POLICY PAPER 119

Secondary Agriculture - Challenges, Opportunities and Way Forward

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
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Preface

The Indian agriculture is looking at a paradigm shift from mere sustenance and food security to profitability and nutritional security. In the 75 years after independence, India has seen significant increase in the production of food. The post-production management infrastructure has also improved a lot and fairly large processing industries have emerged for the conventional food sector, i.e. processing for principal food/ feed/ fibre product. The Indian Agricultural Research and Education institutes, spread across the country, have been providing plethora of technological solutions for higher productivity, efficient processing, proficient management and effective marketing of produce. This has helped India evolve from a distressed importer to be a benevolent exporter of food commodities viz. food grains, fish, meat, etc. However, there is a largely untapped sector where Indian exports, including agro-industrial by-products, forest produce or even the main commodity, come back to Indian market after higher level of processing in the importing countries. The huge profit from this higher-level value addition goes to processors of other countries, making us dependent on them for many items including essential active ingredients of pharmaceutical and other industrial products.

It is therefore conceived that tertiary and higher-level processing of agricultural produce, residues and by-products into high value derivatives or products would help grow a new industrial sector and would help realize the value of the products from agricultural origin, which are otherwise considered as waste or low value. This next level of processing is termed as 'Secondary Agriculture' since it is an upgraded version of the traditional 'Primary Agriculture', which leads to the principal products.

Realising the importance of this burgeoning sector, NAAS organized a brain-storming session to deliberate on various techno-economical aspects on 21st October 2021. Professionals from different areas contributed to the first draft, which was further deliberated upon by a group chaired by Dr Mangala Rai, Former President, NAAS. The present document is an attempt to define the concept, identify opportunities and challenges and recommend the course of action for various stake holders viz. policy makers, researchers, industry, prospective entrepreneurs, academicians, etc. Variety of possibilities for this higher-level processing have been presented in this document. However, it is expected that in coming years many more profitable products and innovative processing models will be introduced.

The academy is thankful to Dr S.N. Jha, Convener of the Brain Storming Session for being the lead contributor and Drs Ravishankar, Director, ICAR-CIFE, Mumbai, Nachiket Kotwaliwale, Director, ICAR-CIPHET, Ludhiana, Devinder Dhingra, Principal Scientist, Agricultural Engineering Division, ICAR, New Delhi and R.K. Vishwakarma, Principal Scientist, ICAR-CIPHET, Ludhiana for providing valuable support in preparing this document. The inputs provided by Dr V. Prakash, as reviewer is duly acknowledged. I am also thankful to Dr Pratap S. Birthal and Dr Malavika Dadlani for editorial support. I am sanguine that this document will help increase prosperity of all the functionaries involved in agriculture.

December, 2022
New Delhi

(Trilochan Mohapatra)
President, NAAS

Secondary Agriculture - Challenges, Opportunities and Way Forward

INTRODUCTION

Agriculture is the culture of plants, animals and microbes. Agricultural activities include cultivation of crops, rearing animals and birds, growing and catching fish, cultivating microbes, raising agroforestry, etc. to harvest the economic product. The aforementioned activities use natural resources such as land, water, air, biomass, sunshine, etc. and their output is intended primarily to meet the needs of human beings with respect to food, feed, fibre, etc., directly or after some primary processing; and indirectly for other living creatures. With a sharp increase in the global population, demand from agriculture to feed this ever-growing population has posed a major challenge especially since, natural resource-based inputs are a major limiting factor for enhancement of production and productivity. Hence, the necessity for conserving the produce through reduction of losses gained importance leading to the adoption of suitable postharvest operations for transforming the raw materials (primary products) by primary processing or converting it to a value-added product for direct consumption or utilization as an input for further processing.

Primary processing activities are generally defined as those activities, which do not significantly change the physical appearance i.e., shape, size, color, etc., of agri-produce. These activities include operations such as threshing, washing, cleaning, sorting, grading etc., many such unit operations are often performed at farm itself and could be mandatory before consumption of the produce. Secondary processing is the stage where the original identity of primary product is changed (e.g., milling of wheat into flour, splitting of pulses, smoking/roasting of meat, etc.). Further processing may be required for making the material useful for food, feed and other uses. All these activities which are in vogue for bringing the agricultural produce in a desired form for consumption constitute the primary agriculture.

Output of these processing operations are crop residue and co-product/by-product of production and processing system. Many times they are further processed for industrial, pharmaceutical, nutraceutical products and this process is referred to as tertiary and quaternary processing. Thus, the secondary agriculture is defined to add value to the finished agriculture and agriculture based industrial produce and generate income even from waste. It is believed that the high value low volume products from high volume low value products through Secondary Agriculture

activities can benefit the overall economy by generating employment, improving export potential, reduce dependence on imports and converting waste to wealth. The process involves cycling and recycling to realise the real potential even of an intermediary produce; i.e. to fully use and have true value as per growing needs, utility, applicability, adoptability and ever unfolding knowledge and technological domain. In the process, the ultimate aim is to sustain the system's sustainability so that the four ecosystem services continue to be continuously provided effectively and efficiently to humanity in perpetuity.

The health of Indian agriculture is evident from the fact that in spite of occurrence of various natural calamities like flood and drought, and adverse climatic events, food production is at its all time high. Despite continuous increase in production and productivity, food and nutritional security is still a challenge globally because of many different reasons. Some of them include (i) unsustainable increase in population, (ii) use of cultivable land for other activities, (iii) increasing input cost, (iv) depleting natural resources, (v) adverse climatic events including global warming, (vi) younger generation not showing interest in agriculture because of lower profitability.

There is tremendous scope for adding further value to the main produce as well as for the utilization of various co-product/ by-product from primary agriculture as well as the post production operations, which has the capability of transforming Indian agricultural scenario if the same is adequately and appropriately utilized. Globally, many such examples are available where the by-product/co-product yields more value/profit as compared to the main product for which the crop was supposedly grown.

Sustainability of the agricultural production system in the changing global scenario where availability of natural resources is scarce, soil and environmental health is a concern, and enhancing value and profitability of agriculture is imperative for sustainability, the following need to be addressed on priority:

(i) Monetisation of farmers' produce

(ii) Bringing organized industry to rural areas to boost non-farm rural economy

(iii) Developing a technologically backed circular economy through value addition.

Such developments in addition to its linkage with as farmers often face problem of marketing their produce at remunerative prices. Agricultural processing level therefore through food processing companies, mega food parks to tiny cottage level industries involved in processing and value addition activities are increasing

at faster rate and also yield considerable agro-industrial by-products, which are hardly being used for manufacturing very high value products.

To mitigate these issues secondary agriculture can play a prominent role. Promoting secondary agriculture can help attain sustainable development goals, which aim to connect primary, secondary and tertiary sectors through optimal use of inputs contributing to primary agriculture production, capturing 'value' in primary agricultural activities, and generating additional income at the rural enterprise level. Unless Tertiary and Advanced Tertiary Processing are linked to the primary agriculture, the profit from it will not reach the base farmer. In a sustainable domain of All Inclusive Agriculture, attention is required for both Primary and Secondary Agriculture.

CONCEPT AND DEFINITION OF SA

The term 'Secondary Agriculture' is not widely used. The EU Economic Accounts for Agriculture (EEAA) include all related service activities as part of the agriculture sector. The United Nations Statistics Division, that classifies various economic activities, does not define secondary agriculture. According to Chengappa (2013), Secondary Agriculture includes "all practices and processes, which add value to primary agricultural commodities using efficient technologies, market information and consumer preference". A Committee on Doubling Farmers Income in India has defined the term "Secondary Agriculture" as a productive activity at enterprise level that utilises raw material as the primary product and by-products of agriculture and other biological resources available locally in its rural agrarian neighbourhood, deploying locally available skills or a high level of rural manpower, to operate/ manage/maintain the production of goods and services; and the activities can be categorised appropriately under the Micro, Small or Medium Enterprises Development (MSMED) Act 2006. The 'Secondary Agriculture' shall be considered as an industry whose inputs are majorly sourced from primary agriculture. It shall not be confused with food processing, because food processing industries are also dependent on the raw materials obtained from the primary agriculture. The products of Secondary Agriculture are much more complex and have diverse applications including food and feed.

The Planning Commission of India had constituted a Technical Advisory Committee on Secondary Agriculture (TACSA) in 2007. The TACSA submitted its report in October 2008 but did not define the term 'secondary agriculture'. Instead, it states that the term "is very broad as it includes all food and non-food bio-resource-based products for human and industrial use". The term is seen to be used as an omnibus expression to relate to the product of agro-based processing

activities of the secondary sector. Effectively, TACSA detailed the output from the activities to explain the term "secondary agriculture". In fact, by correlating secondary agriculture to all food and non-food products it seems the term would encompass all types of industries as long as its input is a bio-resource – making secondary agriculture another terminology for all kinds of agro-industry. The "Secondary Agriculture" as explained by Prof. DPS Verma (2008) is "All practices and processes which add value to the primary agricultural commodities using efficient technologies, market information and consumer preference" and covers the entire post-production system giving emphasis on unused biomaterials/by-products obtained from primary agriculture/processing. Therefore, the secondary agriculture in the Indian context may be defined as "**All practices and processes of converting agricultural produce, residues and by-products into high value commodities for pharmaceutical, industrial, medicinal and specified food uses as per market intelligence and consumer preferences for increasing farmers' income**". High value product/compound extraction from complete biomass of a particular crop, rural industrialization and marketing are the main element of the Secondary Agriculture.

Another definition of SA could be **"the industrial manufacturing of high value compounds / commodities / products such as food/feed supplements, food additives, compounds of pharmaceutical value, agri-inputs, industrial chemicals and consumer goods etc. from the raw materials obtained from the primary sources of agriculture and allied sectors, crop residues and agro-industrial by-products".**

The TACSA report focuses on products of the bio-processing industries, including the secondary and advanced level of manufactured products of the industry, such as ethanol, chemicals, enzymes, biologicals, biopolymers, etc.

SECONDARY AGRICULTURE RESOURCES

Agriculture, besides the main products, produces a huge quantum of by-products. These residues or by-products, if not handled appropriately, may pose threat to the subsequent crops. In absence of efficient and economic handling and disposal protocols, often these resources are dumped or burnt and hence pollute the environment. The potential availability of crop residues/ agro-waste/ agro-industrial by-products is shown in Table 1. It is noteworthy that this huge resource is almost untapped. Although some part of this goes into revitalizing the soil through composting, still there is a great potential to extract some of the industrially vital components before composting.

Table 1: Estimated biomass of a few selected major crops (Based on production figures of 2020-21)

Commodity	Production (mT)	Available for processing (mT)
Rice	**122.27**	
Bran	8.98	6.41
Broken rice	24.37	17.06
Straw	218.04	91.58
Wheat	**109.52**	
Bran	15.17	2.13
Germ	3.31	0.46
Straw	140.20	61.42
Maize	**31.51**	
Corn cob	7.88	2.86
Germ	3.46	0.70
Straw	59.23	21.47
Pigeon pea	**4.28**	
Hulls	0.64	0.44
Broken	0.55	0.39
Stalks	17.12	7.51
Soybean	**12.90**	
Soy meal	9.18	7.31
Soy hulls	1.20	0.96
Guar	**1.52**	
Guar gum	0.86	0.26
Germ	0.47	0.41
Hulls	0.12	0.10
Mango	**20.82**	
Peel	3.12	0.15
Stone	3.74	0.21
Citrus	**14.26**	
Peel	6.18	1.37
Tomato	**24.30**	
Processing by-products	2.06	1.65
Milk	**198.44**	
Whey, Butter milk, Ghee residue	8.3, 57.9, 4.96	1.65, 6.61, 0.50
Colostrum	0.58	0.05
Fish	**14.16**	
Frame	3.64	2.12
Scales, skin	1.36	0.61
Meat and poultry		
Poultry waste	0.70	0.17
Buffalo by-products & waste	2.17	1.1

The extent of processing of almost all categories of agri-produce has increased in the country. In a study conducted by Ministry of Food Processing, the level of processing of food grains was found 49.3% in 2010-11, which increased to 68.2% in the year 2018-19. In the case of oilseeds, the level of processing has been decreased from 60.1% (2010-11) to 49.8% (2018-19). The processing level of fruits and vegetables was 1.9% in 2010-11, which slightly increased to 3.3% in 2018-19.

The growth in the processing of animal products was estimated to be 18.7% during 2018-19 in comparison to 8.7% in 2010-11. A significant increase in the level of fish processing was observed with an increase from a level of 2.8% during 2010-11 to 15.4% in the year 2018-19.

During the 5 years ending in 2019-20, food processing sector in India has grown at an Average Annual Growth Rate (AAGR) of around 11.18 % as compared to that of 4.19 % in Agriculture (at 2011-12 prices) using the total number of food factories in registered food processing sector, as per the latest annual survey of Industries (2018-19). Among the industry, highest numbers of registered factories are located in Andhra Pradesh (13.93%) followed by Tamil Nadu (12.28%), Telangana (9.61%), Punjab (7.67%) and Maharashtra (6.88%). Food Processing Sector thus has emerged as an important segment of the Indian economy in terms of its contribution to GDP, employment and investment. The sector contributes as much as 9.87 per cent and 11.38 per cent of Gross Value Added (GVA) in manufacturing and agriculture sector, respectively in 2019-20 at 2011-12 prices (Annual Report 2021-2022, Ministry of Food Processing Industries, Govt. of India). However, the high-value products from by-products, agro-waste/crop residues for industrial uses such as active pharma ingredients (API), nutraceutical, etc. are negligible in the country. About 90% API and more than 60 % nutraceutical products are imported

Commodity	Possible high value low volume products
Rice	
Bran	Protein isolate, Concentrate
Broken rice	Reconstituted rice, Extruded products
Straw	Enzymes, Ethanol, Fermented feed, Particle boards
Wheat	
Bran	Soluble and insoluble fiber, Animal feed
Germ	Germ oil, Vitamin E
Straw	Cellulose, Oligosaccharides, Animal feed
Maize	
Corn cob	Xylitol, Yeast autolysate
Germ	Oil, Protein isolate, Concentrate
Straw	Ethanol, Animal feed, Particle boards
Pigeon pea	
Hulls	Soluble and insoluble fiber, Animal feed
Broken	Dal analogues, extruded products, Animal feed

Commodity	Possible high value low volume products
Stalks	Cellulose, Particle board
Soybean	
Soy meal	Fortified flour, protein isolate & concentrate, millet fortified extruded products, Daal analogues, Hydrolysate
Soy hulls	Cellulose powder
Guar	
Guar gum	Guar gum derivatives
Germ	Protein isolates, Animal feed
Hulls	Animal feed
Mango	
Peel	Pectin, Fibre, Anti-oxidants, Biofuel
Stone	Starch, Oil
Citrus	
Peel	Peel oil, Flavonoids, Pectin, Limonoids
Tomato	
Processing by-products	Lycopene, Tomato seed oil
Milk	
Whey, Butter milk, Ghee residue	Protein hydrolysates, Lactoferrin, Mannitol, Glycooligosaccharides
Colostrum	Immunoglobulin fraction, Glycomacropeptides, Colostrum powder, Phospholipid rich fraction
Meat and poultry	
Poultry waste	Amino peptidases (from chicken intestine)
Buffalo by-products & waste	Fish feed ingredient (from rumen waste)
	Protein hydrolysates, Bioactive peptides, Neat's foot oil, Ossein (from liver, meat trimmings, feet and bones)
Fish	
Fish head	Fish head stock
Fish eye	Omega-3 fatty acid
Mixed fish waste	Protein hydrolysates
Mixed fish waste	Meal and oil
Fish scale	Dried scale as a raw material for collagen industry, Collagen, Gelatin, Collagen peptide, Hydroxyapatite, Fish scale mineral, Di-calcium Phosphate

Commodity	Possible high value low volume products
Fish skin	Collagen, Gelatin, Collagen peptide, Fish skin extracellular matrix, fish glue
Fish swim bladder	Fish maw, Collagen, Gelatin, Collagen peptide
Fish fins	Ingredients for soup, Collagen, Gelatin, Collagen peptide, Di-calcium Phosphate
Fish Viscera	Enzymes, Protein hydrolysates
Fish bone	Fish calcium, Bone-meal, Collagen, Gelatin and collagen peptide, Bone oil
Shrimp head waste/Shrimp shell waste	Chitin. Chitosan, Glucosamine hydrochloride, chitosan salts, water soluble chitosan, chitooligomers, shrimp meal, shrimp oil, carotenoproteins, Astaxanthine, Pigments, Other chitin and chitosan based derivatives
Mixed squid waste	Protein paste, protein hydrolysates, feed attractant
Mixed cuttlefish waste	Protein paste, protein hydrolysates, feed attractant
Cuttlefish bone and squid pen	Bone powder, dried cuttle bone, squid pen powder, chitin and chitosan,
Ink sac from cephalopods	Melanin, antioxidant peptides, Soup ingredient, flavourings
Shuck water	Protein concentrate, natural peptides, flavourings
Shells from Oyster, clam, mussels	Calcium, Chitin, fillers for packaging materials, fillers in concrete and road making
Skin from cuttlefish and squid	Collagen, gelatin, collagen peptide, gelatin hydrolysates, skin protein hydrolysates, extracellular matrix
Fish frame waste	Protein isolate, protein hydrolysates, Protein concentrate
Fish belly flaps	Fish oil
Shark bone	Cartilage powder, chondroitin sulphate
Shark liver	Liver oil, Squaline
Fish skin	Fish skin leather and products
Shark fin	Shark fin rays
Tail of skates and rays	Dried sticks for pets
Whole waste from small fishes	Fish and poultry feed
Mixed fish waste	Fish silage, fish ensilage, fish amino acid, fish hydrolysates (liquid and powder)
Meat recovered from fish waste	Edible products, coated products, Fish flour, Surimi
Fish scale	Pearl essence
Mixed fish waste	Fish fertilizer, fish manure, fish compost

from China and European countries. Out of 90 % APIs 80 % of them are imported from China only to meet the country's needs. The country's pharmaceutical sector is heavily dependent on imports and the government is trying hard to reduce such imports. Tertiary and quaternary level processing will greatly help in this endeavor. Policy for promotion of Secondary Agriculture, therefore, is the need of the hour in the country. Following is a list of possible high value products which can be derived from different secondary agriculture resources. This, however, is by no means the complete list, as the characterization of many agricultural products is still awaited.

Some examples of secondary agriculture are listed here:

a. A cotton ginning unit, to separate lint and seed from locally grown cotton, using local human resources and within norms for capital investment under MSME rules would be qualified as secondary agriculture.

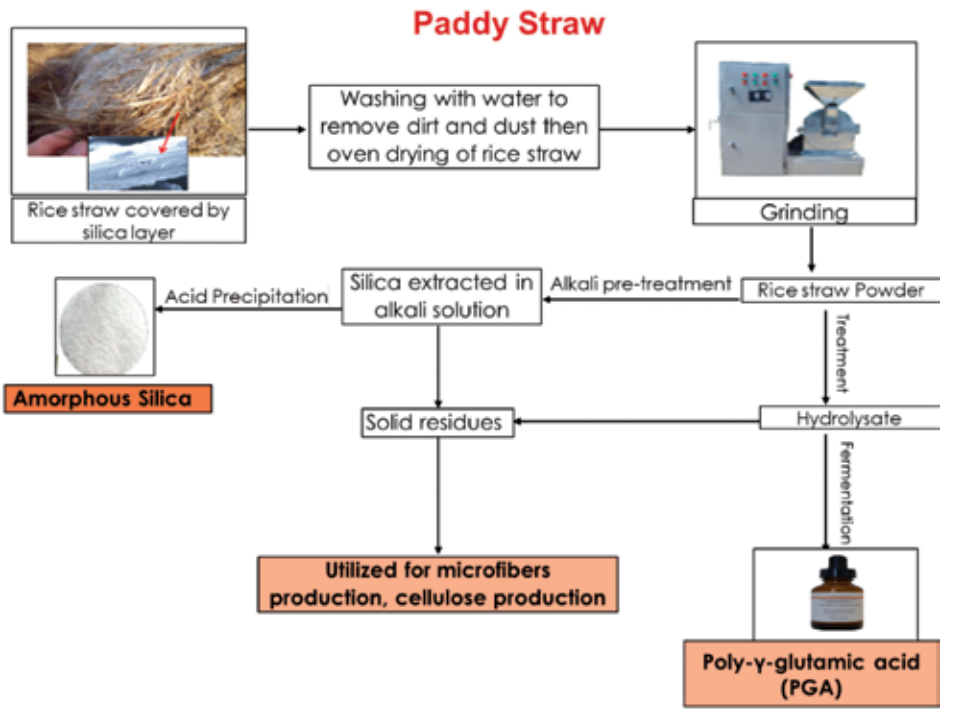
b. A jaggery making unit, in the sugarcane growing area.

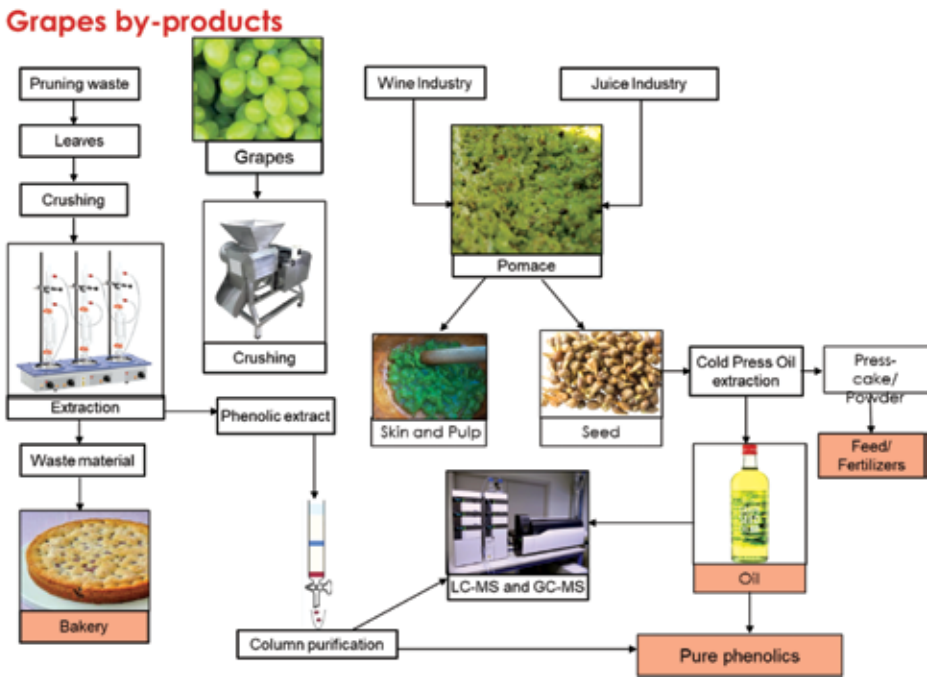
c. A cottage scale unit employing local labour at a village, to create jams, pickles, chips, khadi products, etc

d. A cashew processing unit that shells, salts and packages the cashew from its neighbourhood growers.

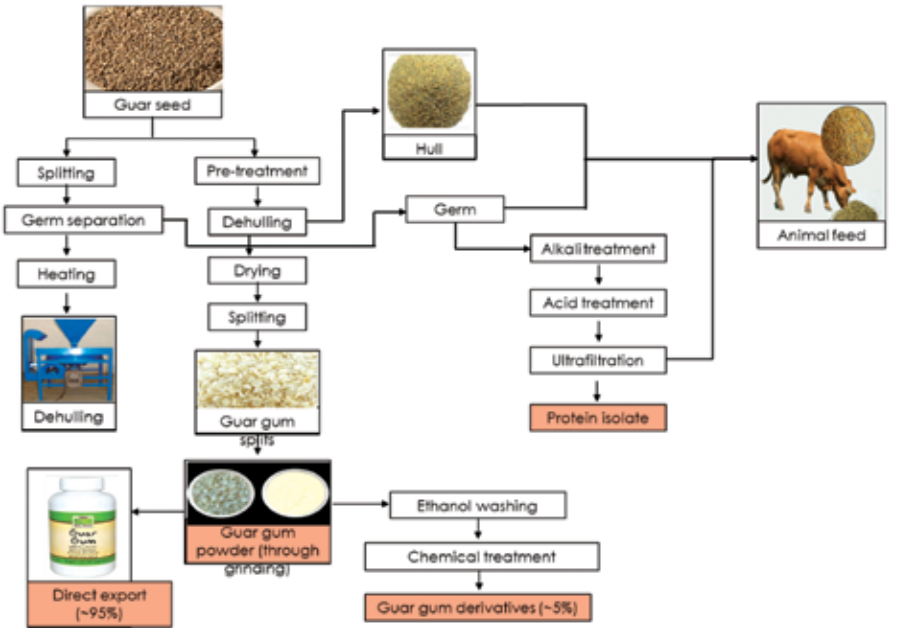
e. If paddy is harvested, threshed, cleaned, dried and stored for marketing is not a secondary Agriculture activity. Processing of stored paddy to rice and further high value products however is secondary agriculture.

Some typical examples of converting agri-produce into variety of primary, secondary, tertiary and quaternary products are shown below:

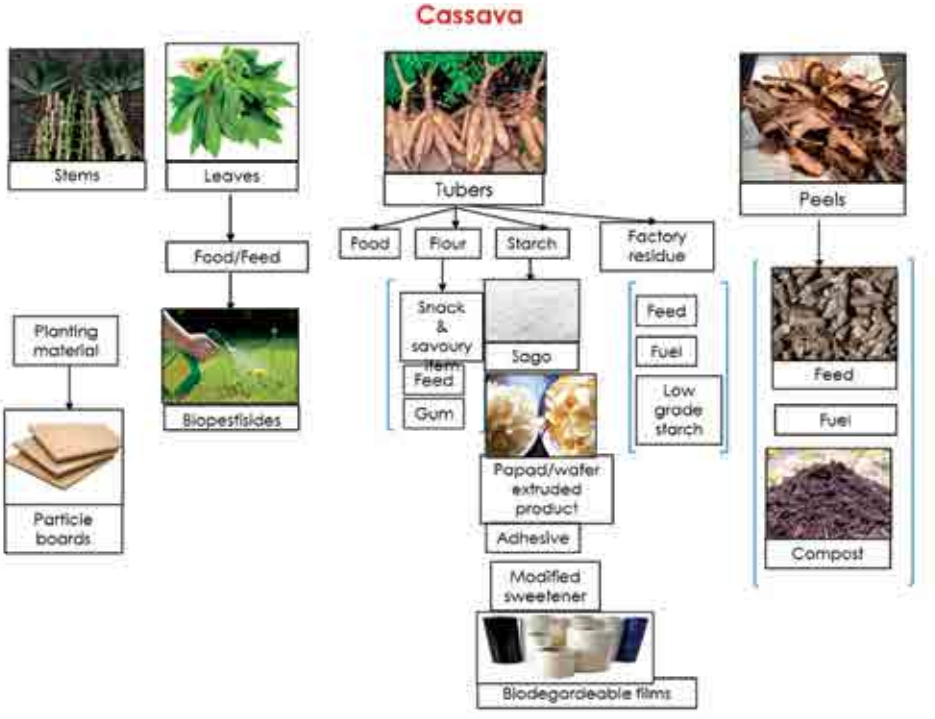

Paddy Straw
Rice straw covered by silica layer
Washing with water to remove dirt and dust then oven drying of rice straw
Grinding
Rice straw Powder
Alkali pre-treatment
Silica extracted in alkali solution
Acid Precipitation
Amorphous Silica
Treatment
Hydrolysate
Solid residues
Fermentation
Utilized for microfibers production, cellulose production
Poly-γ-glutamic acid (PGA)


Grapes by-products
Pruning waste
Leaves
Crushing
Extraction
Waste material
Bakery
Grapes
Crushing
Phenolic extract
Column purification
Wine Industry
Juice Industry
Pomace
Skin and Pulp
Seed
Cold Press Oil extraction
Press-cake/ Powder
Feed/ Fertilizers
Oil
LC-MS and GC-MS
Pure phenolics

Guar Gum & Guar meal



Cassava

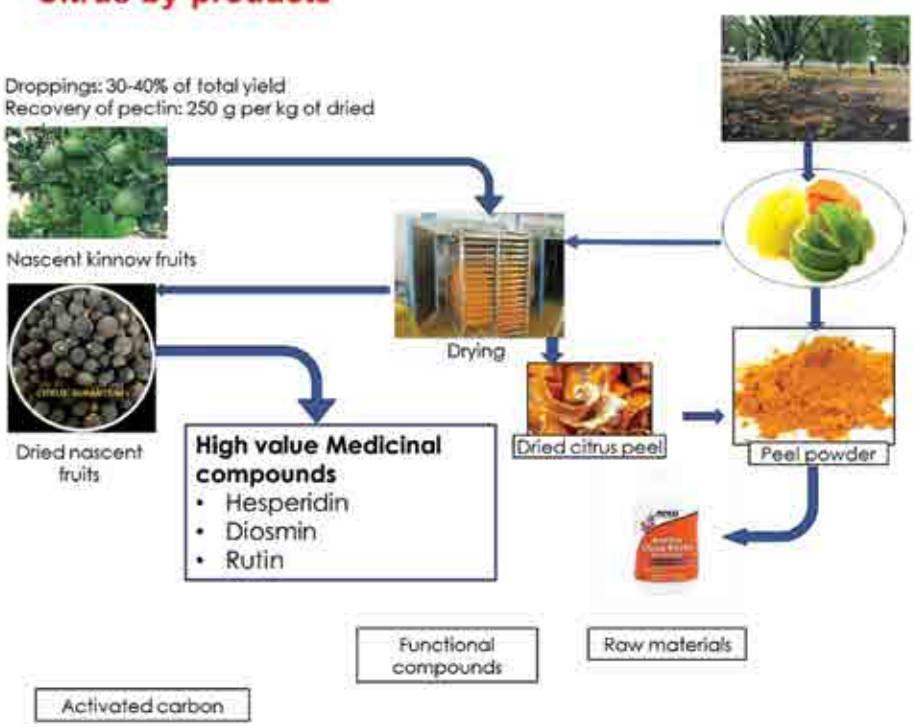


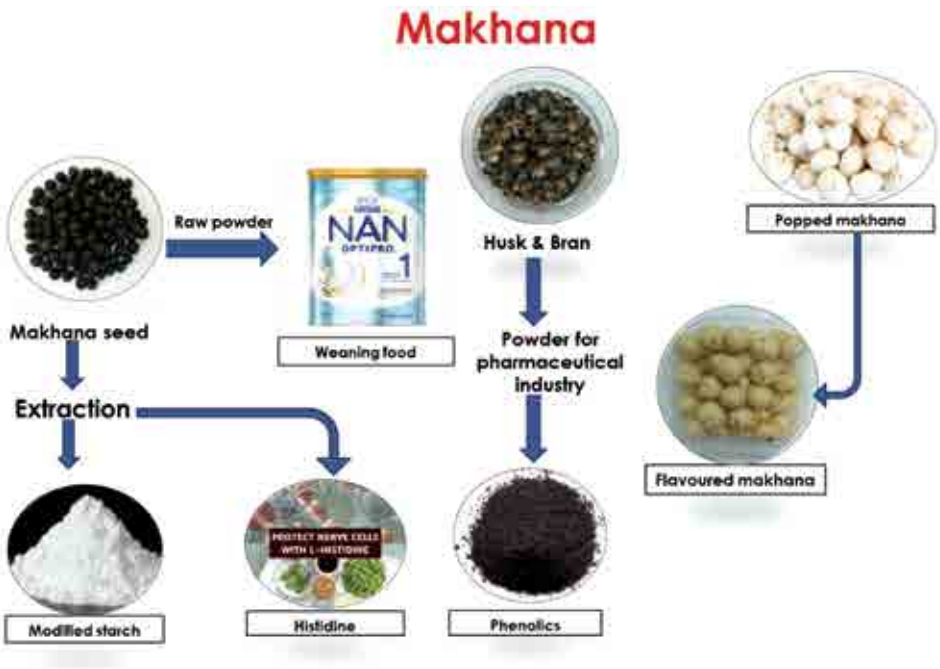
Fish By-products

Products

- **Protein based health formulations**
- **Chitooligosaccharides**
- **Enzyme formulations**
- **Collagen concentrate**
- **Muscle protein derived peptides**
- **Omega-3 concentrate**

Citrus by-products





It is noteworthy that many high value compounds intended to be extracted from conventionally processed products or their by-products are imported for commercial use in India. The industries producing high value products from crop residues and agro-industry by-products, such as **pure proteins, modified starches, derivatives of guar gums & castor oil, enzymes, bio-chemicals, nano-materials, health promoting compounds and active pharmaceutical ingredients** are in the nascent stage, and these products are mainly imported for specific use. The indicative list of the import of important high value compounds pertaining to the above-mentioned categories for the year 2020-21 is presented in Table 3.

It indicates that the annual value of the imports of these commodities stood at Rs 14,879.14 crore, during the year 2020-21.

SECONDARY AGRICULTURE: CHALLENGES

The average land holding in India is 1.08 ha. Collection of the crop residue and by-products therefore are difficult and often not sufficient enough to process them for any kind of value-added products. Similarly, the processing units in India are mainly of small capacities and the quantity of by-products is not sufficient to convert them into high value compounds economically.

Table 3: Import of products of Secondary Agriculture by India during the year 2020-2021

No.	HS code	Description	Value in Rs Lakh (2020-21)
1.	11	Products of the milling industry; malt; starches; inulin; wheat gluten.	49,283.94
2.	13	Lac; gums, resins and other vegetable saps and extracts	189,143.42
3.	33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations	512,719.58
4.	35	Albuminoidal substances; modified starches; glues; enzymes.	403,315.48
5.	2936	Provitamins and vitamins, natural or reproduced by synthesis (including natural concentrates), derivatives thereof	153,250.06
6.	1702	Other sugars, including chemically pure lactose, maltose, glucose and fructose, in solid form; sugar syrups not containing added flavouring or colouring matter, artificial honey, whether or not mixed with natural honey; caramel lactose and lactose syrup	72,325.61
7.	2102	Yeasts (active/inactive); other single cell micro-organisms; dead (but not incl vaccines of heading no 3002); baking powders	20,011.59
8.	210610	Protein concentrates and textured protein Substances	19,045.56
9.	29232010	Lecithins	22,002.58
10.	293930	Caffeine and its salts	5,380.23
11.	29397910	Nicotine	144.74
12.	391231	Carboxymethylcellulose and its salts	41,291.78
		Total	**1,487,914.57**

Source: Dept. of Commerce, Ministry of Commerce and Industry, Govt. of India

The Indian agro-based industries are primarily producing food products from main agricultural produce through primary, secondary and tertiary processing whereas by-products of food industries (such as de-oiled cake, by-products of pulse millings, cereal industry by-products and low-grade stored cereals, by-products of fruits-vegetables industries, by-products of fibre processing industry etc.) are either processed for animal feed in a rudimentary form or thrown away as waste or to make compost. Many appropriate technologies for such activities are either available or are being attempted for the same. Establishment of agri-processing centres or secondary Agriculture unit is however may not be possible for individual farmers particularly by small and marginal ones. This is possible if an Agro-processing

and Marketing Yard (APMY) is established in each village or in every Panchayat either in PP mode or by the Government or some other agencies with partnership of farmers, may be in cooperative mode. For this purpose, first we should have de-centralized storage and controlled raw material movement at village level APMY, panchayat level storage/ godown, block level food bank, district level warehouses, and finally state level grain/by-products warehouses, respectively. Surplus produce of any state could be procured by consuming state and stored at state level grain warehouse. Hence, each district, block and panchayat should have warehouses/godowns for their produces. At panchayat level it may be called a food or agri-produce/by-products bank. Farmers can deposit their produce in these banks, and get any other produce of equivalent value for their consumption, if needed. Surplus items should be used for processing, value addition, labelling and marketing locally or in the national markets through e-NAM/online marketing systems to be established in processing yard, which can be designated as Village Economic Zone (VEZ) or Panchayat Economic Zone (PEZ).

Each VEZ of PEZ may comprise of processing and value addition units for food grain, oilseeds & pulses; fruits & vegetables; milk & milk products; sugarcane/ jaggery; feed, fodder and fibre (including by-products processing and power/ energy generation); local artisan/arts & craft centre and at least one IT hub. These VEZs/PEZs can employ youths of the villages and create employment opportunities locally, particularly for women. If at least one person from each needy household is employed and gets assured salary from these VEZs/PEZs economic conditions of villages may improve significantly. However, there are several constraints and challenges restricting SA in India. Those constraints and challenges are summarised as under:

- Lack of baseline data on availability and quality of secondary raw materials from processing activities
- Lack of awareness on possible utilization of food processing waste
- Highly scattered nature of domestic market of food waste
- Non-availability of prime quality raw material
- Availability of certain processing industries only in certain regions
- Huge transportation cost of by-products collection and handling from multiple points.
- Need of cold chain facilities for highly perishable raw materials
- Lack of cold chain hubs which support the logistics

- Lack of quality indigenous plants and machineries.
- Need of high initial investment and operational cost to establish new processing plants.
- Uncertain demand in domestic market.
- Lack of industries-research institutions participations in research and technology development on secondary agriculture.
- Lack of private-public participations in promoting SA.
- Obscure trade policies and barriers.
- Absence of focused policies to promote secondary agriculture and export.
- Absence of focused policies to promote domestic marketing of products developed from secondary agriculture.
- Lack of proper third-party quality testing facilities to ensure quality and safety of the products of SA.
- Sporadic information on demand and supply of products of SA in national and international markets.
- Production and marketing of high value compounds at internationally competitive prices.

OPPORTUNITIES IN SECONDARY AGRICULTURE

In order to have an idea of the opportunities in Secondary Agriculture, it is important to look at the broad categories of food and non-food secondary agriculture products. These can be categorized under the following groups from their application point of view:

- Absorbents/adsorbents
- Activated carbon
- Adhesives
- Agricultural chemicals
- Alternative fibers /bonded fabrics /textiles
- Bio-based fuels such as ethanol and bio-diesel
- Gases – methane/ CO_2

- Bio-plastics/polymers/films
- Agro-based construction and composite materials - Panels, Laminates, Composites, Hardware
- Biofilters
- Cleaning chemicals, surfactants, soaps, detergents
- Enzymes, vitamins
- Foods, beverages, nutrients
- Fuel additives
- Fertilizers, Phyto stimulants, Plant growth regulators
- Inks, dyes, pigments
- Landscaping materials/ soil amenders
- Lubricants/rust inhibitors/functional fluids
- Oils, waxes, binders, stabilizers
- Biomass-based packaging materials
- Organic paints/coatings
- Nutraceuticals
- Soil remediation, biofertilizers and biocides
- Organic solvents & co-solvents
- Specialty chemicals, fatty and acetic acid, sweeteners
- Paper & paper products from non-conventional sources
- Water & waste water treatment products with agricultural origin

These groups are quite broad and may include multiple products sourced from different raw materials obtained from primary agriculture.

Below is the description of some of the individual products of secondary agriculture, their benefits, applications and raw materials:

Isoflavones from Soybean: Isoflavones present in soybean possess anti-fungal and antioxidant properties. It is used in health products. Total isoflavone content in

soybeans ranges from 1.26 – 3.88 mg/g seed, whereas its concentration is more in the germ than in the cotyledons. Isoflavones are used as health supplements. Separation of germ and extraction of isoflavones and making products with isoflavones ranging from 20 to 70 per cent are available internationally.

Raffinose and Stachyose: Oligosaccharides constitute about 5 % of the soybean. The two principal soy-oligosaccharides are raffinose and stachyose. They are marketed as dietary supplements and added to functional foods. These prebiotics may have anticarcinogenic, antimicrobial, and glucose-modulatory activities.

Saponins: Saponins are present in soybean as a minor constituent (05 – 5.0 %) depending upon the varieties of the soybean. Saponins are recognized to have beneficial effects in the diet as functional ingredients in lowering blood cholesterol, preventing cancer and stimulation of immunity.

Soy Lecithin: Lecithin is one of the most important byproducts of soybean oil refining industry. It is about 1.5 – 2.5 % of the oil. Lecithin has various uses including almost all the food industries, paint, varnish and cosmetic industry.

Vitamins and tocopherols: Around 2.5 % of the wheat kernel weight is germ, which is a good source of vitamin B-complex and trace minerals. It is also a rich source of Vitamin E (oil soluble).

Enzymes: A number of enzymes used industrially can be found in the cereal grains. Lipase is found in wheat germ, bran as well as in oat hulls (Rajeshwara and Prakash 1994). Lipase is used in the food industry as flavour enhancer and in detergents for the improvement of cleaning action. Lectins, acid phosphatase, Beta-amylase inhibitor is extracted from wheat and barley. Beta-amylaseand xylanase are present in cereal brans and pulse husks. In addition, protease, laccase, peroxidase and poly phenol oxidase (PPO) are present in significant amounts in green gram husks and wheat germ. Amylase, xylanase, alpha glucosidase and ferulic acid esterase are used in brewing, bread making, confectionery, and health food industries. Peroxidase from soy husk has significant industrial use.

Rice straw: Disposal of rice straw has become a major problem in grain growing states of India. Rice straw has many uses. In Thailand, approx. 10 % of the straw is utilized as a medium to grow mushrooms, 50 % for animal feed, 30 % in paper making and the rest is burnt as fuel. Rice husk can be compressed into briquettes for fuel and power generation (Lonia 2005). If carbonized, these briquettes become high-quality charcoal. Activated charcoal has many potential industrial uses. Rice straw can be burnt in high efficiency furnaces and the ash produced is a good source of potash as a fertilizer.

Corn starch: Corn starch can be converted into ethanol (bioethanol), biodegradable plastic and additives for the pharmaceutical, paper, cosmetics, and food industry. Dextrose is a pure crystalline sugar obtained from corn starch using enzymatic reactions. Destrose has many food, pharmaceutical and industrial applications. HFCS is used in food industry as a replacement of sugar in beverages.

Other corn products: Corncob can be converted into xylitol, a low-calorie sweetener. Adhesives, baking mixes, caramel color, destrin, emulsifiers, polyols and sorbitol etc. are some of the other products obtained commercially from corn.

Dietary fibre: Dietary fiber is a group of plant polysaccharides not digested by human digestive enzymes. However, they have many nutritional benefits. These dietary fibers consist of polysaccharides such as arabinoxylans, 1,3/1,4-beta-D-glucans, arabino-galactoproteins and cellulose. These are much in demand as food supplements for their use as probiotics. These compounds can be isolated from the cereal bran and pulse husks by appropriate methods for various end uses.

Phenolic compounds: Cereal brans and pulse husks are rich in phenolic compounds such as ferulic acid, coumaric acid, caffeic acid and tannins. Ferulic acid is the precursor of the flavour compound vanillin, vanillic acid etc.

Phytosterols from vegetable oils: Phytosterols such as stigmasterols, beta-sitosterols and campesterol obtained during refining of vegetable oils are in high demand as nutraceuticals.

Tocotrienols from rice bran oil: Tocotrienols, the isomers of tocopherols are similar to Vit E. The other source of these is palm oil. These have many health benefits in preventing stroke induced injuries, reverse the arterial blockage, reduce cholesterol and reduce the risk of type-2 diabetes.

There is a huge potential to make high value secondary agriculture products from grain/oil by-product processing industries.

Natural food colors and dyes: A few commonly used natural colors are Annatto (seed), turmeric, bet juice, red cabbage, spinach (leaf) etc. In view of increased restrictions on the use of synthetic colors, natural colors are being sought for food and non-food sources. Many natural colors including curcumin, beta-carotene, lutein, and lycopene have, in addition to coloring property, pronounced health benefits.

Anthocyanins: These are a class of flavonoids, permitted to be used as food additive with E number 163. These are abundant in most fruits and vegetables, which are colored blue to red. They are relatively more stable than most other natural colors.

Plant growth promoter n-Triacontanol: Waxes from tea waste, rice bran, and sugarcane press mud (SCPM) are important sources of n-triacontanol, which has a marked effect on foliar growth at as low as 1-5 ppm.

Solanesol: It is an anti-hypertensive, anti-hyperlipidemic, and anti-tumour agent being made in China, Japan etc. It is also used as a starting material in synthesis of high-value chemicals such as Vitamin K analogues and Co-enzyme Q10. It is extracted from tobacco leaves.

Recently, many new compounds such as vitamin C, biotin, astaxanthin, isoleucine, zeaxanthin, lutein, ethyl lactate, polyols, organic acids, biodegradable plastics, etc. have been added to the products of Secondary Agriculture.

It is amply evident from the foregoing description that the potential of Secondary Agriculture in India is huge. Promoting SA in India will reduce its dependence on imports, push exports and create more industries and employment opportunities in the country.

The Secondary Agriculture may be categorized into three types according to the nature/type of production units:

i. **Feeder Units in production catchments:** Segregation and conversion of bio-mass/by-products in dense and storable form is done through primary unit operations (sorting, drying, pulverization, densification, packaging). The units for crop residues are of small capacities, designed for handling multiple biomasses to ensure round the year operation, and are established in the production catchments. Establishing call centers or Ola/Uber type models may be tried for collection and transportation of raw materials from villages to processing centers. This can be an independent enterprise at the block or *panchayat* level.

ii. **Secondary processing units for high value compounds production:** Relatively large capacity extraction units to separate high value components from the biomass/by-products with feed/composting units. These enterprises will get the raw material from the feeder units and have facility for processing multiple biomasses. There is a need to establish agro-processing units near the collection centers at block or district level.

iii. **Specialty product units:** Enterprises that separate high value compounds and prepare products as per the demand of consumers of domestic or global markets. These enterprises will be the main customer base for secondary agriculture outputs. These could be established at places where the marketing potential can be tapped fully.

The key to the success of SA is flow of raw materials from villages to *panchayat* to block to district and then finally to Enterprises of Secondary Agriculture (ESA) for making use of residues and wastes. For example, in case of citrus green, immature droppings are to be dried, pulverized and stored in feeder units; extraction of medicinal compounds is to happen in the secondary units, and finally, use in medicines is to be done by the specialty units. In case of citrus processing by-products, separation of seed and pomace, drying and pulverization in feeder units, pectin extraction will be carried out in secondary units; and use of pectin as thickener will be by ketchup industry. Similarly, maize cobs will be dried and pulverized in feeder units, extraction of xylitol in secondary units, and preparation of sugar-free products is to be undertaken by the specialty units. This is further elaborated below with examples with fish and *makhana* processing.

FISH PROCESSING

The Indian fish processing industries are primarily producing fish and shellfish products. They are often eviscerated and exported in the frozen form. The by-products generated during processing are processed into meal, which is utilized as protein ingredient for the production of animal and poultry feed, or converted into manure for agriculture applications or more often, thrown away as discards. The industries producing high value products from fish waste/by-products, such as pure proteins (collagen, gelatin, collagen peptide, protein isolate, hydrolysate), carbohydrates (chitin and chitosan derivatives), PUFA-rich oil, enzymes, bio-chemicals, nano-materials, health promoting compounds, active pharmaceutical ingredients etc. are in the infant stage, and these products are possessing domestic consumption as well as export potential. Appropriate indigenous technologies for producing aforementioned high value products are either available or under development. Its promotion needs capital investment and support through focused programme.

MAKHANA PROCESSING

The popped *makhana* contains 11.03% easily absorbable protein with a unique assemblage of different amino acids having anti-aging properties. It contains appreciable amount of immune-modulating amino acids, arginine and methionine, which are essential for the beauty of skin, nails and hairs. Taurine synthesized from cysteine reduces diabetic effect in cell. Arginine, which produces nitric oxide within the cell, increases the elasticity of arteries and veins, thereby increasing blood flow. Other amino acids like iso-leucine and proline help in growth and

development of the body. In view of these benefits, there is ample scope for *makhana* based secondary agriculture in India

WAY FORWARD

The task of promoting secondary agriculture especially focussed for the benefit of farmers and rural industry needs concerted efforts from different stakeholders viz., Academia, Researchers, Policy makers, Financial organizations, Existing operators like farmers, aggregators, agro-industries etc. Following are suggested for promoting Secondary Agriculture:

1. A comprehensive database on the availability of various raw materials and their quality at different hot spots including primary production sites, location of processing industries and local markets needs to be prepared.
2. Characterization of different produce, crop residues, agro industrial by-products, discovery of high-end-products need urgent action. The concerned research institutions both public and private have to build strategically designed research programs. Dedicated networks of labs and scientists are to be developed in multi-disciplinary mode to explore the un-explored crops/residues/by-products
3. The process innovation as well as product innovation are to be rigorously promoted through financial support to target oriented focussed projects. Technology customization for high value products from secondary raw materials will also require adequate attention and financial support.
4. Different models of value chain (single input multiple output, multiple input single output) and their economic feasibility have to be worked out for adoption and adequate financing.
5. Industry partnership needs to be built starting from product development till large scale manufacturing and commercialization. Engagement of MSME and large industries, depending on the scope in manufacturing of high value products at appropriate locations is to be promoted with adequate Govt. support/facilitation.
6. In certain situations, the establishment of SFP involving SHGs/societies to own and operate specific industrial products in collaboration with research organizations and private companies would be desirable.
7. The mechanism for systematic certification and labeling of products and machines should be increased. A certification program for the primary processing units is required to be introduced for encouraging responsible waste utilization.

8. Technology demonstration units (pilot scale) for handling of secondary raw materials and processing into high value products are to be establish to attached entrepreneurs and investors.

9. Support for establishment of secondary agriculture activities is to be explored under the existing Govt. schemes on Crop Residue Management and waste utilization, or though separate government supported schemes. A dedicated budget provision to the tune of Rs. 5000 crores should be made to support circular economy through secondary agriculture.

10. For promoting export, market studies are to be conducted in order to understand the consumer needs at the global level for new products based on robust scientific evidencewith regards to their health nutrition benefits. Creation of large scale awareness would be essential both in India and aborad.

SA not only brings profits but also helps solve the problem of pollution and indiscriminate disposal of crop & agro processing residue. Right scaling of technology so that output is economically competitive/ viable; this also ensures full capacity utilization of the enterprises engaged in secondary processing activities.

REFERENCES

Acharya, S.S. (2003). "Rural Non-Farm Sector and Its Role in Economic Development in the Changing Scenario", Presidential Address, Agricultural Economics Research Review, 16(2): pp 83-90.

Anon. (2008). International Standard Industrial Classification of All Economic Activities (ISIC), Rev 4. Dept. of Economic and Social Affairs, Statistics Division, United Nations.

Anon. (2008). Report of the Technical Advisory Committee for promoting Secondary Agriculture to the Planning Commission, Government of India. Report "Secondary Agriculture: Value Addition to Primary Agriculture", dated 15-October-2008.

Anon (2015). Swaniti Initiatives. In; Skill Development in India–present status and recent developments. www.swaniti.in.

Anon (2021). Press Information Bureau. Heading towards emptier plates. Hindustan Times, New Delhi, 2019, August 9 p 1.

Anon. (2022). Annual Report 2021-2022, Ministry of Food Processing Industries, India.

Birthal P.S., Joshi P.K., Roy D., Thorat A. (2007). Diversification in Indian agriculture towards high-value crops: the role of smallholders, IFPRI Discussion Paper 00727, International Food Policy Research Institute, Washington, DC.

Chand, R. (2016). "Doubling Farmers' Income: Strategy and Prospects", Presidential Address delivered at 76th Annual Conference of Indian Society of Agricultural Economics held at Assam Agricultural University Jorhat, Assam during 21-23 November, 2016.

Chand R., Srivastava S.K. and Singh Jaspal. (2017). Changing Structure of Rural Economy of India Implications for Employment and Growth. National Institution for Transforming India NITI Aayog.

Chengappa P.G. (2013). Secondary Agriculture: A Driver for Growth of Primary Agriculture in India. Indian Journal of Agricultural Economics. 68(1):1-19.

Dalwai A. (2018). Adding value to primary produce and building agricultural enterprises in the rural India. In: Report of the Committee on Doubling Farmers' Income-Volume IX- Farm linked Activities and Secondary Agriculture. Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare. February 2018.

Jha S.N. (2020). Food for all, Solution Forever. Scientific Opinion, Current Science (25 September), 119(6): 899-900

Jha S.N, Viswakarma R., Ahmed T., Rai A., Dixit A. (2015). Assessment of quantitative harvest and post-harvest losses of major crops/commodities in India. ICAR-All India Coordinated Research Project on Post-Harvest Technology, ICAR-CIPHET, P.O.-PAU, Ludhiana-141004.

Mahapatra R. (2019). Agriculture farmers ageing, new generations disinterested – who will grow our food. www.downtoearth.org.in, July 24.

Sharma V.P., Jain D. (2011). India's Agricultural Development of High Value Agriculture in India: Past Trends and Future. W.P. No. 2011-07-02, Indian Institute of Management, Ahmedabad.

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