INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

BENGALURU

EVALUATION OF RKVY PROJECTS

OF

UNIVERSITY OF AGRICULTURAL SCIENCES,

RAICHUR

"APPLICATION OF NANOTECHNOLOGY
IN
ENHANCING QUALITY
OF
AGRI PRODUCE"

INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

#15, QUEENS ROAD, BENGALURU 560 052

CONTENTS

APPLICATION OF NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRI PRODUCE

EXECUTIVE SUMMARY

Agriculture is always most potentiated and stable sector because it produces and provides raw materials for food and feed industries. Due to the increasing world population, increased nutrient mining, for increase the total food grain production, shrinking arable lands, restricted water availability, deteriorating soil organic matter, climate change and so many other reasons, it is necessary to use the advance technologies.

The term "Nano technology" has been defined as the branch of the science that deals with the understanding and control of matter at the dimensions of about 1-100 nm by the US Environmental Protection Agency. It includes controlling, building and restructuring of the devices and other materials of physical, chemical and biological features at nano scale level, i.e., on the scale of atoms and molecules (a nano meter (nm) is one billionth (10^{-9}) of a meter). The functionality can be added to nano particle by interfacing them with biomolecules or structures (Tejpal Dheva, 2015).

Nano technology is an integration of different range of applied sciences such as chemistry, physics, biology, medicine and engineering in which the structure of the matter is controlled at the nano meter scale to produce materials having unique properties such as high surface area, target site of action and slow release.

Although the scientific studies on the applications of nano technology in agriculture are less than a decade old yet the prospects of nano technology in this field are considerable. The rapid developments in the nano sciences have a great impact on agricultural practices and food manufacturing industries. The significant interests of using nano technology in agriculture includes specific applications like nano fertilizers and nano pesticides to trail products and nutrients levels to increase the productivity without decontamination of soil, water and protection against various biotic and abiotic stresses. Nano technology may act as sensors for monitoring soil quality of agricultural field and thus it maintain the health of crops (Prasad et al., 2017). Nano technology will transform agriculture and food industry by innovation of new techniques such as precision farming techniques, enhancing the ability of plants to absorb nutrients, more efficient and targeted use of inputs, disease detection and control diseases. Increase the nutrient use efficiency of applied fertilizer with the help of nano clays and zeolites and restoration of soil fertility by releasing fixed nutrients. It also plays an important role in developing new generation of pesticides with the safe carriers. Nano herbicides are being developed to address the problems in perennial weed management and exhausting seed bank of weed. Levels of

environment pollution can be evaluated quickly and effectively by gas sensors and nano smart dust (Shaimaa and Mostafa, 2015). Nano technology has an enormous potential to offer smarter, stronger, cost-effective packaging materials, biosensors for the rapid detection of the food pathogens, toxins and other contaminants or food adulterants., preservation and packaging of food and food additives, strengthening of natural fibre, removal of various contaminants from the soil and water bodies by using functionalized nanoparticles and improving the shelf-life of the vegetables, flowers and fruits.

In recent years, some devices and tools developed by Nano technology such as nanodevices, nano capsules etc., are being used to detect and treat the plant diseases, delivery of active components to the desired target sites, treatment of waste water and also to enhance the absorption of nutrients in plants. The targeted delivery of nanoparticles not only reduces the damage to non- target plant tissues, but also minimizes the amount of harmful chemicals that pollutes the environment. Hence, this technology is not only eco-friendly but also helps in reducing the environmental pollutants. There are some specific nanoproducts that have been developed for using as soil-enhancer products which promote the even distribution of water and storage. Thus, useful in water saving. Besides, some of the important developments in production of Nano technology products like nanomaterials, nanostructures, nanofibers, nanotubes, etc. with unique physical, mechanical and chemical properties which make them electrochemically active. Such devices play vital role in plants and animal breeding (Prasanna, 2007), genetic engineering and also have been applied in biochemical sensors due to rapid response along with high sensitivity.

Nanomaterials can also be used in delivery of nutrients and pesticides in the plants (Srilatha, 2011), analysis of soil samples and waste water treatment. Agricultural wastes have attracted their uses as raw materials for the production of nanomaterials. Several efforts have been taken to obtain the nanocomposites based on biomaterials. The productions of nanocomposites are more sustainable and have beneficial properties as compared to the conventional materials such as microcomposite and macrocomposite materials.

Keeping the above in view, **"APPLICATION OF NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRI PRODUCE"** was taken up by University of Agricultural Sciences, Raichur with Rashtriya Krishi Vikas Yojana funding. The project was implemented during 2012-13. The details of the project are as under:

1.	**Title of Project**	**:**	**"APPLICATION OF NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRI PRODUCE"**
2.	**Nodal officer and Principal Investigator**	**:**	**Dr. Sharanaguda Hiregoudar,** Asst. Professor, Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur
3.	**Implementing Institution (S) and other collaborating Institution (s)**	**:**	Departments of Entomology, Microbiology, College of Agricultural Engineering, Raichur
4.	**Date of commencement of Project**	**:**	2012-13
5.	**Approved date of completion**	**:**	2012-13
6.	**Actual date of completion**	**:**	2012-13
7.	**Project cost**	**:**	Rs. 50 lakhs

The objectives of the project are as follows:

1. Improve the food safety and provide the nutrient, diet-based food product by developing the Functional Foods and Nutraceuticals.
2. Nano coating materials to protect from insect pests and diseases for minimizing the post-harvest losses.
3. Study the causes and remedies for improving the chemical properties of water.

The focus of Evaluation is:

i. To evaluate the importance of biosynthesis over other methods of production of nano particles.
ii. To evaluate the utility of the Centre for Nano technology for enhancing the quality of agricultural produce.
iii. To evaluate the impact of nano particles on insects and pest activity during storage.
iv. To evaluate the importance or role of nanoparticles in waste water treatment and purification of drinking water.

Work conducted on improving the food safety and providing nutrient, diet-based food product by developing Functional Foods and Nutraceuticals was mainly confined to improving the nutritional quality of spinach by application of nano zinc.

Another experiment on effect of nano particles on keeping quality of fig revealed that coating fruits with nano particles would delay the maturity development and improve the shelf life.

While the experiments have given encouraging results on use of nanoparticles for improving the food quality, there is need to evaluate their use in the food produced in the area rather than attempt crops which are not normally grown in the area. The very concepts of functional foods, neutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. The most common pulse pests are the cowpea weevil (*Callosobruchus spp*.) and pea weevil (*Bruchids pisorum*). The cowpea weevil has a life span of 10–12 days while the pea weevil only breeds one generation per year. Pulse beetle (*Pachymerus chinensis*) mainly feeds on cowpea, pea, gram, arhar, soybean, beans etc. The damage is caused by the grubs by eating out the entire content of the grain, leaving only the shell behind. Attack of these beetles often stars in the fields from where it reaches the stores. Khapra beetle and Lesser grain borer feed on arhar, peas and urd. Under these circumstances, use of nano particles for managing stored pests is a welcome idea.

Studies undertaken for designing a Nano adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. Nano adsorbents for various types of pollutants like BOD and COD, phosphate, sulphate and nitrate were used for effluent treatment. Nano adsorbents have shown reduction efficiency varying from 64% to 97%.

Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. The model has been installed at Government school, Mavinamatti, Shahapur, Yadgir (Dist) in collaboration with IIT, Chennai for removal of arsenic from drinking water. This has immense commercial value and the University has already developed more than 100 filters and distributed to public.

REFLECTIONS AND CONCLUSIONS

1. The very concepts of functional foods, neutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.
2. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.
3. Final analysis and toxicity work with selected the insecticides for control of storage pests and study the storage losses including Malathion - Nano malathion, Fenvalerate - Nano Fenvalerate, Emamectin benzoate - Nano Emamectin benzoate, Thiodicarb - Nano Thiodicarb, Sweet flag - Nano Sweet flag and Neem seed kernel powder - Nano Neem seed kernel powder is under progress. This should be completed quickly and its commercial application should be taken up.
4. Studies undertaken for designing a Nano adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.
5. Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. Commercial production of the filters should be taken up in PPP model.

ACTION POINTS

1. The equipment procured under the project are exemplary. However, their maintenance cost will be too high. Hence, it is better to convert the centre on PPP mode and generate data as well as work efficiently and maintenance on self sufficiency mode.
2. The techniques of nano encapsulation of ingredients, additives and supplements are good but should be tested for food safety and FSSAI before releasing for commercialization.
3. The techniques of nano particles mixing for effective control of insect pests is a good move. However, its economics needs to be worked out.
4. There is need for working out cost economics of use of nano silver particles and magnetic power used for purification of water and its safety as per FSSAI standards.
5. Side effects on nano particles on human beings needs to be worked out.

6. Studies undertaken for designing a Nano adsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.
7. Water filtration system developed for removal of fluoride and arsenic should be taken up for commercial production of the filters in PPP model.
8. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.
9. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

RESEARCHABLE ISSUES

1. Initiate work on nano silicon and its impact on diseases and nutritional issues.
2. Research on nano microbial components needs to be initiated.
3. Strengthening of research on nano remedial measures for insects and diseases management.

APPLICATION OF NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRI PRODUCE

INTRODUCTION

Agriculture is always most potentiated and stable sector because it produces and provides raw materials for food and feed industries. Due to the increasing world population, increased nutrient mining, for increase the total food grain production, shrinking arable lands, restricted water availability, deteriorating soil organic matter, climate change and so many other reasons, it is necessary to use the advance technologies.

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Nano technology is an integration of different range of applied sciences such as chemistry, physics, biology, medicine and engineering in which the structure of the matter is controlled at the nanometer scale to produce materials having unique properties such as high surface area, target site of action and slow release.

The term "Nano" is derived from the Greek word "nanos" meaning 'DWARF' (Small). "Nano-technology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom/ one molecule or ions."

In the twenty first century, Nano technology has emerged with the great influence on global economy, industries and public lives. If we look at the historical part of agricultural applications of Nano technology, it came only in recent years but the seeds of research in this field start growing nearly half a century ago (Mukhopadyay, 2014). The uses of nanomaterials specifically for the agricultural purposes are required for improving the fertilization process, increase in yields through nutrient optimization and minimized the requirements of plant protection products (Huang et. al., 2015).

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Potential application of Nano technology in agriculture

Use of nanofertilizers for slow release of nutrients and improve efficiency, viz., Nano-5, Nano-Gro as plant growth regulators; nanopesticides encapsulated in nanoparticles for controlled release, nano emulsions for great control of pests, e.g., Allosperse delivery system, Nano revolution-2 and adjuvant; will enhance agricultural input use efficiency. Nano sensor in precision farming and nano material for site specific soil and water conservation, e.g., Geohumus and Nano Clay helps in efficient utilization of natural resources. Production of nano materials helps in recycling the agricultural waste ex. Central research institute of cotton, India has developed technology for production of nano cellulose from agricultural residues.

Application of Nano technology in agriculture and allied sciences

Nano technology have its relevance in numerous fields of science. Out of them few in agriculture and allied are food technology, crop improvement (genetic modified crops), seed technology, precision farming (site specific management), nano-fertilizer for balance crop nutrition, plant disease diagnose, weed management, water management, biosensors and pest management. Controlled Environment Agriculture (CEA) technology, as it exists today, provides an excellent platform for the introduction and utilization of Nano technology to agriculture. With many of the monitoring and control systems already in place, nano technological devices for CEA that provide “scouting” capabilities improve the grower’s ability to determine the best time of sowing and harvest for the crop, the vitality of the crop and food security issues, such as microbial or chemical deterioration (Allah, 2012).

Application of Nano technology in precision farming

Precision farming has been a long-desired goal to applying input as per demand of the crop that maximize output (i.e., crop yields) while minimizing input (i.e., fertilizers, pesticides, herbicides etc.). Precision farming makes use of computers, global satellite positioning systems (GPS), geological information systems (GIS) and remote sensing devices to measure highly localized environmental conditions thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems of crops and edephological environment. Precision farming can also help to recycle agricultural waste and thus keep environmental pollution at minimum extent. Tiny sensors and monitoring systems enabled by Nano technology will have a large impact on future precision farming methodologies. One of the major roles for Nano technology-enabled devices will be the increased use of autonomous sensors linked into a global positioning system (GPS) for real-time analysis. These nano sensors could be distributed throughout the field where they can monitor soil conditions and crop growth. The union of these two technologies in sensors will create equipment of increased sensitivity, allowing an earlier response to environmental changes. For example: (a) Nano sensors utilizing carbon nano tubes or nano-cantilevers has capability to trap and measure small molecules; (b) Nano particles or nano surfaces can be engineered to trigger an electrical or chemical signal in the presence of a contaminant such as bacteria and other pests or pathogens and (c) Other nano sensors perform by triggering an enzymatic reaction or by using nano engineered branching molecules called dendrites as probes to bind to target chemical sand proteins (Tiju and Morrison, 2006).

Nano Sensors

Nano technology is also being developed to increase soil fertility and crop production. Nano sensors could also monitor crop health and magnetic nanoparticles could facilitate removal of soil contaminants (Hg, Pb and Zn). “Lab on a chip” technology also could have significant impacts on developing countries.

Nanofertilizers

In the recent years nanofertilizers are freely available in the market. Nanofertilizers may contain nano zinc, silica, iron and titanium dioxide, different core shell gold nanorods, QDs etc., as well as should endorse control release and improve its quality. Studies on the uptake, biological fate and toxicity of several metal oxide NPs, viz. AlO, TiO, FeO and ZnO nanoparticles were carried out intensively in the present decade for agricultural production (Zhang et al., 2016). So, quantification of nanoparticles is necessary to reduce the toxic effect of it.

Nanoherbicides

Multi-species approach with single herbicide or repeated use of herbicide with similar mode of action in the cropped environment may result in poor control and herbicide resistance. Developing a target specific herbicide molecule encapsulated with nanoparticles is aimed at specific receptor in the roots of target weeds, which enter into roots system and are translocated to parts that inhibit glycolysis or other pathways of food reserve in the root system. This will make the specific weed plant to starve for food and gets killed (Chinnamuthu and Kokiladevi, 2007). In rain fed areas, application of herbicides with insufficient soil moisture may lead to their loss by photodecomposition. The controlled release action of encapsulated herbicides is expected to take care of the competing weeds with crops. Adjuvants for herbicide application are also available that including nanomaterials. One nano surfactant based on soybean micelles has been reported to create glyphosate-resistant crops susceptible to glyphosate when it is applied with the ‘Nano technology-derived surfactant’.

Nanopesticides

The utilization of Nano technology in plant protection and production of food is an under-explored area. It is well recognized that insect pests are the major causes for crop loss in the agricultural fields. Nanoparticles may play a key role in the control of insect pests and host pathogens (Khota et al., 2012). The recent development of a nano encapsulated pesticide formulation has slow releasing action with improved solubility, specificity, permeability and stability (Bhattacharyya et al., 2016). Formulation of nano encapsulated pesticides will lead to reduced dosage of pesticides, improved pesticide efficacy and human beings exposure to them which is eco-friendly for crop protection (Nuruzzaman et al., 2016). Development of non-toxic and promising pesticide delivery systems using nanoparticles for increasing crop productivity per unit time basis while reducing the negative environmental impacts to ecosystem is being tried(Grillo et al., 2016). Recently, few chemical companies openly promoted nanoscale pesticides for sale as “microencapsulated pesticides.” (Karate ZEON, Subdue MAXX, Ospray’s Chyella, Penncap-M) (Gouin, 2004). Syngenta markets some products such as the Primo MAXX, Banner MAXX, Subdue MAXX, etc. Although they are known as micro emulsions, they are really nanoscale emulsions and this technique is commonly used for formulations of organic nanoparticles containing active agrochemicals or substances. A range of formulation types have been suggested including emulsions (e.g., nanoemulsions), nanocapsules (e.g., with polymers) and nanoclays. These products can be used to enhance the use efficacy of existing pesticide active ingredients or to improve sustainability. (Kookana et al., 2014).

Applications of Nano technology in agronomy

Nano sensors will be used to determine the quantity of inputs needed for every small part of a farm. Therefore, economic efficiency of such inputs (fertilizers and pesticide) is increased and timely needs of crops fulfilled. Nano sensors and nano-based smart delivery systems could help in the efficient utilization of agricultural natural resources like water, nutrients and chemicals through precision farming and site specific management. Through the use of nano materials and global positioning system (GPS) and remote sensing, farm managers can detect crop pests or evidence of stress such as drought and nutrient deficiency on the basis of spectral images. Nano fertilizers will be absorbed by plants rapidly and completely due to high surface area and more supply at action site that save fertilizer consumption and minimize environmental pollution. Slow-release fertilizers are outstanding alternatives to soluble fertilizers. Nutrients are released at a slower rate throughout the crop growth as per need of crop without any kind of losses such as leaching, surface runoff, adsorption and decomposition. Slow release of nutrients in the environments could be provided by using zeolites that are a group of naturally occurring minerals that have a honeycomb-like layered crystal structure. This type of interconnection, tunnels and cages can be loaded with nitrogen, phosphorous, calcium and potassium, and a complete suite of minor and trace nutrients. Coating and cementing of nano and subnano-composites have capablility to regulating the release of nutrients from the fertilizer capsule (Liu et al., 2006). A patented nano-composite consisting N, P, K, micronutrients and amino acids that can boost the uptake and utilization of nutrients by grain crops has been reported (Jinghua, 2004).

Seeds can also be imbibed with nano-encapsulations with specific bacterial strain (Pseudomonas spp.) termed as Smart Seed. It will thus reduce seed rate, ensure right field stand and improved crop yield. A Smart Seed can be programmed to germinate when adequate moisture is available that can be dispersed on a mountain range for reforestation (Natarajan and Sivasubramaniam, 2007). Coating seeds with nano membrane, which senses the availability of water and allow seeds to imbibe only at right time of germination, aerial broadcasting of seeds embedded with magnetic particle, detecting the moisture content during storage to take appropriate measure to reduce the spoilage and use of bio analytical nano sensors to determine ageing of seeds are some possible thrust areas of investigation. Siddiqui and Al-Whaibi (2014) reported that application of nano silicon dioxide (nSiO2: size 12 nm) significantly enhanced the germination of tomato seed. Prasad et al. (2012) studied the effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut and reported that treatment of nanoscale ZnO (25 nm mean particle size) at 1000 ppm concentration promoted both seed germination and seedling vigour and in turn showed early establishment in soil manifested by early flowering and higher leaf chlorophyll content. Nearly 30.5% and 38.8% higher pod yield was recorded with the application of nanoscale ZnO at 2 g 15 L^{-1} + NPK compared to NPK alone and 29.5% and 26.3% higher pod yield compared to chelated zinc at 30 g 15 L^{-1} + NPK. Similar results were obtained by kisan et al. (2015) in spinach and Estrada-Urbina et al. (2018) in maize. These results may be due to the fact that Zn acts as a precursor of tryptophan (auxin inducing substance). These results indicated that nano-zinc oxide (1000 ppm) has a potential to be used as a bio fortification agent to improve quality of spinach leaves and there by reduce the malnutrition problem. Effect of nanoparticles is crop specific also. Pallavi et al. (2016) carried out a study to investigate the impact of silver nanoparticles (AgNPs) on the growth of three different crop species of wheat, cowpea and brassica along with their impact on the rhizospheric bacterial diversity. Three different concentrations (0, 50 and 75 ppm) of AgNPs were applied through foliar spray. After harvesting, shoot and root parameters were compared. The effect of nanoparticles varied from one plant species to another; in wheat, no significant effect of AgNPs was observed on growth parameters, with the exception of root fresh weight and root length, which showed a negative response at 75 ppm treatment, while in cowpea and Brassica, a positive response was observed toward AgNPs. But the concentration of AgNPs responsible for the observed effects was different for both cowpea and Brassica; in cowpea, 50 ppm concentration resulted in growth promotion and increased root nodulation indirectly, whereas in Brassica 75 ppm concentration resulted in improved shoot parameters. The exact reasons behind the differential sensitivity of different plants toward nanoparticles remain unidentified to this date.

Applications of Nano technology in food industry

Oxygen is a problematic factor in food packaging, as it can cause food spoilage and discoloration. Nanoparticles have been developed that prevent the penetration of oxygen as a barrier. In other words, the oxygen entry into package is delayed and hence with the long route for oxygen molecules, food spoilage is delayed. Polymer-silicate nano composites have also been reported to have improved gas barrier properties, mechanical strength, and thermal stability. Recently, nano-coatings are produced for covering the fruits completely and prevent of fruit weight loss and shrinkage. (Predicala, 2009). Developing smart packaging to optimize product shelf-life has been the goal of many companies. Such packaging systems would be able to repair small holes/tears, respond to environmental conditions (e.g., temperature and moisture changes) and alert the customer if the food is contaminated. Nano technology can provide solutions for these, for example modifying the permeation behaviour of foils, increasing barrier properties (mechanical, thermal, chemical, and microbial), improving mechanical and heat-resistance properties, developing active antimicrobial and antifungal surfaces, and sensing as well as signalling microbiological and biochemical changes (Moraru et al., 2003).

In particular, silver nanoparticles have been shown to be a promising antimicrobial material. The most effect of controlling the fungus by nanoparticles is in < 24hrs. In addition, the different concentrations of silver nanoparticles controlled A. flavus. (Allahvaisi 2016). Therefore, the concentration of nanoparticles is effective for controlling the fungi into foodstuffs packaging.

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3. Study the causes and remedies for improving the chemical properties of water.

HYPOTHESIS

The context of the evaluation arises from the following facts:

1. Nutraceuticals, functional food ingredients and dietary supplements are important for health promotion and disease risk reduction. Although a myriad of bioactives are known to render the expected beneficial effects, the mechanisms involved are varied and may work individually or collectively in providing the effects. Processing of bioactives may also alter their bioactives and could therefore influence their efficacy in in-vitro and possibly in vivo models. In addition, processing by-products from plant sources are particularly rich in a number of bioactives at much higher concentration than those present in the main products and these can be used as value-added ingredients for application in food or as supplements for alleviating certain health problems.
2. The application of Nano technology in pesticide delivery is relatively new and in the early stages of development. This technology aims to reduce the indiscriminate use of conventional pesticides and ensure their safe application. The focus of ongoing research was on the development of nanoencapsulated pesticide formulation which has slow releasing properties with enhanced solubility, permeability and

stability. These properties are mainly achieved through either protecting the encapsulated active ingredients from premature degradation or increasing their pest control efficacy for a longer period. Nanoencapsulated pesticide formulation is able to reduce the dosage of pesticides and human exposure to them, which is environmental friendly for crop protection. However, lack of knowledge of the mechanism of synthesis and not having undertaken a cost-benefit analysis of nanoencapsulation materials hindered their application in pesticide delivery. Further investigation of these materials behavior and their ultimate fate in environment will help the establishment of a regulatory framework for their commercialization.

3. Nanoparticles have a great potential to be used in waste water treatment. Its unique characteristic of having high surface area can be used efficiently for removing toxic metal ions, disease causing microbes, organic and inorganic solutes from water. Various classes of nanomaterials are also proved to be efficient for water treatment like metal-containing nanoparticles, carbonaceous nanomaterials, zeolites and dendrimers. Nano technology has lead to various efficient ways for treatment of waste water in a more precise and accurate way on both small and large scale.

OBJECTIVES AND ISSUES FOR EVALUATION

The scope of evaluation is to study the impact of scheme, **"APPLICATION OF NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRI PRODUCE"** implemented by University of Agricultural Sciences, Raichur during 2012-13.

1. Stake Holders

a) University of Agricultural Sciences, Raichur – Sponsorer
b) Rashtriya Krishi Vikas Yojane – as Monitoring Authority
c) Institution of Agriculture Technologists – as Consultant
d) Farmers / beneficiaries as target group of evaluation

2. Purpose of Evaluation

Evaluation Framework

The focus of Evaluation is:

i. To evaluate the importance of biosynthesis over other methods of production of nanoparticles.
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LOG FRAME/THEORY OF CHANGE/PROGRAM THEORY

The intention of the project is to take up research projects on use of nanoparticles in various agriculture applications to improve productivity, protect crops from insect pests and diseases, improve food quality by manufacture of functional foods, neutraceuticals and dietary supplements and waste water treatment and develop good infrastructure catering to the needs of various stake holders viz., farmers, researchers, students, scientists, food & processing industries, food grain packers and exporters.

EVALUATION DESIGN

Evaluation design has a rationale of requirement of field level data (primary) that is required to study evaluation objective with respect to beneficiary farmers on one part and the projects taken up for study per se on the other part. The evaluation requires analysis of administration obligations under the two heads and hence a secondary data analysis becomes important and accordingly formats were designed to procure secondary data. The third obligation under evaluation is opinion of stake holders with respect to improvement of the schemes, which require group discussions and exchange of views both in the form of a format, as well as group discussions with the stake holders. The entire evaluation process required a central administration of all activities.

A core team of experts at the Institution level considered three methods to bring a meaningful evaluation of the subject, keeping in mind the scope, evaluation questions and sub-questions duly keeping its focus on the purpose of evaluation. The three methods are:

a. Accessing and analysis of secondary data from the implementing department.
b. Interaction with Principal Investigator and his team.
c. Actual visit to the project site to study and obtain necessary information to elicit answers to the evaluation questions.

DATA COLLECTION AND ANALYSIS

Improving the food safety and providing nutrient, diet-based food product by developing Functional Foods and Nutraceuticals

Since the end of the 20th century, there has been a growing realization of the pivotal link between diet and human health. This has led to the development of a new category of foods, the so-called functional foods. Functional food is simply a convenient way to describe foods, or their components, that may provide health benefits beyond nutrition. In other words, functional foods contain a variety of components, nutrients and non-nutrients that affect a range of body functions that are relevant to a state of well-being and health and/or reduce the risk of a disease.

A functional food can be a natural, whole food that contains sufficient quantities of beneficial components. Many, if not most, fruits, vegetables, grains and fish contain several natural components that deliver benefits beyond basic nutrition, such as lycopene in tomatoes, omega-3 fatty acids in fish, and soluble fibre in oats. The functional components can be enhanced through special growing conditions or through breeding techniques, e.g., β-carotene-rich rice, vitamin-enriched broccoli and soybeans. Meat, poultry, fish and eggs can have their composition altered by the animal's diet, e.g., increased level of conjugated linoleic acid or omega-3 in meat and milk products.

Other foods may be specially formulated with specific components to provide health benefits. Examples are probiotic bacteria added to yoghurts, plant-sterol-enriched margarines, flour with added folic acid and omega-3-enriched bread. A food from which a component has been removed so that the food has fewer adverse effects on health (e.g., reduction in saturated fatty acids) can also be considered to be a functional food. Moreover, a food can be regarded as functional if the nature of one or more components has been modified through processing to improve health (e.g., the hydrolysis of protein by enzymes, suppression of the food matrix through heating/shearing to release bioactive compounds) (Harjinder Singh, 2016).

The functional foods segment of the food industry is estimated to be worth about 168 billion dollars and is growing at about 9% per annum (Bigliardi B, Galati F., 2013). The key drivers that have given rise to this growth include a greater availability of scientific information regarding the link between diet and health, an aging population with greater prevalence of age-related diseases, particularly in Western countries, and an increasing rate of metabolic disorders (heart disease, obesity, diabetes, and arthritis). To meet future demand for functional foods, the food industry must address several critical challenges, including discovering the potential bioactivity of beneficial compounds, establishing optimal intake levels, and developing adequate food delivery matrices and product formulations. The development of functional foods also faces many regulatory challenges (Frewer et al., 2003).

There is a large body of scientific evidence showing that eating foods with functional benefits on a regular basis as part of a varied diet can help to reduce the risk of, or manage, a number of health concerns, including cancer, cardiovascular disease, and gut health.

A number of new processes and materials derived from Nano technology have the potential to provide new solutions in many of these fronts. Nanoscience and Nano technology have the potential to provide new solutions in the development of functional foods, in particular the inclusion of bioactive compounds without affecting the sensory perception of the consumer and improving the uptake of certain components. Nano technology is concerned with the manipulation of materials at the atomic and molecular scales to create structures that are less than 100 nm in size in one dimension. By carefully choosing the molecular components, it seems possible to design particles with different surface properties. Several food-based nanodelivery vehicles, such as protein-polysaccharide coacervates, multiple emulsions, liposomes and cochleates have been developed on a laboratory scale, but there have been very limited applications in real food systems. There are also public concerns about potential negative effects of Nano technology-based delivery systems on human health.

Application of nano zinc to increase nutrient contents of spinach

Application of nano zinc to Spinach is found to increase nutrients viz., protein, fat and fibre. Trials were conducted in different conditions. Proximate analysis was carried out and better results were found. The toxicity analysis of the sample is under progress. Keeping in view, addition of nano particle in selected foods to enhance the quality and its functional parameters is under progress.

Results were found that 1000 ppm treated with Zinc Nano particle could enhance the Protein 3.87 % (1.54), Fat 1.57 % (0.1) and Fibre 6.97 % (2.01). Also increased the length 14.05 cm (13.32), width 7.40 cm (6.60).

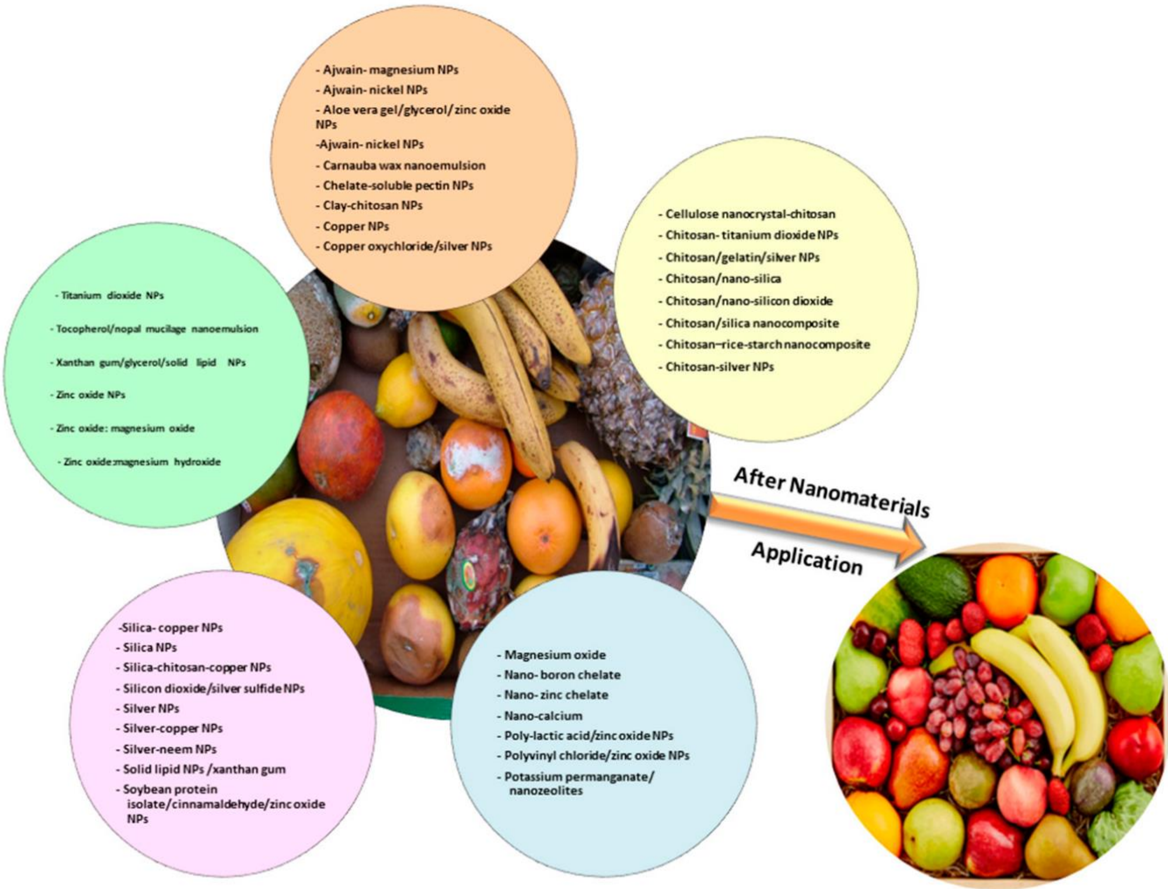
Coating of extracted sweet orange peel oil on fig fruits

Fresh fig fruits were procured from the local market and washed under running tap water. Ten clean fruits were dipped in 100 ml of sweet orange peel oil and kept at room temperature. Sweet orange peel oil was prepared by dissolving 2% w/v of chitosan solution in 1% v/v acetic acid by stirring at room temperature for 3 hours to achieve complete dispersion of chitosan. To this glyceraol at 0.75 ml/ gm concentration was added as a plasticizer and the solution was placed on a hot plate/ magnetic stirrer and stirred for 10 minutes. The resultant chitosan solution was filtered to remove any undissolved particles and sweet orange peel oil mixed with tween 80 was added to the chitosan solution at 0.2%. The final coat forming solution was homogenized under aspetic conditions at 21,600 rpm for one minute.

The results revealed that there was decrease in firmness of the fruit with increase in storage days. Sweet orange peel coated fruits had higher firmness than uncoated fruits. This was mainly due to reduction of degradation of insoluble protopectins to soluble pectic acid and pectin. The uncoated fruits had more pronounced maturation development than coated fruits which was reflected in increase in total soluble solids in fruits. There was at least two days delay in maturation in coated fruits. Similarly, coated fruits showed less microbial count than uncoated fruits.

Nano coating materials to protect from insect pests and diseases for minimizing the post-harvest losses.

Post-harvest diseases of fruit and vegetables are commonly caused by several plant pathogenic microorganisms, including fungi and bacteria, leading to serious losses during storage and transportation. The Food and Agriculture Organization of the United Nations mentioned that 33% of the food delivered worldwide for human consumption is lost after harvest (Gastavsson et al., 2011). Post-harvest diseases of fruit and vegetables have to be controlled because of the high added value of commodities and the great economic loss related to spoilage. Synthetic fungicides are the first choice worldwide to control post-harvest diseases of fruit and vegetables. However, several problems and constraints related to their use have forced scientists to develop alternatives control means to prevent post-harvest diseases. Physical and biological means, resistance inducers, and GRAS (generally recognized as safe) compounds are the most important alternatives used during the last 20 years. The use of edible coatings (mainly based on biopolymers) as a postharvest technique for agricultural commodities has offered biodegradable alternatives in order to solve problems (e.g., microbiological growth) during produce storage. However, biopolymer-based coatings can present some disadvantages such as: poor mechanical properties (e.g., lipids) or poor water vapor barrier properties (e.g., polysaccharides), thus requiring the development of new alternatives to solve these drawbacks. Recently, nanomaterial treatments have demonstrated promising results and they are being investigated to reduce the utilization of synthetic fungicides to control post-harvest rot in fruit and vegetables (Sergio Ruffo Roberto et al., 2019). Nano technology has emerged as a promising tool in the food processing industry, providing new insights about postharvest technologies on produce storage. Nanotechnological approaches can contribute through the design of functional packing materials with lower amounts of bioactive ingredients, better gas and mechanical properties and with reduced impact on the sensorial qualities of the fruits and vegetables (María Liliana Flores-López et al., 2015).



Experiments were conducted on use of sweet flag rhizome oil for control of pulse beetles (*Callosobruchus maculatus*). Nano sweet flag rhizome oil recorded 100 % mortality of pulse beetle on 7th day. Mucor species found zone of inhibition is 12.50 mm followed by Aspergillus species (11.50 mm).

Similarly, application of nano malathian on groundnut seeds was found to increase the shelf life of groundnut seeds by 12 months without any insect infestation. Nano particle of 0.004 % malathion was sprayed using the electrostatic spinning against the 1% of malathion (as per recommendation). After 90 days of storage it was found that the storage pests, viz., Rice – rice weevil, Sorghum – sorghum weevil, redgram – bruchids, ground nut – seed beetle were not activated.

Final analysis and toxicity work with selected the insecticides for control of storage pests and study the storage losses including Malathion - Nano malathion, Fenvalerate - Nano Fenvalerate, Emamectin benzoate - Nano Emamectin benzoate, Thiodicarb - Nano

Thiodicarb, Sweet flag - Nano Sweet flag and Neem seed kernel powder - Nano Neem seed kernel powder is under progress.

Study of the causes and remedies for improving the chemical properties of water

Water is the most important asset of human civilization, and potable water supply is a basic human necessity. Providing clean and affordable drinking water is one of the modern-times challenges. Only 2.5% of the world's oceans and seas harness fresh water. However, 70% of fresh water is frozen as eternal ice. Only <1% of fresh water can be used for drinking. Globally, >700 million people do not have access to potable water (WHO, 2014). The world's growing population causes water scarcity, and pollutants contaminate whatever water sources are left. This problem is severe in developing nations and sub-Saharan African countries. Therefore, water treatment must be implemented in these affected places. Available technologies for water treatment are reaching their limits in providing sufficient quality to meet human and environmental needs (Qu et al., 2013). Therefore, reuse, recycle, and repurpose are the "needs of the day."

Water contaminants may be organic, inorganic, and biological. Some contaminants are toxic and carcinogenic (Ali et al., 2009) and have deleterious effects on humans and ecosystems (Ali, 2012). Some heavy metals are notorious water pollutants with high toxicity. Arsenic is one of the deadliest elements, well known since ancient times. Other heavy metals water pollutants with high toxicity are cadmium, chromium, mercury, lead, zinc, nickel, copper, and so on and they have serious toxicities (Ali, 2012). Nitrates, sulfates, phosphates, fluorides, chlorides, selenides, chromates, and oxalates show hazardous effects at high concentrations. These ions also change the taste of water. For example, high levels of fluoride in water causes fluorosis. Organic pollutants, such as pesticides, fertilizers, hydrocarbons, phenols, plasticizers, biphenyls, detergents, oils, and greases are associated with toxicities (Damià, 2005). Emerging contaminants include pharmaceuticals and personal care products (PPCPs) (Mohapatra et al., 2014). PPCPs are usually resistant against natural biodeterioration. The general origin of such compounds is household and hospital water, which contains metabolized and nonmetabolized (1) drugs, (2) drugs products, (3) additives to detergents, and (4) packaging. PPCP concentration ranges from ng/L up to µg/L, in water. Therefore, conventional water treatments (screening, filtration, micro- and ultrafiltration, crystallization, sedimentation, gravity separation, flotation, precipitation, coagulation, oxidation, solvent extraction, evaporation, distillation, reverse osmosis, ion exchange, electrodialysis, electrolysis, adsorption, setting-out, centrifugal and membrane separation, fluidization, neutralization and remineralization, reduction and oxidation) provide unsatisfactory results, because treatment facilities are not equipped to remove stable low-concentrated pollutants.

Nano technology provided innovative solutions for water treatment. Nanomaterials are fabricated with features, such as high aspect ratio, reactivity, and tunable pore volume, electro-static, hydrophilic, and hydrophobic interactions, which are useful in adsorption, catalysis, sensoring, and optoelectronics (Das et al., 2014). Nano technology-enabled processes are highly efficient, modular, and multifunctional in nature and they provide high performance, affordable water and wastewater treatment solutions.

Studies for designing a Nanoadsorbent filter system for dairy plant effluent treatment was undertaken by the University. Nanoadsorbents for various types of pollutants like BOD and COD, phosphate, sulphate and nitrate were used for effluent treatment. Nanoadsorbents have shown reduction efficiency varying from 64% to 97%.

Nanoadsorbent filter system for dairy plant effluent treatment		
Pollutant	**Nanoadsorbents**	**Results**
BOD and COD	Chitosan zinc oxide (Patent No. 201941005538A)	96.71 and 90.48 % of Reduction efficiency (RE)
	Chitosan titanium dioxide	87.56 and 82.10 % of RE
Phosphate	Zero valent iron (Patent under process)	89.50% of RE
	Graphene oxide	90.01% of RE
Sulphate and Nitrate	Iron oxide (Patent under process)	87.60 and 78.67% of RE
	Nickel	86.36 and 64.67% of RE

Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. The model has been installed at Government school, Mavinamatti, Shahapur, Yadgir (Dist) in collaboration with IIT, Chennai for removal of arsenic from drinking water.

FINDINGS AND DISCUSSION

Work conducted on improving the food safety and providing nutrient, diet-based food product by developing Functional Foods and Nutraceuticals was mainly confined to improving the nutritional quality of spinach by application of nano zinc.

Micronutrient fertilizers can increase the tolerance of plants to environmental stresses like drought and salinity. Zinc has been considered as an essential micronutrient for metabolic activities in plants. It regulates the various enzyme activities and required in biochemical reactions leading to formations of chlorophyll and carbohydrates (Baybordi A., 2006 and Auld Ds, 2001). The crop yield and quality of produce can be affected by the deficiency of Zn (Jamali et al., 2011). Zinc nano-particle is used in various agricultural experiments to understand its effect on growth, germination, and various other properties. Most of the farmers are using either zinc sulfate or EDTA-Zn chelate for soil and foliar applications, however the efficacy is low. (Fageria et al., 2002) have demonstrated essentiality and role of zinc in plant growth, reproduction and yield. It has been indicated that the retention time of Zn in the plant system is low and hence, the bioavailability of Zn for long period is not sure with the use of ZnSO4 fertilizer.

The results of the experiments indicated that the nano-zinc oxide enhanced the leaf physical and nutritional properties of spinach leaves. Nano-zinc oxide (1000 ppm) has a potential to be used as a biofortification agent to improve protein and dietary fibre contents of spinach leaves and thereby reduce the malnutrition (Kisan et al., 2015).

Another experiment on effect of nano particles on keeping quality of fig revealed that coating fruits with nano particles would delay the maturity development and improve the shelf life.

While the experiments have given encouraging results on use of nanoparticles for improving the food quality, there is need to evaluate their use in the food produced in the area rather than attempt crops which are not normally grown in the area. The very concepts of functional foods, neutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. The most common pulse pests are the cowpea weevil (Callosobruchus spp.) and pea weevil (Bruchids pisorum). The cowpea weevil has a life span of 10–12 days while the pea weevil only breeds one generation per year. Pulse beetle (Pachymerus chinensis) mainly feeds on cowpea, pea, gram, arhar, soybean, beans etc. The damage is caused by the grubs by eating out the entire content of the grain, leaving only the shell behind. Attack of these beetles often stars in the fields from where it reaches the stores. Khapra beetle and Lesser grain borer feed on arhar, peas and urd. Many methods are being adopted to manage the stored pests. New age chemicals like carbonyl sulfide and sulfuryl fluoride are gaining acceptance. Carbon dioxide and biogas generated from cow dung can be used as fumigation measures. Natural products like vegetable oil, inert dusts, plant extracts like essential oils, lectins, proteins, and leaf powders, which have insecticidal and antimicrobial activity, have been used as fumigants for traditional storage worldwide. Simple technologies like sun drying and repeated sieving can be adopted by small-scale farmers and traders. Maintaining low oxygen, high carbon dioxide, or pure nitrogen atmosphere in the storage environment is also proving to be beneficial preventive methods. Hot air and irradiation are being used, while dielectric heating is still in the stage of development in many of the developed countries for insect control. Developing countries are beginning to consider the use of these methods to control stored product insects. Under these circumstances, use of nano particles for managing stored pests is a welcome idea.

Studies undertaken for designing a Nanoadsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. Nanoadsorbents for various types of pollutants like BOD and COD, phosphate, sulphate and nitrate were used for effluent treatment. Nanoadsorbents have shown reduction efficiency varying from 64% to 97%.

Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. The model has been installed at Government school, Mavinamatti, Shahapur, Yadgir (Dist) in collaboration with IIT, Chennai for removal of arsenic from drinking water. This has immense commercial value and the University has already developed more than 100 filters and distributed to public.

REFLECTIONS AND CONCLUSIONS

1. The very concepts of functional foods, neutraceuticals and food supplements are new in India and are yet to establish commercially even in urban areas in the country. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.
2. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.
3. Final analysis and toxicity work with selected the insecticides for control of storage pests and study the storage losses including Malathion - Nano malathion, Fenvalerate - Nano Fenvalerate, Emamectin benzoate - Nano Emamectin benzoate, Thiodicarb - Nano Thiodicarb, Sweet flag - Nano Sweet flag and Neem seed kernel powder - Nano Neem seed kernel powder is under progress. This should be completed quickly and its commercial application should be taken up.
4. Studies undertaken for designing a Nanoadsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.
5. Water filtration system for removal of fluoride and arsenic (Domestic model – 15 L capacity) has been developed which has arsenic removal efficiency of 87 % and Fluoride removal efficiency of 92 %. The Cost of the model is Rs. 1000.00. Commercial production of the filters should be taken up in PPP model.

ACTION POINTS

i. The equipment procured under the project are exemplary. However, their maintenance cost will be too high. Hence, it is better to convert the centre on PPP mode and generate data as well as work efficiently and maintenance on self sufficiency mode.

ii. The techniques of nano encapsulation of ingredients, additives and supplements are good but should be tested for food safety and FSSAI before releasing for commercialization.

iii. The techniques of nano particles mixing for effective control of insect pests is a good move. However, its economics needs to be worked out.

iv. There is need for working out cost economics of use of nano silver particles and magnetic power used for purification of water and its safety as per FSSAI standards.

v. Side effects on nano particles on human beings needs to be worked out.

vi. Studies undertaken for designing a Nanoadsorbent filter system for dairy plant effluent treatment undertaken by the University has met with success. This should pave way for use of the technology in treatment and reuse of waste water in urban areas.

vii. Water filtration system developed for removal of fluoride and arsenic should be taken up for commercial production of the filters in PPP model.

viii. Storage pests are a big menace in most of the pulse crops grown in the area. Work on use of nanoparticles for control storage pests is the need of the hour. There is need to focus on this aspect as the region is the major pulse growing region in the State.

ix. With a vast majority of the population in the region living in rural and semiurban areas, the focus of the research could have been more apt had it been concentrated on improving the food quality of common foods consumed in the area.

RESEARCHABLE ISSUES

1. Initiate work on nano silicon and its impact on diseases and nutritional issues.
2. Research on nano microbial components needs to be initiated.
3. Strengthening of research on nano remedial measures for insects and diseases management.

Infrastructure developed from RKVY fund

Sl. No.	Equipment	Applications	Cost, lakhs
01	Ultra sonic spray nozzle	Making powder from liquids	7.61
02	Electrostatic spinning machine	Seed / grain coating	6.25
03	Zeta sizer	Particle analyser	28.69
04	Spectrofluorescence reader	Absorbance	17.25
05	Trinocular stereo zoom microscope	Visual observation	1.24
06	High pressure homogenizer	Size reduction of liquid particles	17.85
07	High speed ball mill	Size reduction of solid particles	15.32
08	Ultra centrifuge	Separation of fluids from solids	14.96
09	Scanning electron microscope	Surface morphology	99.00
10	Liquid dispenser	Uniform deposition of the liquids	9.90
11	Elements detection sensor	Identification of the elements	36.58
12	X-Ray Diffraction	Structural characterization	64.98
13	FT-IR	Structural characterization	39.50
14	Freeze dryer	Powder application	9.70
15	GC-MS	Chemical mixture fractions	39.27
16	AFM	Mechanical properties	72.00
17	Raman Spectroscopy	Structural characterization	49.99
18	UV	Particle characterization	5.31

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TERMS OF REFERENCE

FOR EVALUATION OF PROJECT ENTITLED "CENTRE FOR NANO SCIENCE AND NANO TECHNOLOGY IN ENHANCING QUALITY OF AGRICULTURAL PRODUCE" IMPLEMENTED DURING THE PERIOD 2016-17 BY UNIVERSITY OF AGRICULTURAL SCIENCES, RAICHUR AT CENTRE FOR NANO TECHNOLOGY, UAS, RAICHUR.

1. Title of the study:
"Centre for nano science and Nano technology in enhancing quality of agricultural produce"

2. Department/agency implementing the scheme
Centre for Nano technology, UAS, Raichur-584 104

3. Project approval No. (Sector):KA/RKVY-AGRE/2016/813

4. Year of Start: 2016

5. Year of conclusion: 2017

6. Total Budget of the project: 65,00,000/-

7. Background and context:

The project was sanctioned under the Rashtriya Krishi Vikas Yojana (RKVY) which is a State Plan Scheme of Additional Central Assistance launched by the Govt. of India under the aegis of the National Development Council, which seeks to achieve 4% annual growth in agriculture by incorporating information on the local requirements, geographical and climatic conditions, available natural resources and cropping pattern in districts so as to significantly increase the productivity of Agriculture. Under this scheme several projects are being implemented with the aim of innovating new technology in agriculture for enhancing agricultural productivity.

The University of Agricultural Sciences, Raichur is implementing many RKVY projects in different disciplines. The project entitled "Application of Nano technology in enhancing the quality of agricultural Produce" is one such project.

Nanoparticles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. Man engineered nano materials have received a particular attention because of their positive impact in improving many sectors of economy, including consumer products, pharmaceutics, cosmetics, transportation, energy and agriculture, etc. These are being increasingly produced for a widerange of applications within industry.

Agriculture in a tropical country like India, owing to its climatic conditions and its particular environment, suffers severe losses due to pests. The Indian farmers are in need of effective tools to fight against pests. The environmental problems caused by overuse of pesticides have been the matter of concern for both scientists and public in recent years. It has been estimated that about 2.5 million tons of pesticides are used on crops every year and the worldwide damage caused by pesticides reaches $100 billion annually. The overuse of chemical pesticides is the cause of some environmental problems due high toxicity and non-biodegradable properties of these pesticides and the residues in soil, water resources and crops that affect public health. After severe setback arising from the use of chemical pesticides on living systems and the environment, the use of eco-friendly bio pesticides is gaining momentum. However, the small farmers in India are not yet fully aware of the concept, use or advantages of eco-friendly pest management.

Keeping in view and considering the present local problems, an project proposal entitled "**Centre for nano science and Nano technology in enhancing quality of agricultural produce**" was sanctioned during the year 2016-17 under RKVY grants.

8. The objectives

The objectives of the Project are as follows:

- Strengthening of Centre of excellence Nano Science and Technology laboratory
- Development of nutrient based food product
- Studies on preparation and characterization of release characteristics of insecticides and herbicides in nano and nano encapsulated forms following standard operating procedure (SOP).
- Development of nano material based purification for improving the quality of the water

9. Present status of the project:

- The above project was implemented during 2016-17 at Centre for Nano technology, UAS, Raichur-584 104.
- The Centre for Nano technology has developed various green nanoparticles using different plant extracts and worked with those nanoparticles on different applications.
- The fresh fig fruits coated at nano scale with sweet orange peel oil using electro static spinning machine and treated fruits were stored at room temperature for 6 days. The analysis was carried out for pH, TSS, texture, colour, fruit decay and microbiological analysis for fresh and coated fig fruits
- Conducted experiments on application of sweet flag rhizome oil (from 10 to 70 µl/ml) on *Callosobruchusmaculatus*(Pulse beetle) at nano scale.
- Development and evaluation of nano based adsorbent for waste water treatment

10. Outcome of the Project:

- Nano encapsulated foods will improve the nutritional benefits to the consumers.
- The application of nanopestisides will effectively control insect pests and minimize the post-harvest losses.
- Water purified with nano particles will have more quality.

11. Assets: Includes building, equipment-all assets purchased under the project

Sl. No	Name of the asset	Date of purchase	Qty. (Nos.)	Total cost (Rs.)	Purpose of purchase
1	**X-Ray Diffraction**	**17/03/2017**	**01**	**64,98,000/-**	To know the crystalline nature and elemental composition of nanoparticles

12. Where the Project is undertaken:

Centre for Nanotechnolgy, University of Agricultural Sciences, Raichur-584 102

13. Evaluations Questions and minimum expectations:

1. What is the application of nano based nutrient food product ?
2. How the nano based slow release insecticides and herbicides will help in control of insets and pests ?
3. What is the effect of nano materials in water purification system?

14. Evaluation methodology and sampling:

- Interaction with the Co-ordinators and Principal Investigators to seek information regarding the experiments to be conducted.
- The evaluation should be undertaken in Centre for Nano technology, UAS, Raichur.
- At Centre for Nano technology, synthesis, characterisation and water purification laboratories are to be inspected and evaluated for their utility.
- Preparation and characterization of release characteristics of insecticides and herbicides in nano and nano encapsulated forms is to be inspected and evaluated for their utility.
- Nano based filter system for the removal of fluoride and Arsenic in drinking water needs to be inspected and evaluated for the efficient utility.
- The Centre for Nano technology unit is to be inspected for their utility in terms of research and demonstration.

15. Deliverables:

A detailed report of the impact of Centre for Nano science and Nano technology in enhancing quality of agricultural produce needs to be submitted.

16. Duration and time schedule for the study:

The task should be completed within three months.

- Discussion with Principal Investigators and members regarding the study has undertaken.
- Conducting the experiments on preparation and characterization of release characteristics of insecticides and herbicides in nano and nano encapsulated forms, effect of nanomaterials on extending shelf life and quality of fruits and development of nano material based filter system for improving the quality of the water
- Preparation of draft report
- Presentation of draft report
- Final report to be submitted before the end of year

17. Quality expected from the evaluation report:

The report should highlight the following

- Enhancement of quality parameters and keeping quality of Fig fruit by treating with nanoparticles.
- Inactivation of storage pest during storage by nano coating the grains with sweet flag rhizome oil.
- Development of nanobased filter bed for removal of fluoride and arsenic in drinking water

18. Recommendations:

Specific recommendations leading to policy change in providing more financial grants for conducting more experiments related to enhancement of quality of food and agricultural produce which would helpful to the farming community.

19. Minimum qualifications of consultant:

Consultant should have and provide details of research and evaluation team members having technical qualifications/capability as below.

1. Post-graduation in Processing and Food Engineering having the knowledge of Food, Nano technology application, entomology, storage and food microbiology.
2. Technical assistant having good knowledge in instrumentation, laboratory skills etc.
3. And in such numbers evaluation should be completed within one year of the schedule time prescribed by the TOR. Consultants not having these number and kind of personnel will not be considered for evaluation.

20. Providing Oversight:

Karnataka evaluation Authority will provide the funds and over sight for the study. All technical aspects of the study are subjects to their approval.

21. Contact Persons:

Dr. Sharanagouda Hiregoudar, Assistant Professor, Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur-584 104

Mobile Number: 9448433678

Email: drsharan.cae@gmail.com

will be the contact person for giving information and details for the study

EVALUATION TEAM MEMBERS

Sl. No.	Name	Designation
1	Dr. M. A. Shankar	Principal Investigator
2	Dr. B. C. Suryanarayana	Associate Investigator
3	Sri. Siddaraju	Associate Investigator
5	Dr. Benherilal	Subject Matter Specialist

Dr. M. A. Shankar is a doctorate in Agriculture with specialization in Agronomy. He is former Director of Research, University of Agricultural Sciences, Bengaluru and presently the Executive Member of Institution of Agricultural Technologists, Bengaluru and Co-Chairman of Agribusiness Consultancy Subcommittee. He has implemented 51 research projects for the University funded by International organizations, Central and State governments, Private firms. He has guided 6 Ph. D. students and 15 M. Sc., (Agri) students. As Dean of College of Agriculture, Hassan, he has, with his administrative skills, streamlined accounting, financial, academic and administrative issues. He has been involved in review and evaluation of Technical Reports of 32 All India Co-ordinated Research Projects (AICRP) spread all over India. He has also evaluated 11 operational research projects for the technical feasibility and implementation. He has published 173 peer reviewed research papers. He has also penned 54 booklets and books for the University. He has vast experience in evaluation studies of projects.

Dr.Suryanarayana, B.C. is a doctorate in Agriculture with specialization in Agronomy and is a Certified Associate of Indian Institute of Banking (CAIIB), Fellow of Indian Institute of Valuers. He worked in State Bank of India from the year 1981 to 2014 as a Technical Officer and retired as Asst. General Manager (Rural Development). He is a practicing consultant in the field of Agriculture, Horticulture, poultry, dairy, fisheries and plant tissue culture and covered cultivation. He has about 35 years of experience in the field and has prepared several project reports for financial institution, written books in vanilla cultivation, anthurium, medicinal and aromatic crops, minor irrigation, poultry and dairy farming. He has appraised more than 6,000 proposals in agriculture and related fields for funding by the Bank and has also been involved in many studies relating to development of Agriculture and allied activities. He has served as a General Manager in a bio-fertilizer, bio-pesticides and organic manures manufacturing company and is also a Technical Director in a company involved in manufacture of agricultural implements and equipment.

Sri. Siddaraju is a Graduate in Agriculture with more than 35 experience in the field of Agriculture. He has served in the Karnataka State Department of Agriculture (KSDA) as Asst. Agricultural Officer in Farmers' Training and Education Centre, Soil Testing laboratory and as Subject Matter Specialist. He was Deputy Director of Agriculture (Commercial Crops) for 6 years, District Watershed Development Officer for 2 years. He has also been Joint Director of Agriculture (Inputs) for 5 years. He was involved in preparation of Annual Programme Planning booklets pertaining to Agricultural Inputs in Department of Agriculture. After retirement, he is serving as Chairman, Agriculture Consultancy Subcommittee, Institution of Agricultural Technologists, Bengaluru and has been actively involved in evaluation studies of projects.