Thesis title: **Processing of wild yam (*Dioscorea* spp.) for development of functional foods.**

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ABSTRACT

Rising population, malnutrition, post-harvest losses, food insecurity and alarming prevalence of chronic diseases are the primary challenges that motivated to conduct scientific investigation on indigenous dietary sources. Root and tubers are second major staple food sources after cereals and grains. Yam, is the fourth most important tuber crop after potato, sweet potato and cassava. Thus, this Ph.D. thesis was aimed to explore and utilize the under-utilized root and tubers such as yams for processing into value added functional food products. The primary objective of this research was to document indigenous knowledge on processing and utilization of root and tubers, intervention of processing methods for lesser-known tubers, pre-treatment for removal of antinutrients, drying technology for enhanced shelf life and long-term storage and develop healthy food products.

Preliminary survey was conducted in tribal area of Athamallik block, India for various roots and tubers. Based on the survey, the maximum popular and available three yam species i.e., *karba kanda* (*Dioscorea pentaphylla*), *masiha kanda* (*Dioscorea bulbifera*) and *kulhia kanda* (*Dioscorea hispida*) were selected for this study. Prior to application as product development, the yam species were physico-chemically characterized to assess the potentiality of these yam species towards various applications for food formulations. By evaluating the physicochemical properties, it was determined that all the three species are starchy tubers rich in antioxidants, phenolics, minerals. However, antinutrients such as oxalate, phytate, saponin, tannin and inhibitors were also recorded which limits their wide utilization. But the indigenous people process these tubers conventionally before consumption and used for various medicinal purposes.

To address the issue of antinutrients at domestic or industrial level, different processing methods such as boiling, steaming or autoclaving and soaking were employed for different time period to remove or reduce the phytate, oxalate, tannin, saponin, trypsin inhibitors and α-amylase inhibitors in the three yam species. All the treatment conditions significantly reduced the antinutrients but boiling for 25 min was found to be the most suitable for maximum removal

of antinutrients. The level of reduction differed from one species to another due to variation in composition and structure. Similar to the antinutrients, bioactive compounds and antioxidants were also significantly affected by different processing conditions. SEM micrographs, FTIR and XRD revealed the structural changes after pre-treatment. In comparison to soaking and steaming, boiling had severe influence the morphology changes which showed clear visible of starch damages. After successfully establishing the required protocol for quick removal of antinutrients, the drying experiment was conducted.

Drying is a crucial unit operation in post-harvest processing of perishable commodities. Thus, to produce safe dried products or flour from yams, drying of pre-treated yam slices were conducted. Six different drying methods including both the conventional and modern drying techniques such as sun drying (one sunlight day or 10h), shade drying (48h), hot air drying (60°C, 10h), microwave drying (450 watt, 35min), infrared drying (450 watt, 4h) and freeze drying (-55°C, 48h) for untreated yam slices were employed for the drying experiments. All the six different drying methods had significance effect ($p \leq 0.05$) on physico-chemical, structural, functional, morphological and pasting properties of yam flours. Furthermore, it was noticed that, the influence of various drying methods was differed from one species to another species. Modern drying methods reduced the moisture content below safe limit (<10%) than the conventional methods (>13%) for the given drying time. Different drying methods showed significant ($p \leq 0.05$) effect on the diffraction pattern, functional groups, SEM morphology, pasting properties, functional properties, color attributes, antioxidants and nutritional properties of yam flours. Upon thermal processing of yam (pretreatment and drying) the resistance starch content was reduced in comparison to freeze dried one. Based on certain nutritional parameters (Starch, protein, resistance starch (RS), total phenolic content, total flavonoid content, DPPH scavenging activity and ferric reducing antioxidant power), shade drying, microwave drying and hot air drying were found to be suitable for *D. pentaphylla, D. bulbifera* and *D. hispida*, respectively. Thus, Shade dried yam flours of *D. pentaphylla* and microwave dried *D. bulbifera* flours were used for application in product development.

Snacks are extensively consumed and constitute a significant portion of the human diet as a source of energy. Gluten free yam flour based functional cookies were prepared by incorporating varied proportions of yam flour (100-50%) and chickpea flour (0-50%). The formulated cookies were optimized based on sensory score using Fuzzy logic analysis. Based on fuzzy logic analysis, the cookies samples, containing 60% yam and 40% chickpea flour showed the highest similarity value, mostly liked by the consumers in both the yam species.

Addition of chickpea flour enhanced the protein content, resistance starch and whiteness index of the prepared cookies. The RS of P60 (cookies containing 60% *D. pentaphylla* flour) and B60 (cookies containing 60% *D. bulbifera* flour) was 35.23% and 31.64%. The biological value and protein efficiency ratio of B60 (89.58%, 3.19) was higher than that of P60 (79.44%, 2.93). The findings of this study indicated that using these lesser-known yams for the production of functional cookies is technically feasible and can be processed or developed phytonutrient rich snacks products.

Similarly, another snacks product, extrudates were formulated by mixing yam flour of Guinea yam (*Dioscorea cayenensis*) (100-70%, chick pea (0-15%) flour and sugar kelp flour (0-15%). The crude fat, protein, ash and moisture content ranged between 1.21-3.05%, 4.14-7.19%, 1.40-4.64% and 4.96-15.09%, respectively. Sample $Y_{75}C_{10}S_{15}$ (75% yam, 10% chickpea and 15% sugar kelp flour) and $Y_{80}C_{10}S_{10}$ (80% yam, 10% chickpea and 10% sugar kelp flour) shown to have comparatively high nutritional value within unblanched and blanched samples. Addition of chickpea and sugar kelp flour improved the minerals, protein, fat and ash content of the extrudates. Thermally blanched yam flour based extrudates exhibited higher antioxidants than the unblanched yam flour based extrudates. Similar to the cookies, yam-chickpea-sugar kelp based extrudates processing is feasible and can be industrially produced. Utilizing the unexplored yams in the production of food products will not only increase their usage but also aid in the battle against poverty, hunger, and chronic illnesses. In addition, using yam (an alternative carbohydrate source) in food production is a smart way to reduce postharvest losses and contributes to food and nutrition security, particularly in underdeveloped nations.