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Barley Malting: Potential for Development of Weaning Food in Nepal

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ABSTRACT

The paper aims to review the potentiality of malted barley for the development of weaning food in developing countries like Nepal. Cereals and legumes are mixed to develop weaning food, but the processing step is limited to roasting. Malting activates the enzyme, that converts the complex compound into a simpler form, making it more digestible. Despite commercial baby foods based on malt are imported, utilization of locally available barley is hardly converted to malt and processed to industry. Utilization of malted barley with a proper proportion of legumes, with some fruit, can fulfil the recommended daily allowance of nutrients for weaning children and could be the prospective business in Nepal, if processed hygienically.

Keywords: Malting, Amino acid, Bulk density, Germination

Introduction

Weaning foods is supplementary foods for weaning children i.e. it supplements to older infants (6-12 months) and young children (12-36 years month). For weaning food, a good balance between an amino acid, and appropriate functional properties are required. The weaning food should have low fibre with a good amount of vitamins and minerals require for child growth. Anti-nutritional factors must be absent in weaning food. To achieve a balance between amino-acid, cereals and legumes are present in the right proportion. Weaning food is prepared in a home by the mother, and the selection of raw materials and preparation process depends upon their cultural practices and availability of grains. (Wu and Xu, 2019). In Nepal, the most commonly used cereals are rice, wheat, maize, and barley while legumes used are chickpea, mungbean, and soybean. However, in an urban area, weaning food is bought from the market. As reviewed by Abeshu*et al.* (2016), World Health Organization (WHO) defines complementary feeding as "*a process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk*"

The good malting property of barley can be utilized for baby food, as it makes barley more digestible. The malting process activates the many hydrolytic enzymes, that convert the complex molecules into simple molecules. However malting technology is not quite friendly for rural mothers, so they go more for roasting or fermentation. In Nepal, barley is mostly utilized for feed rather than food due to more availability of handy cereals like rice and wheat. Barley has been recognized as an industrial crop mostly utilized globally for brewing purposes. However, it has been also utilized in preparing baby food and malt drink.

Malting Process of Barley: An Overview

Malting is the term used for the preparation of a brewing raw material, employing controlled germination of grain. Barley is the preferred grain for malting; however, other grains such as wheat, rye, sorghum, millets, triticale, or oats may be malted and subsequently used in brewing, distilling, or food production. Malting aims to convert or modify the physical structure of the barley grain and allow synthesis or activation of a series of enzymes such that the final product, malt, is more readily used in the subsequent stages of food processing. Barley is the most common cereal used for the production of malt since it has a high starch-to protein ratio and produces the characteristic flavours associated with malt for this purpose. The final product of malting, malt, physically resembles the original barley grain but is friable when crushed, reflecting the complex biochemical changes that have occurred during the malting process (Macleod and Preece, 1954). The malting process can be divided into three key stages: steeping, germination, and kilning.

In the first stage, steeping, the acquiescent grain imbibes water and hydrates the embryo and endosperm. In the second phase, germination, enzymes are synthesized, activated, and mobilized, and the embryo begins to develop. In the final stage, kilning, grain growth is halted using a heat treatment (kilning), which dries the grain to constant and low moisture for storage (Macleod and Evans, 2016). Before steeping, the grain is cleaned and graded to remove foreign seeds, stones, straw, small and broken kernels, and dust before entering the steep vessels. Barley is immersed in water to raise the moisture level to 42-47% (Macleod and Evans, 2016). The kernels were immersed in water until imbibed with sufficient water to start the metabolic processes of germination and at the same time dirt, chaff and broken kernels are removed by washing and floatation (Baranwal, 2017). The immersions allow the embryo to absorb water and the air-rest periods allow the water to be distributed into the non-respiring endosperm. Steeping regimes are determined by plant design, barley characteristics, and condition and target malt specifications. Typically, steeping takes between one and two days (Macleod and Evans, 2016).

The germination phase begins after the kernels have absorbed enough water to start enzyme production and starch hydrolysis. Conditions that are necessary during the germination phase are moisture content, temperature, length of germination time, and oxygen availability. Germination takes about 2-6 days and occurs rapidly between 20°C and 30°C with an optimum temperature of 25°C to 28°C. The most important physiological processes associated with the germination phase are the synthesis of amylases, proteases and other endogenous hydrolytic enzymes. During the process, the hydrolytic enzymes migrate from the germ into the endosperm where starch and protein are hydrolyzed to sugars and amino acids, respectively (Iren, 2004). The germination process aims to encourage enzyme synthesis and release, cell-wall breakdown in the endosperm, and the solubilization of stored nitrogen.

Drying is the final stage of the malting process and is required for stopping further growth of the kernels, reducing the moisture content and water activity, hence producing a shelf-stable product with active enzymes. Kernels are dried at a temperature of about 50°C for 24 hours. The malt is loaded to the kiln at <45% moisture and dried up to 4-5% moisture (Mella *et al.,* 2011). The kilning process is the regulated removal of water from germinated grain. Moisture is removed from the grain by passing heated air through the grain bed. The air flowing to the kiln is gradually increased in temperature such that the grain temperature increases slowly and moisture within the grain diffuses to the surface of the kernel where it is absorbed and removed by the hot airstream. Kilning conditions are one of the most significant contributors to the final malt character so careful control of this stage allows a range of speciality malt types to be produced from the malting process (Macleod and Evans, 2016). After drying, the roots and shoots are removed and the kernels milled into malted flour ready for use in the preparations of different food products (Mella *et al.,* 2011). Kilning limits starch modification, to achieve a stable product for storage and transport. It also preserves enzyme activity, and develop and stabilize colour, aroma, and flavour. During the process, it removes undesirable flavours and chemical compounds. The formation of unacceptable chemical compounds such as nitroso-dimethylamine and dimethyl sulfide is inhibited or minimized (Macleod and Evans, 2016). Ojha *et al*., 2020 reported that *soluuwa*, *muktinath* and *bonus* are some variety in Nepal and have good malting properties.

Nutritional changes after malting barley

The malting process aims to change grains into malt with high enzyme and vitamin content. Malting induces important beneficial biochemical changes in grains. Many studies have shown that, by improving phytase activity, the malting process can contribute to the reduction of phytate levels of grain and improve iron and zinc availability. Malting reduces the antinutrients such as phytic acid content. The phytic acid content of the unmalted grain ranged from 2.91% to 3.30% and after germination of 48 hours the phytic acid content was found to be ranging between 0.4 to 0.5 % (Baranwal *et al*., 2017). Other studies reveal that during germination, there is a decrease in tannins and total phenolic contents. Vitamin (B and C) content increases significantly during germination (Coulibaly and Chen, 2011). In cereal grains, germination increases oligosaccharides and amino acids concentration as observed in barley (Rimsten *et al*., 2003). Decomposition of high molecular weight polymers causes the generation of bio-functional substances and improvement of organoleptic qualities due to softening of texture and increase of flavour in grains which leads to particular flavour given to the derived products (Baranwal *et al.,* 2017). Malted grains are extensively used in weaning and geriatric foods. A study examined the influence of malting of finger millet, wheat, and barley on the bioaccessibility of iron, zinc, calcium, copper, and manganese. The bioaccessibility of zinc from wheat and barley increased to an extent of 234 and 100%, respectively, as a result of malting (Platel *et al.,* 2010).

Functional properties changes after malting barley

The viscosity of flour is influenced by chemical composition (protein, fat, β-glucan), the interaction between macromolecules (protein, starch, and lipid), molecular weight, temperature, etc. (Crosbie and Rose, 2007). Ojha *et al*. (2018) reported a decrease in bulk density and viscosity of sorghum after malting. Ojha *et al*., 2020 also reported a decrease in bulk density and viscosity of barley flour after germination. The decrease in bulk density and viscosity may be due to the breakdown of starch and other high molecular components due to enzymatic activity, and change in surface properties (Oti and Akobundu, 2008; Chinma *et al.,* 2017). Further, protein and lipids can interact with the starch and change its viscosity (Crosbie and Rose 2007). Low viscosity food is preferred for weaning food, so nutrition dense food can be prepared from germinated barley (Nefale and Mashau 2018). As reviewed by Mejia *et al.* (2020), decreased viscosity can be related to decreased β-glucan content. Increased reducing sugar and decreased β-glucan may be responsible for a decrease in the density and viscosity of malt. Both reducing sugar and viscosity were reduced by malting and these properties also differ by variety.

Water absorption capacity (WAC) and oil absorption capacity (OAC) of the powder depend upon protein concentrations, degree of interactions with amylose, and amylopectin (Butt and Batool, 2010; McWatters *et al*., 2003). The high water absorption index and oil absorption capacity make it useful in various food applications like soups, baked products, meat extenders, as these properties improve the mouthfeel (Sirivongpaisal, 2008; Onuegbu *et al*., 2013). Ojha*eta.l* (2018) reported an increase in OAC of sorghum flour after malting but did not report a change in WAC after malting. Ojha *et al*. (2020) found that WAC and OAC of barley flour after malting increased in some variety, while there was no change in other varieties. According toButt and Batool (2010), the observed increase in WAC after malting can be due to different concentrations of protein obtained after malting, their conformational characteristics, and their degree of interaction with water. The WAC and OAC of malted flour generally depend upon the availability of polar amino acids in flours and their association of amylose and amylopectin in the native granules of starch, the number of lipophilic constituents, which was altered after malting (McWatters *et al*., 2003; Agrawal*et al*., 2013). Agrawal *et al*. (2013) reviewed that exposure of hydrophilic and lipophilic constituents of protein is increased by germination and breakdown of polysaccharides facilitate hydration, so WAC and OAC of barley have increased after malting.

Nutritional, and functional properties requirement for weaning food

Essential amino acid among 20 amino acidsisnamely histidine, isoleucine, leucine, lysine, phenylalanine, methionine, cysteine, threonine, tryptophan, and valine. Limiting amino acids are essential amino acids in the digested protein that are in the shortest supply relative to body requirements for absorbed amino acids. The limiting amino acid in cereals is lysine while in pulses are cysteine, methionine and tryptophan. As reviewed by Sajilata *et al*. (2002), the RDA of amino acid for infants are listed in table 1:

Table 1: Amino acid requirements for infants

Amino acid	Requirements (mg/100 kcal)
Histidine	26
Isoleucine	66
Leucine	132
Lysine	101
Phenylalanine	57
Methionine	24
Cysteine	23
Threonine	59
Tryptophan	16
Valine	83

The mineral requirement mainly calcium, phosphorous, magnesium, iron, zinc, iodine, and selenium proposed for 6 months to 1 year for a day are 600 mg, 500 mg, 60 mg, 10 mg, 5 mg, 50 µg, and 15 µg respectively. Similarly, the vitamin requirement namely Vitamin A, Vitamin D, Vitamin E, Vitamin K, Vitamin C, Thiamine, Riboflavin, Niacin, Vitamin B_6, and Folacin for a day are 375 µg retinol equivalent, 10 µg calciferol, 3.4 mg αtocopherol equivalent, 10 µg, 35 mg, 0.4 mg, 0.5 mg, 6 mg niacin equivalent, 0.6 mg, and 35 µg respectively for same age group (FNB, 1989).

Low viscosity food is desirable for developing weaning food with low density. As reviewed by Abeshu *et al.* (2016)), a good quality complementary diet must have low bulk density and viscosity with high nutrient content and should have a consistency easy for consumption. As reviewed by Omueti *et al*. (2009) high bulk density will reduce the calorie and nutrient intake of children so they are unable to consume enough to meet their calorie and nutrient requirements. The low water absorption capacity of powder will be desirable for making thinner gruels with high caloric density per unit volume.

Weaning food and baby food developed from malted barley

There are commercial foods based on malted barley from malt beverages to malt-based food from different companies. Baby food is also developed from malted barley. Generally, malted barley is used as an enzyme source and is mixed with cereal to hydrolyze the starch of other cereals. Hot water extractable sugar is separated and dried in a spray drier. In the case of malted milkfood, milk is also added, whereas, in the case of malt-based food, milk is an optional ingredient. FSSAI has developed standards for malt-based food and malted milk food. There are few companies in Nepal preparing commercial weaning food. However in Nepal, there are no such companies now preparing baby food based on malted barley, and commercial malted baby food is imported from India and other countries. In a country like Nepal, where import value is high, it is necessary to developed entrepreneurship based on barley-based baby food with other easily available local nutritious foods, which is not only digestible but also meet the nutritional requirement. Locally available materials like banana, pumpkin etc. can be added to develop weaning food to make it more nutritious and meet the minerals and vitamin requirements. This type of practice has been observed in Bangladesh also.

Conclusions

The utilization of barley for baby food has huge potential in Nepal. Despite having good malting properties barley, they are mainly utilized for alcoholic fermentation (atthe local level) and used for feed. Germination of barley is only carried out for ritual purposes rather than food. *Bonus*, *muktinath*, and *soluuwa* has good malting properties and can be explored as industrial crops. The utilization of barley in baby food has huge potential for new entrepreneurship, which not only provides new opportunities but also reducesthe import of malted barley food.

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References

Abeshu, M.A., Lelisa, A.and Geleta, B. (2016). Complementary feeding: review of recommendations, feeding practices, and adequacy of homemade complementary food preparations in developing countries–lessons from Ethiopia. *Frontiers in Nutrition*. **3**:1-9.

Agrawal, D., Upadhyay, A.andNayak, P.S. (2013). Functional characteristics of malted flour of foxtail, barnyard and little millets. *Annals Food Science and Technology*. **14**(1):44-49.

Baranwal, D. (2017). Malting: an indigenous technology used for improving the nutritional quality of grains: a review. *Asian Journal of Dairy and Food Research.* **36**:179-183.

Butt, M.S. and Batool, R. (2010). Nutritional and functional properties of some promising legumes protein isolates. *Pakistan Journal of Nutrition*.**9**(4):373-379.

Chinma, C.E., Lata, L.J., Chukwu, T.M., Azeez, S.O., Ogunsina, B.S., Ohuoba, E.U. andYakubu, C.M.(2017). Effect of germination time on the proximate composition and functional properties of moringa seed flour. *African Journal of Agriculture, Technology and Environment*. **6**(2):117-133

Coulibaly, A. and Chen, J. (2011). Evolution of energetic compounds, antioxidant capacity, some vitamins and minerals, phytase and amylase activity during the germination of foxtail millet. *American Journal of Food Technology*. **6**(1):40-51.

Crosbie, G.B. and Ross, A.S. (2007). The RVA Handbook (AACC International). *Inc., St. Paul, MN, USA.*Pp 6-9.

Iren, L.(2004). Sorghum and millets, in cultivated plants, primarily as food sources. *Encyclopedia of Life Support Systems (Eolss), Developed Under the Auspices of the UNESCO*, *Eolss Publishers, Oxford, UK.*

MacLeod, D.A.M. and Preece, P.I. (1954). Studies on the free sugars of the barley grain V. Comparison of sugars and fructosans with those of other cereals. *Journal of the Institute of Brewing*. **60**(1):46-55.

McWatters, K.H., Ouedraogo, J.B., Resurreccion, A.V., Hung, Y.C. and Phillips, R.D. (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (Digitariaexilis) and cowpea (Vignaunguiculata) flours. *International Journal of Food Science & Technology*. **38**(4):403-410.

Mejía, S.M.V., de Francisco, A. and Bohrer, B. (2020). A comprehensive review on cereal β-glucan: extraction, characterization, causes of degradation, and food application. *Critical Reviews in Food Science and Nutrition*. **60**(21):3693-3704.

MellaOnesmo, N.O. (2011). Effects of malting and fermentation on the composition and functionality of sorghum flour. M.Sc. Thesis submitted in University of Nebraska in the subject Food Science and Technology.

Nefale, F.E. and Mashau, M.E. (2018). Effect of Germination Period on the Physicochemical, Functional and Sensory Properties of Finger Millet Flour and Porridge. *Asian Journal of Applied Sciences*. **6**(5):360-367.

Ojha, P., Adhikari, R., Karki, R., Mishra, A., Subedi, U., and Karki, T.B. (2018). Malting and fermentation effects on antinutritional components and functional characteristics of sorghum flour. *Food Science & Nutrition*. **6**(1):47-53.

Ojha, P., Gautam, N., Subedi, U. andDhami, N.B. (2020). Malting quality of seven genotypes of barley grown in Nepal. *Food Science & Nutrition*. **8**(9):4794-4804.

Omueti, O., Otegbayo, B., Jaiyeola, O. and Afolabi, O. (2009). Functional properties of complementary diets developed from soybean (Glycine Max), groundnut (Arachis Hypogea) and crayfish (MacrobrachiumSpp). *Electronic Journal of Environmental, Agricultural & Food Chemistry.* **8**(8):563-573.

Onuegbu, N.C., Nworah, K.O., Essien, P.E., Nwosu, J.N. and Ojukwu, M. (2013). Proximate, Functional and Anti-nutritional Properties of Boiled Ukpo Seed (Mucunaflagellipes) Flour. *Nigerian Food Journal*. **31**(1):1-5

Oti, E. andAkobundu, E.N.T. (2008). Potentials of cocoyam-soybean-crayfish mixtures in complementary feeding. *Nigeria Agricultural Journal*. **39**(1):137-145.

Pant, K., Dhawan, S.S., Goyal, R.K. and Dhawan, K. (2004). Effect of pre-drying treatments on nutritional quality of aonla (*Emblicaofficinalis*). *Indian Food Pack*. **58**(5):67-69.

Platel, K., Eipeson, S.W. and Srinivasan, R. (2010).Bioaccessible mineral content of malted finger millet (Eleusinecoracana), wheat (Triticumaestivum), and barley (Hordeumvulgare). *Journal of Agriculture and Food Chemistry*. **58:** 8100–8103.

Rimsten, L., Haraldsson, A.K., Andersson, R., Alminger, M., Sandberg, A.S. andAman, P.(2003). Effects of malting on betaglucanase and phytase activity in barley grain.*Journal of the Science of Food and Agriculture.* **82**: 904–912.

Sirivongpaisal, P. (2008). Structure and functional properties of starch and flour from bambarra groundnut. *Songklanakarin Journal of Science & Technology*. **30**:51-56

Wu, F. and Xu, X. (2019). Sprouted grains-based fermented products. In *Sprouted Grains* (Pp. 143-173). AACC International Press.

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