CHAPTER 7

SUMMARY AND OUTLOOK

"Whatever happens, believe that the journey is worth taking, and then you will reach its end"- Susan Cooper

7.1. Summary

In this thesis, utilization of agricultural by-products to formulate value-added food products followed by proximate composition, nutrient and sensory profiling was presented. Microbial load count as well as the shelf life of the formulated nutrient dense products had been discussed. Food irradiation was used to enhance the storage stability of chemical-preservative free perishable products in room temperature. Dissemination of knowledge regarding processing of the by-products along with their benefits and popularization of the formulated products was then done to transfer the technology from lab to community.

After an introduction to the agricultural by-products and their health benefits, we discussed in **chapter 1**, proximate composition, available dietary fibre, antioxidant activity, minerals like iron, phosphorus, calcium and other bioactive compounds, phytochemicals present in the by-products along with their probable utilization in food formulation. Food irradiation using gamma sources also had been discussed to analyze the effect of the radiation energy to enhance the shelf life of perishable products. The details of various methodologies to estimate nutrient composition, shelf life, sensory profile, microbial load count were disclosed in **chapter 2**. We also discussed the methods to expose food products to gamma sources, measure the attenuation co-efficient and use of GM Counter, Scintillation detector to record the counts.

In **chapter** 3, we presented formulation of fermented products using milling by-products (agricultural by-products). The value-added products were Bran *Paneer* and Instant mix to prepare *idli.* Estimated data showed significant nutrient availability and satisfactory sensory acceptance of the developed products. A notable change in the levels

of mineral content and total carbohydrate of fermented and non-fermented stages of products conveyed the importance of fermented milling by-products. A positive effect was observed in proximate composition, dietary fibre and in vitro digestibility of the formulated food due to fermented milling by-products. Available antinutrient present in the foods was less (within the tolerable level) due to cooking, fermentation, and processing of composite flour. Estimated microbial load count along with free fatty acid value and peroxide value of the developed products also depicted acceptable food quality. Bran *Paneer* was irradiated with gamma sources to study the change in storage stability of the product and stored at room temperature. Irradiated product showed enhanced shelf life than the non-irradiated one.

In **chapter** 4, we studied the probable utilization of the milling by-products to develop bakery products. Multibran cookies (MBC) and bread were formulated using composite flour obtained from the by-products. A notable change in nutrient composition, antioxidant activity, and in vitro digestibility of MBC explored probable utilization of milling by-products, especially the by-product of chickpea and moong bean as alternative food source. Although these by-products contain antinutrient, available antinutrient in MBC was less (within the tolerable level) due to processing of the by-products. Implication of various domestic cooking methods and thermal processing improved the quality of the products. This current study disclosed a potential research area of value-added product formulation by processing the by-products of cereal and legumes in addition to replacement or substitution of conventional flours. This study explored the possibility of the cereal-legume by-products in food formulation as an alternative way to retain the nutrients. Consumption of these underutilized milling by-products through formulation of novel food products or by renovating the local recipes can boost health status to maintain a balanced lifestyle. The current study involved freshly prepared food samples viz., bran bread, multibran cookies without using any chemical preservatives. Further these products were irradiated using very low doses of gamma sources viz., ^{60}Co and ^{137}Cs source to study the effect of radiation upon the storage stability of the products. Evaluated mass attenuation coefficient of these food samples revealed decreasing coefficient value with increase in

photon energy. Shelf life of irradiated breads was increased to seven days in comparison with that of non-irradiated breads which was four days. Irradiated cookies showed zero count after 3rd day of exposure. The recent study explored a significant way to improve shelf life of nutrient rich products by using gamma radiation instead of chemical preservatives.

In **chapter 5,** we have discussed formulation of various nutrient dense snack products such as Gram Pak (Confectionary product), *Papad* (Roasted product), Bran Bar (Nutribar) using the processed agricultural by-products. Estimated nutrient composition of the products depicted enriched nutrient availability. Obtained data exhibited enhanced dietary fibre, mineral availability, antioxidant activity along with reduced antinutrient. Organoleptic evaluation of the products was satisfactory. Microbial load of the freshly prepared products showed acceptable quality of the products. Products were stored up to three months and peroxide value along with free fatty acid value was estimated to check the storage stability. Among other products, Gram Pak stored at room temperature showed spoilage after 5th day. At 4ºC freezer, Gram Pak showed spoilage after 19th day. Hence, the product was exposed to gamma source to enhance shelf life when stored at room temperature. Irradiated Gram Pak stored at room temperature showed improved storage stability up to 10th day.

In **chapter 6,** we studied formulation of Health Drink powder and Detox Tea Substitute using milling by-products. Orange peel was used in the formulation as flavouring agent. Detox Tea Substitute was formulated as an alternative to caffeine drink. Proximate composition and nutrient availability of the products were estimated along with shelf life study and microbial load count. Estimated data showed rich nutrient profile. Sensory acceptance of the products was also acceptable and satisfactory. Peroxide value and free fatty acid of the products were estimated up to three months. Developed products were stored at room temperature. In the succeeding part of the chapter, we also disclosed the use of gamma radiation to detect adulterants present in liquid products like milk in a cost-effective way. Based upon the attenuation coefficient of different milk samples, presence of the adulterants was detected. Addition of urea, vegetable oil, gluten and water

in milk resulted in decreased attenuation co-efficient. Pure milk exhibited the highest attenuation co-efficient. Besides adulteration detection, effect of radiation and adulterants on the milk protein coagulation was also observed. Adulterated milk upon protein coagulation showed smaller curdled mass. Whereas, coagulated protein from pure milk was larger like lumps. The study disclosed that the nature of coagulated protein also can depict presence of adulterants.

Summarizing, we attempted to understand the phenomenon of utilization of plant-based by-products (agricultural by-products) for food formulation along with the waste management by bringing out the 'Best' from the 'waste'. Development of nutrient rich products without effecting quality upholds 'Taste with health'. Use of cost-effective gamma irradiation technology to enhance shelf life of the chemical preservative free and perishable products was also disclosed. Present work also involves general domestic cooking methods which can be done by common people with minimal training and knowledge leading to generation of local business and employment. Concluding the work, it can be stated that the present study will not only be beneficial for health and environment, it will also be beneficial to society economically which can be an approach towards maintaining cost-pressure of society and positive economic impact in post-COVID phase.

7.2. Outlook

In this study, an attempt has been made to process the agricultural by-products such as milling by-products, fruit peels for value added product formulation. The current study depicts probable utilization of agricultural by-products as novel food source due to presence of enriched nutrient composition. Satisfactory Sensory profile and acceptable microbial load count of freshly prepared products indicated incorporation such products in daily diet for better health. Use of food irradiation to enhance shelf life of these chemical preservative free products discloses cost-effective approach to increase storage stability of products. Moreover, transfer of the followed technology and popularization of these products among local village women can be beneficial to maintain economical balance.

Prolongation of the present study might result in different probable aspects in the emerging field of utilization of agricultural by-products in food science. Novel food sources can be utilized for the formulation of different traditional and conventional products. Utilization of agricultural by-products, also known as agricultural wastes may result in nutrition security, food security along with proper waste management. Detailed study of nutrient composition of these by-products might lead to evaluation of novel bioactive compounds and essential phytochemicals. Use of gamma irradiation to enhance the shelf life of the perishable products as well as to detect adulterants in liquid products may lead to health-friendly and cost-effective approaches. Moreover, dissemination of laboratory based processing technology, food formulation techniques using these underutilized by-products to community, can generate local entrepreneurships and support self-help groups.

"Nothing in science has any value to society if it is not communicated."

Anne Roe

(The noted twentieth century American psychologist and writer)