make them gain confidence to utilise the technology. The Institute is assisting farm women in getting loans after being duly trained so as to procure various tools/equipments, building up of linkages with central/state departments, NGOs, banks and other stakeholders to promote adoption of these improved tools/equipments and technologies by providing them the techno economic feasibility report.

2. Crop Production and Management

Technology 1

Quality planting material production through minisett technology

(Developer: Dr. James George)

Brief description

The Institute has developed a rapid multiplication technique for cassava propagation using cassava minisetts in which two-node cuttings are raised in the nursery in shade house. The minisetts are planted end to end horizontally, 5 cm deep leaving 5 cm between the rows. The minisetts are transplanted to the main field after 3 to 4 weeks of planting at a spacing of 45 x 45 cm. The stem yield (no. ha^{-1}) in cassava is 24,000 in normal sett planting, while in minisett technique it is 60,000. This method gives an increased yield of 80 t ha^{-1} for minisett cassava wherein the normal sett planting produces an yield of only 30 t ha^{-1}.

Minisett technology in cassava

Women friendly component

- Easy to adopt
- Less drudgery
- Easy to handle
- More yield

Technology 2

Cropping system models for resource conservation and sustainable income

(Developers: Dr. C.S. Ravindran, Dr. T.V.R. Nair, Dr. G Suja and Dr. M. Nedunchezhiyan)

Brief description

Cropping system aims at crop diversification and intensive cropping in the interspaces available to enhance the productivity of main crop and intercrops per unit area in a system approach. Available farm resources like soil, nutrient, sunlight and water/rainfall resource,

farm labour, agricultural inputs are utilized effectively to produce both food and non-food agricultural products from the farm in an economical way. Sustainability is the main objective of the cropping system, where production process is optimized through efficient utilization of the inputs in safeguarding the environment and natural resources. Different tuber crop based cropping system models were developed by the Institute namely coconut+ tuber crops, banana+ tuber crops, arecanut +tuber crops and fruit trees+ tuber crops. Cropping systems involving cereals, vegetables, pulses and oilseeds in tuber crops were also developed. This technology is more women friendly as women can very well involved in these type of cropping systems which is easy for them to adopt.

Coconut+ cassava

Coconut+ elephant foot yam

Banana+ elephant foot yam

Women friendly component

- Easy to adopt
- More employment and income
- Better resource utilization

Technology 3

Integrated organic farming system for sustainable livelihood and climate resilience

(Developer: Dr. G. Suja)

Brief description

Integrated Organic Farming System (IOFS) model involving tuber crops and animal components was developed. The model includes horticulture crops and food crops, banana +

IOFS Model

elephant foot yam, cassava + vegetable cowpea/amaranthus, taro + maize, vegetables (bhindi, amaranthus, pulses) + oilseeds, pineapple, moringa, agathi (as hedge crops), hybrid napier grass (for fodder), dairy unit, lemon grass and vermicompost unit. Net returns of ₹ 1,18,256 could be obtained from tuber crop-based farming system from an area of 75 cents. Women can easily adopt this model even in their marginal land.

Women friendly component

- Easy to adopt
- More employment and income
- Better nutrition to the family
- Food security

Technology 4

Biofortified varieties of sweet potato for addressing nutritional security

(Developers: Dr. B. Vimala and Dr. Archana Mukherjee)

Brief description

Biofortified sweet potato varieties namely Sree Kanaka, Bhu Kanti, Bhu Ja, Bhu Sona and Bhu Krishna were developed and released for addressing the food and nutritional security. Bhu Krishna is rich in anthocyanin and the other varieties are rich in β-carotene. The cultivation of these varieties is easy to adopt and hence farm women can easily raise these crops. Moreover, these varieties are short duration in nature, require fewer inputs and can also be grown in low fertile soil. The biofortified tubers are rich in vitamins and antioxidants and thus it provides food and nutritional security to the family.

Sree Kanaka
10 mg/100 g

Bhu Kanti
7.8 mg/100 g

Bhu Sona
14.4 mg/100 g

Bhu Ja
6.4 mg/100 g

Bhu Krishna
90 mg/100 g

Women friendly component

- Easy to adopt
- More employment and income
- Better nutrition to the family
- Food security

Technology 5

Soilless production of tuber crops by hydroponic formulation

(Developers: Dr. J. Suresh Kumar, Dr. K. Sunil Kumar and Dr. G. Byju)

Brief description

Soilless production methods such as hydroponics, aeroponics, and aquaponics offer sustainable solution for urban farming of vegetables and tuber crops. These systems eliminate the need for soil, allowing precise control over nutrients and conditions, which accelerates growth and increases yield. They also minimize soil-borne diseases and pests, making urban farming more resilient and efficient. The ICAR-CTCRI has standardized hydroponic nutrient formulation, which is tested for tuber crops namely taro, Chinese potato, sweet potato and greater yam under climate control growth facility and rainout shelter. The yield is higher with no incidence of soil borne diseases, recorded higher palatability in most of the crops and varieties grown in hydroponics.

Hydroponics system

Vertical garden

Women friendly component

- Safe to eat tubers
- Less physical labour
- Easy to practice
- Resource conservation

Technology 6

Production of thippi compost from cassava starch factory solid waste (Thippi)

(Developer: Dr. K. Susan John)

Brief description

During the production of sago, the tapioca tubers are de-skinned and soaked in water. The tubers are then fed into the crusher adding water for extraction of milk which is passed through a sieve to remove the fibrous materials. This fibrous material in pulp form, when dried is known as cassava thippi. Vermicomposting of thippi enriched with *Glyricidia* and cassava leaves, cow dung and rock powder for 2 months resulted in enriched organic manure having highest nutrient content and lowest C:N ratio. The thippi compost can be used as an alternative to farmyard manure, green manuring *in situ* with cowpea, crop residue incorporation, vermicompost and coir pith compost and even fertilizers (NPK up to 50 % of the recommended dose, $MgSO_4$ @ 2.5 kg ha^{-1} and $ZnSO_4$ @2.5 kg ha^{-1}). The cost of production of thippi compost is Rs.10/kg. Thippi compost application can reduce the bitterness and increase the starch content of cassava tubers in addition to saving of chemical fertilizers. This quality parameter is very advantageous to cassava growers as there is market demand for less bitter cassava tubers. Thippi compost production unit may be set up by women entrepreneurs and focusing on a customer centric approach it can be marketed throughout the country.

Thippi

Thippi composting

Thippi compost

Women friendly component

- Easy to produce thippi
- Low cost
- Less time consuming
- Employment generation
- No drudgery

Technology 7

Micronutrient foliar formulations for tropical tuber crops

(Developers: Dr. G. Byju and Dr. D. Jaganathan)

Brief description

Micronol is a microfood or foliar micronutrient formulation that is used in tuber crops cultivation to address micronutrient deficiencies. Micronol can be used for crops such as cassava, sweet potato, elephant foot yam, yams and Chinese potato. Micronol contains all vital micronutrients required for excellent growth of the specified plants and for getting maximum yield. It corrects the symptoms caused by micronutrient deficiency and increases uniform vegetative growth thereby enhancing the size and quality of the produce. It also helps in resistance to diseases, stress, and drought. Women clusters can take up this technology.

Micronol formulations

Women friendly component

- Easy to produce
- Easy to apply
- Low cost
- Time requirement is less
- Women can start small scale enterprises

Technology 8

Customised fertilizers for tropical tuber crops

(Developers: Dr. G. Byju and Dr. K. Susan John)

Brief description

Customised fertilizers were developed for cassava, sweet potato, elephant foot yam, taro, yams and Chinese potato. It is a mixture of primary nutrients, secondary and micro nutrients specific to crops and soil nutrient status. Fertilizers namely urea, di ammonium phosphate, muriate of potash,


Customised fertilizers

magnesium sulphate, zinc sulphate and borax specific to soils were mixed and different grades of customised fertilizers are prepared based on plant requirement as per the grades designed.

Women friendly component

- Easy to produce and use
- No drudgery
- Saving of labour cost
- More profitable

Technology 9

Wax coating technology for cassava tubers

(Developers: Dr. R. Saravanan and Dr. T. Krishnakumar)

Brief description

Wax coating of cassava tubers are done to enhance the shelf-life of fresh cassava. The primary objective is to improve the marketability and shelf-life of fresh cassava roots. By using the wax coating method, the post-harvest deterioration of the cassava roots is significantly reduced, leading to increased profitability for processors and traders. The enhanced shelf-life allows for storage, transportation, and sale of the cassava roots over long distances without compromising their quality. The method involves cleaning, treating them with chlorinated water and allowing them to dry. Then, the roots are immersed in molten paraffin wax or a suitable alternative, ensuring even coating. This wax treatment creates a barrier that prevents the exchange of gases like oxygen, carbon dioxide and water vapour, thereby preserving the freshness of the cassava roots for an extended period up to one to two months.

Wax coating of cassava tubers

Women friendly component

- Easy to implement
- Minimum resource usage
- Extended shelf life
- Cost effectiveness

3. Plant Health Management

Technology 10

Bioactive molecules from cassava crop residues

(Developer: Dr. C.A. Jayaprakas)

Brief description

Biopesticides are used to manage pests in crops in an ecofriendly way. Three biopesticides were developed by ICAR-CTCRI namely N*anma, Menma* and *Shreya* from cassava leaves. The apparatus and the process of extraction was also developed by the Institute. The biopesticide is effective against borer pests like red palm weevil in coconut, pseudostem weevil in banana and sucking insects in horticultural crops. These technologies were perfected more than a decade ago and proved very effective for the eco-friendly management of a variety of insect pests. The women entrepreneurs can establish bio-pesticide production units and they can manufacture the biopesticides which have immense market scope and good demand among the farmers.

Nanma, Menma and *Shreya*


Bioformulation extraction plant

Women friendly component

- Easy process
- Women can establish small units
- Easy to operate the plant
- Easy availability of raw materials

Technology 11

Biocapsules for growth promotion and disease management

(Developers: Dr. S.S. Veena, Dr. R. Praveena, Dr. M.L. Jeeva and Dr. P.S. Sivakumar)

Brief Description

The ICAR-CTCRI, Thiruvananthapuram in collaboration with ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode jointly developed biocapsules of three growth promoting and disease suppressing microorganisms by utilizing the commercialized encapsulation technology for the smart delivery of agriculturally important microorganisms. The technology involves encapsulation of the microorganisms of interest in a gelatin capsule for delivery to agricultural crops for enhanced soil nutrient solubilization, growth, yield and suppression of disease. Women can produce these biocapsules easily and there is a good demand in the market.

Biocapsules of *Trichoderma* and *Bacillus* species

Women friendly component

- Easy to produce
- Eco-friendly technology
- Low production cost
- Easy to handle and store

Technology 12

Management of post harvest rot in elephant foot yam

(Developers: Dr. S.S. Veena and Dr. M.L. Jeeva)

Brief Description

Post harvest rot is a major problem in elephant foot yam which cause 30% loss during storage. Dipping of elephant foot yam corms in botanicals such as turmeric and garlic do prevent post harvest rot. Women can be involved in this activity which can fetch them employment and income.

Elephant foot yam corm treatment

Women friendly component

- Easy process
- Does not require any equipment
- Green technology and eco-friendly
- Low production cost
- Easy to handle and store

4. Farm Mechanization and Post Harvest Processing

Technology 13

Harvesting tools for cassava

(Developers: Dr. G.T. Kurup, Dr. S.K. Nanda and Dr. J.T. Sheriff)

Brief description

First order: The first order lever type harvesting tool comprises a long lever supported on a fulcrum which in turn is supported at the top of a stand. The shorter arm is bent down and has a stem holding mechanism. During operation, the jaws open to get around the cassava stem under. As the longer arm is lowered the rope tension increases, holding the jaws around the stem tightly. Further lowering of the longer arm uproots and raises the cassava plant out of the soil. The tool has a mechanical advantage and its total weight is 14 kg.

Second order: The height of the fulcrum at the far end of the lever can be adjusted which facilitates uprooting of cassava plants raised on flat bed as well as on mounds or ridges. A self-tightening mechanism has been used to grip the cassava stem between the two jaws. Initially the jaws are to get a hold around the stem. After gripping the stem, the plant is uprooted by raising up the effort end of the lever. If the plant is uprooted by applying few gentle jerks, the tubers do not break and get easily detached from the soil. It has mechanical advantages and the total weight is 8 kg with overall length of 2.1 m.

Cassava harvester

Women friendly component

- Easy to operate
- Less energy input

Technology 14

Portable self –propelled cassava sett cutter

(Developers: Dr. T. Krishnakumar, Dr. M.S. Sajeev and Dr. C. Pradeepika)

Brief description

A portable self-propelled cassava sett cutter was designed and developed, comprising several components such as petrol engine (2HP), rotary cutting blade (12 diameter), frame, pulleys, platform, inlet and outlet assembly and stopper. This unit can be operated by hand or pedal by women easily. The adjustable feature on the stopper is used to produce the required

length of cassava setts. Rotary cutting blades attached to the prime mover will produce uniform and round cutting of cassava setts for high quality cassava setts production. The developed cassava sett cutter was tested for its performance, cutting efficiency, percentage of damaged setts and output capacity was 98%, 0.45% and 7500 setts per hour, respectively. The fuel consumption was 1 litre per hr.

Portable self –propelled cassava sett cutter

Women friendly component

- Easy to operate
- More efficiency
- Less time consumption

Technology 15

Power operated size based Chinese potato grader

(Developers: Dr. T. Krishnakumar, Dr. M.S. Sajeev, Dr. C. Pradeepika, Dr. R. Muthuraj and Dr. D. Jaganathan)

Brief description

A size based grader for Chinese potato tubers with a capacity of 1 tonne per hr was developed. The developed grader is mainly made up of five parts: a feeding chute, a rotary type grading drum, rotating guiding rollers, a collection chute and a power transmission system. Chinese potato tubers are sorted into four sizes namely small (less than 20 mm), medium (20.10-30 mm), large (30.10-40 mm) and very large (greater than 40 mm) by the developed grader and collected through the outlets positioned below the grading drum. Grading efficiency of the developed Chinese potato grader was found to be 96 %. Depending on the size of the tuber, the rotating drum can be changed. The total weight of the machine is 200 kg. Mechanical grading of Chinese potato tubers is ten times cheaper than manual grading.

Women friendly component

- Low cost
- Less labour and time
- Easy to use
- Non strenuous

Technology 16

Cassava peeling knife

(Developers: Dr. T. Krishnakumar and Dr. M. S. Sajeev)

Brief description

Peeling (removal of the corky skin alone or along with the fibrous rind) is usually accomplished manually with hand knives. It is the most labour intensive unit operation in the process of starch extraction. A cassava peeling knife of novel design was developed and tested at ICAR-CTCRI and subsequently evaluated on-site at a starch and sago factory in Salem. Results of the on-site evaluation of the improved prototype showed that the average output of the peeling knife is 132 kg/h, comparable to that of the traditional knife used by professional workers. Additional labour cost per tonne of tubers peeled by the improved knife (@ Rs. 3 per basket of 55-60 kg unpeeled tubers) is Rs.12 only; Flesh loss with the improved knife is only 1.38% compared to 5.70% by the traditional knife.

Women friendly component

- Easy to peel
- Time saving
- More efficiency
- Less cost

Technology 17

Cassava chipping machines

(Developer: Dr. S.K. Nanda)

Brief description

Cassava chips are pieces of dried, sliced or chipped roots not exceeding 6 cm length with starch content of 70% or more. Cassava chipping machine is used to slice the cassava tuber

into chips of various thickness and shape. ICAR-CTCRI has developed three types of cassava chipping machines viz., hand operated, pedal operated and motorised. The shorter shelf life of cassava tubers (up to 2 days in ambient conditions) limits their marketability and prevents farmers to transport them to long-distance markets to obtain good price. The cassava chipping machine helps the farmers to make chips from the cassava tubers which can extend the shelf life of cassava tubers in dried form. Produces chips of circular shape and desired thickness. Women can be involved in making dried chips and there lies enormous scope for export of dried cassava chips in the international markets.


Hand operated


Pedal operated


Motorised

Cassava chipping machines

Women friendly component

- Easy to chip
- Time saving
- More efficiency
- Less cost

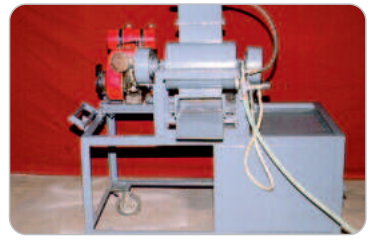
Technology 18

Mobile starch extraction unit

(Developers: Dr. C. Balagopalan and Dr. M.S. Sajeev)

Brief description

Major components of the machine are hopper to feed the tubers, crushing disc rotating inside crushing chamber to crush the tubers, sieving tray to remove the fibrous materials, stainless steel tanks to collect the sieved starch suspension, tuber storage chamber, handle and wheels for easy transportation. Overall dimension of the machine is 135 x 180 x 132 cm and tubers can be fed by a person standing on the ground. Addition of water during processing can be controlled through a water pipe with holes


Mobile starch extraction unit

fixed inside the hopper. An electric motor (¾ hp) or a generator (kerosene–petrol) attached to the frame can be used as the energy source to operate the machine.

Women friendly component

- Easy to maintain
- Easy to transport
- Convenient to operate
- Suitable to use by women
- Generates employment

Technology 19

Quick cooking dehydrated tubers

(Developers: Dr. M. S. Sajeev, Dr. G. Padmaja and Dr. J. T. Sheriff)

Brief description

Quick cooking dehydrated cassava and elephant foot yam tubers were developed. The dehydrated cassava and sliced tubers prepared with appropriate pre-treatment can be cooked within 3-5 minutes. This method is used to increase shelf life, reduce bulkiness during export and enables fast cooking.

Quick cook cassava tubers

Quick cook elephant foot yam corms

Women friendly component

- Easy to adopt
- Extended shelf life
- More export potential

5. Gluten-free Snack Foods from Cassava and Sweet Potato

Technology 20

Fried cassava chips with improved textural quality and better colour

(Developers: Dr. G. Padmaja and Dr. M.S. Sajeev)

Brief description

Tubers of 8-9 months maturity having starch content less than 28% and sugar content less than 1% are ideal for making fried cassava chips. Sree Jaya and Sree Vijaya released from ICAR-CTCRI were found to be best suited varieties. In the case of high starch and high sugar varieties, soaking the chips in acetic acid/citric acid-brine solution followed by parboiling, surface drying and deep frying were found to yield good chips. The product has reduced hardness and good texture compared to the market product available and has better market potential.

Cassava chips

Women friendly component

- Highly suitable for women
- Reduces drudgery
- Enhances output
- Generates more income

Technology 21

Fried snack foods from cassava based composite flour

(Developers: Dr. G. Padmaja and Dr. M.S. Sajeev)

Brief description

Ten fried food products viz., hot fries, hot sticks, sweet fries, sweet dimons, salty fries, salty delight, murukku, crisps, nutrichips (with egg) and nutrichips (without egg) were prepared. Edible grade cassava flour can be mixed with maida, rice flour, Bengal gram flour or other ingredients depending upon the type of products. The sweet products had sugar content from 31-38% while the salty and hot fries had sugar content of 3-4%. The fat content in the various products ranged from 15 to 26%. The crude protein content was in the range of 5-11%. Fried food products from composite flour based on cassava have high nutritional and textural quality as well as longer shelf life. They can easily capture the urban markets.

Fried snacks

Women friendly component

- Highly suitable for women
- Reduces drudgery
- Enhances output
- Generates more income

Technology 22

Protein and dietary fibre enriched cassava mini-papads

(Developers: Dr. G. Padmaja and Dr. M.S. Sajeev)

Brief description

Cassava flour has very low protein and hence it is not much used in the food industry. This defect could be overcome through the use of high protein sources like cheese, defatted soy flour and whey protein concentrate. The products developed had protein content in the range of 8-16%. Similar products with high dietary fibre content were also developed using fibre sources like rice bran, wheat bran, oat meal and cassava fibrous residue as possible. The products had dietary fibre enhancement to the tune of 8-14%. The mini-papads developed through fortification with protein and fibre sources have use as functional foods having prophylactic effect on diseases/conditions like heart problems, obesity, intestinal diseases etc.

Cassava mini papad

Women friendly component

- Highly suitable for women
- Reduces drudgery
- Enhances output
- Generates more income

Technology 23

Functional pasta and noodles from cassava and sweet potato

(Developer: Dr. M.S. Sajeev)

Brief description

Fortified and gluten free pastas and noodles can be easily prepared which contains whey protein, dietary fibre, betanine and carotene.

Functional pastas

Women friendly component

- Easy to adopt
- Extended shelf life
- More export potential

Technology 24

Sweet potato jams, nutri jellies, pickles

(Developer: Dr. M.S. Sajeev)

Brief description

β-carotene rich and anthocyanin rich jams are prepared from sweet potato varieties viz., Bhu Sona and Bhu Krishna respectively. Natural supplementation of anthocyanin which acts as antioxidant. β-carotene (precursor of Vitamin A) helps to eradicate the Vitamin A deficiency. This is a ready to use functional food having good texture and taste, made out of biofortified sweet potato extract. Available in two versions as β-carotene rich jelly from var. Bhu Sona; Anthocyanin-rich jelly from var. Bhu Krishna. It is a natural supplementation of anthocyanin and act as an antioxidant.

Sweet potato jams, nutri jellies, pickles

Women friendly component

- Easy to adopt
- More market potential
- .Generates more income

6. Functional Bakery Products

Technology 25

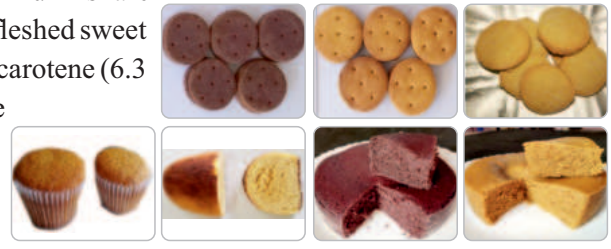
Functional bakery products

(Developers: Dr. M.S. Sajeev and Dr. C. Pradeepika)

a. Gluten free functional cookies

Brief description

Protein and fiber enriched gluten free functional cookies from orange and purple fleshed sweet potato are prepared. They are rich in carotenoids and anthocyanin. Protein and anti-oxidant enriched sweet potato muffins are prepared. The cake made from orange fleshed sweet potato flour is an excellent source of β-carotene (6.3 mg/100g). Anthocyanin rich cake made from purple fleshed sweet potato flour is a good source of anthocyanin (39 mg/100g). In addition to this sweet potato flour nutri bar, gluten free sweet potato cookies, sweet potato flour supplemented muffins are also prepared.

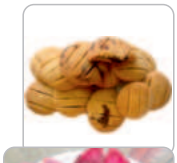


Gluten free functional cookies and cakes

b. Protein fortified rusk: It has different proportions of cassava flour, wheat flour and whey protein concentrate (WPC). Good amounts of fiber (4%) and protein (8.30%) with cassava flour- 40 g, wheat flour- 55 g and WPC- 7.5g.

c. Sorghum incorporated sweet potato thin crackers: Sweet potato and sorghum-based thin crackers (40 % of sweet potato flour, 40 % of sorghum and 20 % of wheat flour) by completely replacing the maida.

d. Pearl millet incorporated sweet potato choco-filled cookies: Pearl millet incorporated choco-filled cookies developed by replacing maida with sweet potato flour, pearl millet and wheat flour.



e. Vacuum fried chips: Vacuum fried chips prepared from orange fleshed and purple fleshed sweet potato are lower in fat content and higher in bioactive compounds (β-carotene: 6.81 mg/100g & anthocyanin: 57.44 mg/100g).

Vacuum fried chips from sweet potato

Women friendly component

- Easy to adopt
- More market potential
- .Generates more income

Technology 26

Ready to cook products from sweet potato

(Developers: Dr. V. Bansode and Dr. M. Nedunchezhiyan)

Brief description

Paratha mix: Major ingredients include sweet potato flour, pearl millet and wheat flour.

Ladoo mix: Purple fleshed sweet potato flour and Bengal gram flour.

Nutri-pasta: Sweet potato flour, buckwheat flour and quinoa flour

Technology 27

Nutri meal mix

(Developers: Dr. V. Bansode and Dr. M. Nedunchezhiyan)

Brief description

Nutri meal mix is a healthy combination of cereals, pulses, ragi, biofortified sweet potato and dry fruits. It is nutritious, healthy and gluten free product. Eight products are available with elaichi (4) and vanilla (4) flavours. Suitable for all age groups and healthy diet plan. Bhu Krishna flour with sugar, Bhu Krishna flour with jaggery, Bhu Sona flour with sugar, Bhu Sona flour with jaggery.

Nutri flours

Women friendly component

- Easy to adopt
- Less input cost
- No drudgery
- Extended shelf life
- More market demand

7. Smart Farming

Technology 28

Electronic Crop (e-Crop) for smart farming

Developer: Dr. V.S. Santhosh Mithra

Brief description

This is a weatherproof electronic device which works directly in the field. Sensors in the device are used mfor collecting data on weather and soil parameters. The data collected by the sensors are sent to the control unit for processing from where it is sent to the cloud. This system simulates crop growth in real-time, in response to weather and soil parameter data collected from the field and generates agro advisories that are sent to the farmer's mobile as SMS.This device can be used for giving real-time agro advisory of any crop that can go on to reduce yield gap and to achieve the targeted yield. Weather parameters of the day, the potential yield that can be achieved by the crop after its stipulated duration as per its present crop condition and anticipated weather scenarios, N, P, K and moisture required to be applied to achieve this targeted yield, etc., are included in the advisories sent to the mobile phone as SMS.

The e-Crop helps to achieve higher productivity by reducing yield gap as:

- This product calculates plot by plot yield gap daily, and quantifies N, P, K and waterrequirement
- This information is sent to farmers daily as SMS.
- Through the daily/frequent application of nutrients and water, its total requirement for the entire season is less (about 25-50% reduction) whereas yield increases at least by 100%;
- Reduced application of chemicals and water helps to save resources and minimizes damage to the environment;

e Crop

Women friendly component

- Easy to adopt
- Helps in reducing input cost
- Real time agroadvisory services
- Generates more profit

8. Innovative Extension Approaches for Women Empowerment

The important technology dissemination activities in tuber crops implemented by ICAR-CTCRI include training programmes, frontline demonstrations, community approaches, participatory technology development/transfer, sustainable livelihood analysis, farmers field schools, promotion of self help groups, value chain analysis, research-extension-farmer linkage, Mera Gaon Mera Gaurav, social media, attracting students towards agriculture, seminars, group meetings, exhibitions, information communication through mass media like radio, television, newspapers and farm magazines, extension pamphlets, CD ROMs, video films etc., providing consultancy through field visits and replying postal, e-mail queries etc. The details of the important extension approaches are described below.

Training programmes

On campus/off-campus training programmes for farmers and extension personnel on specific topics on tuber crops such as improved varieties, planting materials production, agrotechniques, integrated pest and disease management, organic farming technologies, tuber crops based cropping/farming systems and post harvest technology form an important component of TOT programmes to enhance their knowledge and skill for better technology utilization. Women are trained on the improved technologies of tuber crops covering all aspects including processing and value addition for enhancing productivity and profitability in tuber crops farming. Training programmes were highly successful in improving the skill and knowledge of the farmers and stakeholders.

Training for officials

Training for SHG members

Front Line Demonstrations (FLD)

The ICAR-CTCRI has been organizing frontline demonstrations in farmers' fields of several states on different cultivation technologies of tuber crops such as improved varieties, cropping/farming systems, nutrient management, pest and disease management, use of post harvest machineries etc. Such demonstration programmes have proved to be effective in convincing the farmers about the technical feasibility and economic viability of the

technologies. Demonstrations on improved varieties/ technologies of tropical tuber crops are established in major tuber crops growing states viz., Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and North Eastern States for proving the technical feasibility and economic viability of the technologies.

FLD on improved varieties of sweet potato in Kerala

FLD on SSNM in elephant foot yam in Tamil Nadu

Community approaches for sustainable livelihood security of tribal people

Livelihood of a substantial number of families in rural poor communities in India depends on tuber crops farming. To augment the production and productivity of such small and marginal holdings, which are also fragmented, group management of resources to overcome the inherent weaknesses of such holdings was taken up through community approaches by ICAR-CTCRI in selected localities. Such an approach helped efficient management of farmers' resources to reduce cost of cultivation and to increase productivity through integration of technologies. NEH, SCSP and TSP programmes were implemented with the objectives viz., to increase area under tuber crops cultivation, to increase farm productivity, to increase the availability of tubers, vegetables, egg, meat and other cereals for household consumption, to increase employment and household cash income.

Distribution of planting materials of sweet potato in Meghalaya

Village incubation centre at Riha village, Manipur

FLD on improved variety of yam bean in Odisha

Farm advisory visit in Odisha

Participatory Technology Development/Transfer

Farm families of manageable contiguous area (5-10 ha) join in Participatory Technology Development/Transfer approach wherein multidisciplinary team of scientists, extension officials, farmer representatives, local village representatives, women, youth etc. forms the stakeholders. The awareness, knowledge, attitude and adoption of farmers towards the technology package *viz.,* varieties, agro-techniques, plant protection measures, value added products and services were improved significantly over the pre-implementation level. The monitoring, appraisal and evaluation of the technology implementation and impact were done with the stakeholder participation and documented in 'farmer-scientist-extension dialogue session' for further scaling up by other agencies. Sree Jaya and Sree Vijaya are the short duration cassava varieties with excellent cooking quality which were identified through PTD approach. Similarly, short duration sweet potato varieties namely, Sree Arun and Sree Varun were released using PTD approach.

Sustainable livelihood approach

Sustainable livelihood approach is used as a framework helps to better understand and respond to the multi-dimensionality of poverty and food insecurity in a given project area. Village livelihood profile describes resource status (physical, economic, natural, social, political), their utilization process, problems and opportunities in the village. It serves as status document for planning and implementation of development programmes. The village livelihood profile provides the information which can be used in planning and implementing technology interventions.

Sustainable livelihood analysis of tuber crops farmers and non-tuber crops farmers were conducted during 2014-2019 in Kerala (60), Tamil Nadu (120), Karnataka (120), Andhra Pradesh (120) and Odisha (100) with a total sample size of 520 farmers. Tuber crops *viz.,* cassava, sweet potato elephant foot yam and taro and non tuber crops *viz.,* paddy and banana were covered for analysing the sustainable livelihood capital index using DFID methodology.

Livelihood assessment among elephant foot yam growers in Andhra Pradesh

Livelihood assessment among taro growers in Odisha

Farmer Field Schools (FFS)

The FFS approach is an innovative, participatory and interactive learning approach that emphasizes problem solving and discovery based learning. FFS aims to build farmers' capacity to analyze their production systems, identify problems, test possible solutions, and eventually encourage the participants to adopt the practices most suitable to their farming systems. FFS can also provide an opportunity for farmers to practice and test/evaluate sustainable land use technologies, and introduce new technologies through comparing their conventional technologies developed with their own tradition and culture. FFS is usually a time bound activity (generally one agricultural production cycle or a year), involving a group (commonly 20 to 30) of farmers. It is facilitated by extension staff or – increasingly – by farmer facilitators (FFs). The method emphasizes group observation, discussion, analysis, presentation and collective decision making and actions. The basic component of FFS is setting up of a Participatory Technology Development (PTD), whereby the farmers put the FFS concept into practice. PTD can be developed using subjects of agriculture, tuber crops, livestock, forestry, agroforestry, livelihoods and others.

Promotion of women's Self Help Groups

Entrepreneurship Development Programmes are regularly organized for women to train them on value addition in tuber crops. Various topics including the concept and practices of entrepreneurship development, group approach for micro level interventions, product diversification in tuber crops are included in the programme. The experiences and impact of organizing such programmes clearly indicated the scope and importance for enhancing the income of resource-poor women and socio-economically disadvantaged rural women through product diversification in tuber crops.

Training for SHGs on value addition in tuber crops

Farmers' participation in tuber crops research

This approach invariably enhances the extent of technology utilization at farm level. The ICAR-CTCRI was one of the selected centres to implement the Institution-Village Linkage

Programme (IVLP) under National Agricultural Technology Project (NATP) during 1999-2004. The TAR-IVLP project was implemented in selected villages. Implementation of the project revealed the effectiveness of participatory approach in the performance assessment of various technologies related to improved varieties, cropping/farming system, nutrient management and crop protection in tuber crops.

Value chain analysis of sweet potato in Karnataka

In India, sweet potato is one of the important staple food crops among disadvantaged section of population, and majority of the farmers consider it as a major source of food and is used in limited extent as animal feed and industrial raw materials. Though sweet potato is cultivated in almost all states of India, four states, viz., Odisha, West Bengal, Uttar Pradesh and Kerala contribute nearly three fourth of total area and production. Karnataka is one of the emerging states in sweet potato production in India with a production of over 36000 tonnes annually and Belagavi district accounted for the highest productivity of sweet potato (14.2 t/ha) in comparison to other districts of Karnataka. With the existence of well-developed marketing system especially in the Belagavi and Uttara Kannada districts along with entrepreneurial attitude of the farmers, the Karnataka state has the ideal ecosystem of developing sweet potato based industries.

Interaction with the stakeholders on Value chain of sweet potato in Karnataka

Considering the potential of sweet potato processing industries to enhance farmers' income in a shorter period, the sweet potato value chain analysis was conducted during 2017-2018 in Belagavi district of Karnataka with a sample size of 137 covering 112 farmers, 10 from APMC market, 5 wholesalers and 10 retailers. The average yield of sweet potato was 9.83 t ha^{-1}. On an average the farmers were selling sweet potato tubers at Rs.599/quintal. The major problem faced by the sweet potato farmers was incidence of pests and diseases besides unforeseen weather due to erratic rainfall which affects the production. The farmers also reported low price for their produce and commission fee charged by the commission agents at APMC market as important constraints in marketing their produce.

Strengthening Research-Extension-Farmer linkage in tuber crops sector

Various agencies both from research and extension systems strive for the development of tuber crops sector and for better impact, such extension activities are to be coordinated at different levels. Research-Extension-Farmer interface programme is an approach for strengthening the ToT efforts for the development of tuber crops sector and the experiences of ICAR-CTCRI in implementing such programme indicate the relevance of strengthening linkages at different levels. Researchers, extension personnel and farmers are brought together on a common platform and the activities for the sustainable development of tuber crops are streamlined. The interface programmes could enhance the awareness and knowledge about the technologies for improving productivity and income of farmers from tuber crops farming.


R-E-F interface programme

Mera Gaon Mera Gaurav

The innovative initiative 'Mera Gaon Mera Gaurav' – 'My Village My Pride' by Ministry of Agriculture and Farmers' Welfare, Govt. of India has been planned to promote the direct interface of agricultural scientists with the farmers to hasten the lab to land process. The ICAR- CTCRI, Thiruvananthapuram and its Regional Station, Bhubaneswar have started implementing the programme in 49 villages from October, 2015 as per the guidelines. Training programmes, demonstration on improved practices, farm advisory visits, mobile advisory services are organized in the selected villages for the benefit of farming community. Cutting across all disciplines, farm problems are diagnosed and effective solutions are delivered and showcased in farmer's fields. National priorities such as secondary agriculture, climate change, good agricultural practices and soil and health management of crops are envisaged in this programme.


Farm advisory visits to MGMG villages

Social media

Social media is playing a crucial role in technology transfer. Farmers are connected with the researchers through whatsapp, facebook, twitter etc. Farmers and other stakeholders are sharing their experiences through social media and this would help the fellow farmers to know about the technologies and their success. It serves as a discussion group for the farming community and this strengthens the farmer to farmer communication.

Collaborative extension programmes involving multiagencies

Most of the technology transfer programmes are done in collaboration with multiple agencies. Effective linkages are established with various agencies such as ICAR institutes, Kerala State Industrial Development Corporation (KSIDC), SAUs, State Department of Agriculture/Horticulture, State IT Mission, NGOs like MSSRF, people's representatives and farmers' organizations for the effective conduct of the interactive videoconferencing programmes by ICAR-CTCRI to strengthen technology transfer programmes.

Attracting students towards agriculture

The Institute conducts awareness programmes and trainings to school and college students on the different aspects of tuber crops production and value addition. The students are taken around the Institute and are exposed to the farm activities, visit to laboratories, museum and other research facilities to imbibe the importance of agriculture in the young minds.

Training programmes for agricultural students

Conclusion

Women are the one whose presence brings prosperity in all and every field around the globe. A world can never survive in the absence of women. Women stand alone in their perspective and have an ambition to learn, do and contribute. Capacity building of farm women to adopt improved technologies is the need of the hour to empower them in all aspects. Keeping this in view, ICAR-CTCRI has developed women friendly technologies with an aim to enhance the participation of women in tuber crops cultivation thereby reducing their ergonomic issues and drudgery. Technologies are meant for promoting economic development and social empowerment of the women in our country who hold the means for the welfare of the country.

Tuber crops for.....

Food, Health, Wealth and Prosperity

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