SECTION V
SUMMARY AND CONCLUSION
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Pearl millet is termed as an ‘orphan crop’ or even ‘lost crop’ despite the fact that it is staple for millions of people in the semi arid regions of the world particularly Africa and India. Notwithstanding the developments in this area, pearl millet is still underutilized. The major reason is that it is under-researched. Pearl millet is mostly used as whole flour for traditional food preparations and hence confined to traditional consumers and to people of lower economic strata. The major constrain for its wide utilization and acceptability is non – availability of products in convenience form. While rice and wheat consumption trends have remained stable, pearl millet consumption reduced sharply both in rural and urban India. Consumers of pearl millet in rural areas have shifted away from pearl millet to consumption of wheat and rice. Consumption in urban India was always low because of the low shelf life of processed flour and hence grain has to be milled just before consumption (Basavaraj et al 2010).

Numerous studies have been reported on the influence of processing on the nutrient composition of pearl millet (Archana et al 1998, Pawar et al 1990; Badau et al 2005; Arora et al 2003). However, these reports are on varieties developed by Agricultural research institutes. Studies on the commercially available (market sample) pearl millet is lacking. Pearl millet grains are usually processed (dehusking and polishing) before they reach the market, in order to make them edible and suitable for human consumption. Generally, dehulling or dehusking and milling process are known to affect the taste and keeping quality of millets (Gulia et al 2007).

An in depth investigation was undertaken to explore various aspects of pearl millet such as chemical composition, antinutrients content, bioaccessible mineral content and nutrient digestibility as influenced by commonly used household
processing methods. Two commercially available pearl millet varieties such as *Kalukombu* (K) & Maharashtra Rabi Bajra (MRB) were subjected to various processing methods [milling, heat treatments (Pressure cooking, boiling and roasting) and germination respectively] and studied for its influence on the physico–chemical properties, nutrient composition and antinutrient profile. The results demonstrated a wide variation in the nutrient composition of raw and processed pearl millet. MRB contained higher protein and fat, while K exhibited higher ash reflecting its higher mineral content. The process of milling resulted in semi refined flour (SRF) and bran rich fraction (BRF). BRF, a by product of milling, retained significant amounts of fat, ash as well as antinutrients. Semi refining of pearl millet flour displayed desirable nutritional qualities of both whole and refined flour. The nutrient content of semi-refined flour was comparable to whole flour. Semi refined flour and bran rich fractions are two milling by-products which could be used as functional ingredients for value addition. The use of semi refined flour for better quality of the product and utilization of bran as a functional ingredient can be instrumental in popularizing pearl millet. Heat treatments and germination respectively reduced proteins, fat and ash content. Functional properties varied with the processing methods with germination showing higher bulk density. Variations in the total mineral content due to processing were seen. For example, milling and heat treatments lowered iron, while the same was high in the germinated millet. Calcium content increased due to processing methods applied while phosphorus reduction was caused by heat treatments and germination respectively. The SDS – PAGE performed on the soluble protein extracts of two pearl millet varieties showed similar electrophoretic patterns. Expression of low molecular
weight bands or minor protein bands was found as a result of heat treatment and germination respectively.

Starch isolated from the two pearl millet varieties were lower (approx. 26.5%) than that reported (Wankhede et al 1997). Water and oil holding capacity of pearl millet starches were higher than that of corn starch, mostly used food starch. Swelling power of corn and pearl millet starches increased with increase in the temperature (55 to 95 °C). However solubility patterns did not follow the trend set by swelling power. As the swelling power increased with temperature, its solubility decreased. X – ray diffraction of corn and pearl millet starches exhibited semi crystalline structure. Relatively sharper peaks exhibited in the starch compared to respective whole flour suggested the interference of other components such as proteins, fat etc. An *invitro* method for measuring nutritionally important starch fraction provided a means for predicting the rate and extent of digestion in the human digestive system. Although RDS and SDS were lower than corn starch, RS and TS were relatively higher.

The antioxidant activity of pearl millet varied with the processing methods and between the two varieties (K and MRB). K variety had higher content of antioxidant components reflecting its higher antioxidant capacity, compared to MRB. Bran rich fraction (BRF) showed high antioxidant activity (RPA) which reflected its high tannin, phytic acid and flavonoid levels. Heat treatments exhibited significantly higher antioxidant activity (DPPH scavenging activity and RPA) mainly due to its flavonoid content. It was worthy of notice that significantly high radical scavenging activity in heat treated millet had the lowest yield, whilst germinated millet which showed lowest activity had highest yield.
Bioaccessible iron and calcium content \((\text{in vitro})\) was higher in MRB than K variety. Semi refining, heat treatment and germination respectively improved the bioaccessible iron and calcium in both varieties. Highest increase in bioaccessible iron content as a result of processing was seen in MRB, while increase in bioaccessible calcium was similar in both varieties. Cooking effectively improved bioaccessible calcium while the same was less effective in improving bioaccessible iron content suggesting that calcium and iron combined in a meal may decrease iron bioaccessibility. Use of tap/de – mineralized water for boiling, pressure cooking and germination respectively led to an increase in the bioaccessible iron and calcium content, nonetheless, this increase is not statistically significant. Changes in mineral and antinutrient content during processing led to variations in the antinutrient/mineral molar ratios which had a positive impact on the bioaccessible iron and calcium content. Milling fractions exhibited higher RS values while a considerable decrease of the same due to heat treatment or germination was seen as a result of complete starch digestion. Pearl millet revealed lower \(\text{in vitro}\) protein digestibility. Milling, roasting and germination respectively were effective in improving the protein digestibility of pearl millet. A positive correlation, was found between % IVPD and tannin content \((r = 0.605, P \leq 0.01)\). For IDF, SDF and TDF the correlations were positive but not significant.

Complete/or partial replacement of potentially low cost pearl millet flour improved the overall nutritional quality of the prepared food products. A considerable increase in total iron, calcium and phosphorus content as well as bioaccessible iron and calcium of \textit{dosa}, \textit{roti}, \textit{puttu} prepared from pearl millet was seen. Nutritionally important starch fractions of the breakfast items prepared from pearl millet revealed
low RDS and SDS with increased RS content. The sensory scores of baked items (bun and cakes) prepared with 40% pearl millet flour as well as traditional sweets (ladoo and burfi) and cookies prepared from 100% pearl millet flours were in the acceptable range (6.6 – 7.8). The acceptability scores of the stored traditional sweets and cookies packed in various packing materials remained constant until the end of the study period. Lower moisture, FFA and PV values of cookies packed in foil indicated that foil is a suitable packaging material for storage of cookies up to 12 weeks or more without any apparent undesirable changes. Thus the highly beneficial pearl millet could be a successfully used in the production of value-added, nutritious convenience foods for the human consumption.

Pearl millet is gaining popularity since it is gluten free. Due to its gluten free nature, pearl millet can be successfully used in breads, cookies or breakfast items. This study has shown a potential use of inexpensive and underutilized pearl millet flour in the preparation of various breakfast items, traditional sweets and bakery product. The challenge for future researchers is to understand the consumer’s preferences of pearl millet and work in this direction. Popularizing pearl millet in form of RTE snacks or health mixes can be worked on.