Tratitional grains – their contribution to health

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Summary

Cereals, together with oil seeds and legumes, supply a major part of the dietary needs to a vast majority of the populations in low-income countries. Cereals may account for as much as 77% of the total energy consumption in African countries and also substantially contribute to the daily protein needs. Of the micronutrients, cereals provide significant amounts of minerals such as iron and zinc, and some B-vitamins. However, only minor amounts of provitamin-A are present. Irrespective of the favourable content of many nutrients, cereals need proper preparation techniques in order to make these nutrients available for absorption. Minerals and proteins may be largely unavailable for absorption due to presence of certain antinutritional factors. However, these factors can be substantially reduced with the help of traditional food processing technologies such as, soaking, germination and fermentation, and with input of new knowledge in enzyme technology and molecular biology.

Introduction

Several methods are employed to improve the nutritional quality of cereals. These include genetic improvement, amino acid fortification, and supplementation with minerals, vitamins and protein-rich sources. Of equal importance is the application of different processing technologies in order to increase the bioavailability of nutrients in the grains such as proteins, starch and minerals.
Wide-spread in many developing countries, at household-level as well as in small scale food industries, are the application of bioprocessing techniques such as fermentation and enzyme treatment.

Fermented Foods

In Africa, the majority of fermented cereal products are produced at house-hold level without the use of starter cultures. Instead, the backslopping technique is used, where a part of the previous fermentation is used as an inoculum.

The changes occurring during the fermentation process are mainly due to enzymatic activity generated by the microorganisms and/or by enzymes present in the grain. More recently, the use of commercial enzymes has gained wide-spread applications in the food industry. These bioprocesses will cause considerable changes that will affect the organoleptic properties (taste and viscosity), the nutritional value and the microbial safety of the food.

It is the aim of this chapter to explore changes in the nutritional value brought about by the lactic-fermentation process as well as by additional enzymes in the production of safe and nutritious cereal-based foods and these aspects will be discussed in subsequent paragraphs.

Effects on Nutritional Value

The different ways by which the fermentation process can affect the nutritional quality of foods include improving the nutrient density and increasing the amount of and the bioavailability of nutrients. The latter may be achieved by degradation of anti-nutritional factors, pre-digestion of certain food components, synthesis of compounds that improve absorption and by influencing the uptake of nutrients in the intestine.

Nutrient density – Dietary bulk

Traditional weaning foods in Eastern and Southern Africa are based on the local staple food, usually a cereal such as maize, millet, sorghum or rice and sometimes on starchy foods such as cassava, potato or plantain. The staple food is commonly prepared as a thick porridge for adults and older children or as a liquid gruel for younger children.

A thick porridge containing about 30% flour has an energy density of about 1.2 kcal/g, while a liquid gruel with a flour concentration of about 5% provides only 0.2 kcal/g. Compared with the energy density of breast-milk, 0.75 kcal/g, the thick porridge could provide enough energy. However, its thickness may prevent young children from consuming adequate quantities. The thin gruel may be more easily consumed but its energy density is too low to meet the energy requirements of young children [1].

The use of flour of germinated grains - *power flour* - as an additive to already-prepared thick porridge was shown to make the thick porridge into a liquid gruel within minutes [2], due to *amylase* hydrolysis of water-binding carbohydrates, see Figure 1. This treatment thus combined the favourable characteristics of adequate energy density of the thick porridge and a suitable liquid consistency of the thin gruel. The same mechanisms are being utilized by the baby-food industry by adding *amylases* in the pre-cooking stage of breast-milk substitutes.

A fermentation technique which involves a combination of *power flour* and a small amount of a lactic starter culture (the previously lactic acid fermented gruel - *togwa*) provided a similar improvement in the dietary bulk properties [3].

Figure 1. Sorghum porridge before…

..and after addition of power flour.

Availability of nutrients

Most cereal-based diets have poor bioavailability of nutrients as a result of the presence of anti-nutritional factors such as phytates and in some varieties significant amounts of polyphenols and/or tannins.

Minerals - effect of phytate degradation

The inhibition of non-haem iron absorption by phytates is dose dependent and even low levels (less than 90% of the phytate content in whole sorghum flour) exhibit a strong inhibition.

Phytase, an enzyme that degrades phytate, are present in most cereals and are believed to be activated during the germination and fermentation processes. The fermentation process can provide optimal pH conditions for degradation of phytate. The pH of the unfermented gruel is about 6.5 and reaches about pH 3.6 once fermentation has been completed. The pH interval 4.5 - 5.0, believed to be optimal for cereal *phytases,* is thus achieved during the fermentation process. In order to completely degrade the phytate, sufficient time is needed within the optimum pH range, which is obtained by initial soaking of the flour in water for about 24 h. During soaking, the pH of the water/flour slurry slowly decreases to about 5.0 after which the fermentation can be initiated by adding a starter culture. This modification of the traditional method to prepare *togwa* increases the amount of soluble iron up to ten-fold.

Figure 3. Young Tanzanian child drinking togwa with improved iron availability.

Effect of polyphenol degradation

There seems to be no or little effect on the iron availability due to reduced levels of tannins as an effect of lactic fermentation of tannin-rich cereals. *In vitro* studies showed that polyphenols in fermented gruels of high-tannin sorghum strongly inhibit iron solubility. The amount of soluble iron was only about 13% after complete phytate degradation, while in non-tannin sorghum the amount of soluble iron was about 40% with the same treatment. Similar findings are reported in human studies [4]. However, oxidation of the polyphenols present in high-tannin cereals with a specific enzyme (*polyphenol oxidase - PPO*) in fruit extracts might be an option. In a recent study [5], we succeed to both degrade the phytate and polyphenol content in high-tannin sorghum flour with the use of water extracts from pear, banana or avocado all containing *PPO* activity. The amount of soluble iron increased almost two times with this treatment.

Proteins

The lactic fermentation process has been reported to improve the *in vitro* protein digestibility of non-tannin cereal grains and to some extent of high-tannin varieties. In children the protein digestibility was reported to increase from 47% to 73% after lactic acid fermentation of whole grain sorghum (non-tannin) flour that was prepared into *Nasha*, a traditional fermented Sudanese food for infants and young children [6].

Fermentation and hygienic safety

There is now increasing evidence that the lactic fermentation process inhibits the growth of diarrhoeal pathogens in different food products. Over the last years a series of studies have been performed on mainly cereal products. A possible reason for the reduction of diarrhoea causing pathogens in fermented cereal foods is their relative sensitivity to low pH (below 4.0) and presence of organic acids. Our findings indicate that it is not the low pH *per se* which inhibits pathogens during fermentation.

A living culture of lactic acid bacteria seems also necessary for a more efficient inhibition. We also showed that the fermentation process inhibited the formation of enterotoxins from toxin producing strains of *Escherichia* and *Campylobacter* [7].

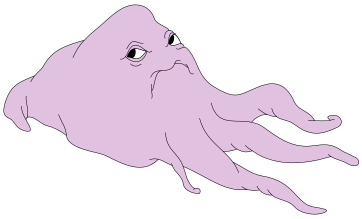

Figure 4. Togwa fermentation inhibits growth of diarrhoea pathogens.

The effectiveness of fermented cereal-based preparations in reducing the prevalence of diarrhoea was also studied among young children in a village setting in Tanzania [8]. In two neighbouring villages, two groups of 100 children in each were followed over a 9 month-period. The group of children using fermented gruels had a significantly lower prevalence of diarrhoea. The average number of diarrhoea episodes was 2.1 in this group compared with 3.5 in the non-fermented diet group over the study period.

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