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Food extrusion: Effects on micronutrients

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Abstract
Extrusion technique is a process in food processing technology which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming. Food extrusion is a form of extrusion used in food processing. It is a process by which a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate. The extruder consists of a large, rotating screw tightly fitting within a stationary barrel, at the end of which is the die. Which results in huge changes in nutritional quality of extruded foods macro and micronutrient levels.

Keywords: extrusion technique, food processing, extruded foods, macro and micronutrient levels

Introduction
Extrusion cooking has some unique features compared to other heat process. Precooking would be important in developing countries where quick cooking saves scarce fuel and simplifies preparation. Again, a precooked product that requires minimal further cooking before serving is obtained from extrusion cooking. To achieve such aims of precooking targeting enzyme denaturation, anti-nutrient inhibition, microbial inactivation, general product acceptability etc., extrusion cooking presents the best option (Anuonye *et al*., 2009) [1].
Extrudates are microbiologically safe, can be stored for long periods because of low moisture content. Different breakfast cereals can be categorized into traditional (hot) cereals that require further cooking or heating before consumption and ready-to-eat (cold) cereals that can be consumed from the box or with the addition of milk which are mostly produced with the help of extrusion. Traditional cereals are those that are sold in the market as processed raw grains or as cooked grains requiring the addition of hot water. Ready-to-eat cereals are cereals manufactured from grain products that have been cooked and modified in some way (e.g., flaked, puffed,)
Today a wide variety of extruded foods and food ingredients are available but there is no formal system to track how much of these materials are consumed. Thus the role of extruded food stuffs in human health cannot be accurately estimated. Extruded snack foods accounts for a large share of energy extruded foods consumed in the U.S., although many consumers perceive snack food to be unhealthy (Dinkins, 2000) [5]. Ready to eat extruded breakfast cereals have been targeted for nutritional enhancement including fortification and the addition of dietary fibre rich and other health promoting ingredients. Extrusion offers the means to convert whole grain consumption in the U.S is less than one serving per day, for below the recommended three servings. (Wells and Buzby, 2008) [14].
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Effects of extrusion on micronutrients
Vitamins: Vitamins are essential for human health because they are enzymes co factor that cannot be produced by humans. The diverse nature of these compounds is reflected in their varying solubility under extrusion cooking conditions (Killet, 1994) [8]. (Riaz. 2009) [9] have summarized factors affecting vitamin retention in extruded foods.

Vitamin A and carotenoids: Vitamin A is essential for proper immune functions and deficiency of this vitamin is leading cause of blindness in many nations with developing economics. Vitamin A and related caretenoids are not stable in the presence of oxygen and heat, thus they are particularly vulnerable during extrusion. Fortification of an extruded rice substitute called ultra rice provide a simple means to add micronutrients to the local rice concerns about potential losses of vitamin A from this product lead to an investigation of numerous antioxidant systems. After six months of storage (Li *et al*, 2009) [10] reported that vitamin A stability generally declined as post extrusion storage temperature increased.

Lipid soluble vitamins Vitamin D and K are stable during food processing, and little is known about the effects of extrusion on these vitamins. Vitamin E and related tocopherol decreased in samples extruded at higher temperatures during storage (Shin *et al*, 1999) [11]

B Vitamins: Refined grains in the U.S and many other nations must be enriched with thiamine, riboflavin, niacin and folic acid to prevent deficiencies in these vitamins. The extrusion of wheat flour at lower temperatures combined with puffing produced by carbon di oxide aided in thiamine retention, increasing feed moisture and barrel temperature decreased thiamine levels while the reduction on residence time by increasing screw speed appeared to protect the vitamins (Schmid, 2005) [12]. Based on series of experiments using a short barrel, single screw extruder. (Arhar *et al*, 2006) concluded that riboflavin and niacin were more stable than thiamine and pyridoxine and that retention of specific vitamins varies with composition of material being extruded.
Ascorbic acid: Vitamin C is susceptible to heat destruction and oxidation. Surface application of ascorbic acid postextrusion is the typical solution to potential losses with in the extruder barrel. Ascorbic acid added to cassava starch was retained by at least 50% (Sriburi *et al*, 2000) [13]. Bulberry concentrate appeared to protect 1% added vitamin C product in an extruded breakfast cereal, compared with a product containing corn, sucrose, and ascorbic acid (Chaovanalikit *et al*, 2003).

Minerals: Many minerals nutrients are heat stable, thus fortification prior to extrusion is possible, while the minerals may not be destroyed during processing, their bioavailability could be reduced due to their inclusion in a matrix of macromolecules, particularly dietery fibre and phytate was not reduced due by the extrusion of corn millet blends (Onyango *et al*, 2005) [7]. Extrusion barrel temperature and moisture content had little impact on the vitro iron and Zn dialyzability of bean flour (Drago *et al* 2007) [6].
Iron depleted Indian children fed extruded rice containing micronized dispersible ferric pyrophosphate was as effective as extruded rice containing ferrous sulphate in combining iron deficiency anaemia (Angeles *et al*, 2008) [2].

Table 1: Factors that influence nutritional properties during extrusion

Primary	Secondary
Extruder Model	
Feed composition including moisture	
mechanical mass energy product	
Feed particle Size	Pressure
Feed rate	Specific
Barrel Temperature profile	Temperature
Screw Configuration	
Screw speed	
Die Geometry	

***Source*:** Medeni and Aylin, 2011

Conclusion

Extrusion cooking can lead to both improvements and decreases in nutritional quality. This technology has many advantages like versatility, low cost, better product quality and no process effluents. Additional research is needed to understand the effects of extrusion, processing parameters on the changes at the molecular level. The impact of extrusion on micronutrients and other healthful food components is an evolving area that is expected to expand significantly in the next few years.

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