3rd International Conference & Exhibition on Nutrition & Food Science
Track 6: Food Processing and Technology
Valencia – September 23-25, 2014

Gluten-Free Extruded Lentil –based Snacks Rich in Dietary Fiber and Protein

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USDA-ARS-WRRC

ACKNOWLEDGEMENT

Organizing Committee Members of the
3rd International Conference on Nutrition & Food Sciences

Pulses

Food and Agricultural Organization of the United Nations (FAO):

"Annual leguminous crops yielding from one to twelve grains or seeds of variable size, shape and color within a pod, harvested solely for the dry grain."

EXCLUDES

green beans and green peas, considered vegetable crops

crops mainly grown for oil extraction (soybeans and peanuts)

crops used exclusively for sowing (clovers, alfalfa)

FAO recognizes 11 primary pulses

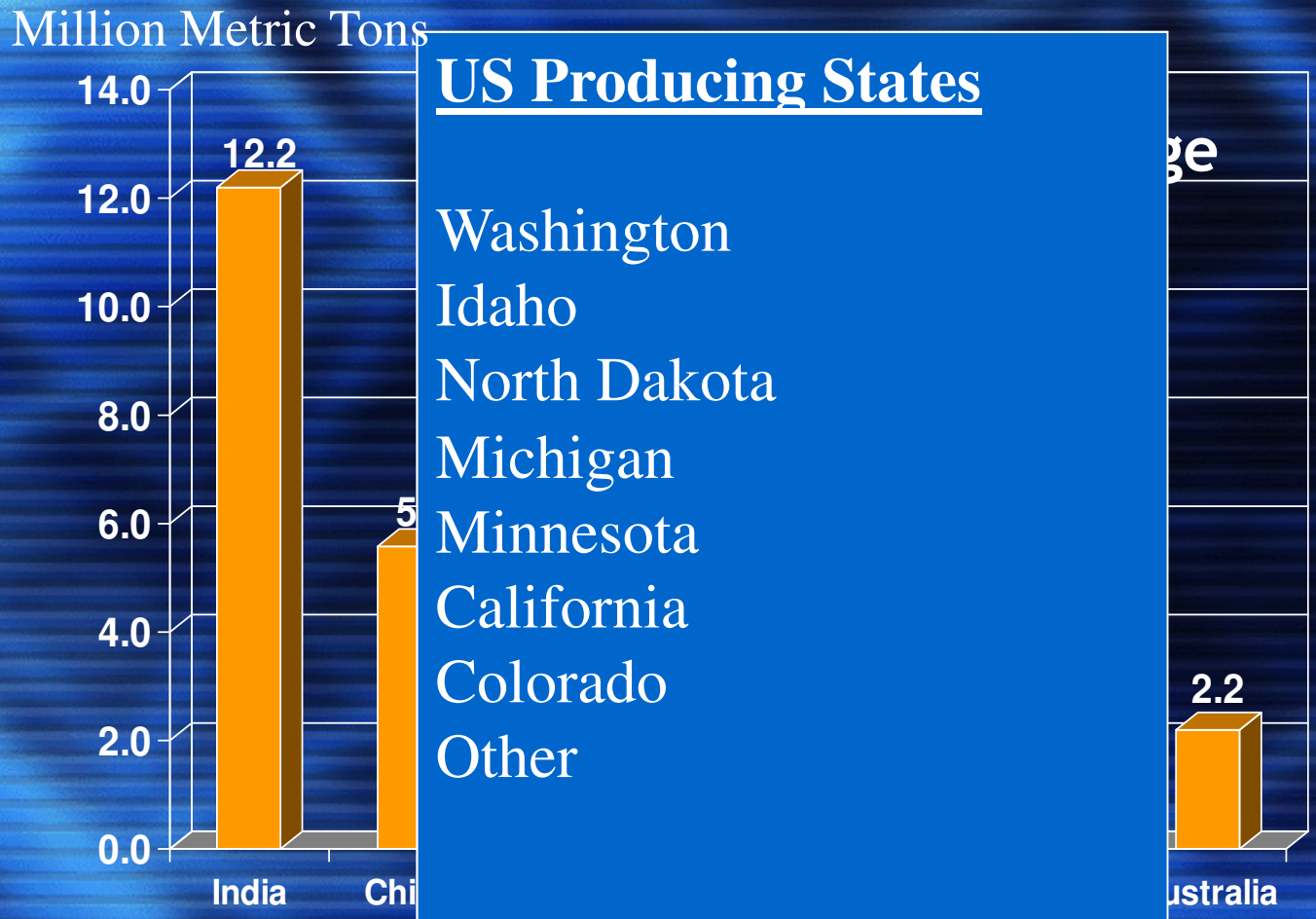
Dry beans (*Phaseolus spp,* including several species now in *Vigna*)

Dry peas (*Pisum spp*.)

Lentils (*Lens culinaris*)

Chickpea, Garbanzo, Bengal gram (*Cicer arietinum*)

Largest Producers of Pulses in the World



US Producing States

Washington
Idaho
North Dakota
Michigan
Minnesota
California
Colorado
Other

Gluten containing (forbidden grains) and Gluten Free Flours

Gluten Containing Flours

- Wheat
- *Barley*
- Rye
- Oat

(W-BRO)

Gluten-Free Flours, Cereals and Starches

- Pulse flours *(beans, lentils, chickpea/garbanzo, pea)*
- Corn, Sorghum, Amaranth, Buckwheat
- Rice *(black, brown, glutinous/sweet, white, wild)*
- Tapioca *(cassava/manioc),* Sweet Potato Flour
- Potato Flour, Potato Starch
- Quinoa**, Soy, Teff, Sago
- Nut flours *(almond, hazelnut, pecan)*

***American Journal of Clinical Nutrition, 96(2): 337-344,* published August, 2012
"Variable activation of immune response by quinoa (Chenopodium quinoa Willd.) prolamins in celiac disease". Zevallos VF1, Ellis HJ, Suligoj T, Herencia LI, Ciclitira PJ.

Gluten & the Coeliac Disease

- Gluten: common name for the natural proteins gliadins and prolamins present in wheat, barley and rye, and also contaminated oats.
- Coeliac Disease: Digestive disease that damages the small intestine and interferes with absorption of nutrients from food. People who have coeliac ("celiac") disease cannot tolerate gluten.

Symptoms of coeliac disease vary from person to person. Symptoms may occur in the digestive system or in other parts of the body. Digestive symptoms are more common in infants and young children and may include:

- abdominal bloating and pain
- chronic diarrhea
- vomiting
- constipation
- pale, foul-smelling, or fatty stool
- weight loss

Malabsorption of nutrients, during the years when nutrition is critical to a child's normal growth and development, can result in other health problems.

Adults are less likely to have digestive symptoms and may instead have one or more of the following:

- unexplained iron-deficiency anemia
- fatigue
- bone or joint pain
- arthritis
- bone loss or osteoporosis
- depression or anxiety
- tingling numbness in the hands and feet
- seizures
- missed menstrual periods
- infertility or recurrent miscarriage
- canker sores inside the mouth
- an itchy skin rash called dermatitis herpetiformis

People with coeliac disease may have no symptoms but can still develop complications of the disease over time. Long-term complications include malnutrition—which can lead to anemia, osteoporosis, liver diseases, and cancers of the intestine, among other health problems.

Market for Gluten-Free foods and beverages in the US valued $2.64 bn in 2010 and is due to reach about $5.5bn by 2015, as 1 in 133 consumers suffer from Coeliac Disease.

Package Facts report 2011; US Department of Agriculture.

Nutritional & Health Value of Pulses

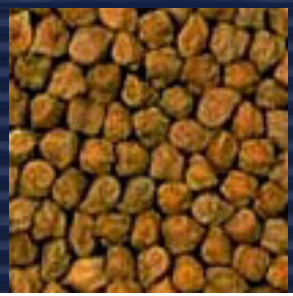
1. High in Protein and Cpx Carbs
2. High in Dietary Fiber
3. High in Phytonutrients: ACN, PPC, Car
4. High in Vitamins: B Cpx & Folic acid
5. High in Minerals: Fe, Ca, K, P
6. Low in Fat
7. "Gluten Free"

Dry Beans

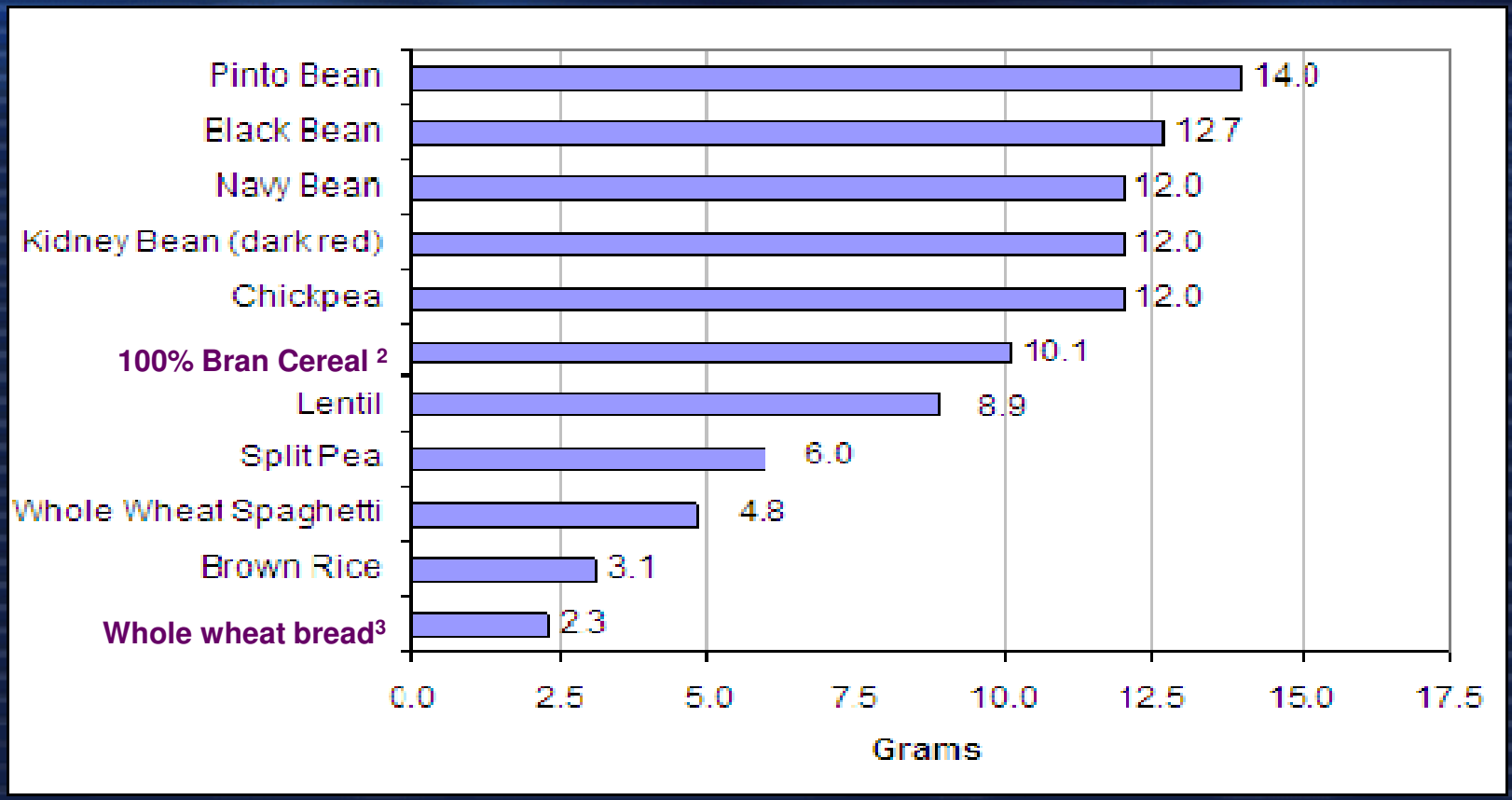
Lentils

Dry Peas

Garbanzo



Pulses are High in Fiber



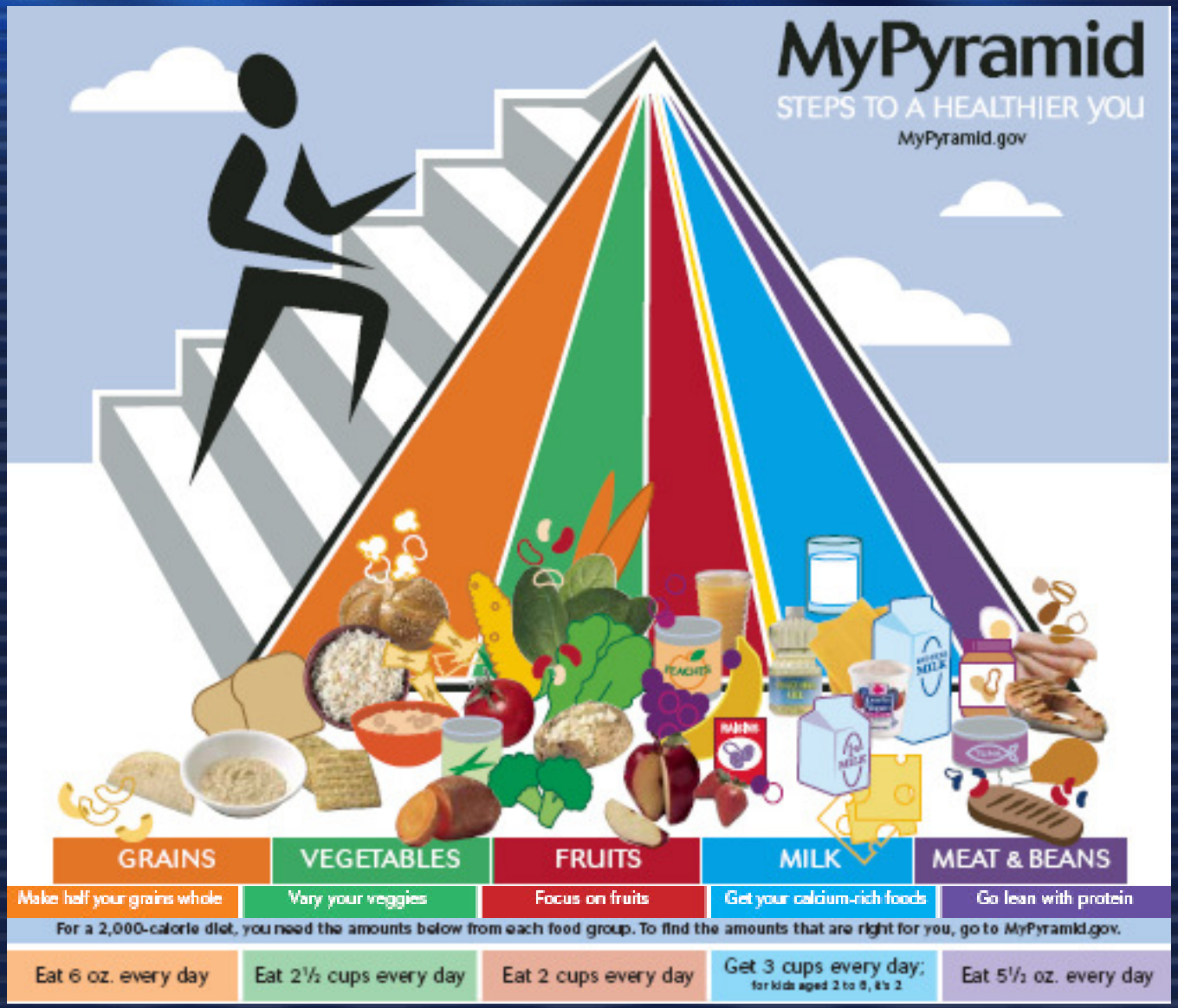
1. Source: Canadian Nutrient File (CNS) 2001b, Health Canada; Serving size = 1 cup boiled unless otherwise indicated.
2. 30 g
3. 1 slice

Dietary Fiber Function & Benefits

Functions	Benefits
Attracts water and turns to gel during digestion which traps carbohydrates and slows absorption of glucose	Lowers variance in blood sugar levels
Lowers Total and LDL cholesterol	Reduces risk of heart disease
Regulates blood sugar	May reduce onset risk, or symptoms of, metabolic syndrome and diabetes
Balances intestinal pH and stimulates intestinal fermentation production of short-chain fatty acids	May reduce risk of colorectal cancer
Speed the passage of foods through the digestive system	Facilitates regularity
Adds bulk to the stool	Alleviates constipation
Adds bulk to your diet which makes you feel full faster	May reduce appetite

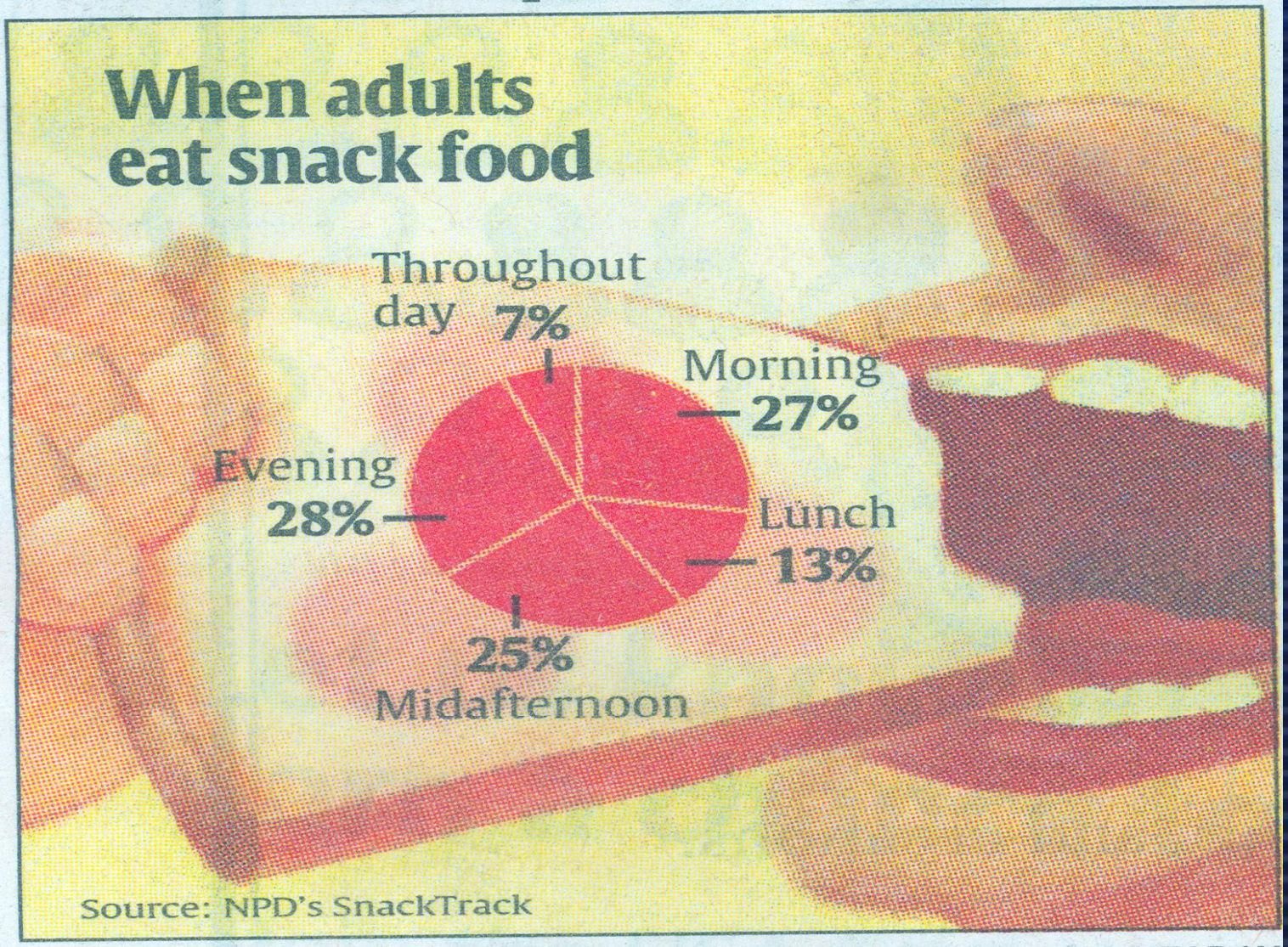
- Soluble fiber only
- Insoluble fiber only
- Both soluble & insoluble fiber

The Food Pyramid



USA TODAY Snapshots®

When adults eat snack food



Source: NPD's SnackTrack

By Anne R. Carey and Keith Simmons, USA TODAY

Food Choices from the Top of Food Pyramid

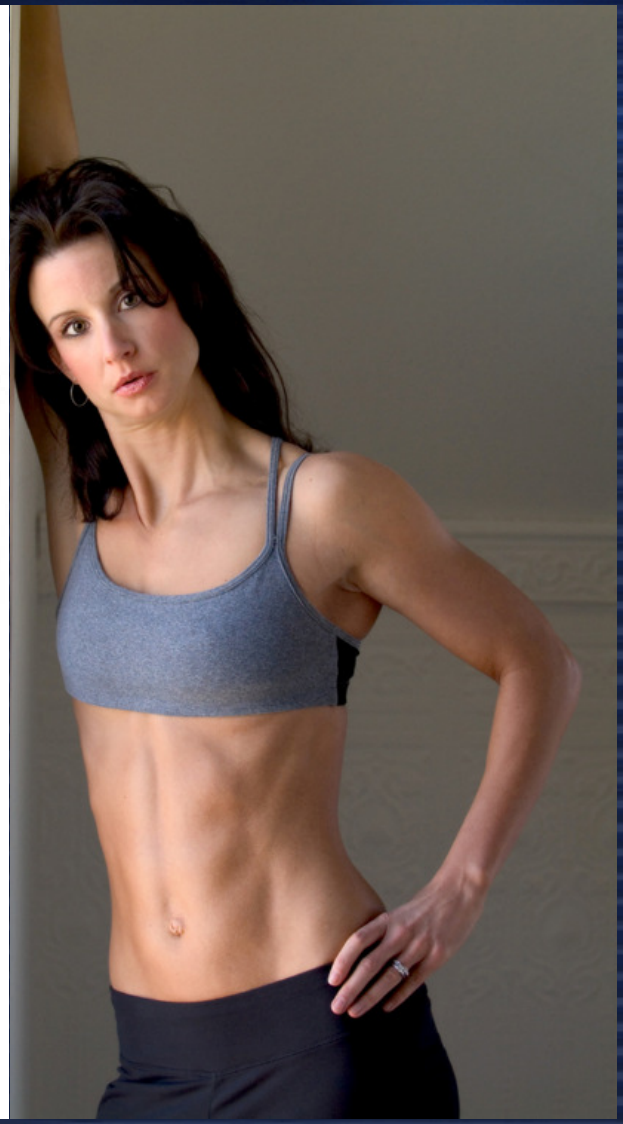
First Lady and HHS announce obesity initiative

First Lady Michelle Obama and the Department of Health and Human Services (HHS) announced an initiative to reduce overweight and obesity in children and adults.

Mrs. Obama, HHS Secretary Kathleen Sebelius, and Surgeon General Regina Benjamin plan to help Americans lead healthier lives through better nutrition, regular physical activity, and by encouraging communities to support healthy choices.

Food Choices from the Bottom of Food Pyramid

"The Surgeon General's vision for a healthy and fit nation"



Global Market (billion USD)

Category	Projected Value by 2012 (billion USD)	
Savory Snack Industry:	61.5	*(CAGR: 3.7%)*
Breakfast Cereal Industry:	26.2	*(CAGR: 3.1%)*
Functional Foods:	90	*(CAGR > 4%)*
Gluten Free:	2.5	*(CAGR > 5%)**

*: Faster growth - $4.2 bn by end of 2012 and $6.6 bn (CAGR > 20%) in **2017**

Whole Grain and High Fiber food market - $27.6bn by **2017**

Source: Datamonitor

Food Products Suited to be Made from Legume Pulse-Based Formulations

Product attributes

♪ : High in Protein & Dietary Fibers

♪ : High in Cplx Carbs & Resistance Starch

♪ : High in Vitamins: B Cplx & Folic Acid

♪ : High in Minerals: Fe, CA, K, P

♪ : Very low in Fat, Sodium & Sugar

RTE Snacks and B-Cereal type products, as good vehicles for delivering Nutrients & Healthy components in: Convenient, Attractive, & Tasteful Gluten-free form

What Products are Made on an Extruder?

Food:

- Breakfast cereals
- Snack foods
- Flat bread
- TVP
- Caseinate
- Corn flakes
- Chocolate
- Spices
- Your products….
- Starch
- Instant foods
- Modified starches
- Swelling starch
- Instant flours
- Filled tubes

Shapes:

- Flakes
- Rings
- Stars
- Tubes
- Rods
- Spheres
- Granulates
- Alphabet
- Pictures

Feeds:

- Pets
- Cat food
- Fish Feed
- Your products…
- Calf fattening feed
- Extruded corn
- Extruded barley
- Extruded wheat
- Debittered soya
- Extruded soya

Objectives

Development of gluten-free, nutritious lentil-based expanded extruded snacks and evaluate the effect of adding different sources of dietary fiber into the formulations with respect to:

- Acceptability of developed value-added snack-type products
- Expansion characteristics, nutritional value, shelf stability, and color of the fiber-fortified expanded extruded products

Materials & Methods

Materials & Methods

Raw Materials

- **Lentil (*Lens culinaris*)**
- **Wheat bran (WB)**
- **Apple pomace (AP)**
- **Nutriose (N)**
- **Whole grain corn flour (WGCF)**

Formulation & Extrusion Processing

Texture Modifiers

H_2O Starches Emulsifying agents

Salt + Sweeteners

Flour

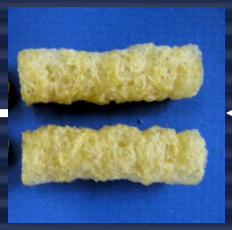
Fibers

Ground To Flour

Pulse-Based Formulation

Formulation: Continuous Mixer

Twin Screw Extruder



Extrudates

Cooling/ Drying/ Toasting

Flavoring

Packaging

Materials & Methods

- **Expansion Ratio:** cross-section area extrudate/cross-section area die
- **Bulk Density:** Volume extrudate/Mass extrudate

Pilot Plant-Scale, Co-rotating 32 mm Twin Screw Extruder

Processing capacity: 50⁺ kg/h & Screw speed: 1,200 rpm

Materials & Methods

Sensory Evaluation: 7-point hedonic scale

-Overall liking: taste/flavor, texture and appearance.

3 stages

-Stage 1 & 2 – "bench top" scale, 10 untrained panelists choosing best 6 of 14 extruded products.

- Stage 3 – BIB Rating Test, 65 untrained panelists choosing best 4 extruded products.

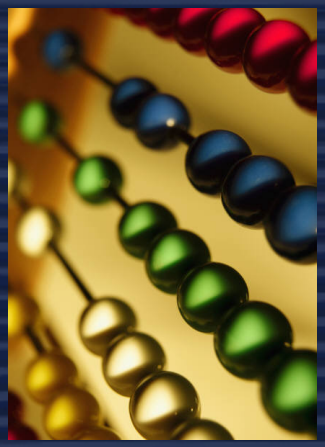
Dietary Fiber: AOAC Intl., 18th ed., Method 991.43

Proximate Analysis: AACC (1984) and AOAC (1990) Standard Methods

Water Activity: AquaLab CX-2

Color: Minolta CM-508D. hue angle = arctan (b*/a*)

RESULTS & DISCUSSION



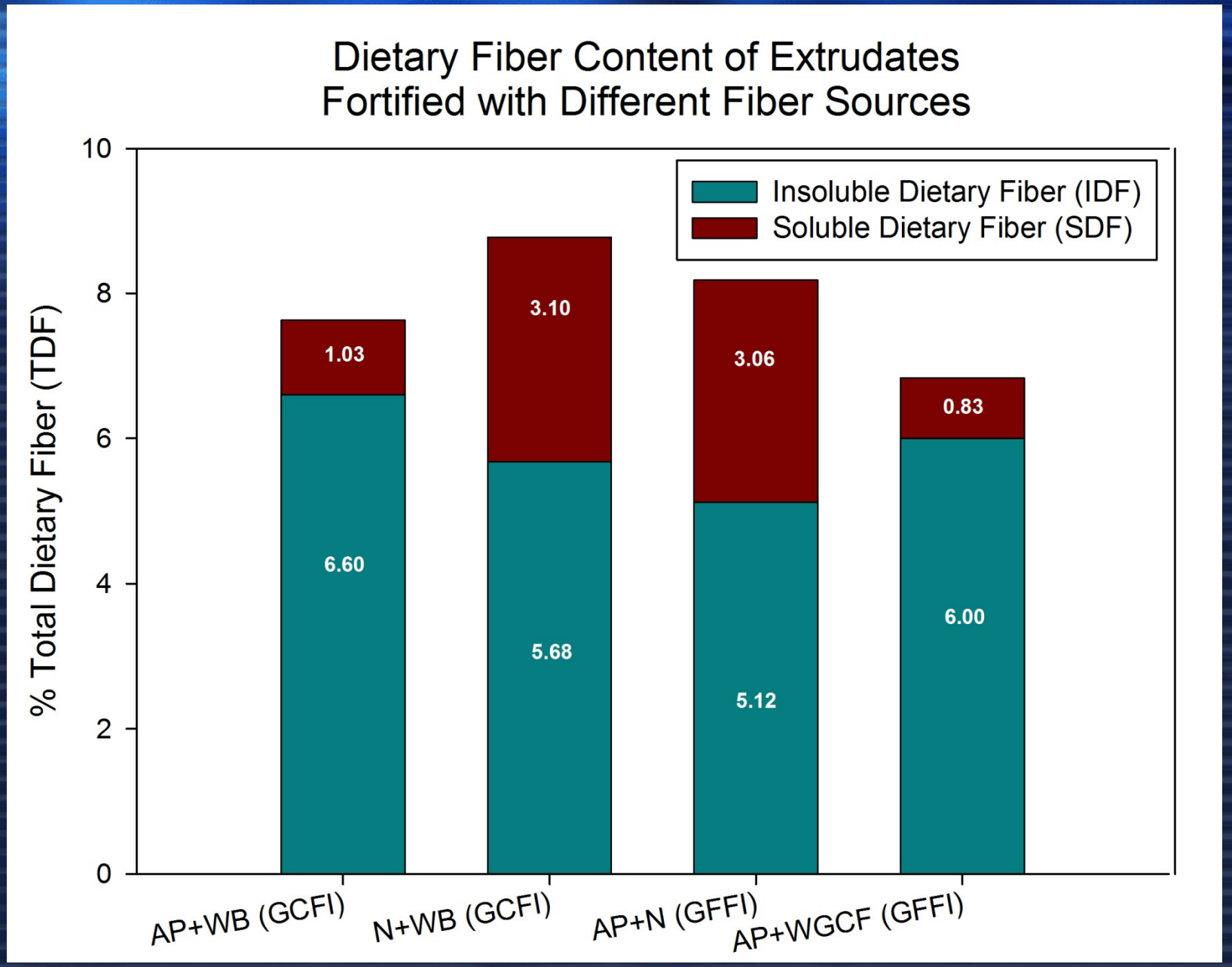
Sensory Evaluation Results

Description	N	Mean
AP+WB (GCFI)	65	4.969[a]
N+WB (GCFI)	65	5.169[a]
AP+N (GFFI)	65	5.292[a]
AP+WGCF (GFFI)	65	5.138[a]

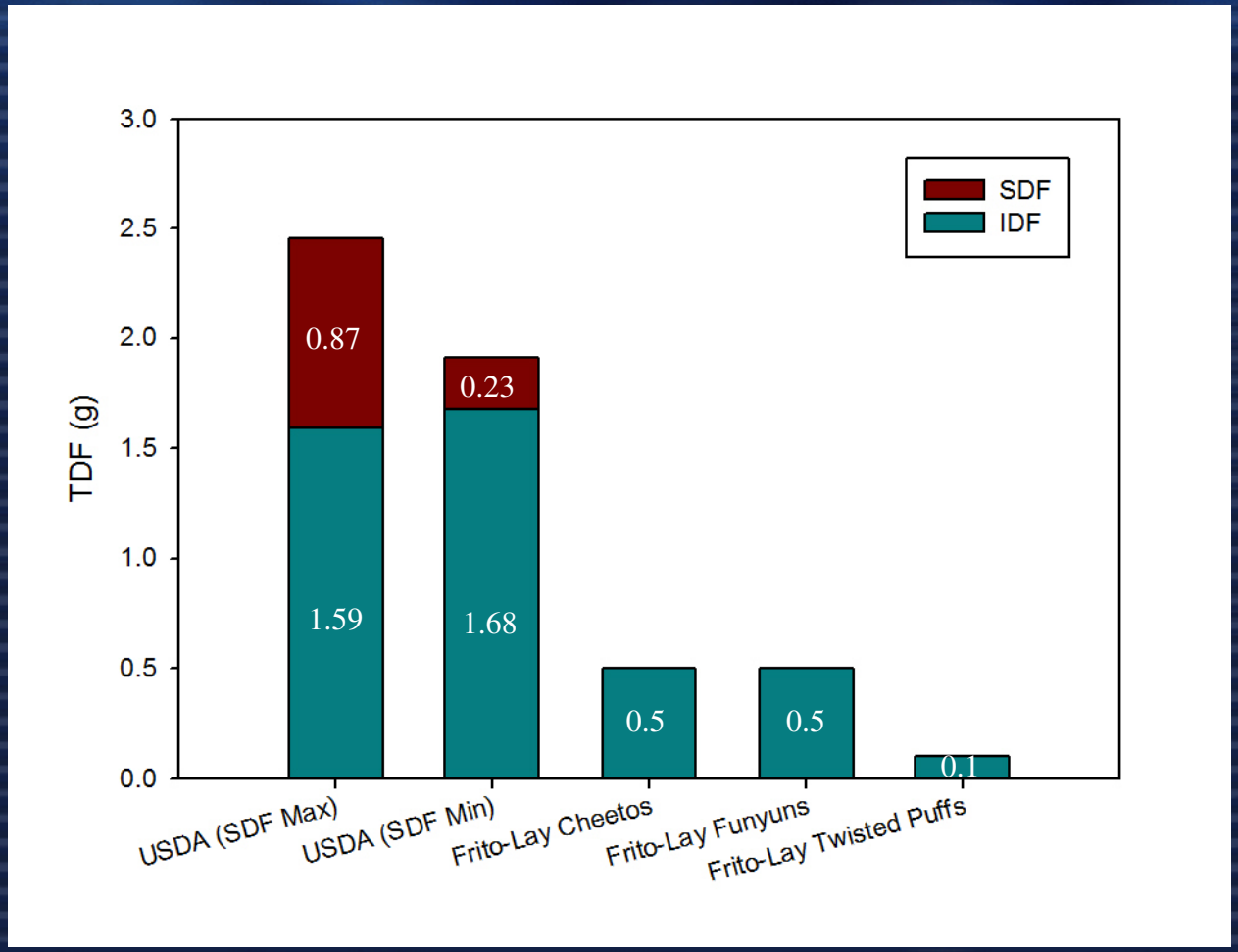
USDA (Lentil-based)

vs

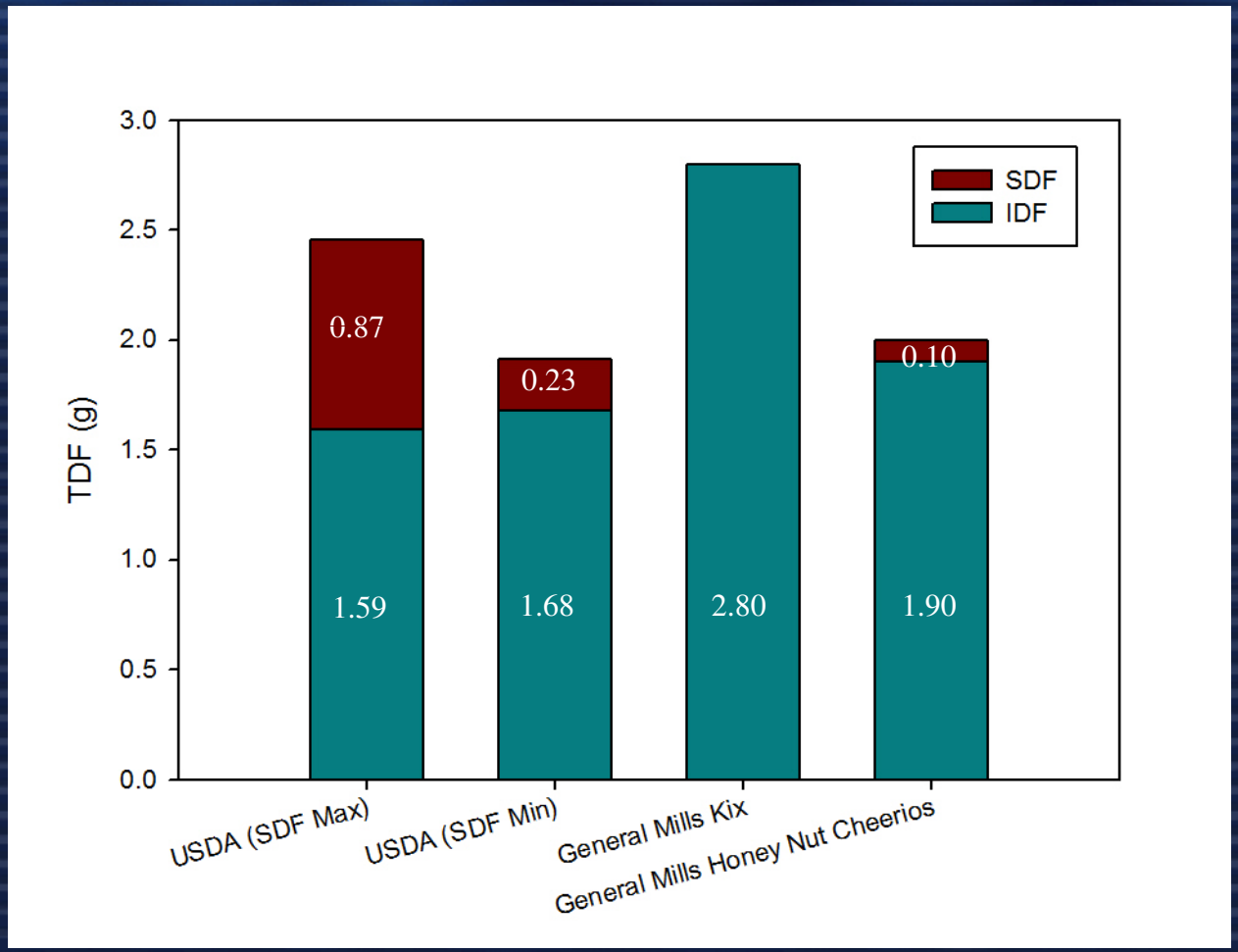
Commercial Expanded Snacks & Breakfast Cereal Products

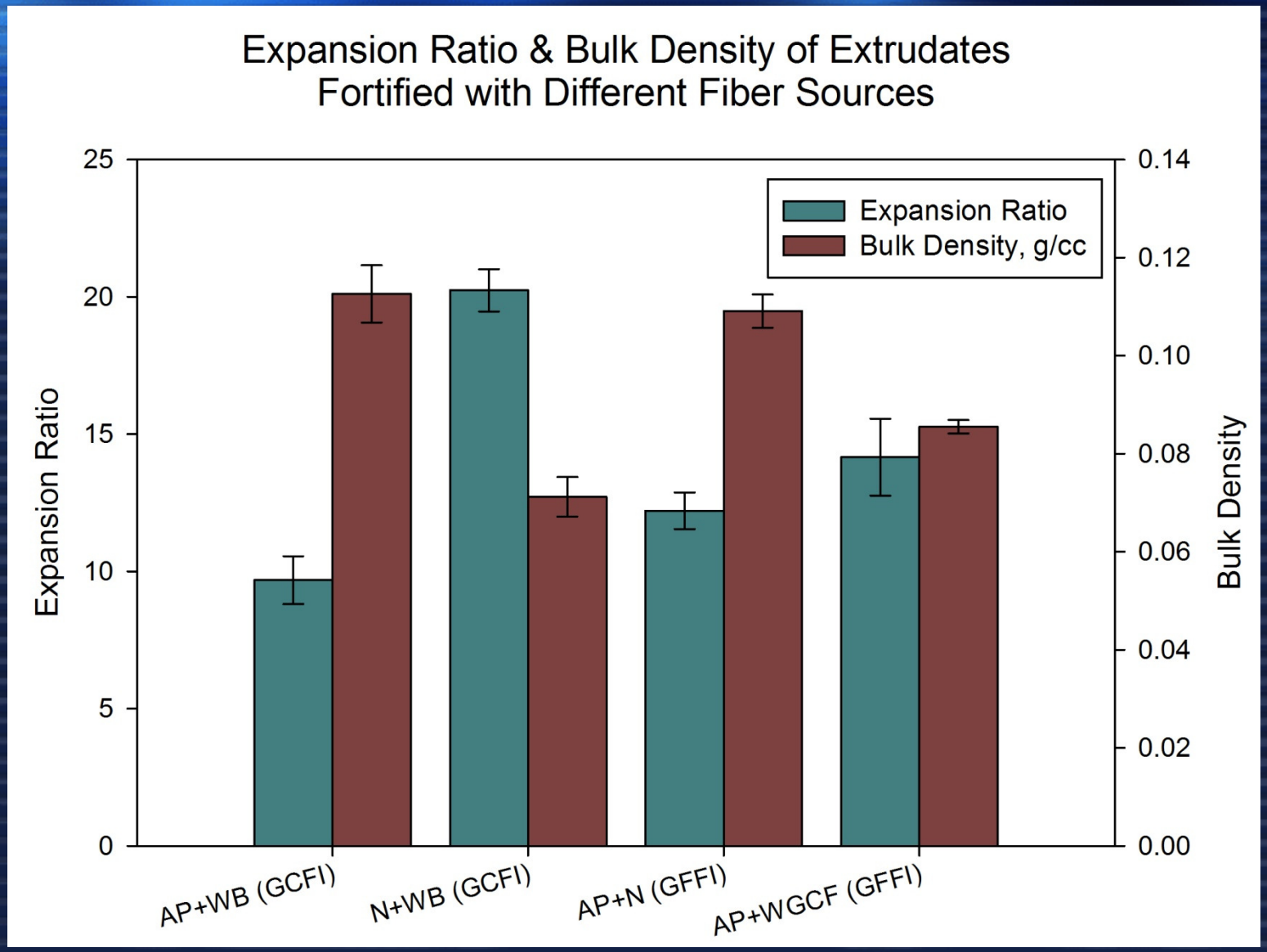

Dietary Fiber Content of Extrudates
Fortified with Different Fiber Sources
% Total Dietary Fiber (TDF)
10
8
6
4
2
0
Insoluble Dietary Fiber (IDF)
Soluble Dietary Fiber (SDF)
1.03
6.60
3.10
5.68
3.06
5.12
0.83
6.00
AP+WB (GCFI)
N+WB (GCFI)
AP+N (GFFI)
AP+WGCF (GFFI)

TDF Content of Snack-type foods (28 g serving)



TDF Content of Cereal Breakfast-type foods (28 g serving)




Expansion Ratio & Bulk Density of Extrudates
Fortified with Different Fiber Sources
Expansion Ratio
Bulk Density, g/cc
Expansion Ratio
Bulk Density
25
20
15
10
5
0
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
AP+WB (GCFI)
N+WB (GCFI)
AP+N (GFFI)
AP+WGCF (GFFI)

Proximate Analysis - Range of nutritional values among GFFI and GCFI:

Protein:16.1-18.3%

Ash 3.5-4.0%

Fat: 0.2-0.5%

carbohydrate 68.2-70.2%

Moisture 8.8-9.5%

Water Activity - Range of Aw values among GFFI and GCFI samples was 0.44-0.48, which is similar to dehydrated foods.

Color - Hue values for all the samples were very similar, from 87-88°, except for the formulation containing WGCF which was slightly lower at 83°.

- Sensory evaluation demonstrated that the novel, value-added, and expanded extruded lentil-based snacks fortified with GFFIs had a desirable crunchy texture and were highly

U.S. Patent Application:

"Extruded Legumes"

Serial No. 11/64,1318

- Based on Aw values, all extruded snacks are considered safe, shelf-stable products.
- Hue values ("pure colors") represented a desirable tan color.

rich in dietary fiber made as RTE snacks and breakfast cereals, would provide a suitable, healthy and safe food alternative to the large population suffering of the Coeliac Disease and/or gluten sensitivity and gain a share in the increasing market of Gluten-Free products.

That tastes good! Let me try another one!!!

My Students love the Pulse Snacks!

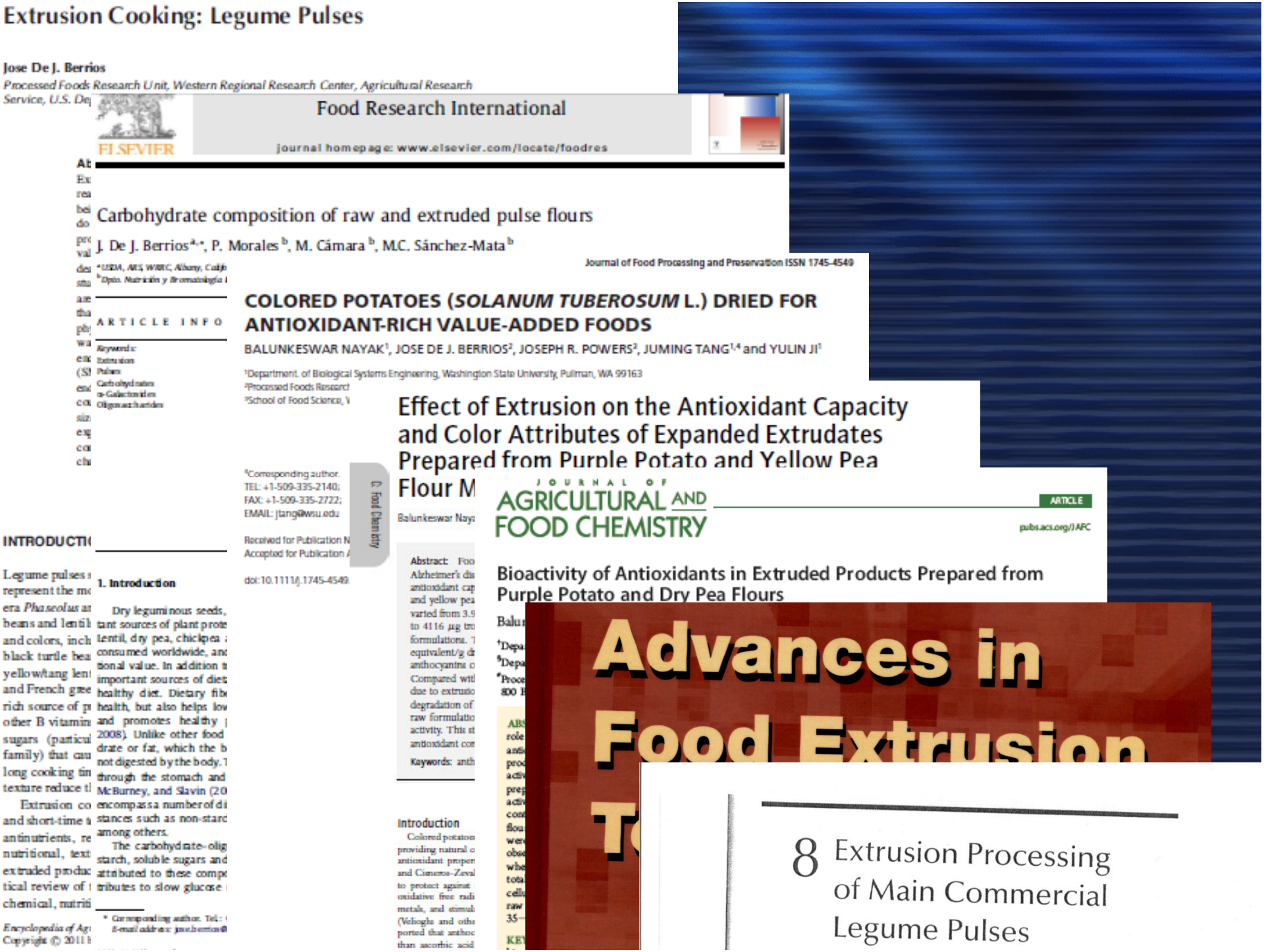
Children love our product!

Acknowledgment

Mr. James Pan
Chemist,
Extrusion Program
Processed Foods Research Unit

Matthew Tom
Industrial & Systems Engineering
Extrusion Program
PFRU

My working team



Extrusion Cooking: Legume Pulses

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journal homepage: www.elsevier.com/locate/foodres

Carbohydrate composition of raw and extruded pulse flours

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Pulses
Carbohydrates
α-Galactosides
Oligosaccharides

INTRODUCTI

1. Introduction

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COLORED POTATOES (*SOLANUM TUBEROSUM* L.) DRIED FOR ANTIOXIDANT-RICH VALUE-ADDED FOODS

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Effect of Extrusion on the Antioxidant Capacity and Color Attributes of Expanded Extrudates Prepared from Purple Potato and Yellow Pea Flour M

Balunkeswar Nay

Abstract:

Keywords:

Introduction

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

ARTICLE

pubs.acs.org/JAFC

Bioactivity of Antioxidants in Extruded Products Prepared from Purple Potato and Dry Pea Flours

Balu

Advances in Food Extrusion T

8 Extrusion Processing of Main Commercial Legume Pulses


WRRC
Thank You!!
FreeFoto.com

Where do we go from here?

Generate the interest of product manufacturers in using legume pulses to produce value added food products

Join Venture: Match industry needs with research capabilities & Support transfer of technology

- Ø Obesity
- ♥ Heart disease
- ♦ Diabetes type 2
- ● Colon cancer

Promote the consumption of legume pulses!!

Available Products from Legume Pulses

- Whole Pulses
  - canned, micronized, split, flaked
- Products made with Whole Pulses
  - soups, chilis, refried beans, frozen entrees, snack mixes, roasted and fried snacks
- Ground Pulses

  - Flours or powders
- Products made with Ground Pulses

  - specialty bakery mixes, vegetarian foods (frozen entrees, vegi burgers), and dips
- Pulse Ingredients
- - Pea: protein [c] & (Isolate), starch, and fiber
- Products made with Pulses Ingredients
- -Possible used in similar products as indicated for Ground Pulses, when used as ingredients

Food Products Suited to be Made from Legume Pulse-Based Formulations

- Expanded Snacks and Breakfast Cereal-type food products
- High rehydration rate dry flours: soups, dips, sauces
- Healthy and nutritious ingredients for food formulations
- Beverages – "Drink your Pulses"

"Gluten-free products & Special Dietetics foods"

Snack bars

- Crackers
- Bakery products: bread, flatbread, biscuits
- Muffins: high fiber
- Breading and Batters
- Special pastas: spaghetti and noodles
- Baby & weaning foods: porridge-soup like preparations
- Tortillas

Back

Potential Products made with Pulses Ingredients based on their functionality

Protein: - Meat analogs/alternatives of different types (beef, chicken, fish); cheese type foods ("tofu"); instant soups ("miso", other types); fortification in bakery and confectionary products, yoghurts, drinks, industrial "non-food" applications, others…

Starch: - thickening agents; coating applications, industrial "non-food" applications (packaging, fillers, biofuel), others…

Fiber: - fortification in bakery and confectionary products, yoghurts, drinks, industrial "non-food" applications, others…

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