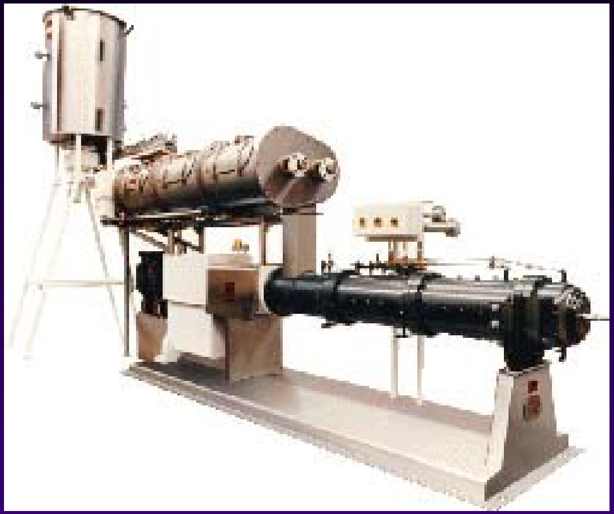
Utilization of Sorghum in Extruded Products



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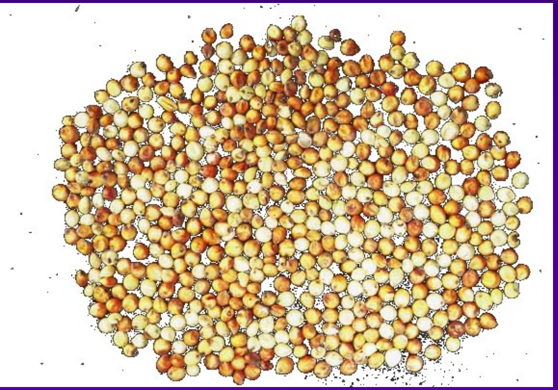


LACC4, Mexico City
March 12, 2018

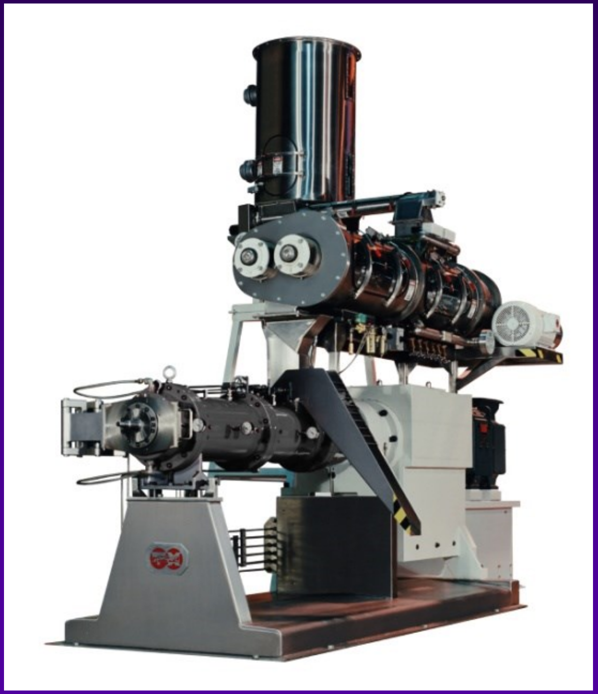
Extrusion as Sustainable Processing Technology

extrude \ik-'strüd\ vb

(Webster's Ninth New Collegiate Dictionary)

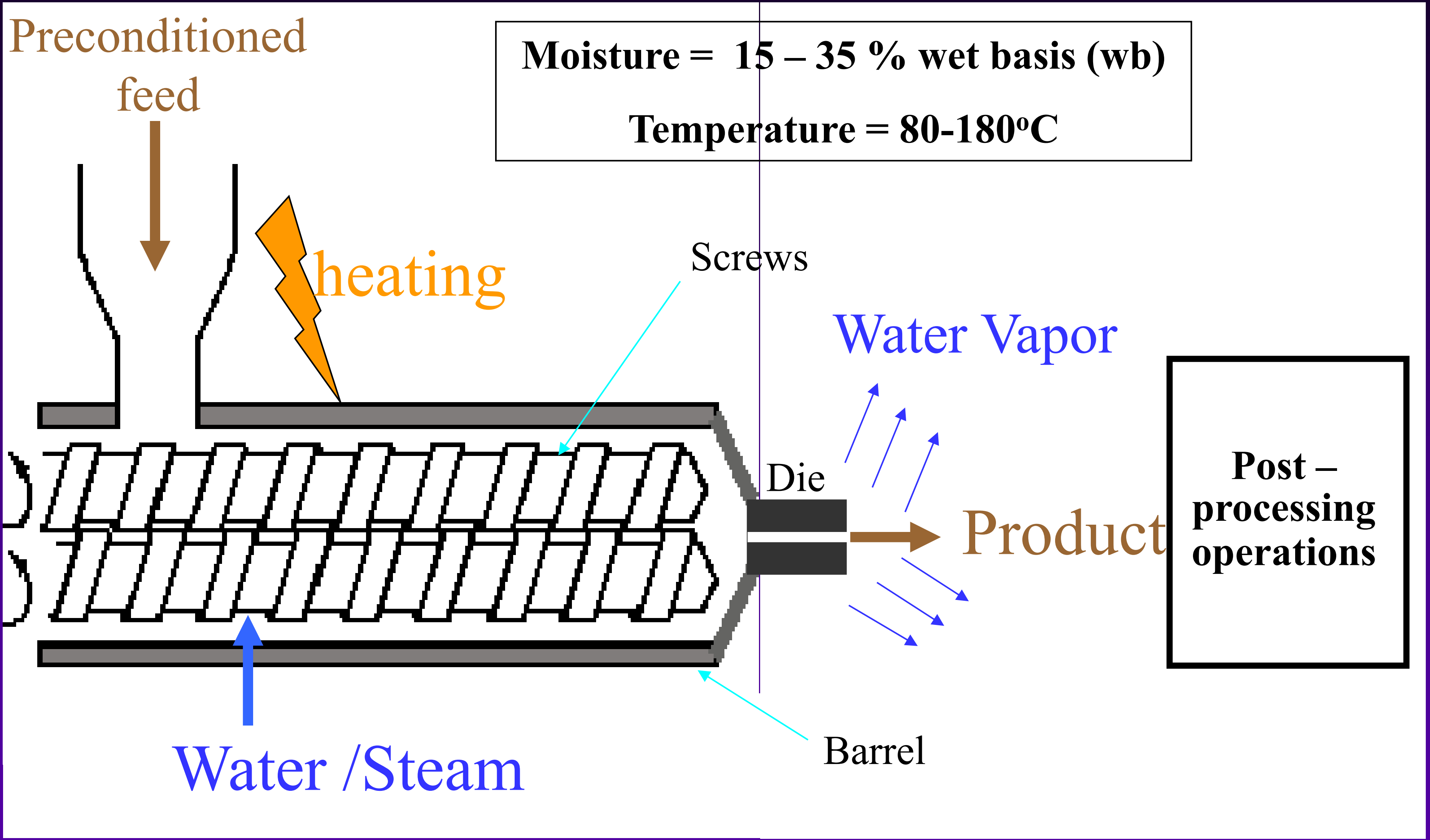
Origin – Latin *extrudere* – to thrust

1. to force, press or push out
2. to shape by forcing through die

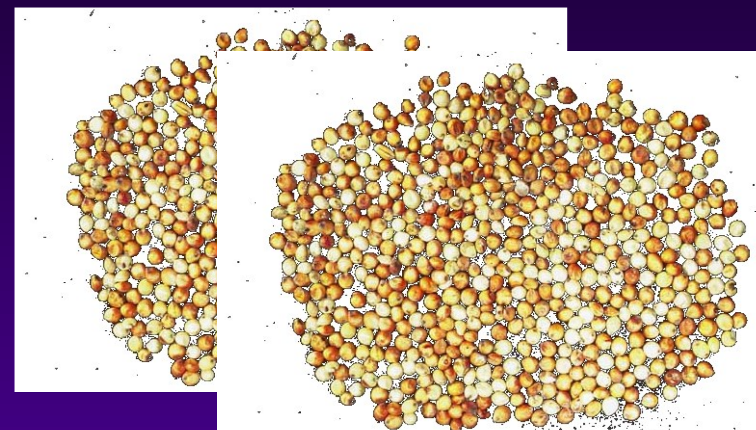


extruder \ik – 'strüd-ər \ n

Extrusion cooking



Grain Sorghum and Co-Products as an Ingredient in Value-Added Applications



Expanded Snacks and Breakfast Cereal

Pasta

Sorghum Protein Concentrates

Up to 85% protein content; high functionality in baked goods and beverage applications

Pre-Cooked ‘Rice Analog’

Corn
+ Wheat

Sorghum
+ Wheat

Pre-Cooked 'Bean Analog'

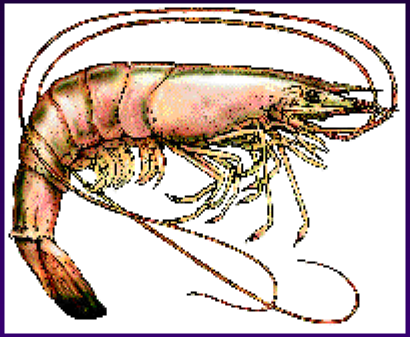
Sorghum
+ Wheat
+Soybean

KS Grain Sorghum Commission 2010-11

Sorghum-Based Fortified Blended Foods

United Sorghum Checkoff Program 2011-13
KS Grain Sorghum Commission 2011-12
USDA Foreign Agriculture Service 2012-16

Aquatic Feed (Sorghum DDGS)



Sorghum DDGS as replacement of soybean meal as protein source for Pacific white shrimp (trials done in Auburn Univ)

United Sorghum Checkoff Program 2011-13

Pet Food

Low digestibility and glycemic index of sorghum starch

United Sorghum Checkoff Program 2014-15

United Sorghum Checkoff Program 2015-17

‘Industrial’ Applications

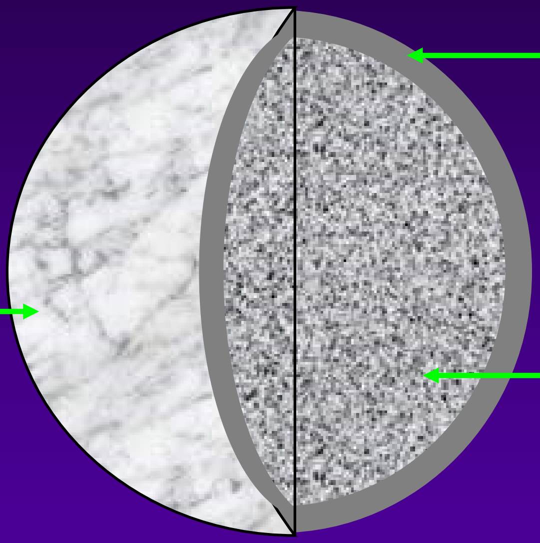
Loose fill for packaging (sorghum+<5%PVOH)

UNLOCKING SORGHUM PROTEINS VIA EXTRUSION

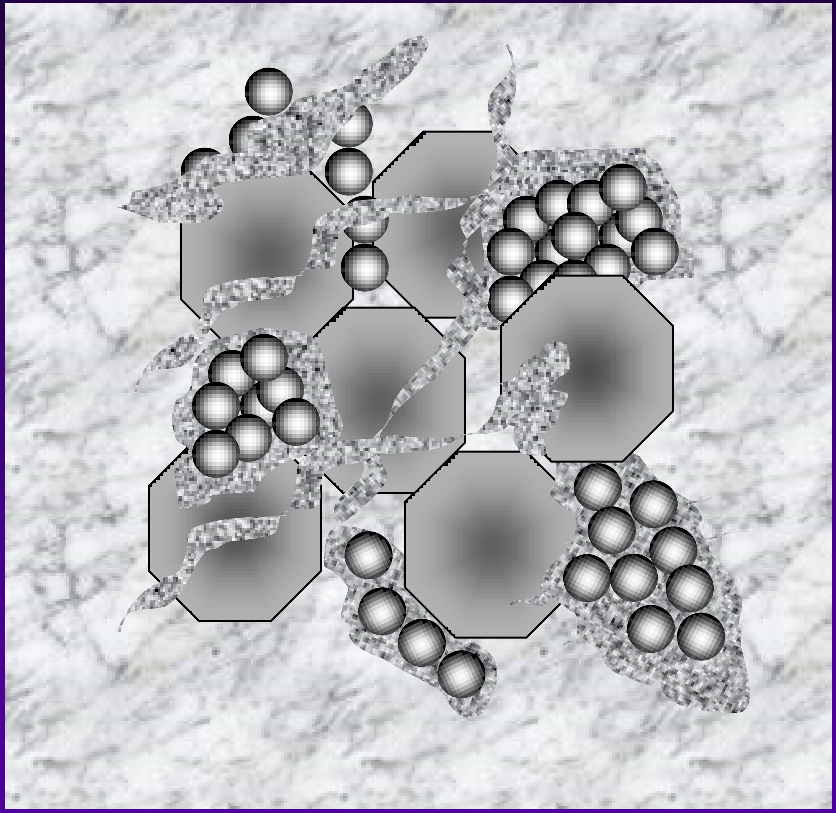
Properties of Kafirins

- ~70% of sorghum proteins; prolamins
- Hydrophobic; Soluble in non-polar solvents (60% t-Butanol; 70% Ethanol)
- Extracted with SDS
- pH 10 (typical); or very strong acid (glacial acetic acid)
- M_w of kafirins
  - α: 23-25 kDa; 66-84% of kafirins; easily digestible
  - β: ~18 kDa; 8-13% of kafirins; highly crosslinked
  - γ: ~20 kDa; 9-12% of kafirins; highly crosslinked
  - δ: ~13 kDa; not well-characterized

Sorghum protein body schematic



Protein bodies and starch granules are embedded in the glutelin matrix.



Sorghum Protein Digestibility

- Raw, condensed tannin-free, white sorghum:
  - 55.8 % (raw, whole grain)
  - 67.4 % (raw, decorticated)
  - 36.6 % (boiled, whole grain)
  - 39.4 % (boiled, decorticated)

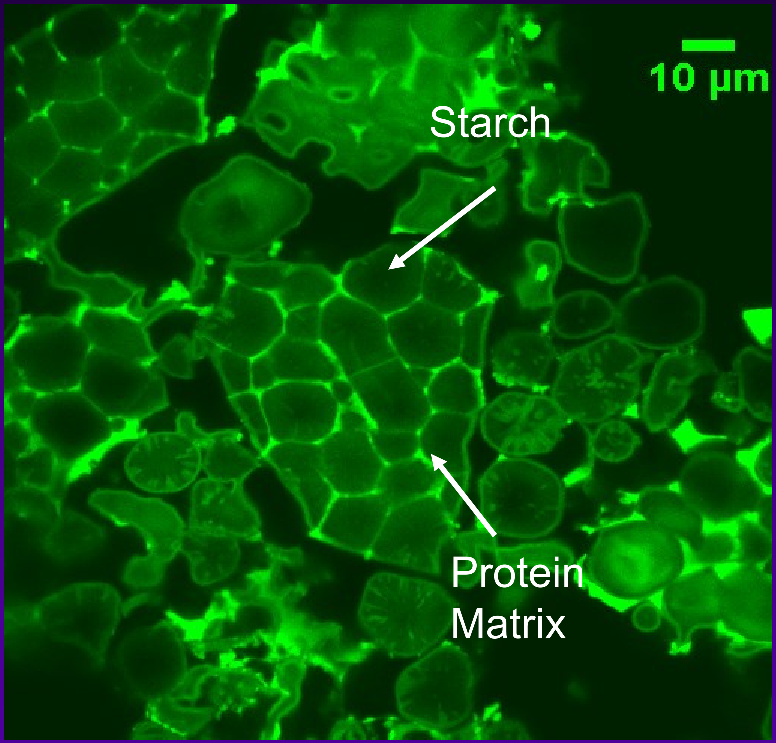
  (Duodu, 2002)

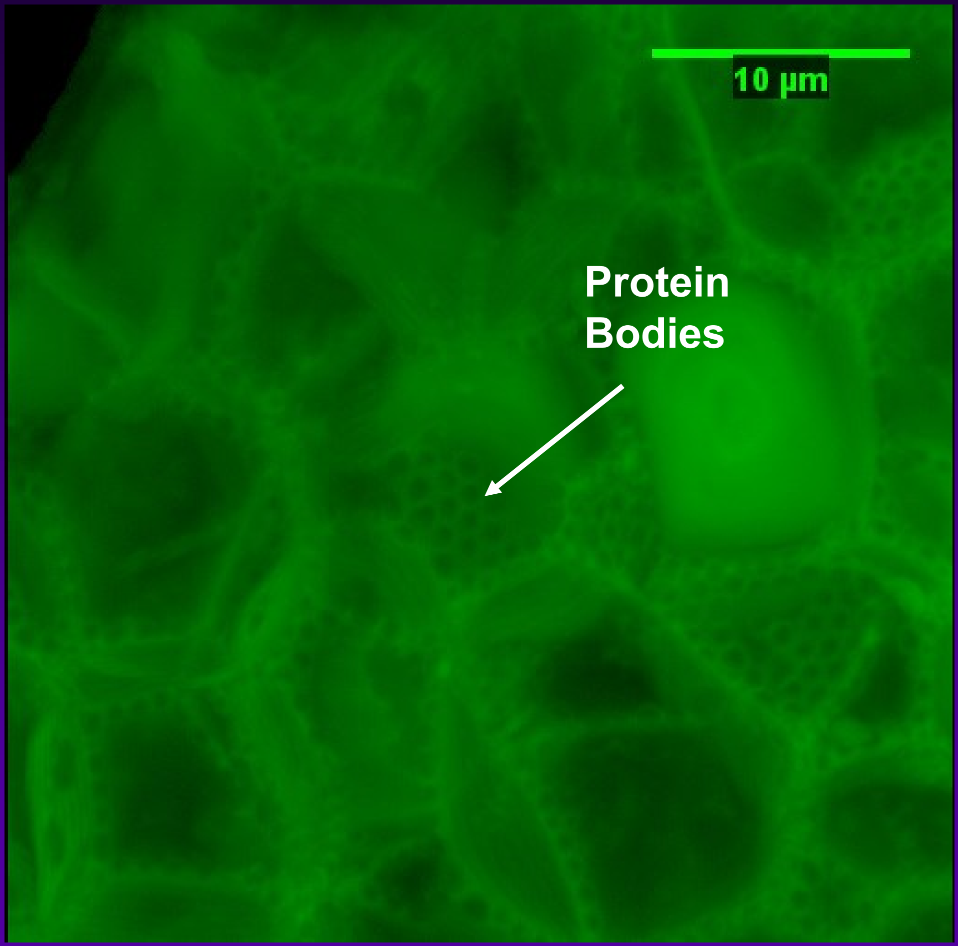
Wet cooking reduces protein digestibility.

Extrusion/ Dry Cooking improves *In Vitro* Protein Digestibility (IVPD)

- Extrusion -
  - 25% moisture, 200°C: increased IVPD to 75% of whole sorghum flour (Fapojuwo, 1987)
  - @ < 20% moisture, 177°C: increased IVPD from 61 to 70% of whole sorghum flour (Hamaker, 1994)
  - Decortication & extrusion increased IVPD to 79% (Mertz, 1984)
  - Increased *in vivo* protein digestibility (MacLean, 1983)

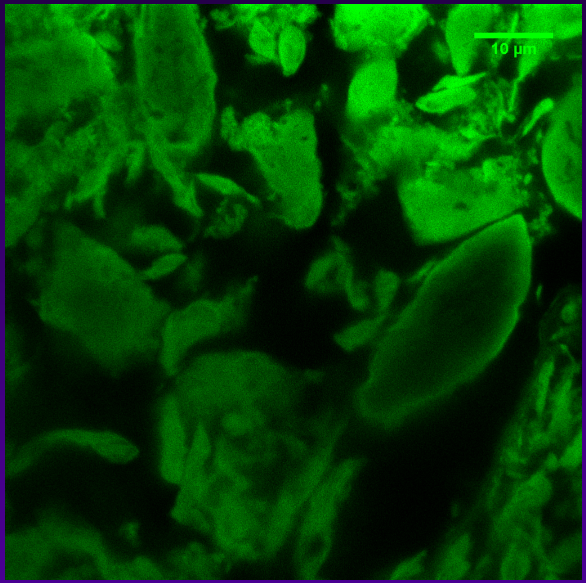
Raw Sorghum Flour





Sorghum Protein After Extrusion Cooking

Confocal Laser Scanning Microscopy (CLSM) is a useful tool in explaining the structural changes underlying the differences in digestibility.



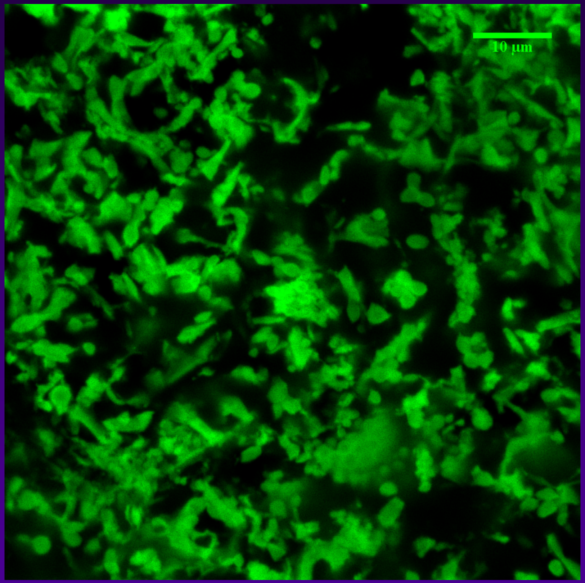
38 % digestibility

%SP-IP-RP: 4-4-92

71% protein content

14% In-barrel moisture

Extrusion energy (SME) = 1336 kJ/kg



66 % digestibility

%SP-IP-RP: 6-5-89

46% protein content

32% In-barrel moisture

Extrusion energy (SME) = 329 kJ/kg

NOVEL SORGHUM-BASED FORTIFIED BLENDED FOODS FOR INFANTS AND YOUNG CHILDREN

Novel Sorghum-Based Fortified Blended Foods for Infants and Young Children

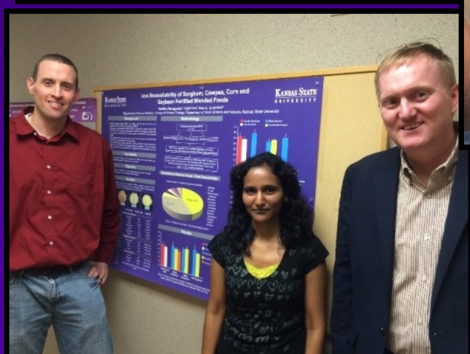
USDA-FAS Micronutrient Fortified Food Aid Products Pilot (MFAPP) Program

Budget: $5,039,854

PIs: Drs. Sajid Alavi , Nina Lilja, Edgar Chambers, Brian Lindshield and Sandy Procter

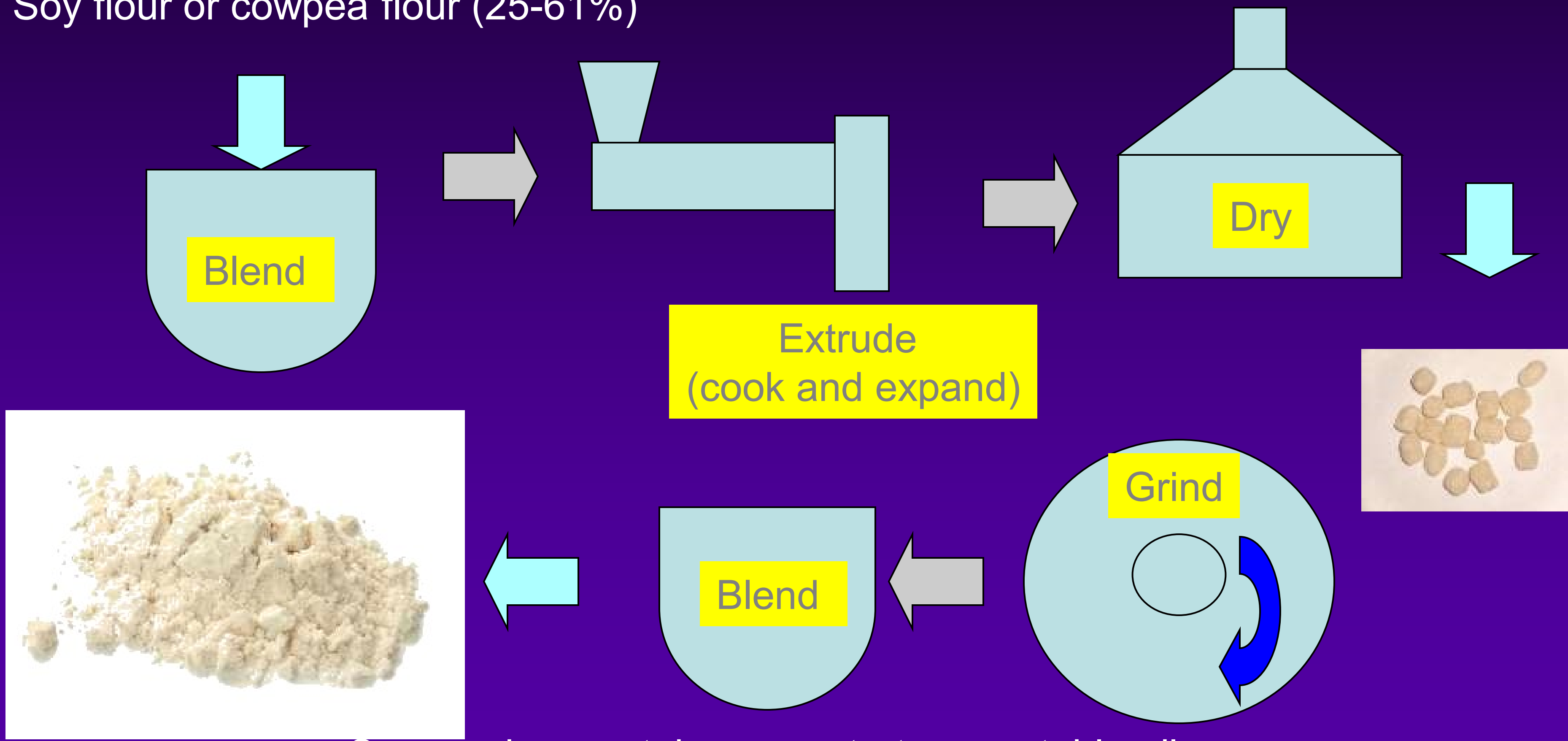
The overall goal of the study is to develop novel, extruded, high-protein, sorghum-based micronutrient fortified blended foods that can be used for nutritional aid programs in Tanzania. These products will be pre-cooked sorghum-soybean and sorghum-cowpea blends or 'porridge mixes' that can be used for supplemental feeding and nutrition programs for infants and children below the age of 5 years. These blends require much lower energy/fuel to prepare into gruels compared to fortified blended foods currently used in feeding programs. In addition, these products enhance the use of U.S. sorghum, soybeans and cowpea for value-added food applications. This can lead to greater demand for these drought-tolerant crops in Africa and reduce the current dependence on corn that is a cause of food insecurity in cereal deficient countries. Research and development on non-GMO food aid commodities, such as sorghum and cowpea also is important because several food aid recipient countries have strict regulations relating to the imports of GMO products.

KSU Fortified Blended Foods USDA MFFAPP Project



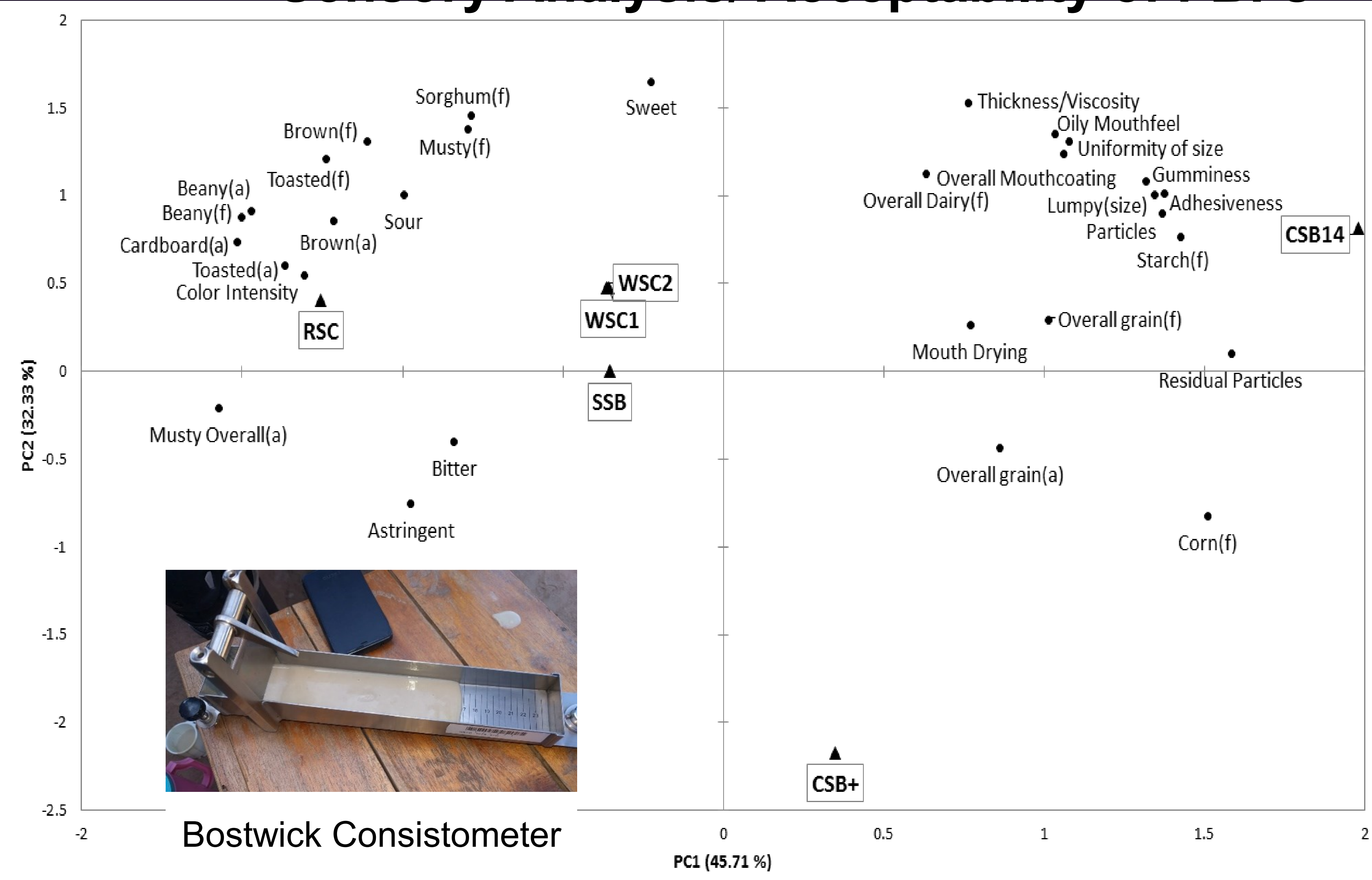
Extruded Sorghum Based Fortified Blended Foods (FBFs)

Sorghum (39-75%)
Soy flour or cowpea flour (25-61%)



Sugar, whey protein concentrate, vegetable oil, mineral premix and vitamin premix

Sensory Analysis/ Acceptability of FBFs



Bostwick Consistometer

Principal component analysis representing sensory characteristics for porridge prepared from 6 fortified blended foods.

Nutritional Efficacy of Sorghum-based Fortified Blended Foods

RESEARCH METHODOLOGY/STUDY DESIGN

CURRENT DEVELOPMENTS IN NUTRITION

The MFFAPP Tanzania Efficacy Study Protocol: Newly Formulated, Extruded, Fortified Blended Foods for Food Aid[1–4]

Nicole M Delimont,[5] Sirichat Chanadang,[5] Michael V Joseph,[6] Briana E Rockler,[5] Qingbin Guo,[6] Gregory K Regier,[7] Michael R Mulford,[8] Rosemary Kayanda,[8] Mwita Range,[8] Zidiheri Mziray,[8] Ambaksye Jonas,[8] Joseph Mugyabuso,[8] Wences Msuya,[8] Nina K Lilja,[7] Sandra B Procter,[5] Edgar Chambers IV,[5] Sajid Alavi,[6] and Brian L Lindshield[5]*

Departments of [5]Food, Nutrition, Dietetics, and Health, and [6]Grain Science, and [7]Agricultural Economics, Kansas State University, Manhattan, KS; and [8]Project Concern International–Tanzania, Mwanza, Tanzania

ClincialTrials.gov Identifier NCT02847962

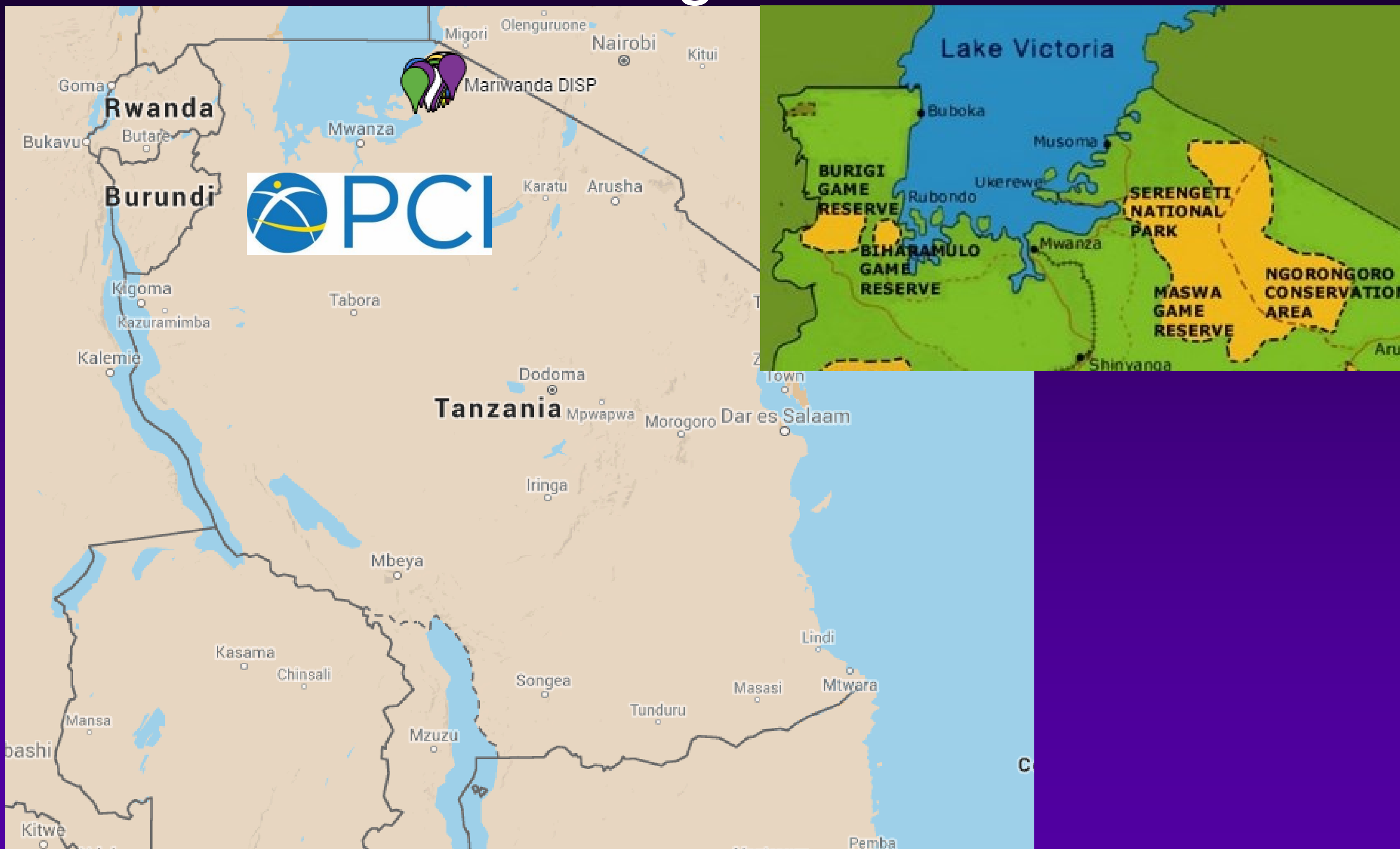
Field Trial Objective

- Critically assess the acceptability and nutritive value of new, extruded, sorghum-based fortified-blended foods (FBFs) and the current USAID FBF, CSB+ with a particular emphasis on iron and vitamin A outcomes in a field trial in Tanzanian children <5 years old.

Efficacy Study Groups

- Control (No FBF until after trial)
- Extruded white sorghum 1 cowpea (WS
- Extruded white sorghum 2 cowpea (WS
- Extruded red sorghum cowpea (RSC)
- Extruded white sorghum soybean (WSS
- Extruded corn-soybean (CSB14)
- CSB+ (Current USAID FBF)

Field Trials for Sorghmum-based Extruded FBFs in Mara Region of Tanzania



http://ontheworldmap.com/tanzania/tanzania-national-parks-map.html

Overall Conclusions from Field Trials of Sorghum-based Extruded FBFs

- Intervention clusters showed improved micronutrient outcomes as compared to control
- Extruded sorghum-cowpea and sorghum-soy FBFs are suitable alternatives to corn-soy blends, and in some cases outperformed CSB+ and extruded CSB14.
- Extruded sorghum based blends also have high acceptability and are more suitable for energy dense (higher solids) porridges.
- Only a longer duration longitudinal study will be able to verify the efficacy of whey protein concentrate inclusion in FBFs.

Thanks!