ZEA MAYS

A Monograph

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INTRODUCTION

This monograph is a research document about *Zea mays*, more commonly as corn. It is a complete investigation of its origins and uses. In the first chapter its ecology is discussed.

Corns affinities and origins have been discovered and studied, scientists got to a common conclusion based on their research that proposed that there was another type of corn that is known extinct or unknown. Around 1930 a student of the Cornell University named George Beadle stated that they were related and moreover that *Z.mays* is a domesticated species of teosinte.

Corn is distributed all around the world, it's been spread throughout world tropics and subtropics that have temperatures above 10 degrees Celsius. As mentioned before *Zea mays* can be planted in every place that's above 10 degrees celsius. Moreover, biology, propagation and management and its emergent products and markets are studied and analyzed in latter chapters..

2. ECOLOGY

2.1. ECOLOGY

2.1.1. Affinities

It has been a very laborious task for corn archeologists to find its ancestors. Many of them did not find any connection between *Zea mays* and any other plant or crop. They got to a common conclusion based on their research that proposed that there was another type of corn that is known extinct or unknown. But nevertheless, a group of scientist in the first half of the 20th century discovered a possible ancestor of corn. It was a tall grass called teosinte. Many years later, around 1930 a student of the Cornell University named George Beadle found that these two crops had very similar chromosomes and finally stated that they were related and moreover that Mays is a domesticated species of teosinte.

2.1.2. Origin

After the discovery of George Beadle about the familiarity of *Zea mays* and teosinte a group of botanists led by John Doebley discovered that

> *"all maize was genetically most similar to a teosinte type from the tropical Central Balsas River Valley of southern Mexico, suggesting that this region was the "cradle" of maize evolution."* (Carroll, 2010)

About 10,000 thousand years ago human beings started to crop for the main purpose of self-alimentation. According to Franklin (date of reference here) Zea

mays primarily comes from Mexico approximately 9,000 years. The scientific name comes from the Spanish word “maiz”.

http://www.ezilon.com/maps/images/northamerica/political-map-of-Mexico.gif

2.1.3. Present Distribution

As mentioned before, corn has its origins in ancient Mexico. Now, it’s been sow throughout world tropics and subtropics that have temperatures above 10 degrees Celsius.

2.2. Environmental Factors

2.2.1. Elevation

Zea mays can really grow in any part that has temperatures above 10 degrees Celsius, what really varies is its final production and time of harvest.

"The period of flowering and to maturity varies greatly in East Africa. Allan (1973) divides Kenya into four zones:

- *Zone A*
    - *Below 200 m. Lowland tropics with high maximum and minimum temperatures. Quick-maturing varieties flower in two months and mature in four.*
- *Zone B*
    - *200-1,200 m. Most of these areas have low rainfalls and little maize is grown. In Australia most of the maize is grown from sea level to 500 m.*
- *Zone C*
    - *1,200-2,100 m. contains over 90 percent of the maize grown in Kenya. The highest yields are regularly obtained in this area. The Kitale hybrids (prefixed by the number 6) flower in about three months and mature in six at 1,500 m. At 1 800 m, flowering is at 3.5 months and maturity at 7, while at 2,100 m, the figures are 4 and 8, respectively.*
- *Zone D*
    - *2,100-3,200 m. little maize is grown above 2,000 m, as only long-term varieties can survive in such high altitudes. At Ol Joro Orok (2,400 m) the maize takes 6.5 months to flower and more than a year to mature."* ("Zea mays," n.d.)

2.2.2. Climate

Corn has been one of the most cultivated crops in America, “Maize (Zea Mays) originates in the Andean region of Central America.

> *“It has been very used by humans because it has many different uses and it can be harvested in a very short period of time. Zea Mays normally germinates in 5 to 12 in summer depending on soils temperature.*
>
> *“The crop is grown in climates ranging from temperate to tropic during the period when mean daily temperatures are above 15°C and frost-free.” (jean, 2003)*

Corn needs a soil base temperature of 12 degrees Celsius. These crops germinate faster if the soil temperature is between 20 degrees Celsius to 30 degrees Celsius. It’s also true that maize can grow in temperatures below 10 degrees Celsius but it will take it almost 300 days to mature. The reason why corn can't grow at low temperature is because it is frost sensitive. Therefore, corn needs a fundamental temperature of 3500 meters above sea level.

2.2.3. Rainfall

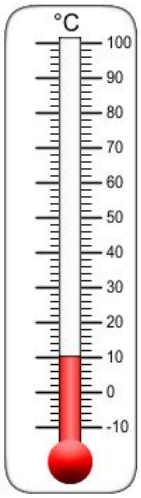
Maize is one of the most water absorbent crops in the cereal family. Depending on the soil`s temperature corn absorbs between 500 mm and 800mm of water annually: depending on how much water is applied to maize its production will be increase or decrease. As its true that corn absorbs and get all the benefits of water it can also subsist with minimum amounts of this liquid, the less water it absorbs the less production it will have, this is one of the main reasons corn can't grow in really cold places, water will no complete all its functions. As said before

> *“An annual rainfall of more than 500 mm is needed, with best yields*

usually in the 1 200-1 500 mm range; it is often an irrigated crop. Kitale experiments show that the more rainfall after five weeks' growth, the higher the yield." (Carroll, 2010)

2.2.4. Temperature

Zea mays can really grow in any part that has temperatures above 10 degrees Celsius, what really varies is its final production and time of harvest.



http://www.teacherfiles.com/clipart/Thermometers/Thermometer_10C.jpg

2.2.5. Geology Soils

For a good harvest and a good crop is needed

"a well-drained, fertile soil. Alluvial loams, deep latosols and clay loams are preferred." (Carroll, 2010)

Clay loams are essential because they retain moisture making it great to plant corn because these crops really depend on a good irrigation. Another fundamental requirement is a well-drained soil because maize roots are almost superficial and must have where grab. As said before maize

"is comparatively shallow rooted and needs loose soil in which the roots

can forage" (Carroll, 2010)

therefore

"a deep (20 cm) friable seed-bed should be prepared" (Carroll, 2010)

2.3. Veg Components

2.3.1. Associated Species

Maize and other species and subspecies of teosinte are sexually compatible and can produce fertile hybrids (Wilkes, 1977). Related species to Zea mays are geographically circumscribed and only occur in Mexico or in the neighbor; Guatemala. Zea Mays closest relative is Tripsacum.

2.3.2. Relationship with Animals/Insects

Life forms	Common name	Interaction with Z. mays (Pathogen; Symbiont or Beneficial Organism; Consumer; Gene Transfer)
Colletotrichum graminicola	Anthracnose stalk rot and leaf blight	Pathogen
Erwinia stewartii	Bacterial leaf blight	Pathogen
Fusarium spp	Fusarium seedling blight, root, stalk and kernel rot	Pathogen
Gibberella zeae	Gibberella stalk and ear rot	Pathogen
Pseudomonas syringae	Holcus spot	Pathogen
Puccinia sorghi	Leaf rust	Pathogen
Pythium spp.	Pythium seedling blight and root rot	Pathogen
Rhizoctonia spp.	Rhizoctonia seedling blight and root rot	Pathogen
Setosphaeria turcicum	Northern corn leaf blight	Pathogen
Sphacelothecia reliana	Head smut	Pathogen
Ustilago maydis	Corn smut	Pathogen
Agrotis ipsilon	Black cutworm	Consumer
Chaetocnema pulicaria	Corn flea beetle	Consumer
Delia patura	Seedcorn maggot	Consumer
Diabrotica spp.	Corn rootworm	Consumer
Elaterid spp.	Wireworm	Consumer
Heliothis zea	Corn earworm	Consumer
Nitidulid spp.	Sap beetles	Consumer
Ostrinia nubilalis	European corn borer	Consumer
Papaipema nebris	Stalk borer	Consumer
Pseudaletia unipuncta	Armyworm	Consumer
Rhopalosiphum maidis	Corn leaf aphid	Consumer
Animal browsers	(e.g., deer, raccoon)	Consumer, Symbiont or Beneficial Organisms
Beneficial insects		Symbiont or Beneficial Organisms
Birds (e.g., crows)		Consumer
Earthworms		Consumer, Symbiont or Beneficial Organisms
Soil microorganisms		Consumer, Symbiont or Beneficial Organisms

Soil-borne insects		Consumer, Symbiont or Beneficial Organisms
Other Z. mays		Gene Transfer

(Government of Canada, 2012)

3. BIOLOGY

3.1. CHROMOSOME COMPLEMENT

"It has a large genome of of about 2.4 gigabases with a haploid chromosome number of 10" (Schnable et al., 2009; Zhang et al., 2009).

3.2. LIFE CYCLE AND PHENOLOGY

3.2.1. Life cycle

Corn, *Zea mays,* can grow easily from a home garden or in a huge field in the hot summers. All the corn varieties have the same life cycle but grow at a different rates and at different circumstances. Maize has two principal stages, vegetative and reproductive. Its life cycles is short, around from 120 to 150 days. The corn plant will grow to a minimum of 3 feet tall and a maximum of 10 feet depending on its class. Corn seed are directly planted in the ground where they absorb most of their nutrients and water before bursting the outer covering, called the pericarp. After germinating corn stem emerges from soil, creating from 15 to 20 wide leaves that absorb energy from photosynthesis. These process converts sunlight, water and carbon dioxide to produce sugar that feeds the growing corn plant. (Rose, n.d.) In corn plants pollen is transported by the wind, insects or birds.

3.3. Phenology

3.3.1. Deciduousness

Frost should be avoided during the entire life cycle of maize as should water stress, the latter especially between two weeks to pollen shed and silking where it could cause disproportional yield losses. Generally, maize is less water stress tolerant than other crops, including sorghum (Farrell & O´Keeffe 2007; Beckingham 2007)

3.3.2. Flowering and fruiting

Corns male flower is known as tassel. After the plant has fully bulk tassels will appear on the highest part of the plant. Corn plant tassels can be green, purple or yellow. (Patterson, 2016) Corn usually grows better when the daytime temperature is between 12 or 33 degrees celsius and night temperature oscillates in between 11 or 23 degrees celsius. Corn needs appropriate tasseling, pollination and silking to grow proper tassel and complete its cycle.

> "Variable flowering dates in a given field may reduce total pollen available to receptive silks. Severe heat or moisture stress may delay silking and hasten pollen shed reducing fertilization. Poor pollination can cause barren ears or unfertilized ovules near the tips of the ears." (Asgrow, n.d.)

3.3.3. Year-to-year variation in flowering and fruiting

All the corn varieties have the same life cycle but grow at a different rate and circumstances.Maize has two principal stages, vegetative and reproductive. Its life cycles its substantially short, its life cycle goes from around from 120 to 150 days.

3.4. REPRODUCTIVE BIOLOGY

3.4.1. Pollen

"Wind-pollinated plants do not invest in resources that attract pollinating organisms, such as showy flowers, nectar, and scent. Instead, they produce larger quantities of light, dry pollen from small, plain flowers that can be carried on the wind. Female structures on wind pollinated plants are adapted to capture the passing pollen from the air, but the majority of the pollen goes to waste."(Woodcock, n.d.)

3.4.2. Sexuality

Furthermore, corn is a monoecious plant which means it has male flowers and female flowers within the same plant. The female flowers are borne on a part called the ear; the ear development begins in the early stages of the plant. The difference is that corn has male and female flowers are in separate locations within the same plant. As a result of being a rare monoecious plant, fertilization does not occur until the male reproductive organ expels pollen unite with female cells released from the ovule. As a result, fertilization is not always achieved

after pollination. However, when fertilization is achieved when corn-silks detach from fertilized ovules.

3.4.3. Anthesis

> "*Corn is monoecious, which means that male and female reproductive structures are present on each plant. However, unlike many other monoecious grasses and dicots, male and female flowers are in separate locations on the plant. Given the separation of the ear and tassel and considering the vast amounts of pollen transported within a field, it is understandable why corn is primarily cross-pollinated. Only a very small percentage (<5%) of kernels may be fertilized by pollen from the same plant*."(Emberlin,Adams-Groom, & Tidmarsh., 1999.)

Corn plants are composed by two main parts the tassel and the ears. The tassel is the male flower of corn. Each tassel is comprised of a central tassel stalk and a bunch of lateral branches. (Asgrow, n.d.)

> *"Around 1,000 spikelets are formed on each tassel bearing 2 small florets. Contained within each floret are 3 anthers, producing thousands of pollen grains."*(Asgrow, n.d.)

The anther and attached filament comprise the stamen, or male reproductive structure. Furthermore, the ear is the female flower of corn.

> *"Potential ears are initiated at each node up to about the 12th to 14th leaf node, but typically only the uppermost ear fully develops. The female florets are located in paired rows along the surface of the ear."* (Asgrow, n.d.)

The florets, contain the ovules that will become kernels after successful fertilization process. A primary ear may develop up to 1,000 ovules, and around 400-700 are usually harvested or fertilized. Row number is determined shortly after ear initiation, but ear length is not set until just before tasseling." (Asgrow, n.d.)

3.4.4. Pollination and potential pollinators

"Pollination occurs when pollen grains are transferred from the tassel to the silks. Fertilization does not occur until pollen which is the male reproductive cells get togetehr with female reproductive cells from the ovule." (Asgrow, n.d.) World's most important crops are pollinated by the wind this is called anemophily. In corn plants pollen is transported by the wind, insects or birds.

3.5. Fruit development and seed set

3.5.1. Ovule development

"Pollen grains germinate immediately after settling on the silk. The pollen tube takes between 12 and 24 hours to reach and fertilise the ovule (Sleper & Poehlman, 2006). Upon completion of fertilisation the silk detaches from the ovary and dries out.

3.5.2. Ovary wall development

Corn is a plant recognized for being monoecious which means that within the same plant it has flowers sexually categorized as male and other flowers

categorized sexually as females. The male sexual organ is called stamen while the female sexual organ is called pistil: composed by the ovary, the stigma and the style. The ovary will then grow into a kernel while the ovary wall becomes the kernel's protection. It is important to specify that every kernel has a seed inside, as to avoid the separation the seed coat fuses slightly to the ovary wall.

3.4 ECOPHYSIOLOGY

For a good harvest and a good crop is needed "*a well-drained, fertile soil. Alluvial loams, deep latosols and clay loams are preferred*." (FAO, n.d.) Clay loams are essential because they retain moisture making it great to plant corn because these crop really depends on a good irrigation. Another fundamental requirement is a well drained soil because maize roots are almost superficial and must have where grab. As said before maize is "*is comparatively shallow rooted and needs loose soil in which the roots can forage*", therefore "*a deep (20 cm) friable seed-bed should be prepared*" (FAO, n.d.)

4. PROPAGATION AND MANAGEMENT

4.1. NATURAL REGENERATION

Corn has many variations in it species so it very difficult to generalize a specific procedure for it. Also, it depends on the climate condition, the amount of water the crop has received and the amount of sunlight it was exposed to. Corn needs to be artificially regenerated when

> "*the number of viable seeds per accession is <1500 in active or base collections of panmictic populations and <250 seeds in inbred lines.*" (Taba & Twumasi-Afriyie, 2008) Panmitic populations are where all individuals are potential partners - random mating in the true sense of the word. Artificial regeneration is mostly done by controlled pollination. Artificial pollination is
>
> *"commonly used for germplasm accession regeneration and multiplication. It can be done either by plant-to-plant or chain crossing. Chain crossing is recommended for regenerating large numbers of accessions."* (Taba & Twumasi-Afriyie, 2008).) When corn is naturally regenerated is done also by pollinisation.

4.2. NURSERY PROPAGATION

4.2.1. Propagation from seed

Corn breeding is often made to modify the plant's resistance to climate changes, to adapt in different conditions and to increase its quality. This is made when the corn`s tassel has fully emerged from the upper leaf sheath, and consequently pollen-shed will begin, spreading the whole tassel with pollen. Pollen grains are produced in anthers which open up under appropriate weather conditions. For example, good water and enough sun hours. Pollen, which is only usable from 18 to 24 hours, is very light and can travel long distances by the wind. And when other corn plants are pollinated by the wind is another process called wind pollination. Pollen shed from the tassel usually begins 2-3 days before silk emergence and can continue for several days thereafter, but will stop when the tassel is too wet or too dry. (Farmwest.com, 2012).

The silks are covered with fine, sticky hairs that catch and anchor pollen grains. After some minutes of landing, the pollen grain germinates and a pollen tube grows down the silk to fertilize the ovule or potential kernel. Normally it takes 12 to 28 hours to complete the process. Under good conditions, all silks will emerge and be ready for pollination in a short time of normally 3 to 5 days. Unfavourable environmental conditions during pollination can have a great impact on grain yield. Since there is usually more than enough pollen (a given tassel can produce up to 5 million pollen grains), problems generally occur when there is poor synchronization between silk emergence and pollen shedding. (Farmwest.com, 2012)

"Corn with its separate male and female flowering parts is a naturally cross-pollinating plant. This means that ovules can be pollinated by pollen from neighbouring plants. Therefore, care must be taken in a breeding program to ensure that pollen from the appropriate tassel fertilizes ovules on the appropriate ear. This is usually achieved by hand-pollinating. As soon as ear shoots are visible in the leaf axils of a plant, a small paper 'shoot-bag' is placed over the shoots; this allows the ear to continue growing and the silks to emerge but prevents any pollen from falling on the silks." (Farmwest.com, 2012) This process is mostly made and controlled by humans to produced a stronger maize variety." (Farmwest.com, 2012)

http://www.cornandsoybeandigest.com/sites/cornandsoybeandigest.com/files/uploads/2013/04/corn-seed-germination-121095349.jpg

4.2.1.1. Pre- preparation and implication for germination

The preparation of soil for corn is the same for almost all the crops. Corn is really sensible to climate changes so therefore germination of corn is very temperature dependent. Germination will not occur when soil temperatures are below 10°C. In Colombia this will rarely happen because we don't have seasons. Corn´s most favorable germination and emergence happens when the soil temperature at a depth 4 inches reaches 12 to 15°C (Manitoba Agriculture n.d.) Consequently, for a good germination an appropriate climate should be taken as a primordial condition to germinate and plant corn.

4.2.1.2. Sowing and the germination process

As mentioned before corn is a really climate sensitive plant, so it should be planted by May 1 and May 15 right after the last frost. It only applies to countries that have seasons, in this case Colombia hasn't so there is no problem. If maize is planted before or after the specificated dates it can have some side effects that will be reflected on its production. If the seeding suggestions are not followed correctly and decide to seed late

> *"...yield potential is reduced significantly and the risk of crop failure increases. Research has shown that, on average, a yield reduction of 1 bushel per acre per day occurs when the date of seeding is delayed beyond mid-May. Planting earlier than the first week in May may be warranted when an open spring occurs. Under these circumstances a 5% increase in plant*

population would be advised to allow for losses that may occur due to climatic and biological factors." (Johnson, 2013)

Climate can drastically change corn's development, it's so significant that if it's planted earlier than supposed the whole plantation is in risk,

> *"since as planting dates are moved earlier, soil temperature becomes a more important consideration. When soil and air are cool, germination and growth can take significantly longer, during which time micro-organisms and insects can cause damage leading to stand establishment problems. As well, there is the possibility that plants can be damaged from late spring frosts if the growing point emerges above ground level."* (Johsnon, 2013)

It's true that corn has a very wide range of temperatures and climates, but if one of these is overpassed the whole crop is in a huge danger.

4.2.1.3. Storage

The secret of a good storage is having the corn really well dried before entering the storage shelter. There are many drying techniques, none is better than the other, because it is based on the inclination it has and the external factors that exist to operate including

> *"...drying capacity, grain quality, fuel/drying efficiency (BTUs per volume of water removed), convenience, manpower required to run the dryer, ability to dry a variety of crops, maintenance required and capital cost".* (Brown, 2009.)

All the drying machines and techniques “move "dry" air past the grain to evaporate moisture within the kernel and carry the water vapour away. (Brown, 2009) Later, after removing the inside moisture from the kernels corn is let to sit to avoid stress cracking.

4.2.2. Vegetative propagation

4.2.2.1. Grafting

Not all the plants can be grafted. It all depends on the cambium which

> *“...is a layer of dividing cells in a stem that is responsible for increasing the stem diameter.”*

Therefore,

> “Plants lacking cambium (example: monocots such as corn) cannot be grafted. The cambium of a stock and scion must be in close contact to form a union. Cambial activity during spring facilitates easy separation of bark from the wood.” (Kumar,2011)

4.3. PLANTING

Corn is really picky when it's about the soil temperature. The soil where the seed is going to be planted needs to be at a minimum temperature of 16 °C so the seed can germinate, the grounds temperature determines the variety of corn that will be harvested.

> *“Plant seeds 1 inch deep and 4 to 6 inches apart. Rows 30 to 36 inches apart.”* (The Old Farmer´s Almanac, n.d.)

Water is a crucial factor in corns growth, it requires a minimum of one inch of water per week. A good or a bad watering can affect the production of corn kernels.

4.4. MANAGEMENT

4.4.1. Fruiting

Corn has been misunderstood for many years by people, some people say it is a vegetable and other says it's a grain, but perhaps maize has been classified by experts as a fruit, as are tomatoes, green peppers, cucumbers, zucchini and other squashes. (Walker, n.d.)

4.4.2. Pest and disease control

Corn has many problems at the time of planting it and collecting it. But, they are easily controlled, by humanmade techniques, for example

> *"diseases aren't much of a problem, and insects can easily be kept in check. Birds and four-footed visitors who want to share your corn harvest can be kept out with any number of scare-off devices and fences. Prevention can be 100 percent of the cure. If you sow your corn in well drained soil that has balanced nutrient levels, you're on the road to having healthy plants. Healthy plants can withstand nibbling or insect damage better than weakened ones. In many cases, a crop that's healthy will often be spared disease and insect attack altogether."* (The National Gardeners Association, 2008).)

Some diseases that affects corn are Stewart's Bacterial Wilt, Root Rot, Corn Smut and Southern Corn Leaf Blight (The National Gardeners Association, 2008) Corn is not unsusceptible to insects, some insects attack corn but this doesn't mean that the harvest is lost. Some of the insects that attack corn are the Corn earworm, European corn borer, Corn Sap Beetles, Corn Root Aphids, Wireworms are slender, Seedcorn maggots The National Gardeners Association, 2008) As said before these unwanted visitors can be avoided with some precaution at the time of planting and harvesting.

5. EMERGING PRODUCTS, POTENTIAL MARKETS

5.1. THE OVERALL PICTURE

Corn derived products are presents in our everyday routine. Corn is present since the moment we wake up. We start the morning with a delicious Colombian arepa which is made up of corn. After this, the first encounter with corn for many people is while tooth brushing, corn is used in toothpaste. Sorbitol is used in toothpaste as a bulking agent. The next encounter is in the car, commonly corn is used in oils, gas, tires, spark plugs etc. After arriving to work the only thing we want is an instant coffee which contains Maltodextrins. After eating lunch with an ice cold Coke which also contains corn we receive a candy that contains corn syrup. Finally after a long day of work we get a beer before sleeping.

5.2. FOOD ITEMS BASED ON PULP, SKIN AND JUICE

5.2.1. Fresh fruit

5.2.1.1. Corn:

5.2.2. Confectionary

5.2.2.1. Cake Mixes:

Astonishingly corn is used in cake mixes, for these people use a pregelatinized corn starch that after applying water it will will create a paste to make what we most love. Cake. Corn is also used in other mixes that use yeast as a riser. Corn is used in bread, cupcakes, cookies and many more bakery products. (Products that use Corn, n.d)

5.2.2.2. Candies:

As awesome as it sounds, corn syrup is used to make hard candies by giving them a chewable texture for us the consumers. Also, it is used for candy coating. Furthermore, we commonly use corn syrup in the hot cakes, waffles and crepes. (Products that use Corn, n.d)

5.2.2.3. Carbonated Beverages - Coke:

High fructose corn syrup is commonly used to sweetened carbonated beverages like coke. As it contains many sugar it is often used to sweeten many beverages. High fructose corn syrup is used industrially to sweeten beverages like juices, sodas, coffee, teas and many more sweet drinks. (Products that use Corn, n.d)

5.2.2.4. Cookies:

As mentioned before, corn is used in mostly all bakery products.

> *"Cornstarch, corn flour or dextrose may be found in cookies."* (Products that use Corn, n.d)

5.2.2.5. Corn Flakes:

Are a very common corn product,

> *"Corn starch is derived from the wet milling process and is an important manufactured product. Some uses depend on the properties in the dry state, but most applications relate to its*

properties as a cooked, hydrated paste. " (Products that use Corn, n.d)

5.2.3. Juice, nectar, puree and flavoured products

5.2.3.1. Instant Coffee & Tea:

Not only instant coffee or tea has maltodextrins

"They are a dextrose equivalent product of complete solubility but little or no sweetness." (Products that use Corn, n.d)

This is used to keep contents free flowing

5.2.3.2. Yogurt:

Yogurt is obviously made out of milk buts is normally sweetened by corn syrup as i mentioned before.

5.2.4. Alcoholic beverages

5.2.4.1. *Beer:*

Beer is normally made out of malt but as the demand of lighter beers grow people have sought they way to fulfill this demand.

"However, demand for lighter, less filling beer, especially in the U.S., has permitted use of more refined carbohydrate sources of two types:

a) dry adjuncts, primarily dry milled corn grits, broken rice, refined corn starch, and more recently, dextrose.

b) liquid adjuncts, namely corn syrups" (Products that use Corn, n.d)

5.2.4.2. Whiskey:

As many people know whiskey is made out of corn,

> *"A typical Canadian whiskey is made from a mixture of about 90% corn, 5% rye, and 5% barley malt."* (Products that use Corn, n.d)

5.3. ITEMS BASED ON KERNELS

As the demand of biofuels grow people had found the way to supply this demand.

> *"Corn kernels are used as pelletized fuel for pellet stoves and furnaces. Corn kernels are a natural pellet, which gives them an economic advantage over other man-made biomass pellets and wood pellets.*" ("Corn Kernel")

The use of corn kernels in pellet stoves brings a huge positive ecological impact because it's more eco friendly to the environment

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