



CORN TORTILLAS & SNACKS
“Ingredient & Product Innovation”

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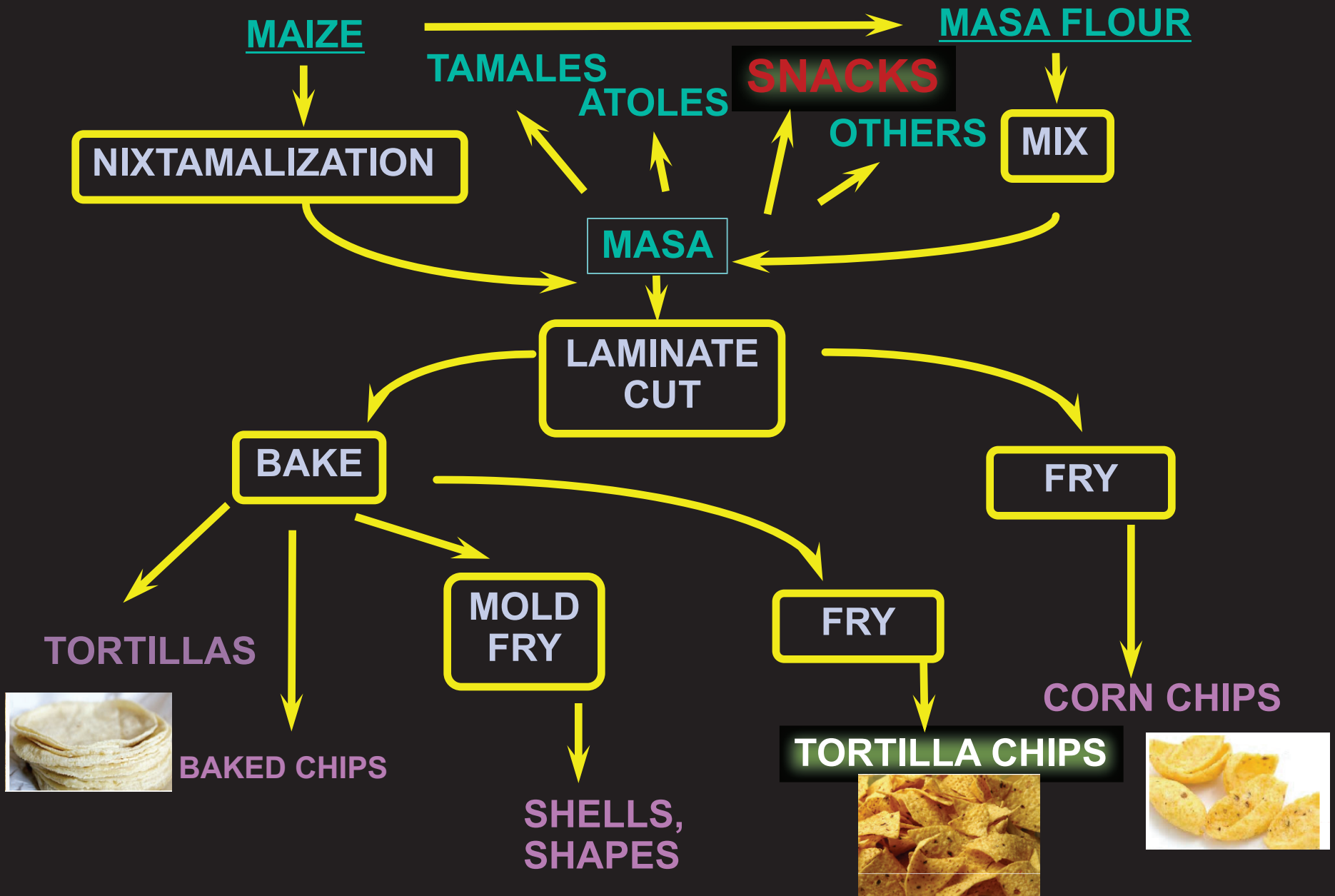
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Innovation Universe of Possibilities

“Strategic ↔ Tactical”



UNIVERSE OF CORN MASA PRODUCTS



FACTORS THAT AFFECT QUALITY OF CEREAL-BASED FOODS

Have Effective Controls in Place ?



SEED



PRODUCTION



GRAIN



PROCESSING



FOOD

GENETICS
VARIETY/HYBRID
UNIFORMITY

QUALITY
PHYSICAL PROP' S
CHEMICAL PROP' S
UNIFORMITY

FUNCIONALITY
UNIFORMITY



ENVIRONMENT
MASS PRODUCTION
DRYING
HANDLING/STORAGE
MIXING

MECHANICAL ENERGY
HEATING
CHEMICAL MODIFICATION
MICRO STRUCTURE
MOISTURE

Snacks- Comparative Review

<u>Snack</u>	<u>Products</u>	<u>Major Ingredients</u>	<u>Key Processes</u>
Potato Chips	Potato Chips, <i>Pringles</i> ®	Potatoes, Potato Granules/Flakes	Refrigeration/Cutting, Frying or Baking Dough Forming
Alkaline Cooked Corn Masa Products	Tortilla Chips, Corn Chips	Corn, Calcium Hydroxide	Cook/Grind/Sheet/Cut Fry or Bake Dough Forming
Extrusion (DX)	Corn Swirls, <i>Cheetos</i> ®	Corn, Rice, Wheat, etc	Dry mixing High Shear Extruder
Crackers	<i>Cheez- It</i> ® <i>Wheat Thins</i> ® <i>Wheatables</i> ®	Wheat, Starch, others	Dough Equip/ Sheet/Cut Baking Shred Mills
Extruded Dough	Pretzels, Sticks,	Wheat, Corn, Potato, others	Dough Forming Caustic Cooking Baking
Die Cut Pellets	Pork Skins, Rings, Tubes, etc.	Corn, Rice, wheat, potato	Extrusion Cook/Form Puff: Fryer/oven/gun/tower
Sheeted Pellets	3-D shapes, Pillows	Corn, Rice, wheat, potato	Cook: Extrusion, Rotary Sheet/Cut Puffing
Other	Popcorn, <i>Corn Nuts</i> ®	Corn	Tempering Tunnels, hot air puffing, frying

Snacks- Comparative Review

<u>Snack</u>	<u>Products</u>	<u>Major Ingredients</u>	<u>Key Processes</u>
Potato Chips	<p><i>Hybrids food forms are a common trend across food categories</i></p>		
Alkaline Cooked			
Extrusion (DX)			
Crackers			
Extruded Dough			
Die Cut Pellets			
Sheeted Pellets			
Others			

COOK/ STEEP/WASH CONTROLS

CONTROL PARAMETERS:

Grain quality

Batch size

Lime quality

Temp-Time profile

Stirring

EFFECTS:

Water and lime uptake

Nixtamal moist: Tort = 45-54% Chips = 38-50%

Partial pericarp removal and degradation

Partial degradation and solubilization of cell wall components into a fragile structure

Partial/limited swelling/gelatinization of starch granules

Some dry matter losses

Little germ modification

MAIZE TORTILLAS QUALITY ATTRIBUTES

- **Dimensions**
 - Thin: 18-23 g/piece
 - Thick: 28-34 g/piece
- **Moisture Content: 45-55%**
- **Texture**
 - Flexible
 - Shelf stable: 1-4 weeks?
 - Re-heatable
- **Color**
 - Clean, bright white or yellow
- **Nixtamal flavor and aroma**
- **Shelf life**
 - 2-3 days local, daily market
 - 1-4 weeks (more?) supermarket
- **Black specks “hilum”**

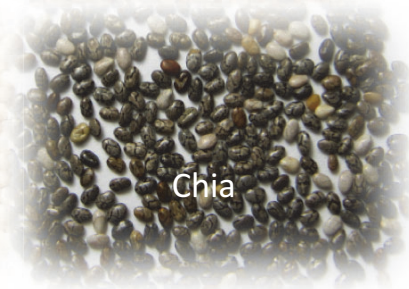
TORTILLA CHIPS QUALITY ATTRIBUTES

- **Thickness (tortilla wt prior to frying)**
 - **Thin: 8-12 g/piece**
 - **Thick: 15-20 g/piece**
- **Moisture content: 1-2%**
- **Texture: Crunchy/Crispy**
- **Color**
 - **Clean, bright white or yellow**
- **Nixtamal flavor**
- **Oil content: 18-25%**
- **Appearance**
 - **Uniform, small pillows**
 - **Undesirable opaque, oily**
- **Presence of black specks “hilum”**



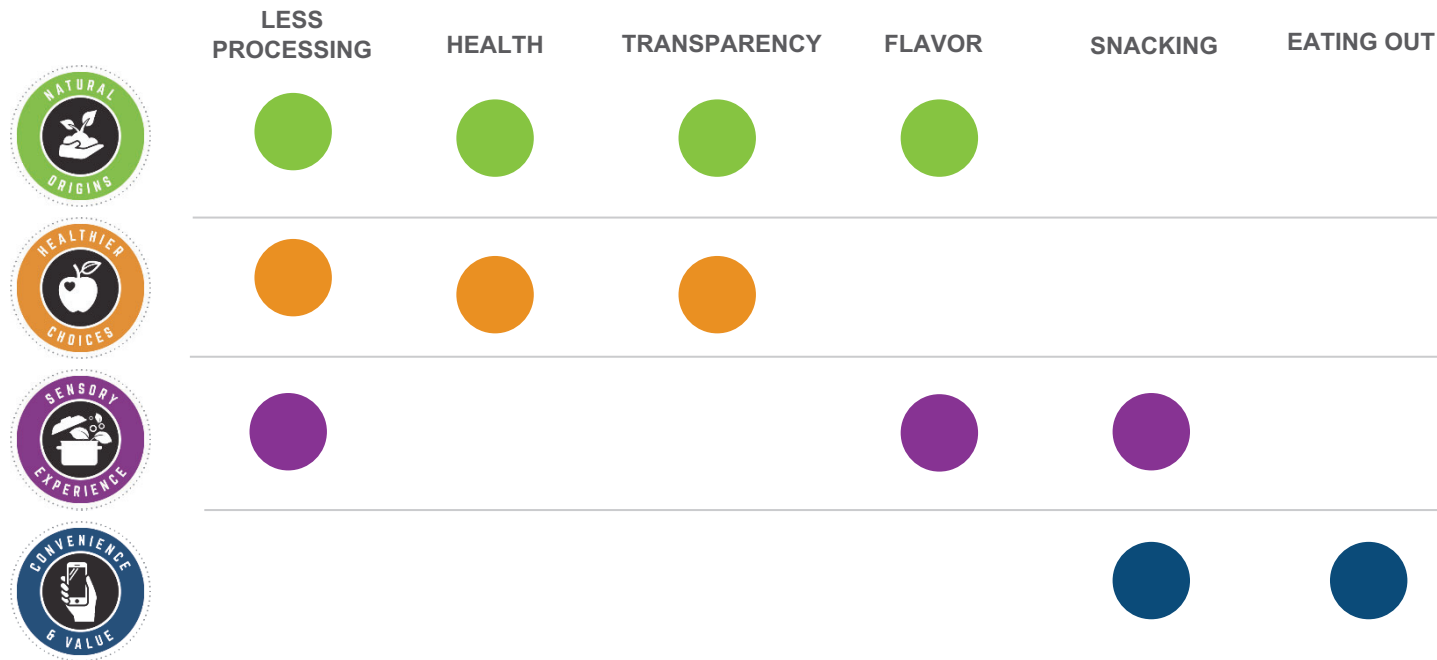
Grains of Cereal & Beyond

- Market Trends
- Grain Types & Historical
- General Benefits
- Food Applications-
Process, Product,
Challenges & Innovation



Global Food Trends

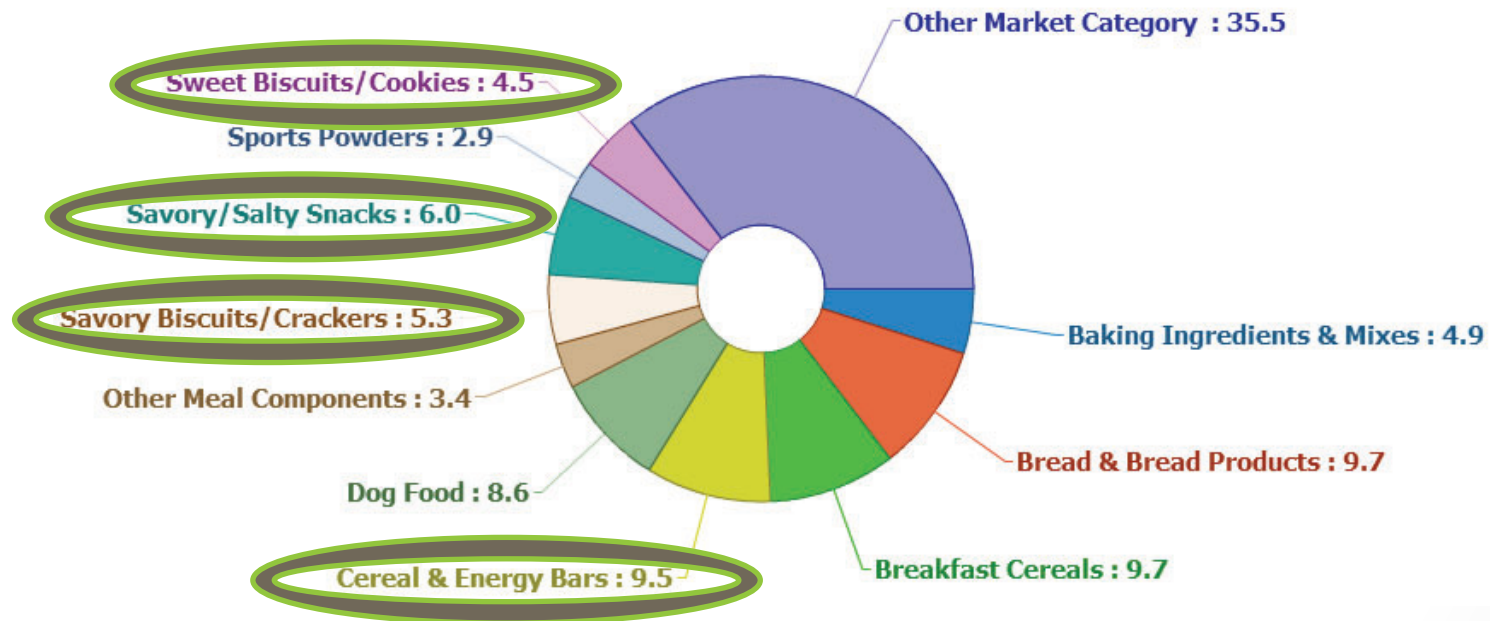
“Grain-based foods key Strategy Drivers”



Ancient Grains Intersect With Snacking Trends

Snacks continue to grow as busy consumer lifestyles make them more of a necessity; snacks are the most popular way of accessing the health benefits of ancient grains.

Percent of Total Ancient Grain Launches



Source: Innova Market Insights



Ancient grains, Modern Times

- From whole grain council “ancient grains” refers to grains and seeds that haven’t been modified or extensively cross-bred to enhance their features.
- There is no official definition
Grains that have ‘survived intact for centuries’
Not altered by modern plant science practices



Some Market Characteristics

- ✓ Superior nutritional value
- ✓ Unique flavor
- ✓ Considered Healthy
- ✓ Gluten free (some)

World Grains- *Categories*

Cereals Grass family, high in carbohydrates		Pseudocereals Broad leaf plant families	Pulses. Pea (pods) Family higher protein	Oilseeds. High oil
<u>Warm-season</u> finger millet fonio foxtail millet Japanese millet kodo millet maize (corn) pearl millet proso millet Sorghum	<u>Cool-season</u> Barley Rye barley oats rice rye spelt teff triticale wheat	amaranth (Amaranth family) buckwheat (Smartweed family) chia (Mint family) quinoa (Chimopodium family) kañiwa Kiwicha	Chickpeas Common beans Common peas Fav beans Lentils Lima beans lupins mung beans peanuts pigeon peas runner beans Soybeans	Mustard family. Rapeseed black mustard India mustard Canola) Aster family. Sunflower seeds safflower Sunflower Other families flax seed (Flax family) hemp seed (Hemp family) poppy seed (Poppy family)

Ancient Grains and Seeds



Super Seeds & Grains

Examples of Ancient Grains...



Farro (Emmer)



Spelt



Kamut



Quinoa



Amaranth



Chia



Sorghum



Freekah



Teff



Millet



Bulgur



Wheat Berry



Buckwheat



Kernza



Einkorn

Sorghum / Milo (*Sorghum bicolor*)

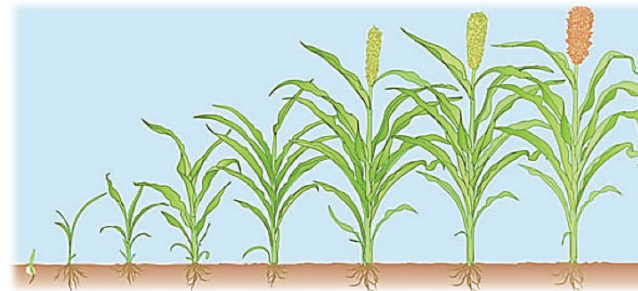


- Origins: Africa (Ethiopia), however is grown in Asia, North America and Latin America
- Kernels are generally spherical, ranging in size from **3 to 4 mm** and in weight from **20 to 30 mg**
- Color may vary from white and pale yellow to deep reds, purples and browns depending on the variety



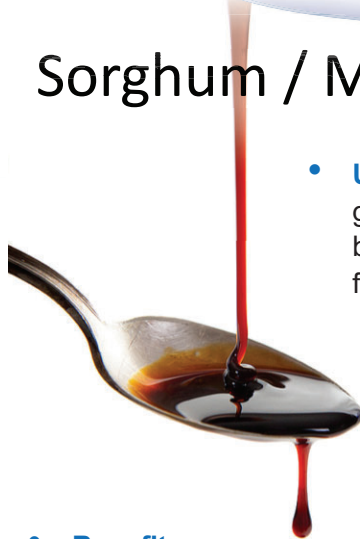
Dr. Jeff Dahlberg, Texas AgriLife Extension Service. Texas A&M University

- Sorghum is a summer annual or short term perennial plant, what means that germinates during spring or early summer and mature by autumn of the same year. **From planting to harvest sorghum takes 5-6 months**
- Sorghum can growth under adverse conditions, is high-energy efficient and drought tolerant crop, however is susceptible to frost. Sorghum can grow in a altitude range from sea level to 1,000 m.



University of Illinois, Extension

Sorghum / Milo (*Sorghum bicolor*)



- **Uses:** sorghum molasses (Brewing industry, gluten free), **sorghum syrup** (Food industry), baked goods, **popped sorghum**, livestock feed, pet food, ethanol production.



- **Benefits:**
 - **Antioxidants** in sorghum have been associated with cancer tumor growth inhibition, protection against diabetes and insulin resistance, and may help manage cholesterol.



Millets

Kodo Millet
(*Paspalum scrobiculatum*)



Pearl Millet
(*Pennisetum glaucum*)



Little Millet
(*Panicum sumatrense*)



Proso Millet
(*Panicum miliaceum*)



High variable small round
seed plant species.
Size (2-3 mm) / Weight (2.5-14 mg)

Finger Millet (Ragi)
(*Eleusine coracana*)



Barnyard Millet / Japanese millet
(*Echinochloa esculenta*)



Foxtail Millet
(*Panicum italicum L.*)



Millets

- **Uses:** Staple in Africa and India, baked goods, porridge, millet beer and other alcoholic beverage, puffed candies, pet food, livestock feed,



- **Benefits:**
 - Rich in **B vitamins** and **minerals**
 - High in **protein**, more than corn, rice and oats
 - Rich in **antioxidants** (depending on variety)
 - Anti-diabetic, anti-tumorigenic effects and antimicrobial properties
 - Pearl millet is significantly rich in **resistant starch**, soluble and insoluble dietary **fibers**
 - Foxtail millet is rich in **lysine** an essential amino acid important for anxiety and stress control, absent in most cereals.



Quinoa (*Chenopodium quinoa*)

- **Uses:** Baked goods, soups, drinks, alcoholic beverages, desserts, snacks, puffed grain, oil, animal feed and pet food.
- Quinoa saponins have potential uses in the pharmaceutical industry due to its antibiotic and antimycotic properties.
- ❖ Quinoa starch has an excellent stability under freezing and retrogradation



- **Benefits:**
 - Rich in **minerals, vitamins** and **antioxidants**
 - Rich in **polyunsaturated fatty acids (PUFAs)** that have positive effects on cardiovascular disease and improve insulin sensitivity.
 - Contains **20HE** a phytoecdysteroid that acts as body building agent, stress reducer and athletic performance enhancer. 20HE may also helps to prevent and treat diabetes and obesity.
 - **All essential amino acids:** According to FAO quinoa is the only plant that contains all the essential amino acids in the quantities that meets the requirements for human nutrition.



All ancient grains are Non-GMO so far

Ancient grains macronutrient comparison

Grain/ g/100g	Protein	Fat	PUFA's	Total Dietary Fiber	Ash	Water	Gluten Free
Corn	3.2	1.2	0.6	2.7	0.6	76.0	✓
Rice	7.1	0.7	0.2	1.3	0.6	11.6	✓
Weat	12.6	1.5	0.6	12.2	1.6	13.1	
Sorghum	10.6	3.5	1.6	6.7	1.4	12.4	✓
Millet	11.0	4.2	2.1	8.5	3.3	8.7	✓
Quinoa	14.1	6.1	3.3	7.0	2.4	13.3	✓
Kañiwa (1)	16.3	6.6	6.0	5.3	3.6	13.3	✓
Amaranth	13.6	7.2	2.8	6.7	2.9	11.3	✓
Teff	13.3	2.4	1.1	8.0	2.4	8.8	✓
Spelt	14.6	2.4	1.3	10.7	1.8	11.0	
Spring Emmer (2)	14.4	2.3	No data	11.8	1.6	10.3	
Buckwheat	13.3	3.4	1.0	10.0	2.1	9.8	✓
Chia seeds	16.5	30.7	23.7	34.4	4.8	5.8	✓
Flax seeds	18.3	42.2	28.7	27.3	3.7	7.0	✓
Coix seeds	15.4	6.2	No data	0.8	1.9	11.2	✓

Made using USDA National Nutrient Database for Standard Reference Release 27, February 10-2015; URL: <<http://ndb.nal.usda.gov/ndb/>> ; Millet, raw; Sorghum grain; Quinoa, Uncooked; Chia seeds, dried; Corn, sweet, yellow, raw; Rice, Long grain, raw; Wheat hard red winter; Amaranth grains uncooked; Teff uncooked; Spelt uncooked; Buckwheat; Flaxseed ;**Bold values represent the highest nutrient content for "common grains"; cells in pink represent nutrient content greater than highest value for common grains.** (1) Food Reviews International, Nutritional Value and Use of the Andean Crops, R. Repo-Carrasco, C. Espinoza, and S.-E. Jacobsen, Peru, 2003. (2) Czech J. Food Sci. Composition, Protein Contents, and Microstructural Characterization of Grains and Flours of Emmer Wheat (*Triticum turgidum* ssp. *dicoccum*) of the Central Italy Type, Giacintucc, Guardeño, Hernando, Sacchet, Pittia, Spain, 2014. (3) Asian Foods science and technology, Y.W Ang, KeShun Liu and Yao-Wen Huang, United States, 1999.

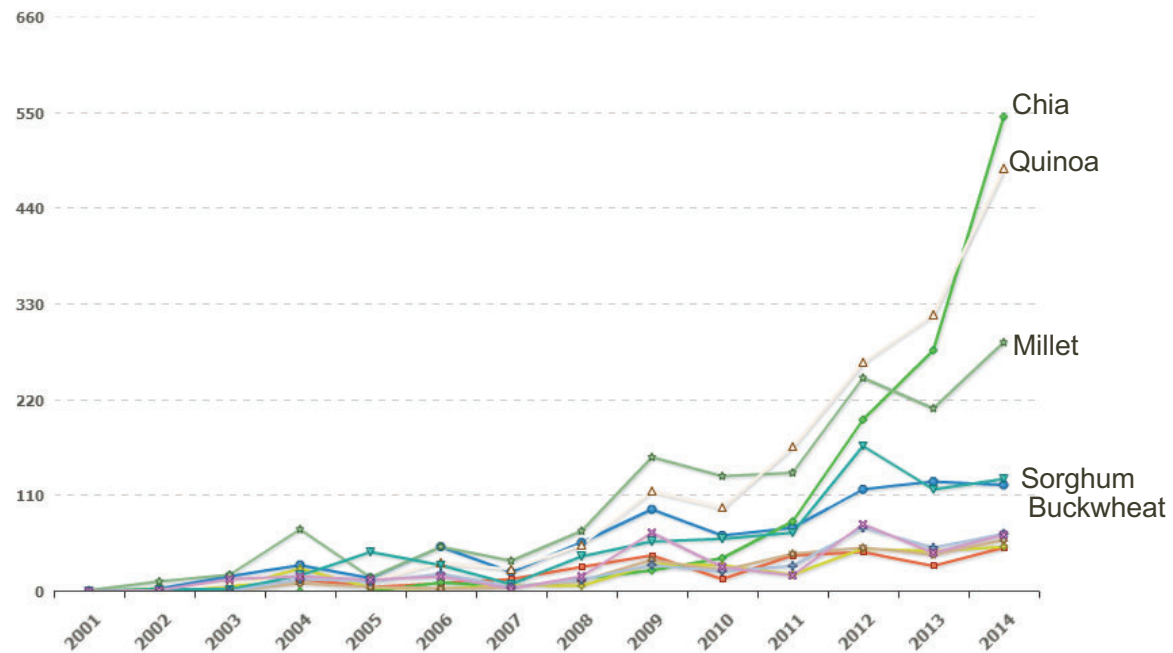
Barriers to Ancient Grain Consumption

- Taste
- Inclusion levels
- Functionality
- Unlike ingredient forms-Develop the expertise beyond typical Corn, Wheat, Rice
- Supply

Ancient Grain Products Exploding In Popularity

Retail product launches containing ancient grains have exploded over the past couple of years and show no signs of slowing as more manufacturers enter the growing segment.

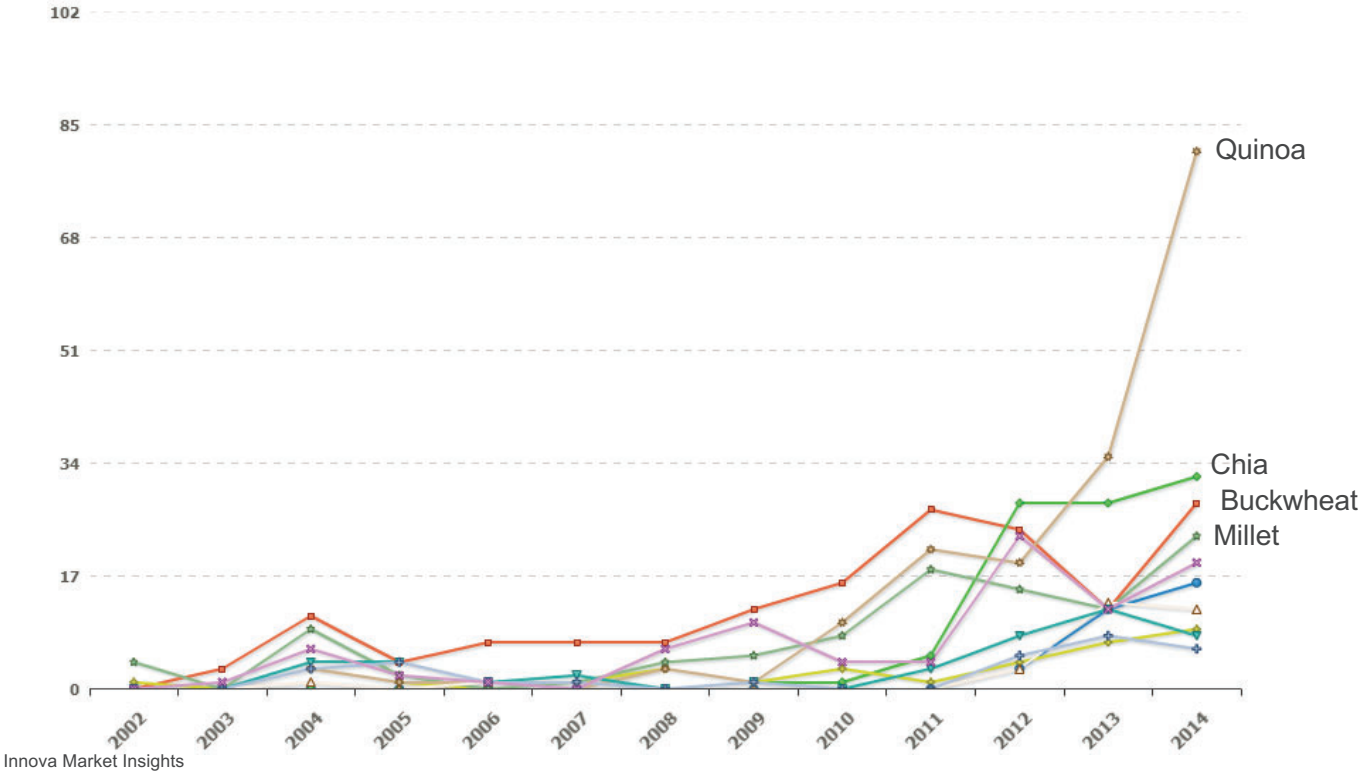
US Product Launches with Ancient Grains by Ingredient



Source: Innova Market Insights

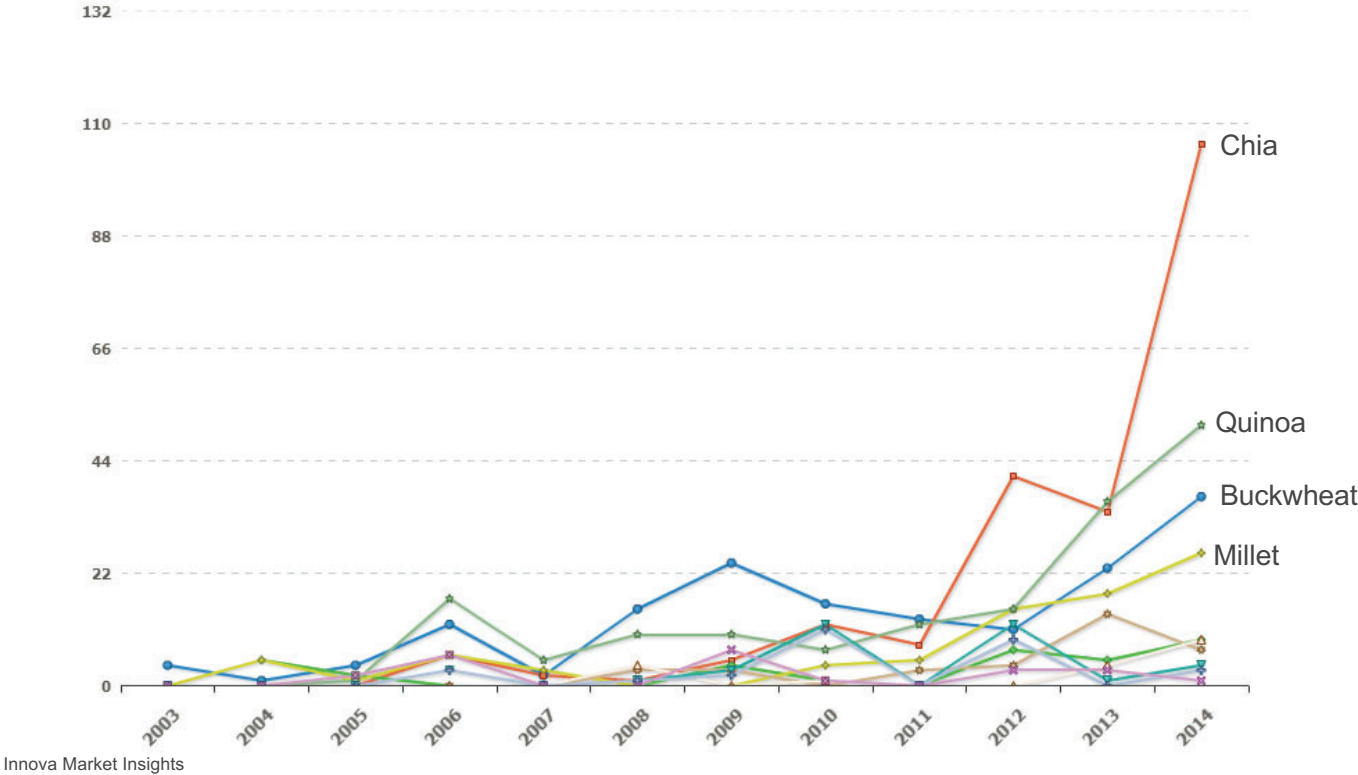
Quinoa Leads in Breakfast Cereals

US Cereal Product Launches with Ancient Grains by Ingredient



Chia Leads in Snack Bars

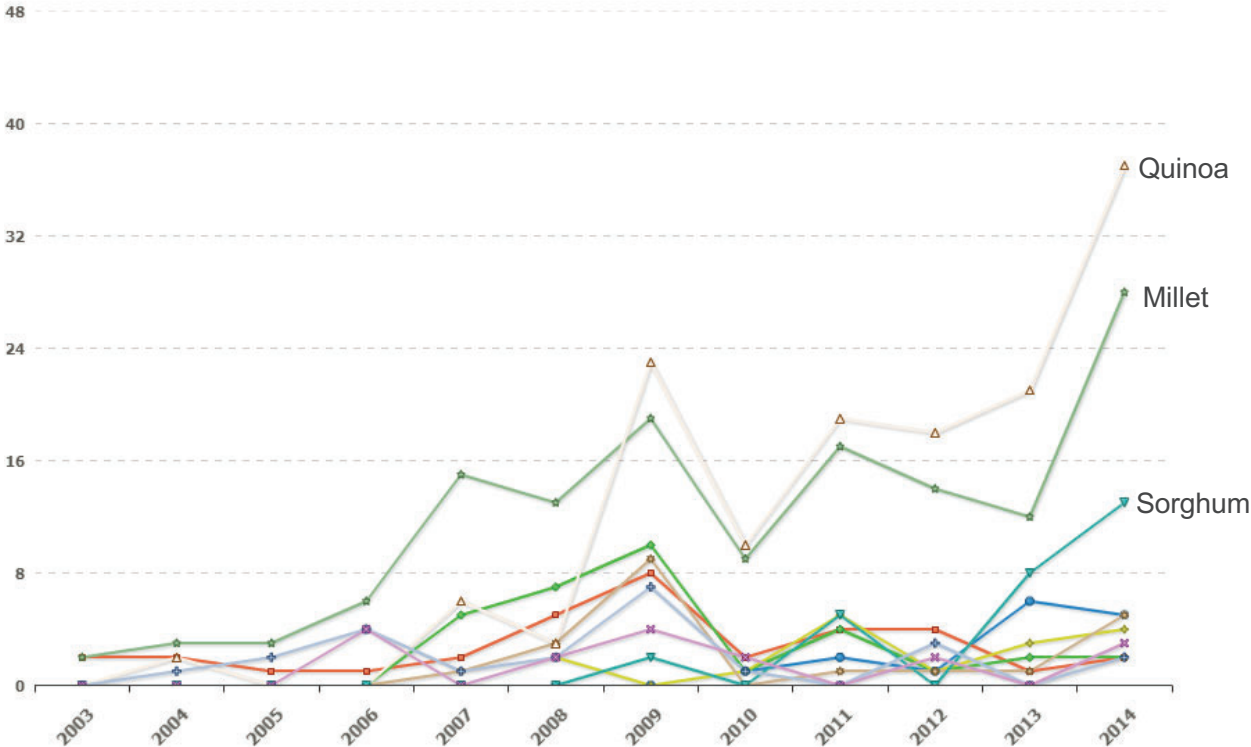
US Snack Bar Product Launches with Ancient Grains by Ingredient



Innova Market Insights

Quinoa & Millet Lead in Crackers

US Cracker Product Launches with Ancient Grains by Ingredient



Innova Market Insights

Ancient Grains Technologies

Opportunity:

“Unique Nutrition and flavor”

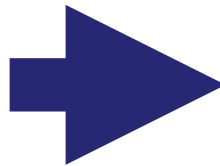
- Simple and natural
- Snacks, Breakfast applications
- Visual integrity
- Sweet or savory flavors
- Whole multi-grains

Technology Status:

- Regional, artisanal presence
- Ethnically driven
- Much to develop

Grains

- sorghum,
- pearl millet
- , Quinoa
- Chia
- Amaranth
- Teff
- Buckwheat
-



Puffing

- Hot Air
- Frying
- Vacuum
- IR

Toasting

- Hot Air
- Frying-Deep
- Radiant

Bars

- Syrup Bind

Flours

- Simple process



Why Not with Masa Technology ?

Food Applications



Pasta



Tortillas



Bread



Batters



RTEC



Granolas



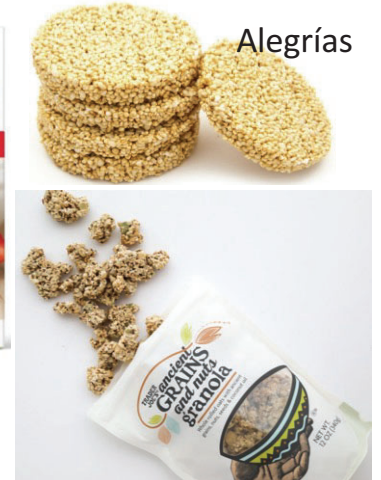
Crackers



Chips



Extrudates



Alegrias

TARGETED INGREDIENT FUNCTIONALITY

Masa Technology

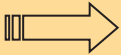
- Maize : (Alkaline Cooked, other)
- Lime : (< 1%)
- Gums : (CMC, other)
- Emulsifiers : (Mono & Diglycerides)
- Acidifying Agents : (Fumaric Acid, other)
- Preservatives : (K Sorbate, Ca Propionate)
- Multigrain : (Sesame, Oats, Quinoa Corn Bran, Wheat)
- Optional : (Vitamins, Other Nutrients)
- Flavors: Adobo, fajitas, Chilli, Beans

Inherent Critical Functionality

“First step where components are activated”

Partial solubilization of hemicelluloses from pericarp and cell wall

Hemicelluloses with polyelectrolytic character, large molecular size due to intramolecular electrostatic repulsions: viscosity, thickening, emulsifier, stabilizer

NIACIN CONVERSION: NIACITIN  NIACIN
(Aleurone inclusions) (Free)

LIME UPTAKE:

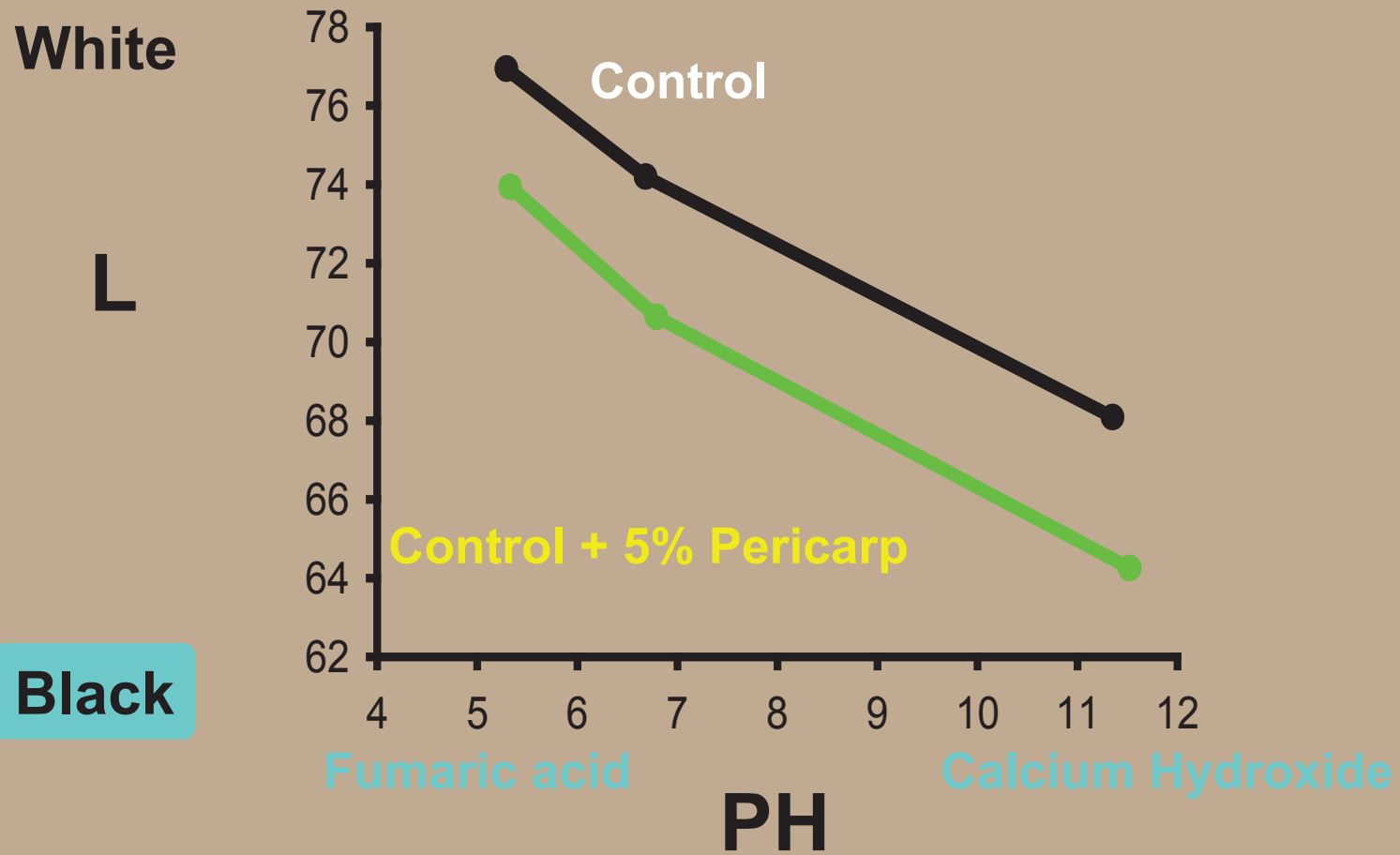
Through germ, remains at aleurone layer and pericarp
Affect FLAVOR, pH  COLOR

EFFECT OF COB AND PERICARP COLOR ON COLOR OF CORN TORTILLAS

L= white-black b: yellow-blue

	MASA		TORTILLA	
	L	b	L	b
WHITE CORN				
WHITE COB	72.5	17.4	73.9	14.3
RED COB	72.2	18.2	70.6	16.4
YELLOW CORN				
WHITE COB	70.7	29.0	71.2	27.2
RED COB	67.2	28.9	66.6	26.5

EFFECT OF ADDITIONAL PERICARP AND PH ON COLOR OF TORTILLAS



Pericarp from nixtamalized corn hulls

OPTIONAL ADDITIVES

- **Texture**
Hydrocolloids/Gums: CMC, Xanthan, Carragenan
Enzymes: Barley Malt, Amylases, others
Glycerides: Mono & Diglycerides, Glycerin
- **Color**
Acids: Fumaric, Phosphoric
Oxidants: Calcium or Benzoyl Peroxide,
Titanium Dioxide, others
Alkali: Lime (Calcium Hydroxide)
- **Shelf Life**
Preservatives: Ca or Na Propionate, K Sorbate
Acids: Fumaric, Phosphoric, Sorbic
Alkali: Lime
- **Nutritional** Vitamins, amino acids, multigrain, Fiber (cereal, fruit) legumes, ancient grains, others

• *Flavors ??*

Much Progress Achieved

- From Teosint(l)e to Current Hybrids
Yield, Quality, Hybrids, Distribution

How about nutrition?



Genetics
Environment
Science & Technology
Industry



International Center for Maize and Wheat Breeding (CIMMYT)



Initiatives:

- Bio-fortification with Maize Seed of Discovery
- MasAgro farmer support
- Sustainable Intensive Agriculture

Typical Composition Of Yellow Dent Corn

CELL WALL:
Hemicelluloses,
pentosans, protein

Hard Or Horny
Endosperm

Soft Or Floury
Endosperm

ENDOSPERM:
STARCH, PROTEIN

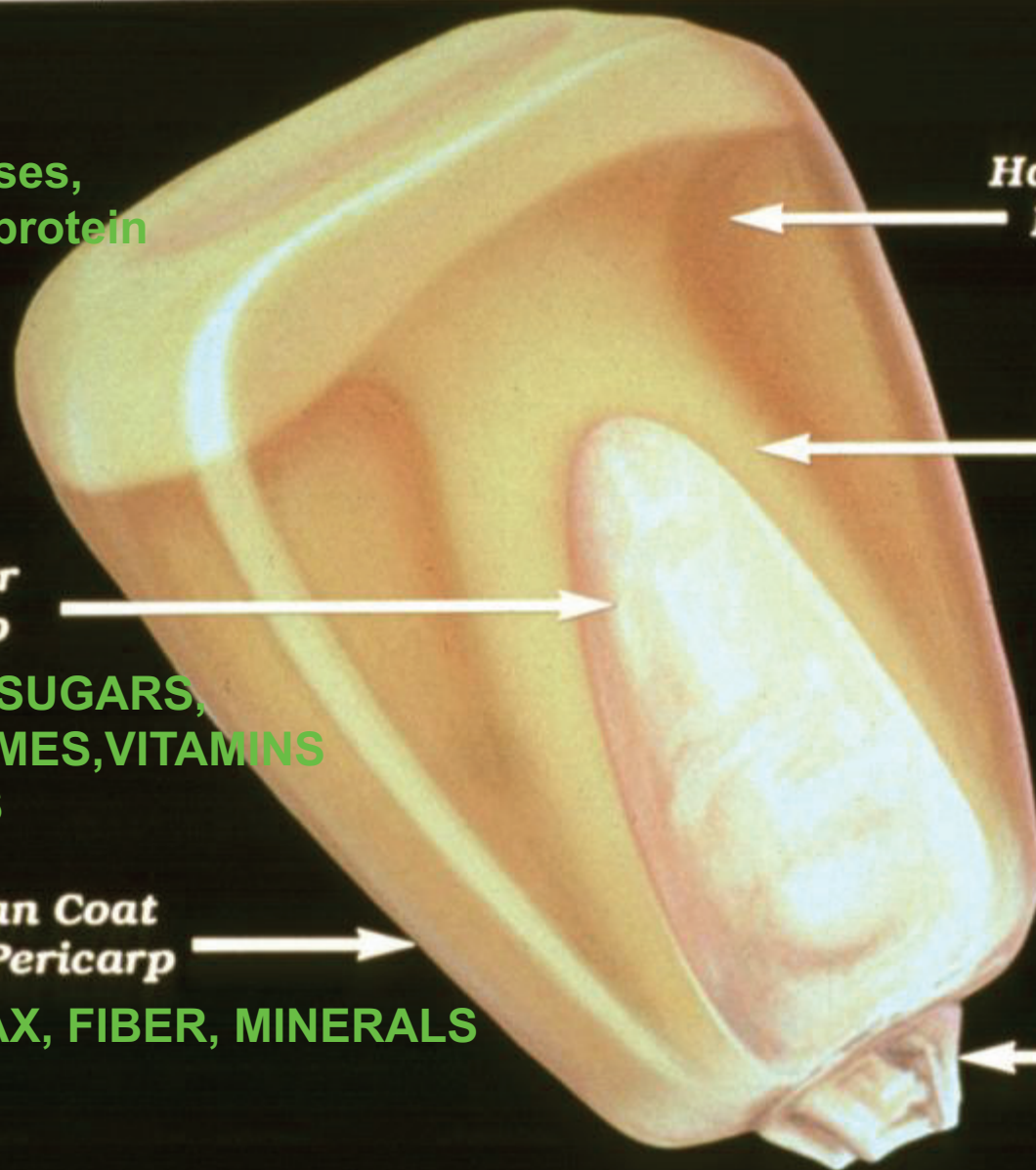
Germ Or
Embryo

PROTEIN, SUGARS,
FAT, ENZYMES, VITAMINS
MINERALS

Bran Coat
Or Pericarp

WAX, FIBER, MINERALS

Tip Cap
Or Pedicel



Nutrition Areas of Opportunity in Corn - Global **CIMMYT** Breeding Program

Compound		Maize structure	Relative Importance
Fiber	Soluble	Mainly in pericarp.	Decrease glycemic index. Reduce the risk of diabetes,
	Insoluble	Pericarp	Reduce risk of constipation, hemorrhoids and colon cancer.
Phytici acid and inositol		Pericarp and aleuron layer.	Antioxidant. Efect in colon and skin cancer
Phenolic compounds	Ferulic acid	Pericarp	Prevent oxidative stress
Anthocyanins and flavonoids	Antocianinas Flavonoles	Aleurone layer	Prevent oxidative stress, fibrosis and cell aging
Carotenoids	b-caroten, b-cryptoxanthin, a-caroten	Endosperm of yellow maize	Provitamin A activity
Xanthophils	<i>Lutein Zeaxanthin</i>		Prevent macular degeneration. Antioxidant.
Phytoestersols	Sitosterol, Stigmasterol Campesterol	Germ, pericarp, aleurone layer	Reduce cholesterol
Lecitin and Colin	Phosphatidil colin, ethanol amin, inositol, and serine	Germ	Cell aging. Reduce cholesterol
Policosanols	Octacosanol Tricontanol Hexacosanol Dotriacontanol	Pericarp and germ	Reduce cholesterol
Zn	Mineral		Conversion of Pro Vit A to Vit A-essential for vision
Sulfur cont. amino acids	Lys, Trp	Endosperm/Germ amino acids	Improve essential amino acids balance

Functional Flours

“Development of targeted Functional properties by design”

Grain Formulation

“Corn”

Rice

Wheat

White Sorghum

Pearl Millet

White & Red

White Quinoa

Sunflower

Masa

Corn & Sorghum

Others

Processing Tech

Grain fractionation

Thermoplastic Cook

Low Shear Cook

Medium Shear Cook

High Shear Cook

Hot air puffing

“Masa Tech”

Functional Property

Water Absorption

Adhesiveness

Cohesiveness

Swelling

Suspensions

Binding

Stabilizers

Thickeners

Extenders

Food Application

Breakfast Food

Snacks

Drinks

Fillings

Coating

Baking

Crackers

Cookies

Batters

“Tortillas & Chips”

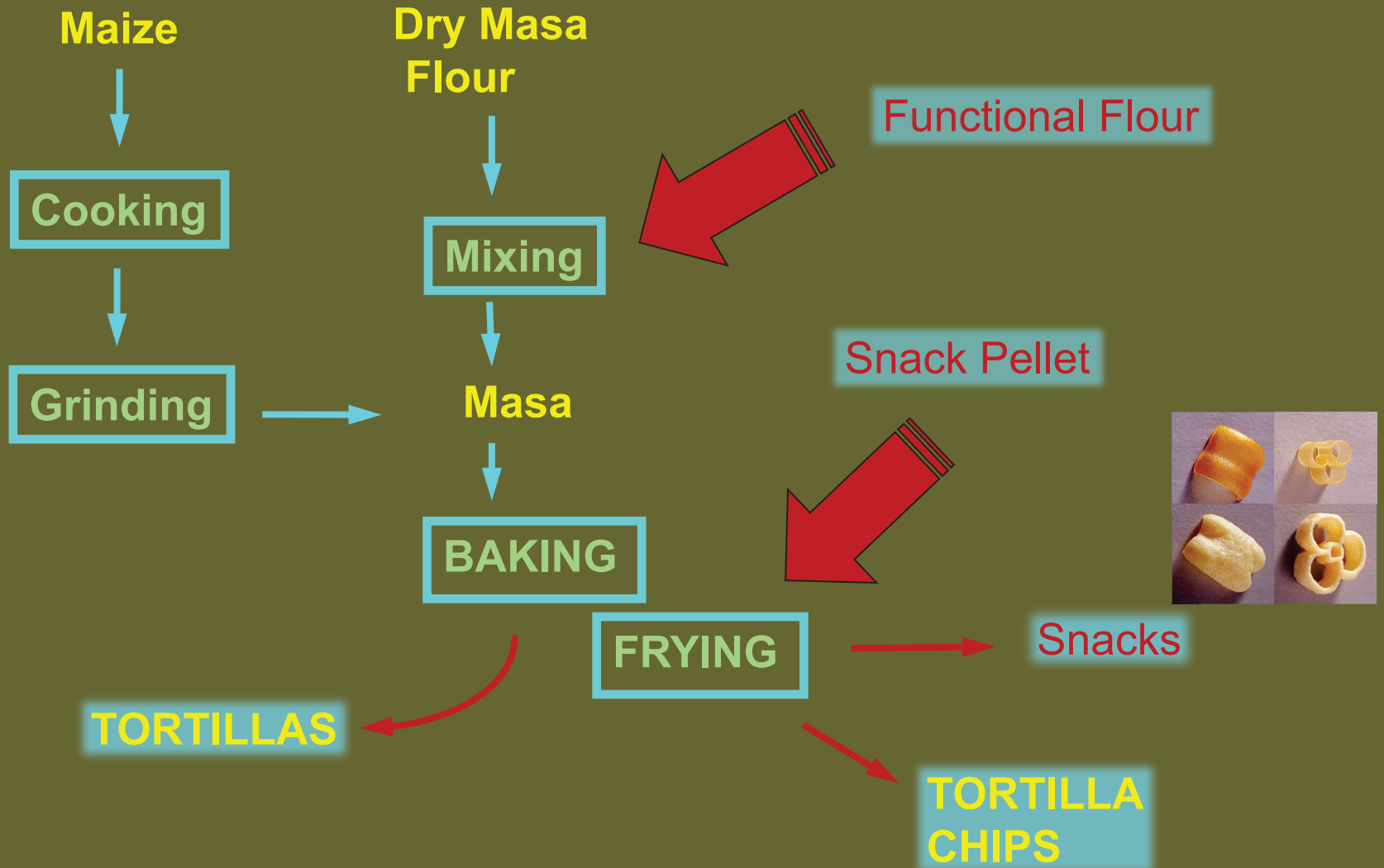
Ancient grain / Whole grain Tech Challenges

- Innovation / Expansion Strategies.
- Food Sensory attributes – targeted
- Cost management vs Benefit
- Production processes and controls tailored for effectiveness
- Ingredient legend, label



Improve technologies for processing whole grains to create more palatable whole grain food products that consumers will ENJOY!

INNOVATION OPPORTUNITIES FOR CORN TORTILLA TECHNOLOGY



Questions ?

- **Corn Tortillas & Snacks**
- **Grains of Cereals & Beyond**
- **Ingredient Functionality**



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