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Utilisation of corn and its applications

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Abstract
Maize usually known as corn is a major cereal grain grown all over the world and one of the most important crops in the United States. Corn with yellow dent has become the most popular. It differs significantly from sweet maize grown for human consumption. They have health benefitting properties. Antioxidant, anti-inflammatory, anti-mutagenic, anti-carcinogenic, anti-cancer, and anti-angiogenesis qualities assists to alleviate lifestyle disorders like obesity, diabetes, hyperglycemia, hypertension, and cardiovascular diseases. The antioxidant capacities of corn phenolic compounds as well as their anti-inflammatory effects are largely responsible for these therapeutic benefits. Precooked refined maize flour, dehydrated nixtamalized flour, fermented maize flours as well as other maize products are produced in various areas of the world. Corn is used for HFCS and other sweeteners and also for starch, breakfast cereals, snacks, tortillas, and also applied in alcoholic beverages.

Keywords: Maize, corn, antioxidants, HFCS

Introduction
Corn is scientifically known as Zea mays. Mays is originated from the Taino word mahiz that means life-giver and Zea is a Greco-Latin term indicating a wheat-like grain. The Gramineae (Poaceae) family includes Zea mays (Susan *et al*., 2008) [23]. Maize was easily introduced throughout Africa and Asia after the discovery of the Americas, after the distribution of corn varieties by Portuguese and Spaniards in their colonies (Serna-Saldivar *et al*., 2015) [21]. It is one of the most widespread crop species on the planet. There is no other cereal with such a wide range of flexibility. It is thought to have originated in pre-Columbian Mexico and Central America, from where it moved north to Canada and south to Argentina.Corn is grown primarily as an energy crop and is also used as a food and feed grain due to its high protein and oil content. Cereals account for over half of all dietary protein consumed worldwide. Cereals make up roughly 70% of the diet in developing countries. Protein content in corn is typically between 9 and 10%. Wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), and corn (*Zea mays* L.) account for around half of all calories and half of all protein consumed by individuals in developing countries (Olson *et al*., 1987) [12].
Corn is increasingly being used as an ingredient in ready-to-eat (RTE) breakfast cereals, snacks, and mixes as customers want convenience foods that suit their nutritional and health needs. This grain has recently been hailed as a suitable choice for making gluten-free products to help celiacs avoid the symptoms of celiac disease. Corns with higher yields and quality are in demand from the dry-milling sector and food processors to improve end-product qualities. Blue corn, for example, is becoming increasingly popular in specialised food stores. Cereals are the world's primary source of calories and protein. Wheat, milled rice, and corn are the most important grains. According to the FAO (2018), in 2013, average daily wheat, rice, and corn intake per capita was 179, 148, and 49 g respectively (Serna-Saldivar *et al*., 2019) [20]. Corn is a key cereal crop that is used to make human food, animal feed, and industrial products such as corn-starch, cereals, adhesives, sweetener as well as alcohol. In 2017, global corn production was estimated to be around 1.03 billion tonnes (Davis *et al*, 2001). In the United States, dent corn (Zea mays var. indentata) is the most widely grown variety. A dent corn kernel comprises about 74 percent carbohydrate, 9 percent protein, 7 percent total dietary fibre, 4.7 percent lipid, and 10% water. It is a major carbohydrate source as well as an excellent supply of minerals such as magnesium, phosphorus, and potassium, and vitamins like vitamin A, and folate for both humans and animals. Large volumes of by-products such as corn stover, corncob, corn germ, condensed distillers solubles (CDS), corn distillers dried grains with solubles (DDGS), and processing wastewater are produced during corn harvesting and processing.

Corn stover and corncob are two by-products of corn harvesting (Ruan *et al*., 2019) [18]. The main carbohydrate in the kernel is starch, which accounts for about 85% of the endosperm weight and 72% of the total kernel weight. Typical normal maize starch contains around 75–80 percent extremely branched and very large amylopectin and 20–25 percent linear amylose by weight. Also commercially relevant are waxy and high-amylose mutants, which contain basically 100% amylopectin and up to 50%–90% amylose, respectively. The non-starch polysaccharides in maize are arabinoxylan and cellulose (Hamaker *et al*., 2019) [9]. Dry-milling or wet-milling are the two milling procedures used to process corn for food usage. Corn dry-milling is the process of separating the components of clean, tempered grain into endosperm, germ, and bran. Dry-milling is mostly used to recover the endosperm fraction for usage as corn grits, meals, and flours, whereas the germ is recovered for oil. Corn bran on the other hand, is today of low value and is frequently used for animal feed (Duensing *et al*., 2003) [6].

Corn is first steeped in water and sulphur dioxide before wet milling. The moisture content of the kernels increases during this procedure and the kernels are softened to assist separation of the components such as starch, gluten, fibre, and germ. The starch (endosperm) and oil (germ) from the maize kernel are the valuable results of wet-milling. Corn fibre, corn gluten, and steeping solids are all co-products of wet milling and are occasionally mixed and sold as corn gluten feed (Johnson *et al*., 2003) [10]. The maize kernel is made up of four major components such as they are the endosperm, germ, pericarp, and tip cap, which account for 83%, 11%, 5%, and 1% of the maize kernel, respectively. Vitamins from the B complex, as well as antioxidants like vitamin E are found in the germ. Polyunsaturated fatty acids are abundant in maize germ oil and account for around 54.7%.The pericarp is a semipermeable, high-fiber barrier that surrounds the endosperm and germ except for the tip cap. During the development and dry down of the kernel, the tip cap is the component through which complete moisture and nutrients travel. The fiber-rich outer layer (pericarp) which includes B vitamins and minerals as well as the tip cap are referred to as bran (Gwirtz *et al*., 2014) [8].

Kernel structure

The starchy endosperm, aleurone outer layer, basal endosperm transfer layer and embryo-surrounding region are the four types of tissues found in maize endosperm. Corn germ contains the embryo, a root meristem, a shoot meristem, and leaf primordia during seed maturity all of which are protected by the coleoptile. A protective sheath called coleorhiza covers the embryonic root as well (Scanlon *et al*., 2009) [19]. The pericarp often known as the "hull," is the outermost cover of the kernel and accounts for 5–7% of the dry weight of the kernel. From the surface inward, the pericarp tissue is divided into five sections: epidermis, mesocarp, cross cells, tube cells, and seed coat (Watson *et al*., 2003) [29]. The epidermis is the pericarp's outermost covering, which covers the entire kernel except for the tip cap. The mesocarp is the thickest layer, accounting for over 90% of the pericarps mass. The pericarp connects with the tip cap at the kernel base. Spongy, star-shaped cells are found inside the tip cap joined only by the ends of the branches that forms a robust yet porous structure that is continuous to the cross-cell layer. A single layer of cells that serves as the endosperm's outer coating is aleurone. This layer protects the germ and the endosperm. Oil bodies are found in aleurone cells which are also high in phosphorus, potassium, and magnesium. The endosperm makes up 80–82 percent of the dry weight of the kernel and is made up of 86–89 percent starch by weight. (García *et al*., 2019) [7]. Corn gets its yellow hue from the carotenoid pigments in the endosperm, which are classified into carotenes and xanthophylls. The fat-soluble vitamin A and the majority of the water-soluble vitamins are found in endosperm. Lutein and zeaxanthin are the most important xanthophyll pigments in yellow maize, accounting for 90% of the total carotenoid pigments. The germ accounts for 10%–12% of the dry weight of the kernel. The germ contains nutrients as well as hormones and is the richest mineral storehouse. It contains 78 percent of the kernel minerals which are necessary for early embryo development. During germination, most cells in the embryo and scutellum become metabolically active. This also stimulates hydrolytic and synthetic enzymes, as well as growth hormones which mobilise nutrients and manufacture all growth-promoting substances. The scutellum is the germ's food storage organ (Silverio *et al*., 2019) [7]. Hemicellulose in pericarp walls is comparable to scutellum cell walls. It's a polymer with a xylose backbone and short xylose, arabinose, galactose, and glucuronic acid side branches. The scutellum is certainly responsible for the majority of the about 10% of total kernel sugars and minerals (Watson *et al*., 2003) [29].

Specialty corns

The endosperm of white and yellow corn hybrids is tougher. Furthermore, the cobs of these hybrids are white. These food-grade corn hybrids are frequently offered with a little premium by farmers, have greater processing efficiencies in dry-milling plants, and are requested by large breakfast and snack food firms due to their higher quality (Rooney *et al*., 2015) [16]. Popcorn is a type of flint corn that was chosen by Indians in ancient Western cultures and is said to be the world's first snack food. The size and shape of the kernels as well as the capacity of sound kernels to rupture and produce big puffed flakes when heated are the main characteristics that distinguish popcorn from other genotypes (Ziegler *et al*., 2003) [32]. Popcorn is a flint corn that does not include any soft starch. The kernels expand and explode as a result of the heat (Susan *et al*., 2008) [23]. Popcorn comes in three varieties of kernels: white, small yellow, and large yellow. Genetic differences in the pericarp, aleurone, and endosperm cause colour differences in popcorn kernels. White popcorn kernels are often rice-shaped, whereas small and large yellow popcorn kernels are pearl-shaped. Farmers should harvest kernels when they have reached full maturity and retain about 17 percent moisture to obtain the greatest quality popcorn (Serna-Saldivar *et al*., 2010) [22].

Sweet corn hybrids were created with the goal of producing corn with the desired colour, sweetness, and tenderness. Sweet corn has become a popular dish due to its capacity to maintain sweetness longer than conventional dent corn when collected at the kernel milk stage. Sweet corn cultivars on the other hand produce lesser yields than ordinary hybrids. A recessive gene i.e. sugary1 or su1 causes a change in the endosperm of maize, resulting in increased soluble sugar levels and lower starch levels in the kernel (Tracy, 2000) [27]. Sweet corn is mostly cultivated in the northern states of the United States. One of the oldest types flour corn has a soft

starch that makes it easier to crush into meal. This type is primarily utilised as white or blue flour in the southwest of the United States (Shultz *et al*., 2008) [23]. Because of the higher protein quality, QPM-based food can improve the nutritional condition of many new borns who consume cereals on a daily basis. Blue corn has a floury or soft endosperm and grows in large ears around 8–12 rows in most cases. To make refined meals and flours, blue corn is crushed with stone mills and the resulting fractions filtered to remove some of the very granular pericarp. Navajos in the southwest of the United States utilise these flours to make Pika, a ceremonial paper bread (Sergio *et al*., 2019) [20].

Nutritional composition of corn

(Rouf *et al*., 2016) [17] (Per 100 g of edible portion of maize)

Table 1: Show the proximity amount

Proximity	Amount
Carbohydrate	71.88 g
Protein	8.84 g
Fat	4.57 g
Fiber	2.15 g
Ash	2.33 g
Moisture	10.23 g
Amino acids	1.78 mg
Minerals	1.5 g
Magnesium	139 mg
Sulphur	114 mg
Sodium	15.9 mg
Phosphorus	348 mg
Calcium	10 mg
Iron	2.3 mg
Potassium	286 mg
Copper	0.14 mg
Riboflavin	0.10 mg
Thiamine	0.42 mg
Vitamin C	0.12 mg

Utilisation and applications

Corn stover refers to the stalks, leaves, and husks left over after corn harvest. Cellulose around 35 percent w/w, hemicelluloses around 20 percent w/w, and lignin around12 percent w/w make up the majority of the material. To sustain soil productivity in the United States, a small amount of maize stover is left in the field and absorbed into the soil by tillage. Corn stover is used to make biogenic diols particularly 1,4-pentanediol which is utilised as an intermediary in the manufacture of high-strength biodegradable polyester, medicines, fine chemicals, and cosmetics (Ruan *et al*., 2019) [18]. The balance of the maize stover is gathered and utilised as ruminant feed and cattle bedding. Corn stover is one of the most important lignocellulosic biomass resources for biofuels production such as ethanol and bio-oil due to its high carbohydrate content (Perlack *et al*., 2011) [14]. Corn stover is also thought to be a viable substrate for the manufacture of industrially important enzymes such as cellulases and xylanases that are used mostly in animal feed, food, textile, brewery, wine, laundry, and the pulp and paper sectors (Tirado *et al*., 2016) [26]. Corn stover also includes beneficial chemicals including phenolic compounds derived from lignin. The extraction of such chemicals is critical for increasing the value of corn stover (Buranov *et al*., 2009) [4]. Extraction agents such as ethanol, alkali, and acid are frequently utilised. Corn stover could be a possible source of natural antioxidants due to the bioactivities of the phenolic components in the extract (Vazquez *et al*., 2019) [28].

All-purpose or soft wheat flour, chemical leavening agents such as sodium bicarbonate, mono-calcium phosphate, sodium aluminium phosphate and others, sugar, shortening or oil, salt, milk powder, and other minor ingredients are used in most corn bread recipes. Biscuits, muffins, hush puppies, and corn fritters are the most well-known corn breads. Maize bread is a type of biscuit made with corn flour and leavened with baking powder. Wheat flour's functional gluten provides more aerated breads, while maize flour gives the bread its distinctive flavour. Corn dry-milled products are most commonly used in the brewing industry. Grits are employed as a low-cost fermentable carbohydrate source. Vodka, whiskey, gin, and a variety of other alcoholic beverages are made with whole ground maize and corn grits. In the United States, straight bourbon whiskey is made by distilling a fermented mash containing at least 51% maize. The distillate is matured in wooden barrels for 2–10 years before being mixed and packaged (Sergio *et al*., 2019) [20].

Corn-based sweeteners are the most prevalent type of sweetener in the United States, accounting for 52 percent of the market. High fructose corn syrup (HFCS) is the most frequently utilised of all corn-based sweeteners. HFCS is made by first grinding corn (maize) to make corn starch, then processing that starch to make corn syrup, which is almost all glucose, and finally adding enzymes to convert some of the glucose to fructose. For the sweetening of carbonated beverages, HFCS is now the industry standard. HFCS is a fructose-glucose liquid sweetener that can be used instead of sucrose. It was initially commercially introduced to the food and beverage industries in the 1970s. In terms of composition and metabolism, HFCS is similar to other fructose-glucose sweeteners like sucrose, honey as well as fruit juice concentrates (White *et al*., 2010) [30]. Both HFCS-55 and HFCS-42 have a number of functional advantages in common, but each has its own set of characteristics that appeal to different food makers. HFCS-55 is sweeter than sucrose due to its increased fructose concentration and it is widely used as a sweetener in soft juice, and carbonated drinks. The gentle sweetness of HFCS-42 does not impair the natural flavours of food. As a result, it's commonly found in canned fruits, sauces, soups, condiments, baked products, and a variety of other processed foods. The dairy industry also uses it extensively in yogurt, eggnog, flavoured milks, ice cream, and other frozen desserts (Parker *et al*., 2010) [13].

The food industry swiftly adopted high fructose corn syrup because of its sweetness which is comparable to sucrose, enhanced stability and functioning, and convenience of usage. HFCS is stable in acidic meals and beverages unlike sucrose which hydrolyzes in acidic systems changing the sweetness and flavour qualities of the product (Singh *et al*., 2014) [24]. HFCS has been identified in a variety of grocery store foods. Baked goods such as pastries, biscuits, breads, cookies, and shortcakes, soft drinks, juice drinks, carbonated drinks, jams and jellies, dairy products such as ice creams, flavoured milks, eggnog, yoghurts, and frozen desserts; canned ready-to-eat foods such as sauces and condiments, cereals and cereal bars, and a variety of other processed foods are among them. In the United States, HFCS is used in the majority of processed foods to provide some functionality (Salas *et al*., 2010) [13]. It consist of 42 percent

fructose (HFCS-42) and 55 percent fructose (HFCS-55) (HFCS-55). Free glucose and minimal amounts of bound glucose primarily maltose (di-glucose) and maltotriose (tri-glucose), make up the remaining carbs in HFCS.HFCS has a glucose-to-fructose ratio of roughly 1:1, which is similar to sucrose, invert sugar, and honey (White *et al*., 2008) [31].

Endosperm pieces of 3.35–4.77mm make up flaking grits which are mostly utilised to make corn flakes. Yellow maize with similar kernel size and hard endosperm that is not fissured is preferable. The grits are germ and pericarp-free. The granulation of maize meal and flour is less than that of grits. These goods are typically used to make a variety of chemically leavened baked and fried dishes such as corn bread, muffins, pancakes, corn sticks, fritters, and spoon bread, and are often fortified with thiamin, riboflavin, niacin, folic acid, iron, and zinc. Corn flour is also widely used in RTE breakfast foods, snacks, and processed meats as a binder. Corn flour is a key component of corn and soy blends. Most corn bread recipes uses wheat flour in order to make the bread lighter as well as more aerated as corn proteins do not form gluten when hydrated and mixed. Too much wheat flour on the other hand masks the corn flavour. In the southern United States, a strong maize flavour is preferred (Sergio *et al*., 2019) [20]. Rice, corn, and sorghum are the most common gluten-free grain flours and starches used to make gluten-free items. Cookies, pasta products, and yeast-leavened breads have all been successfully tested with corn flour and starches. Cookies produced with corn and rice flours had an excellent spread ratio and were nutritionally appropriate (Rai *et al*., 2014) [15].

Whole grain meals or flours are the latest trend in the food market since they contain more minerals, vitamins, phytochemicals, and other nutraceuticals that are beneficial to human health. Particle size reduction utilising stone mills or traditional roll milling procedures is used in the production of whole corn flour. Corn is one of the commercial cereals that has the fattest particularly polyunsaturated fatty acids which are more susceptible to both enzymatic and non-enzymatic oxidation. As a result, whole corn flours are not shelf-stable necessitating a heat treatment to destroy lypolitic and lipooxygenase enzymes in the germ-rich fractions (Gwirtz *et al*., 2014) [8]. Corn flakes are most widely consumed breakfast cereal in the world. Because of its greater flavour and rich golden colour after toasting, yellow dent corn with consistent kernel size and un-fissured firm endosperm is chosen for flake manufacture. Short time, high temperature–pressure extrusion cooking, and puffing are used to make a variety of vital breakfast foods. To make a variety of products, corn flour or meal is moistened and mixed with starches, flavourings, and colouring agents. One of the most popular RTE breakfast foods is extruded gun-puffed cereal. Corn flour, cones, meal, or small grits are cooked with other cereal flours like wheat flour, oat meal, etc. and also with sweeteners, flavourings, and colouring agents to make a dough that is shaped by a die and carved into the final shape (Serna-Saldivar *et al*., 2019) [20].

Cooking and steeping corn kernels in lime or wood ashes, removing the cooking liquor or nejayotl, and rubbing the resulting soft nixtamalli between the hands to remove the bran were traditional methods of processing corn. Nixtamal the cleansed product was ground by hand using a cylindrical stone or flat stone slab. The resulting masa known to the Aztecs and Mayans as tamalli and yokem respectively formed the foundation for the creation of several basic dishes. To make tortillas pieces of masa called textli were pressed into thin round discs and baked on a hot round clay surface called comalli. The thickness varied, but the diameter was usually around eight fingers. Some of the tortillas were paper-thin. Blue corn has traditionally been used to make piki, a corn or paper bread made by mixing corn meal, water, and a pinch of wood ashes in the southwestern United States (Sergio *et al*., 2015) [21]. Maize germ oil is recognised fit for human consumption despite being a little component of the entire corn market. One of its most essential nutritional features is that it includes considerable amounts of tocopherols and tocotrienols which are the most important dietary antioxidants and help oils maintain their oxidative stability. Corn oil also includes a large amount of unsaturated fatty acids, the majority of which are linoleic and oleic acids. Because it has a nice and slightly sweet flavour, the buyer considers it to be a high-quality product. It has a long shelf life and is resistant to transformations under poor processing circumstances due to its intrinsic stability. Corn oil that has been refined is used for frying, salad oils, and as a raw material in various lipid modification procedures to produce technical fats. As a result of its high sensory and nutritional qualities, as well as its good performance in a variety of food applications, it stands out among vegetable oils (O'brien. 2008) [11].

Originally, the majority of maize oil was sold as a liquid oil for a number of domestic purposes including salad dressing and the preparation of baked, fried, and roasted foods. Its use was expanded to the manufacture of numerous industrialised products such as mayonnaise, mixes, shortenings, technical fats, sauces, and margarines as it became more affordable. Corn oil is popular among consumers because of its moderate aroma, excellent oxidative stability, and reputation as a healthy oil due to its high polyunsaturated fatty acid content. These characteristics set it apart as a premium vegetable oil. Corn oil is mostly utilised as an ingredient in snacks, baking mixes, bakery products, and as a topping. In comparison to other typical vegetable oils, corn oil has an excellent performance and has a better oxidative stability (Daniel *et al*., 2019) [2].

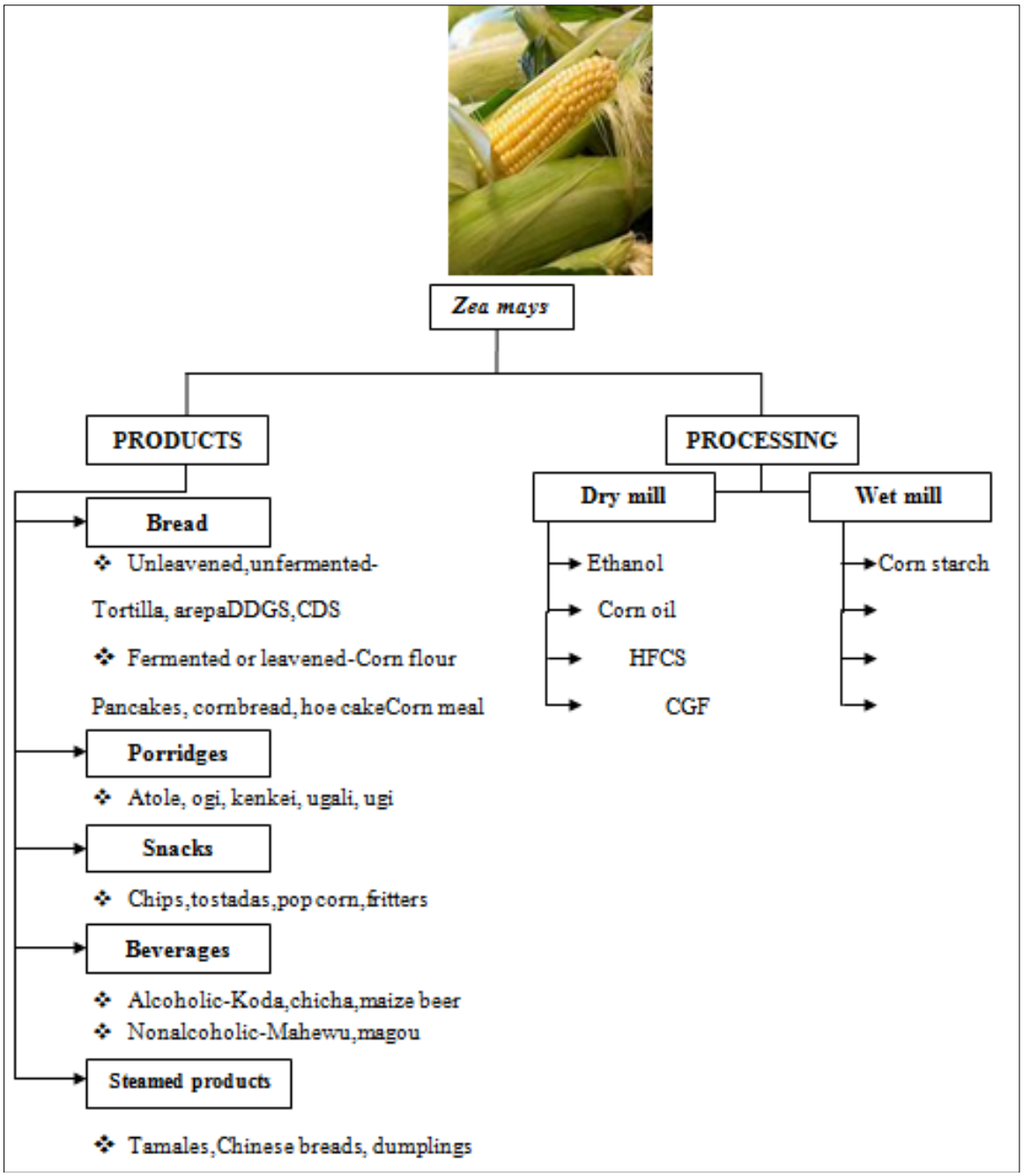

Fig 1: Define the Corn-based foods

Conclusion

Corn-based foods are the most important source of calories, protein, B vitamins, and minerals throughout Latin America as well as in many African countries. Corn foods are primarily thought of as calorie-dense or starchy, and as a good source of dietary fibre. The amino acid composition and digestibility of corn protein are the most important factors to consider. Corn has apparent protein digestibility's ranging from 85 to 90 percent. Because of the elimination of fibre and the enzymatic breakdown of proteins, dry-milling, fermentation, and germination increase protein digestibility's. The essential amino acid profile is best in the albumin and globulin protein fractions which are mostly found in the germ. The goal of grain enrichment is to replenish critical minerals such as Fe and Zn and vitamins such as thiamine, riboflavin, niacin and folic acid that are lost during milling.

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