PEARL MILLET: A CRITICAL REVIEW ON PROCESSINGTECHNIQUES AND ITS PRODUCTS

Abstract:

Pearl millet (Pennisetum glaucum) is a rich source of nutrients as in contrast to the primary cultivated cereal crops. However, important factors which restrict its utilization are the presence of anti-nutritional factors (phytate, tannins and polyphenols) which decrease availability of minerals and horrible conserving exceptional because of increased lipase activity. Therefore, this paper ambitions to focus on the have an influence on of unique processing methods on the nutrient composition and anti-nutritional components and its products of pearl millet. This is a literature overview research about from 1983 to 2017, focusing on studies related to pearl millet processing and their effectiveness in the enrichment of dietary charge via reduction of anti-nutritional compounds. From the literature reviewed, pearl millet processing by way of a range strategies consisting of milling, malting, fermentation, blanching and acid as nicely as heat redress had been determined to be magnificent in achieving the higher mineral digestibility, retardation of off flavor, bitterness as properly as rancidity problems found in the direction of storage of flour. Through this overview paper, possible processing techniques and their impact on the nutrient and anti-nutrient profile of pearl millet are discussed after focused studied of literature from journal articles and thesis.

Keywords: Fermentation, Processing, Pearl millet, Dehulling, Anti-nutritional elements

INTRODUCTION:

Pearl millet (Pennisetum glaucum) is a versatile cereal cultivated for food, feed and forages (Arora *et al.,* 2003) especially in African and Asian countries (Nambiar *et al.,* 2011). It has the functionality to live to inform the story below drought and excessive temperature conditions which in addition will increase its achievable to be grown in these areas

Fig 1.Pearl millet (Pennisetum glaucum)

the vicinity wheat, maize and other cereal vegetation fail to persist. Among all the millet varieties, large than 29 million hectare region is occupied through pearl millet; however, its distribution is restricted geographically generally in Africa (15 million) and Asia (11 million), as being the largest producer (Rathore *et al.,* 2016). More than ninety five per cent pearl millet production comes from developing countries, and India as the largest producer (Basavaraj *et al.,* 2010) covers an region of 9.8 million hectares out of total world manufacturing (Rathore *et al.,* 2016). Pearl millet had larger protein (14.0 per cent), fats (5.7 per cent), fiber (2.0 per cent) and ash (2.1 percent) content material (Sade, 2009) when compared to the important cultivated cereal vegetation such as wheat (Kavitha and Parimalavalli, 2014), rice (Ahmed *et al.,* 2014), sorghum (Awadelkareem *et al.,* 2015). Superior protein nice in time period of its tryptophan and threonine content fabric (Elyas *et al.,* 2002) alongside with larger content of calcium, iron as well as zinc (Yadav *et al.,* 2014; Sade, 2009; Lestienne *et al.,* 2007) makes this crop very advisable for human. Energy content material of pearl millet is large than sorghum and equal to brown rice due to its rich unsaturated fatty acids (75 per cent) and linoleic acid (46.3 per cent) contents (Jaybhaye *et al.,* 2014).

Despite its dietary qualities, high quality anti-nutritional factors (phytate, tannins and polyphenols) are moreover current in pearl millet (Ranasalva and Visvanathan, 2014). Presence of these factors leads to chelation of dietary minerals in the gastrointestinal tract, thereby reducing their bioaccessibility and bioavailability (Nour *et al.,* 2014). Moreover, existence of polyphenolic pigments in pericarp, alurone and endosperm areas might also cause the development of unpleasant gray coloration and fashion to the finished product (Rathi *et al.,* 2004). Development of off odors and fashion in the flour and its merchandise was once regularly attributed with the prevalence of lipase exercise in pericarp, aleurone layer and germ of grains (Galliard, 1999; Yadav *et al.,* 2012). To enhance the shelf lifestyles of pearl millet flour as well as processed products cut price of anti-nutritional factors is indispensable which ought to be carried out by means of the use of the use of several processing techniques for event dehulling, milling, malting, blanching, parboiling, acid and heat treatments (Singh and Saini, 2012; Legesse, 2013). Therefore, essential focal point of this overview is on the effect of processing methods on the wonderful parameters of peal millet.

PROCESSING TECHNIQUES:

Processing is commonly performed to beautify the great of the grains by way of converting them into edible form. Utilization of millets can also prefer to be extra suitable with the aid of using processed them into a variety of types like rice, flour, roasted, popped, sprouting, salted ready-to-eat grains, porridges and fermented merchandise (Jaybhaye et al., 2014).

Dehulling:

Fig 2. Processing technique

Dehulling is the approach accompanied with the resource of removal of the outer layer of the grains, hull as well as pericarp (Taylor and Duodu, 2014). In pearl millet and other small millets, fraction of husk more than a few from 1.5 to 29.3 per cent (Jaybhaye *et al.,* 2014). Previously for family level, millets had been decorticated with the useful resource of hand pounding. Nowadays, rice milling machines (Singh and Raghuvanshi, 2012) and rice huller with polisher (Agu *et al.*, 2007) are often used for this purpose. Abrasive mill (Ayo and olawale, 2003) or disks with mechanical dehullers are still used for decortication purposes. About 12 to 30 per cent of outer grain ground is removed via decortication; decortication previous this restrict motives huge loss of ash, fat, micronutrients, fiber, proteins and amino acids such as lysine, histidine and arginine (Rai *et al.,* 2008). Devisetti *et al.,* (2014) said that unit operation like dehusking in a centrifugal sheller, observed by using ability of removal of bran resulted in the production of pearl and little millets grains with terrific quality. Central Institute of Agricultural Engineering (CIAE, ICAR), Bhopal, created a laptop for pearl millet processing which has a grinding capacity of one hundred kg/h, at 10-12 per cent moisture content. This laptop works at one horse electrical energy single section electric motor having ability of processing even 1 kg of grains. Moreover, husk is separated simultaneously with a suction association and cyclone separator attached to the machine (Balasubramanian, 2015). Rural Industries Innovation Center (RIIC), Kane, Botswana, moreover manufactured a dehuller having potential of 4 hundred to 600 kg/h which can be applied for sorghum as proper as pearl millet decortication. This dehuller additionally has the potential to be mixed with hammer mill and thereby will increase milling effectively appreciably (Rai *et al.,* 2008). Effect of dehulling on nutrient composition of pearl millet was once studied by way of means of a number of researchers, and evaluation used to be moreover carried out through the use of first-rate decortication methods. It used to be reported with the resource of Serna-Saldivar *et al.,* (1994) that decortication carried out up to 17.5 per cent degree showed full-size improvement in protein and dry rely digestibility. However, after decortication, increased reduction in protein, fat, insoluble dietary fiber, ash, lysine, tryptophan and exceptional

amino acids used to be additionally determined which can also be due to the elimination of pericarp and germ all through the gadget of decortication. El Hag *et al.*, (2002) studied the have an impact on of dehulling on two (Standard and Ugandi) cultivars of pearl millet. Their penalties showed that protein, polyphenols as nicely as phytic acid contents of each kinds decreased notably after dehulling which used to be due to elimination of outer layers. Moreover, in vitro protein digestibility of favored and Ugandi extended up to 79.1 and 78.6 per cent, respectively. Increased in vitro protein digestibility after dehulling which used to be due to elimination of antinutrients such as polyphenols which precipitate proteins, minimize their digestibility and additionally resulted in production of off-colored products. Lestienne *et al.,* (2007) studied the have an impact on of abrasive decortication on the nutrient and antinutrients profile of pearl millet cultivars (Gampela and IKMP-5) which had been grown typically in Burkina Faso. Results of their find out about showed that abrasive decortication of pearl millet notably decreased some antinutritional compounds (fiber and iron binding phenolic compounds) which were placed in the bran of grains. However, higher phytate content material fabric after decortication may also be related with their occurrence on the whole in germ and endosperm region. Hama *et al.,* (2011) studied the impact of information and mechanical decortication on the nutrient composition of pearl millet (Gampela) grains and further in contrast it with systematized abrasive decortication method. In this study, no good sized distinction was once found between these conventional manageable of decortication. Minerals (iron, zinc), fiber and phytate content material fabric had been reduced appreciably after the ordinary decortication. However, abrasive decortication carried out with tangential abrasive dehulling device resulted in increased zinc and lipid losses per chance resulted from the removal of germ all thru processing. Decorticated millet can be cooked internal 6 min into soft, suitable for consuming grains having low hardness values. This discount in cooking time would possibly be related with a range of factors such as smaller size, removal of seed coat, large floor place and presence of pre-gelatinized starch in decorticated millet (Dharmaraj *et al.,* 2014). From the above studies, it may choose to be inferred that acceptability of pearl millet flour and its product can be most appropriate substantially by the use of the applicable decortication methods.

Milling:

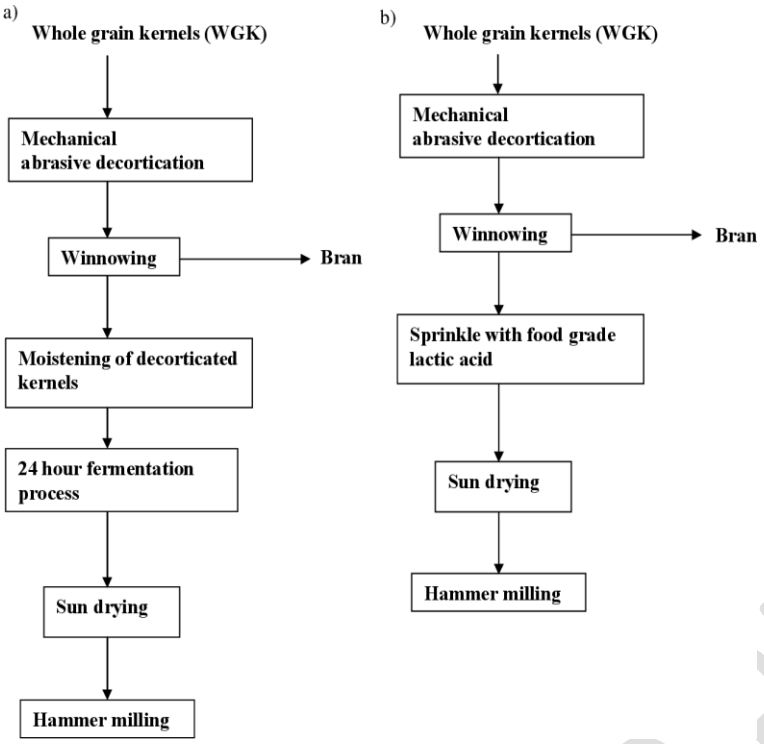

Fig 3. Milling process model

Milling is carried out in the fundamental for setting apart endosperm, bran and germ to the most extent and for bargain of particles size of endosperm to facilitate the production of satisfactory flour. Milling of pearl millet is challenging due to the reality of its small kernel with a firmly embedded germ along with challenging endosperm (Abdelrahman *et al.*, 1983). Pearl millet can be milled through hammer and curler mill. Hammer mills produce a flour with large particle dimension which limits its utilization for practice of skinny and stiff porridge of difficult texture and moreover in making baked and steamed food products of easy texture. However, these food merchandise can be developed without problems from the quality flour obtained by roller mills (Rai *et al.,* 2008). Millet grains can be cooked swiftly to gain smooth texture which may also associated with greater hydration expenditures of milled grains. Grinding movement of curler mills is moreover accountable for physical harm of starch granules, thereby developing enzymatic susceptibility of starch granules (Singh and Raghuvanshi, 2012). In rural areas, domestic motive flour is bought by milling of grains through non-motorized grain mill that is in generic hand operated (Saleh *et al.*, 2013). Recently, Central Food Technology Research Institute (CFTRI) has industrialized a new method for bettering the protecting excellent of pearl millet flour which includes moist heat therapy of grains followed by means of means of drying to 10-12 per cent moisture and then dehulling up to the favored degree of pulverization is carried out. After treatment, a variety of pearl millet varieties established giant enhancements in their milling characteristics due to high proportion of floury endosperm. Flour subsequently produced can be saved up to three to 4 months along with the blessings of retaining free fatty acid underneath 10 per cent at some stage in the storage period (Rai *et al.*, 2008). Abdelrahman *et al.*, (1983) examined that roller mills can be used for the manufacturing of low fat grits from pearl millet. This manner was once accompanied with the resource of decorticating, tempering and milling of the

grains through finely corrugated rolls which resulted in an common yield of sixty one per cent grits (from whole grains) with 1.2 per cent fats content. Chowdhury and Punia (1997) investigated the effect of milling on nutrient and anti-nutrient profiles of pearl millet. Results of their learn about printed that milling and warmness treatment when making chapathi (unleavened flatbread) lowered polyphenols and phytic acid levels alongside with massive enhancement in protein and starch digestibility. According to a analyze about conducted through Pushparaj and Urooj (2011), two cultivars of pearl millet (Kalukombu and Maharashtra Rabi Bajra) when subjected to milling (whole flour, bran wealthy fraction and semi-refined flour) showed higher percentage of in vitro protein digestibility particularly in bran rich fraction. These discovering showed that tannin may now not be accountable for decrease protein digestibility and more than a few factors such as interaction of proteins with non-protein elements and proteins themselves can additionally affect protein digestibility. Above research proven that milling has a fine an effect on extremely good of the product prepared from pearl millet. Therefore, it is the want of time to promote the utilization of appropriate and motorized milling technological expertise on the business scale which now not solely enhances the milling traits alternatively also promotes the utilization of underused pearl millet crops.

Malting:

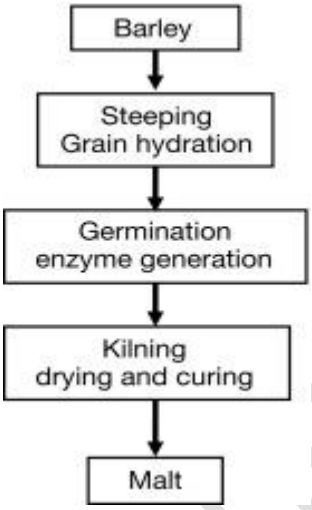

Fig 4. Malting model

Malting is the process accompanied through restricted sprouting of cereals in humid surroundings along with managed set of conditions. Although protein content of the grains decreased significantly after malting, but points such as elevated protein pleasant and greater protein efficiency ratio make this one very popular method of processing (Singh and Saini, 2012). Higher electrical energy density, food plan content material cloth and extended digestibility of nutritional vitamins are some common aspects which can be performed thru malting (Preetika *et al.,* 2004). During germination process, starch is broken down into low molecular weight carbohydrates (oligoand disaccharide) by way of the undertaking of amylase enzymes. Resulted germinated flour had reduced water maintaining ability and excessive electricity density which beautify its possible in the production of child foods, weaning foods and enteral foods. Malted

millet flour can additionally be used in the manufacturing of a quantity specific objects such as milk-based beverages, confectionary and truffles (Shobana *et al.,* 2013). Germination manner was once as soon as determined to be to blame for activation of enzymatic undertaking of sprouted seeds, thereby inflicting the disintegration of carbohydrates, proteins and lipids into much less challenging forms. Bioavailability of vitamins also improved appreciably as a quit end result of degradation of proteins by means of way of protease enzymes (Singh *et al.,* 2015). Effect of germination on nutrient and anti-nutritional factors used to be studied by various researchers. Khetarpaul and Chauhan (1990) stated that total soluble sugars (6.13 g/100 g), lowering (3.43 g/100 g) and non-reducing sugar (2.70 g/100 g) contents of germinated pearl millet had been larger than the manipulate pattern values (1.76, 0.36, 1.40 g/100 g). Germinated slurry when processed by means of homogenization and autoclaving showed in addition enhancement of these elements alongside with diminished starch content material which would possibly be due to starch hydrolysis accompanied through way of emission of larger soluble sugars content. According to a research about performed thru Archana and Kawatra (1998), pearl millet grains when subjected to 48 h malting showed tremendous cut price of polyphenols and phytic acid from 764.45 to 468.27 mg/100 g and from 833.42 to 449.32 mg/100 g, respectively. However, destruction was as soon as in addition greater with seventy two h malting of grains which had been determined to have a polyphenol and phytic acid content cloth of 451.92 and 393.08 mg/100 g, respectively. This reduction of polyphenol after malting would per chance also be related with the presence of polyphenol oxidase or might also moreover appear due to the hydrolysis of tannin protein and tannin enzymes complexes which promotes the removal of tannin or polyphenols. Furthermore, avert in phytic level after soaking and germination can also cease quit end result from their leaching in soaking water under concentration gradient. Pelembe *et al.,* (2004) investigated the have an impact on of germination moisture and time on pearl millet malt quality. Two pearl millet cultivars (SDMV 89004 and 91018) had been used and germinated at 25°C underneath three remarkable watering regimes for a period of 5 days. Results indicated that pearl millet malt used to be tremendous in contrast to sorghum as of its accelerated b -amylase exercising as nicely as free a-amino nitrogen profile which further enhances its manageable for beer brewing. Badau *et al.,* (2005) studied the have an effect on of germination duration and varieties on phytic acid profile and HCl extractability of minerals. Results confirmed that phytic acid content material cloth diminished and HCl extractability of minerals (Ca, Fe, Zn, P, I, Cu and Mn) greater terrific notably with the germination time. This may additionally be due to the manufacturing of phytate in the route of the approach of germination which resulted in breakdown of phytic acid substance that binds minerals making them accessible for the physique system. In any different discover out about carried out with the resource of Nithya *et al.*, (2007), pearl millet sorts (CO7 and COHCU-8) when subjected to forty eight hours sprouted large reduce in entire phenols and tannins content which may be attributed with higher enzymatic hydrolysis. Higher level of crude fiber resulted from production of more telephone wall material, accompanied by more shoots and rootlets formation, thereby growing fiber content.

Fermentation:

Fermentation is critical in general for foods preservation, taste improvement and for enhancement of dietary fantastic of raw merchandise (Saleh *et al.*, 2013). Fermentation procedure is finished by using malting and souring with mixed cultures of yeast and Lactobacilli. Starch and soluble sugar modern-day in millet get degraded through way of the enzymes existing in grains and fermenting media (Rai et al., 2008). Impact of fermentation time and temperature on dietary and anti-nutritional composition was once evaluated with the useful resource of a number of researchers, and effects of their work. Pearl millet flour when subjected to lactic acid fermentation (20, forty and 50°C) for a period of seventy two h or longer confirmed approximately entire exclusion of phytic acid content cloth alongside with the benefits of enhancement of extractable phosphorus content. Higher extractability of phosphorus may additionally be due to the hydrolysis of phytic acid by using the phytase enzymes existing naturally in meals grains (Mahajan and Chauhan, 1987). Dhankher and Chauhan (1987) investigated the penalties of fermentation time (3, 6 and 9 h) and temperatures (35, 40, forty five and 50°C) on polyphenols and phytic acid tiers of rabadi prepared from a mixture of pearl millet flour and butter milk. It was once mentioned that for all temperature conditions, as the fermentation duration increased, phytic acid and polyphenol content material

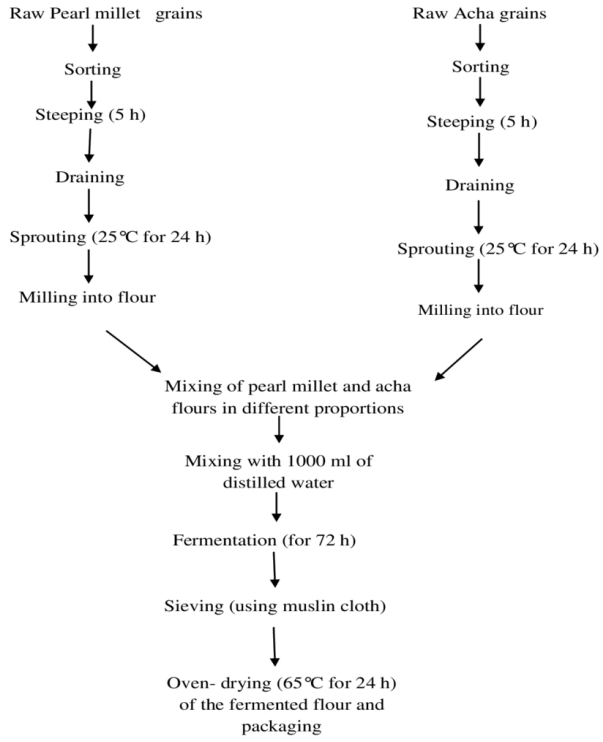

Fig 5. Fermentation process

decreased steadily. Moreover, at all temperature combinations, a fermentation length of nine hours was once as soon as found to be sufficient for most reduction of phytic acid (27-30 per cent) as well as complete polyphenols (10-12 per cent). This reduction of phytic acid would

possibly also be due to its hydrolysis brought on via way of pearl millet phytase and by way of capability of the microflora of fermenting media. Furthermore, lowering of polyphenols after fermentation may also be due to the pastime of polyphenol oxidase or microflora of fermentation media. Khetarpaul and Chauhan (1989) described that herbal fermentation of pearl millet showed significant enchancement of fat as properly as thiamine content cloth except having any great impact on its protein content. Higher fats content material after fermentation would possibly also be due to the fat producing have an impact on of yeast strains came about at some stage in the herbal fermentation of pearl millet. Khetarpaul and Chauhan (1990) cited that sprouts fermented with S. diastaticus and L. brevis mixture confirmed the best content material of entire soluble (reducing and non-reducing) sugars alongside with lowest starch content. Lesser starch content after fermentation would possibly be associated with amylolytic motion of microorganisms in the fermenting mixture. Elyas *et al.,* (2002) studied anti-nutritional profile in addition to in vitro protein digestibility of naturally fermented pearl millet cultivars (Composite Population III and Baladi). Their penalties showed that for Composite Pop. III, polyphenols tiers came down to 196 from 319 mg/100 g after 24 h and for Baladi, these stages diminished to 294 mg/100 g after 20 h which may be related with the exercise of enzyme polyphenol oxidase for the duration of fermentation process. Dough fermented on room temperature for 36 h revealed considerable reduce of phytic acid profile from 786 to 393 mg/100 g and from 618 to 309mg/100 g for Composite Population III and Baladi, respectively. This bargain in phytate content may also be due to the pastime of endogeneous phytase all via the fermentation process. Furthermore, in vitro protein digestibility used to be improved from 60.5 to 86.0 per cent (24 h) and from 61.9 to 86.2 per cent (28 h) for each the cultivars. According to a find out about carried out with the useful resource of El Hag *et al.,* (2002), Standard and Ugandi cultivars of pearl millet when subjected to fermentation (14 h at room temperature) proven large limit in complete polyphenols and phytic acid content. However, large bargain in starch content material used to be once moreover mentioned in this study which possibly resulted from yeast growth which leads to degradation of sugars into ethanol and CO2. Therefore, it may additionally be concluded that destruction of anti-nutritional compounds and higher in vitro protein digestibility as properly as improved vitamins stages (thiamine) are the features which can be without difficulty after the fermentation carried out with optimized conditions.

Blanching:

One of the most tremendous techniques for enhancing the shelf lifestyles of pearl millet flour is blanching, which slows down the enzymatic exercise barring having any big impact on its nutritional composition. It is accomplished through ability of boiling water at 98°C, observed with the aid of immersing of the grains in the boiling water (1:5 ratio of seeds to boiling water) for 30 s and drying at 50°C for 60 min (Rai *et al.,* 2008). Blanching of pearl millet grains done at 98°C for 10 to 20 s resulted in a meal having three- to fourfold limit fats acidity, acid rate and share free fatty acid (FFA) profile than untreated meal sample (Kadlag *et al.,* 1995). Archana and Kawatra (1998) mentioned that pearl millet when blanched at 98°C for 30 s demonstrated a

significant cut price in polyphenols (from 764.45 to 544.45 mg/100 g) and phytic acid content (from 833.42 to 512.10 mg/100 g) which would per chance be due to the leaching of polyphenols and phytate ions into the soaking medium underneath the impact of attention gradient. Singh et al. (2006) suggested higher calcium (34.13 mg/100 g), phosphorus (185.34 mg/100 g), iron (3.97 mg/100 g), manganese (0.52 mg/100 g) and polyphenol content material cloth (202.81 mg/100g) in the biscuits geared up after the blanching of pearl millet grains (98°C 60 min). According to Bhati *et al.,* (2016), bleaching of pearl millet accomplished for 90 s resulted in advantages of higher in vitro iron availability (from 2.19 to 3.29 mg/100 g), greater reduction in free fatty acid content (from 44.56 to 20.59 mg/100 g) and grains with improved coloration characteristics Therefore, nutritional first-rate and shelf existence of the pearl millet flour can be expanded successfully through appropriate blanching methods.

Acid treatment:

Dark grey colour of pearl millet grains limits their utilization in meals preparation. This problem can be overcome with the resource of treating the decorticated seed with pretty a number herbal acids such as (acetic, fumaric, tartaric acid) or every so often herbal acidic cloth such as tamarind (Rai et al., 2008). Effect of acid treatment on nutrient and anti-nutritional elements have been studied by a number of researchers from a longer time. Dilute hydrochloric acid when in contrast with other acidic options such as citric acid, acetic acid was once as soon as decided to be higher superb during the depigmentation of entire grain earlier than milling (Naikare *et al.,* 1986). Arora *et al.,* (2003) concluded that acid remedy carried out thru soaking the grains in HCl solution (0 0.2 N) for 6, 12, 18 and 24 h, observed with the aid of washing, blanching (98°C for 30 sec) and sun drying (two days) confirmed massive enchancement in extractability of phosphorus, calcium and iron as the length of acid soaking prolonged. This enchancement of HCl extractability was similarly accompanied by means of ability of greater bioavailability of minerals. Bhati et al. (2016) stated that pearl millet grains when subjected to acid remedy (2, 12, 18, 24 h) published decrease polyphenols and free fatty acid profile. Moreover, 18 h acid therapy was once decided to be most effective in most enhancement of in vitro iron availability as compared to uncooked grains (2.19 to 3.01 mg/100 g). However, limit iron content fabric decided in this examine about ought to be associated with leaching of minerals that had been present normally in pericarp of seed. Therefore, for the production of pearl millet-based food products having the blessings of decrease anti-nutritional profile, higher bioavailability of minerals and accelerated shade characteristics, it is indispensable to promote the use of acid treatment on a large scale.

Heat therapy:

Pearl millet flour when saved developed the problems of bitterness and rancidity which limited its shelf life. These problems befell due to the hobby of lipase enzymes which precipitated the breakdown of glycerides and subsequent amplify of free fatty acid profile (Arora et al., 2002). Therefore, its inactivation before milling is crucial for the enhancement of meal quality. This can be finished through way of exposing the pearl millet grain to a dry warmness treatment which

notably retard the lipase task and restriction the lipid decomposition at some stage in storage (Rai *et al.,* 2008). Dry heating can be done by using way of heating the grains in hot air oven maintained at a hundred 6 2°C for 60 to one hundred twenty min, located by means of way of rapid cooling and finally milling to obtain whole meal (Kadlag *et al.,* 1995). Combination of acid treatment (18 h) and dry warmness (120 min) additionally showed big discount of fats acidity, free fatty acid and lipase pastime of pearl millet flour for the duration of a storage length of 28 days. These consequences had been in addition accompanied through the higher shelf existence of the flour than it's manipulate sample (Rai *et al.,* 2008; Singh and Saini, 2012).Therefore, it can be concluded that pearl millet-based food products having the advantages of longer shelf life with reduced anti-nutritional content will be produced commercially through the use of heat treatments.

PRODUCTS OF PEARL MILLET:

Fig 6. Pearl millet products

Pearl millet cereals are used to produce a variety traditional foods. Most widely reachable normal pearl millet include porridge and flatbreads (Roti). Other meals are additionally accessible in market such as alcoholic beverage (opaque beer or Dogon millet beer, chibuku shake, mbeg, Merissa) and non-alcoholic drink (pombe, pito, boza, kunun Zaki, bushera, mahewu, oskikundu,marewa) (Adebiyi *et. al.,* 2018). Pearl millet flour is historically used with the aid of Indian housewives to put collectively variety of one of a variety products like Laddoo, chips, wadi, bread, cake etc.

CONCLUSION:

Processing strategies and there have an effect on over the nutrient and anti-nutrient profile of pearl millet had been reviewed in details. It can be concluded that processing techniques are necessary for improving the nutritional availability and storage balance of flour as nicely as the products. Therefore, for encouraging the business utilization of pearl millet grains in food formulations and to reap the higher food security feature, it is crucial to use appropriate processing methods.

Pearl millet is a staple ingredients with most effective dietary charge and health benefits. As consumers are larger attentive towards their health so the pearl millet has one of the choice

selections for nutritious food. Despite excessive nutrition rate and fitness benefits, use of pearl millet is confined due to the truth excessive lipid content material fabric which limit the shelf life and acceptability of pearl millet products. Some methods are described to approach pearl millet but more unique research is wanted to determine the real viable and availability of this "nutri-cereal" to decorate the quality of pearl millet product. Non thermal and other novel methods are required to decorate improved approach protocol for bettering shelf existence and preserving essential nutrient in the pearl millet product.

REFERENCES:

Abdelrahman, A., Hoseney, R.C. and Varriano-Marston, E. (1983), "Milling process to produce low-fat grits from pearl millet", Cereal Chemistry, Vol. 60 No. 3, pp. 189-191.

Adebiyi, J.A., Obadina, A.O., Adebo, O.A. and Kayitesi, E. (2017), "Comparison of nutritional quality and sensory acceptability of biscuits obtained from native, fermented, and malted pearl millet (pennisetum glaucum) flour", Food Chemistry, Vol. 232, pp. 210-217.

Agu, H.O., Jideani, I.A. and Yusuf, I.Z. (2007), "Nutrient and sensory properties of dambu produced from different cereal grains", Nutrition & Food Science, Vol. 37 No. 4, pp. 272-281.

Ahmed, K., Shoaib, M., Akhtar, M.N. and Iqbal, Z. (2014), "Chemical analysis of different cereals to access nutritional components vital for human health", International Journal of Chemical and Biochemical Sciences, Vol. 6, pp. 61-67.

Archana, S.S. and Kawatra, A. (1998), "Reduction of polyphenol and phytic acid content of pearl millet grains by malting and blanching", Plant Foods for Human Nutrition, Vol. 53 No. 2, pp. 93-98.

Arora, P., Sehgal, S. and Kawatra, A. (2002), "The role of dry heat treatment in improving the shelf life of pearl millet flour", Nutrition and Health, Vol. 16 No. 4, pp. 331-336.

Arora, P., Sehgal, S. and Kawatra, A. (2003), "Content and HCl-extractability of minerals as affected by acid treatment of pearl millet", Food Chemistry, Vol. 80 No. 1, pp. 141-144.

Arora, S., Jood, S. and Khetarpaul, N. (2011), "Effect of germination and probiotic fermentation on nutrient profile of pearl millet based food blends", British Food Journal, Vol. 113 No. 4,pp. 470-481.

Awadelkareem, A.M., Hassan, E.G., Fageer, A.S.M., Sulieman, A.M.E. and Mustafa, A.M.I. (2015), "Nutritive value of two sorghum cultivars", International Journal of Food and Nutritional Sciences, Vol. 4 No. 1, pp. 1-7.

Ayo, J.A. and Olawale, O. (2003), "Effect of defatted groundnut concentrate on the physico-chemical and sensory quality of fura", Nutrition & Food Science, Vol. 33 No. 4, pp. 173-176.

Adebiyi, J., Obadina, A., Adebo, O., & Kayitesi, E. (2018). Fermented and malted millet products in Africa: Expedition from traditional/ethnic foods to industrial value added products. Critical reviews in Food Science and nutrition, 58(3):463–474.

Andrews, D. J., and Rajewski, J. F. (1991). "1990 Pearl Millet Regional Grain Yield Trials: Preliminary Report," pp. 9. Univ. of Nebraska-Lincoln. (mimeo).

Asp, N.G.(1996). Dietary Carbohydrate: Classification by Chemistry and Physiology, Journal of Food Chemistry, 7:9-14.

Badau, M.H., Nkama, I. and Jideani, I.A. (2005), "Phytic acid content and hydrochloric acid extractability of minerals in pearl millet as affected by germination time and cultivar", Food Chemistry, Vol. 92 No. 3, pp. 425-435.

Balasubramanian, S. (2015),"A machine for dehulling millets", The Hindu, pp. 2-3.

Basavaraj, G., Rao, P.P., Bhagavatula, S. and Ahmed, W. (2010), "Availability and utilization of pearl millet in India", SAT eJournal, Vol. 8, pp. 1-6.

Bhati, D., Bhatnagar, V. and Acharya, V. (2016), "Effect of pre-milling processing techniques on pearl millet grains with special reference to in-vitro iron availability", Asian Journal of Dairy and Food Research, Vol. 35 No. 1, pp. 76-80.

Berwal M K, Verma K, Goyal P and Chugh L K (2017). Impact of Decortication on Phytate Content in Pearl Millet Grains. Journal of Nutrition and Food Science 2:006.

Bhati, D., Bhatnagar, V. and Acharya, V. (2016), "Effect of pre-milling processing techniques on pearl millet grains with special reference to in-vitro iron availability", Asian Journal of Dairy and Food Research, 35(1):76-80.

Chavan, U.D., Chavan, J.K. and Kadam, S.S. (1988), "Effect of fermentation on soluble proteins and in vitro protein digestibility of sorghum, green gram and gram blends", Journal of Food Science, Vol. 53 No. 5, pp. 1574-1575.

Chitra, U., Singh, U. and Rao, P.V. (1996), "Phytic acid, in vitro protein digestibility, dietary fiber and minerals of pulses as influenced by processing methods", Plant Foods for Human Nutrition, Vol. 49 No. 4, pp. 307-316.

Chowdhury, S. and Punia, D. (1997), "Nutrient and antinutrient composition of pearl millet grains as affected by milling and baking", Food/Nahrung, Vol. 41 No. 2, pp. 105-107.

Devisetti, R., Yadahally, S.N. and Bhattacharya, S. (2014), "Nutrients and antinutrients in foxtail and proso millet milled fractions: evaluation of their flour functionality", LWT-Food Science and Technology, Vol. 59 No. 2, pp. 889-895.

Dhankher, N. and Chauhan, B.M. (1987), "Effect of temperature and fermentation time on phytic acid and polyphenol content of rabadi – a fermented pearl millet food", Journal of Food Science, Vol. 52 No. 3, pp. 828-829.

Dharmaraj, U., Ravi, R. and Malleshi, N.G. (2014), "Cooking characteristics and sensory qualities of decorticated finger millet (eleusine coracana)", Journal of Culinary Science & Technology, Vol. 12 No. 3, pp. 215-228.

El Hag, M.E., El -Tinay, A.H. and Yousif, N.E. (2002), "Effect of fermentation and dehulling on starch, total polyphenols, phytic acid content and in vitro protein digestibility of pearl millet",

Food Chemistry, Vol. 77 No. 2, pp. 193-196.
Elyas, S.H., El -Tinay, A.H., Yousif, N.E. and Elsheikh, E.A. (2002), "Effect of natural fermentation on nutritive value and in vitro protein digestibility of pearl millet", Food Chemistry, Vol. 78 No. 1, pp. 75-79.
Gabrelibanos, M., Tesfay, D., Raghavendra, Y. and Sintayeyu, B. (2013), "Nutritional and health implication of legumes", International Journal of Pharmaceutical Science and Research, Vol. 4 No. 4, pp. 1269-1279.
Galliard, T. (1999), "Rancidity in cereal products," in Allen, J.C. and Hamilton, R.J. (Eds), Rancidity in Foods, Aspen Publishers, Gaithersburg, pp 140-156.
Hama, F., Icard-Vernière, C., Guyot, J.P., Picq, C., Diawara, B. and Mouquet-Rivier, C. (2011), "Changes in micro and macronutrient composition of pearl millet and white sorghum during in field versus laboratory decortication", Journal of Cereal Science, Vol. 54 No. 3, pp. 425-433.
Hassan, A.B., Ahmed, I.A.M., Osman, N.M., Eltayeb, M.M., Osman, G.A. and Babiker, E.E. (2006), "Effect of processing treatments followed by fermentation on protein content and digestibility of pearl millet (pennisetum typhoideum) cultivars", Pakistan Journal of Nutrition, Vol. 5 No. 1, pp. 86-89.

Inyang, C.U. and Zakari, U.M. (2008), "Effect of germination and fermentation of pearl millet on proximate chemical and sensory properties of instant 'fura' – a Nigerian cereal food", Pakistan Journal of Nutrition, Vol. 7 No. 1, pp. 9-12.
Jaybhaye, R.V., Pardeshi, I.L., Vengaiah, P.C. and Srivastav, P.P. (2014), "Processing and technology for millet based food products: a review", Journal of Ready to Eat Food, Vol. 1 No. 2, pp. 32-48.
Kadlag, R.V., Chavan, J.K. and Kachare, D.P. (1995), "Effects of seed treatments and storage on the changes in lipids of pearl millet meal", Plant Foods for Human Nutrition (Dordrecht, Netherlands), Vol. 47 No. 4, pp. 279-285.
Kavitha, S. and Parimalavalli, R. (2014), "Effect of processing methods on proximate composition of cereal and legume flours", Foodsci: Indian Journal of Research in Food Science and Nutrition, Vol. 1 No. 4, pp. 1-5.
Khetarpaul, N. and Chauhan, B.M. (1989), "Effect of fermentation on protein, fat, minerals and thiamine content of pearl millet", Plant Foods for Human Nutrition, Vol. 39 No. 2, pp. 169-177.
Khetarpaul, N. and Chauhan, B.M. (1990), "Effect of germination and fermentation on available carhohydrate content of pearl millet", Food Chemistry, Vol. 38 No. 1, pp. 21-26.
Kindiki, M.M., Onyango, A. and Kyalo, F. (2015), "Effect of processing on nutritional and sensory quality of pearl millet flour", Food Science and Quality Management, Vol. 42, pp. 13-19.
Legesse, E. (2013), "Effect of processing on qualtiy characteristics of pearl millet (pennisetum glaucum) based value added products", MSc thesis.
Lestienne, I., Buisson, M., Lullien-Pellerin, V., Picq, C. and Trèche, S. (2007), "Losses of nutrients and anti-nutritional factors during abrasive decortication of two pearl millet cultivars (pennisetum glaucum)", Food Chemistry, Vol. 100 No. 4, pp. 1316-1323.

Mahajan, S. and Chauhan, B.M. (1987), "Phytic acid and extractable phosphorus of pearl millet flour as affected by natural lactic acid fermentation", Journal of the Science of Food and Agriculture, Vol. 41 No. 4, pp. 381-386.
Naikare, S.M., Chavan, J.K. and Kadam, S.S. (1986), "Depigmentation and utilization of pearl millet in the preparation of cookies and biscuits", Journal of Maharashtra Agriculture University, Vol. 11, pp. 90-93.
Nambiar, V.S., Dhaduk, J.J., Neha, S., Tosha, S. and Rujuta, D. (2011), "Potential functional implications of pearl millet (pennisetum glaucum) in health and disease", Journal of Applied Pharmaceutical Science, Vol. 1 No. 10, pp. pp. 62-67.
Nithya, K.S., Ramachandramurty, B. and Krishnamoorthy, V.V. (2007), "Effect of processing methods on nutritional and anti-nutritional qualities of hybrid (COHCU-8) and traditional (CO7) pearl millet varieties of India", Journal of Biological Sciences, Vol. 7 No. 4, pp. 643-647.
Nour, A.A.M., Sokrab, A.M., Ahmed, I.A.M. and Babiker, E. (2014), "Supplementation and cooking of pearl millet: changes in anti-nutrients, and total minerals content and extractability", Innovative Romanian Food Biotechnology, Vol. 15, pp. 9-22.
Obadina, A., Ishola, I.O., Adekoya, I.O., Soares, A.G., de Carvalho, C.W.P. and Barboza, H.T. (2016), "Nutritional and physico-chemical properties of flour from native and roasted whole grain pearl millet (pennisetum glaucum [L.] R. Br.)", Journal of Cereal Science, Vol. 70, pp. 247-252.
Osman, M.A. (2011), "Effect of traditional fermentation process on the nutrient and antinutrient contents of pearl millet during preparation of lohoh", Journal of the Saudi Society of Agricultural Sciences, Vol. 10 No. 1, pp. 1-6.
Pelembe, L.A.M., Dewar, J., Taylor, J.R.N. and Brew, J.I. (2004), "Effect of germination moisture and time on pearl millet malt quality with respect to its opaque and lager beer brewing potential", Journal of the Institute of Brewing, Vol. 110 No. 4, pp. 320-325.
Preetika, A., Padmini, G. and Shobha, U. (2004), "Nutrient dense mixes for enteral feeding in India", Nutrition & Food Science, Vol. 34 No. 6, pp. 277-281.

Pushparaj, F.S. and Urooj, A. (2011), "Influence of processing on dietary fibre, tannin and in vitro protein digestibility of pearl millet", Food and Nutrition Sciences, Vol. 2 No. 8, pp. 895-900.
Rai, K.N., Gowda, C.L.L., Reddy, B.V.S. and Sehgal, S. (2008), "Adaptation and potential uses of sorghum and pearl millet in alternative and health foods", Comprehensive Reviews in Food Science and Food Safety, Vol. 7 No. 4, pp. 340-352.
Ranasalva, N. and Visvanathan, R. (2014), "Development of cookies and bread from cooked and fermented pearl millet flour", African Journal of Food Science, Vol. 8 No. 6, pp. 330-336.
Rathi, A., Kawatra, A. and Sehgal, S. (2004), "Influence of depigmentation of pearl millet (pennisetum glaucum L.) on sensory attributes, nutrient composition, in vitro protein and starch digestibility of pasta", Food Chemistry, Vol. 85 No. 2, pp. 275-280.
Rathore, S., Singh, K. and Kumar, V. (2016), "Millet grain processing, uilization and its role in health promotion: a review", International Journal of Nutrition and Food Sciences, Vol. 5 No. 5,

pp. 318-329.
Rekha (1997), "Efficiency of processing techniques in the utilization of pearl millet for value added products'', MSc thesis, CCS HAU, Hisar.
Sade, F.O. (2009), "Proximate, antinutritional factors and functional properties of processed pearl millet (pennisetum glaucum)", Journal of Food Technology, Vol. 7 No. 3, pp. 92-97.
Saleh, A.S.M., Zhang, Q., Chen, J. and Shen, Q. (2013), "Millet grains: nutritional quality, processing, and potential health benefits", Comprehensive Reviews in Food Science and Food Safety, Vol. 12 No. 3, pp. 281-295.
Serna-Saldivar, S.O., Clegg, C. and Rooney, L.W. (1994), "Effects of parboiling and decortication on the nutritional value of sorghum (sorghum bicolor L. Moench) and pearl millet (pennisetum glaucum L.)", Journal of Cereal Science, Vol. 19 No. 1, pp. 83-89.
Shobana, S., Krishnaswamy, K., Sudha, V., Malleshi, N.G., Anjana, R.M., Palaniappan, L. and Mohan, V. (2013), "Finger millet (ragi, eleusine coracana L.): a review of its nutritional properties, processing, and plausible health benefits", Advances in Food and Nutrition Research, Vol. 69, pp. 1-39.
Singh, A.K., Rehal, J., Kaur, A. and Jyot, G. (2015), "Enhancement of attributes of cereals by germination and fermentation: a review", Critical Reviews in Food Science and Nutrition, Vol. 55 No. 11, pp. 1575-1589.
Singh, N.B. and Saini, R.S. (2012), "Products, diversification, marketing and price discovery of pearl millet in India", Documentation, National Rainfed Area Authority, Todapur Village, Pusa.

Singh, P. and Raghuvanshi, R.S. (2012), "Finger millet for food and nutritional security", African Journal of Food Science, Vol. 6 No. 4, pp. 77-84.
Singh, G., Sehgal, S., Kawatra, A. and Preeti (2006), "Mineral profile, anti-nutrients and in vitro digestibility of biscuit prepared from blanched and malted pearl millet flour", Nutrition & Food Science, Vol. 36 No. 4, pp. 231-239.
Sun, Q., Gong, M., Li, Y. and Xiong, L. (2014), "Effect of dry heat treatment on the physicochemical properties and structure of proso millet flour and starch", Carbohydrate Polymers, Vol. 110, pp. 128-134.
Taylor, J.R. and Duodu, K.G. (2014), "Effects of processing sorghum and millets on their phenolic phytochemicals and the implications of this to the health-enhancing properties of sorghum and millet food and beverage products", Journal of the Science of Food and Agriculture, Vol. 95 No. 2, pp. 25-237.
Tiwari, A., Jha, S.K., Pal, R.K., Sethi, S. and Krishan, L. (2014), "Effect of pre-milling treatments on storage stability of pearl millet flour", Journal of Food Processing and Preservation, Vol. 38 No. 3, pp. 1215-1223.
Yadav, D.N., Anand, T., Kaur, J. and Singh, A.K. (2012), "Improved storage stability of pearl millet flour through microwave treatment", Agricultural Research, Vol. 1 No. 4, pp. 399-404.