# Innovative Way of Making Millet and Sorghum *Couscous* by Using a Single Screw Mini-Extruder for West African Market

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CAPE TOWN, APRIL 2018



- Millet and sorghum foods including *couscous*, porridges and beverages are popular products in many African countries
- Couscous is a steamed product made from cereal flours
  - Traditional preparation:
    - Decortication and milling grain into flour (mortar and pestle)
    - Mixing flour with water
    - Agglomerating the flour-water mixture into couscous granules by hand rolling
    - Steaming and drying
- Manual intensive and laborious process
  - Low efficiency, generally limited to household use, limited quantity available in marketplace

❑ In past years, several attempts were made to mechanize flour agglomeration which constitutes the most critical step in sorghum and millet couscous making in West Africa

❑Though, quality consistency, production efficiency and yield are problematic at the commercial level

Moussa, Hamaker, Chen, Campanella ,Int J. of Food Science & Technology, 2011; Aboubacar and Hamaker ,Cereal Chem, 2000

❑There exist significant market opportunities for processed sorghum and millet in Niger and West Africa :


- Extrusion technology allows for high production amount of grain based foods and with high potential to be used as nutrition vehicle.

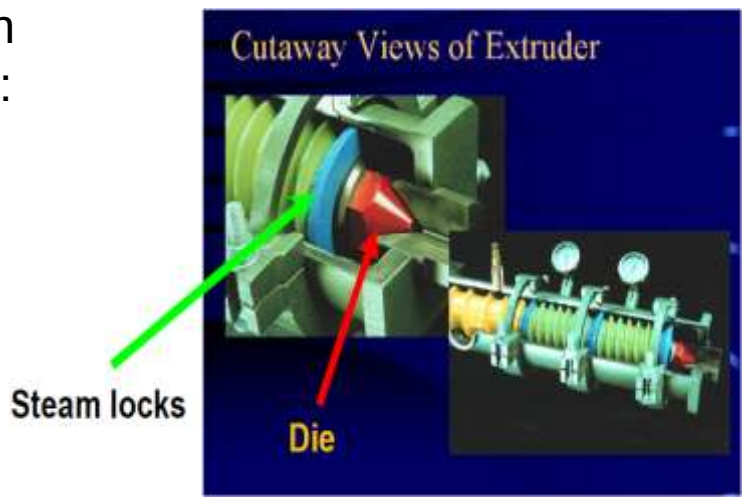
- Include instant flours for making agglomerated couscous like products and thin and thick porridges

- Extrusion technology help improve grain processing capacity/scaling up; helps make uniform desirable products range with improved nutrition; safety and quality and market

Jean Marie Bouvier, Osvaldo H. Campanella, Wiley Blackwell, 2014;

# Single screw mini-extruder development at Purdue University

**Motivation**
Mission to Mars
6-8 month
outbound
600 days
surface stay
6-8 month return
Lift cost to Mars:





http://www.nasa.gov/mission_pages/juno/launch/

❑A low-cost single-screw extruder was installed at INRAN and staff trained

❑In novel work, a high quality couscous product was developed using the extruder whereby production was **increased ten-fold**; and shorten steps of processing millet grains to couscous and related foods and cost reduction over the conventional method

# Extrusion Process flow

Whole Grain

Decortication

Milling to grits

Moisture addition and equilibration

Extrusion: degree of cook determined by die temperature >115°C

Variety of products

Drying and milling of extrudates

Pre-cooked flour

Variety of products (couscous)

**Overall goal :**

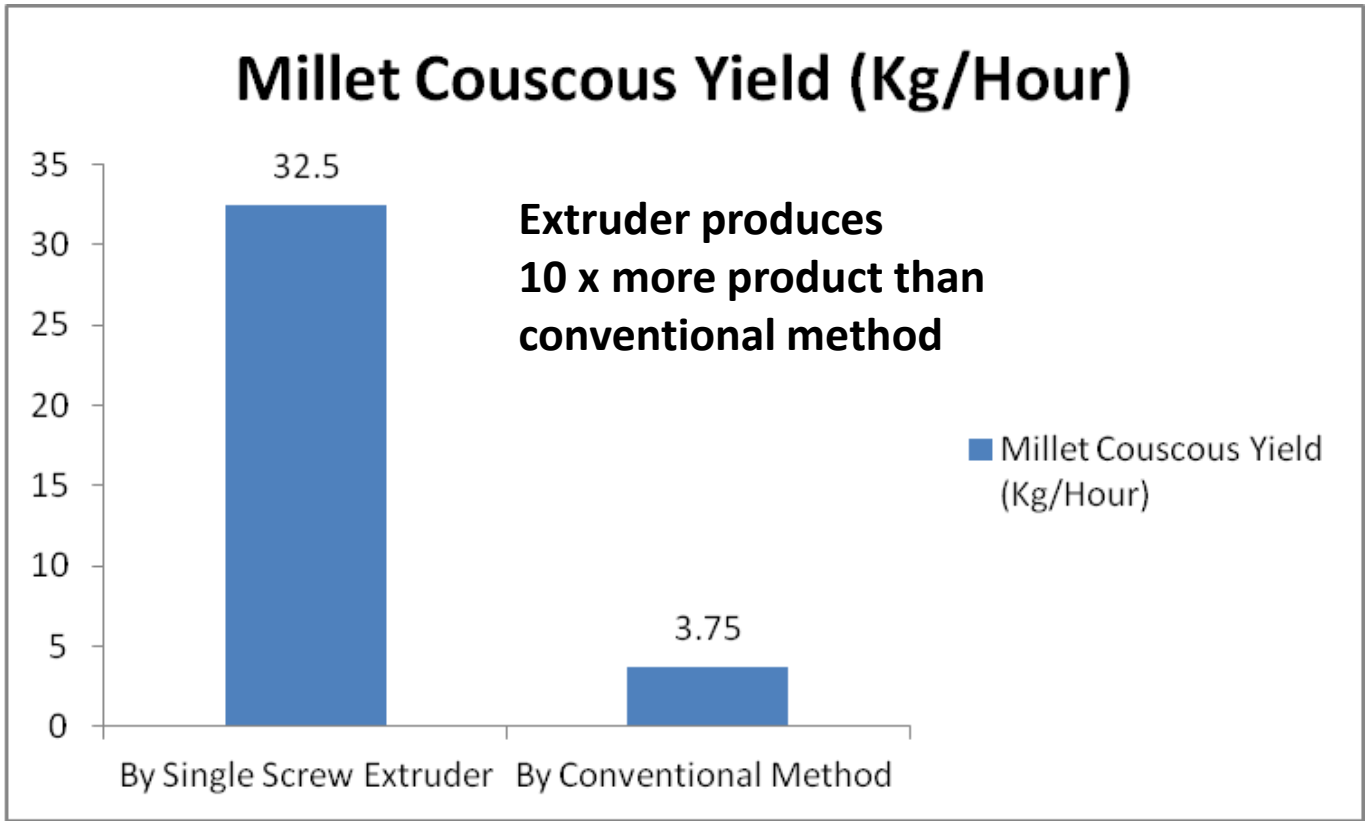
**Expand Market for Sorghum and Millet Grains** to benefit smallholders farmers by Strengthening Entrepreneur Processors with innovative extrusion technology to diversify, scale up and promote nutritionally healthy cereal based foods in Niger and West Africa

**Specific Objectives:**

- Develop and optimize processes of making extruded millet products including agglomerated (*couscous*), porridges and fortified and other related nutritious products
- Test marketing of extruded millet products
- Promote and facilitate scaling up and uses of the Single Screw Extruder in West Africa

## Millet grain processing capacity of the single screw extruder

| Millet Varieties | Initial Grain (Kg)/Hr | T(°C) | Speed(RPM) | Extrusion Output (Kg)/Hr | Product Recovery(%) |
|---|---|---|---|---|---|
| ICRI TABI | 36 | 130 | 874 | 34.8 | 97 |
| 9SOSAT | 36 | 138 | 875 | 33.6 | 93 |
| 89305 | 36 | 131 | 875 | 31.8 | 88 |
| 99001 | 36 | 130 | 875 | 31.2 | 87 |
| PPBSerkin H | 36 | 128 | 872 | 31.2 | 87 |
| MIL DE SIAKA | 36 | 128 | 875 | 34.8 | 97 |


Millet Couscous Yield (Kg/Hour)
35
30
25
20
15
10
5
0
32.5
3.75
By Single Screw Extruder
By Conventional Method
Extruder produces
10 x more product than
conventional method
Millet Couscous Yield (Kg/Hour)

## Particle distribution of millet couscous samples (%)

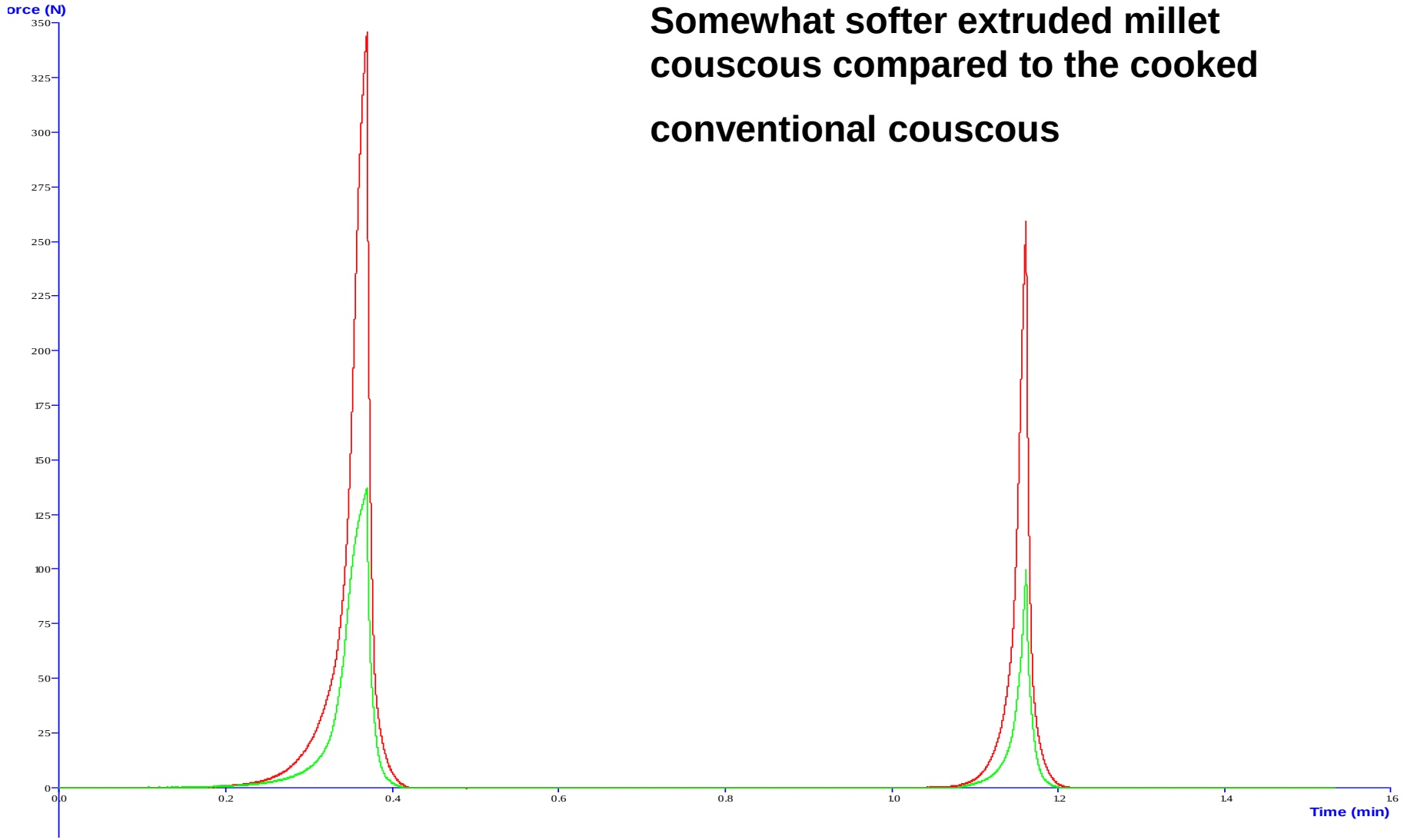
| *Couscous Samples* | *1.68mm* | *1mm* | *0.85mm* | *<0.85mm* |
|---|---|---|---|---|
| Control (conventional) | 13.40$^{c}$ | 64.61$^{a}$ | 16.88$^{a}$ | 5.11$^{c}$ |
| Extruded (94206) | 39.46$^{b}$ | 32.26$^{b}$ | 6.55$^{a}$ | 21.73$^{a}$ |
| Extruded(Sosat) | 61.60$^{a}$ | 19.13$^{c}$ | 15.92$^{a}$ | 15.43$^{ab}$ |
| Extruded(GB) | 67.36$^{a}$ | 21.54$^{c}$ | 2.98$^{a}$ | 7.59$^{bc}$ |
| Extruded(Jirani) | 67.01$^{a}$ | 19.61$^{c}$ | 6.20$^{a}$ | 7.18$^{bc}$ |
| Extruded(Icri-tabi) | 33.52$^{b}$ | 43.14$^{b}$ | 6.90$^{a}$ | 16.43$^{a}$ |
| Extruded(221) | 39.55$^{b}$ | 32.15$^{b}$ | 6.56$^{a}$ | 21.75$^{a}$ |

Corresponding mesh size: 1.68mm , 1mm, 0.85mm. Values are means of triplicate determinations. Different superscripts within columns indicate significant differences ($P<0.05$, Duncan's Multiple Range test).

## Color of millet couscous

| *Couscous Samples* | *l** | *a** | *b** |
|---|---|---|---|
| Control (conventional) | 27.72$^{d}$ | 3.71$^{a}$ | 14.89$^{b}$ |
| Extruded (94206) | 36.74$^{c}$ | 2.04$^{b}$ | 14.10$^{bc}$ |
| Extruded(Sosat) | 39.57$^{b}$ | 1.85$^{b}$ | 14.29$^{bc}$ |
| Extruded(GB) | 42.32$^{ab}$ | 1.6$^{b}$ | 13.15$^{c}$ |
| Extruded(Jirani) | 41.72$^{ab}$ | 1.10$^{c}$ | 11.45$^{d}$ |
| Extruded(Icri-tabi) | 41.35$^{ab}$ | 2.08$^{b}$ | 14.26$^{bc}$ |
| Extruded(221) | 43.49$^{a}$ | 1.88$^{b}$ | 17.02$^{a}$ |

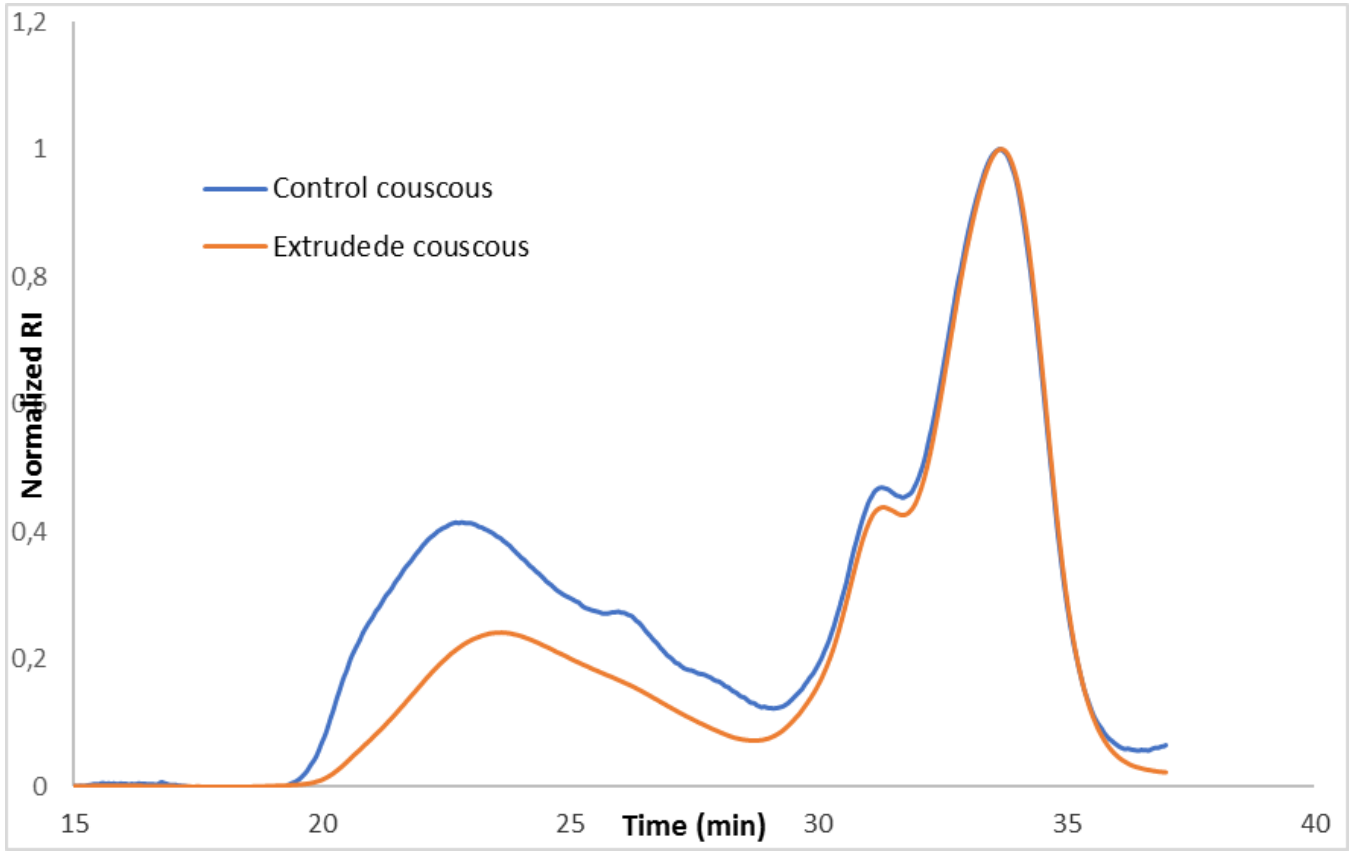
l*= black (0) to white (100), a*=green (-) to red (+), b*= blue (-) to yellow (+). Values are means of triplicate determinations. Different superscripts within columns indicate significant differences ($P<0.05$, Duncan's Multiple Range test).




**Somewhat softer extruded millet couscous compared to the cooked conventional couscous**

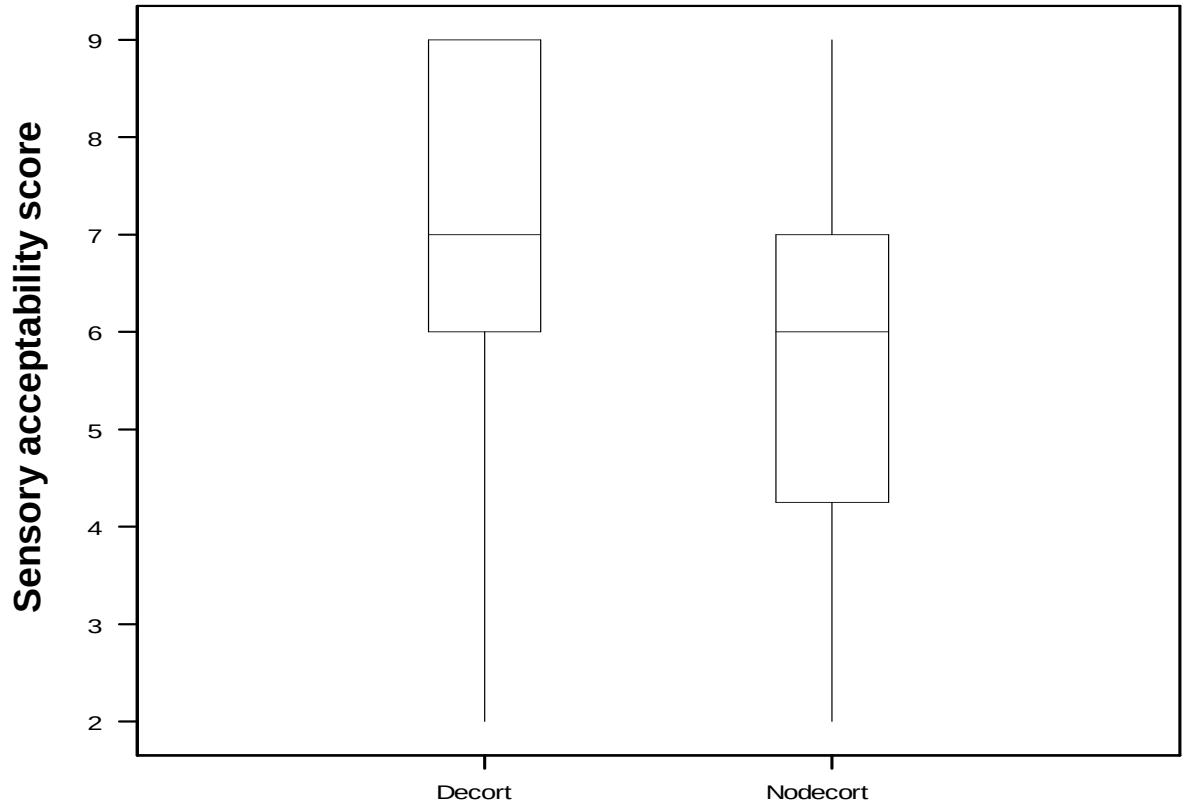
Figure**2**. Two (02) stroke peaks by compression test using TPA representing the Hardness (textural characteristic) of extruded millet couscous (green color) versus conventional one (red color). Values are means of triplicate determinations ($P<0.05$, Duncan's Multiple Range test).
Note: TA. HD plus texture analyser(Stable Micro-System conditions include: 50 kg load cell 75% Strain; test speed 0.5mm/s; 3.00s and 50g trigger force

# Less starch fragmentation makes a smoother texture of extruded couscous



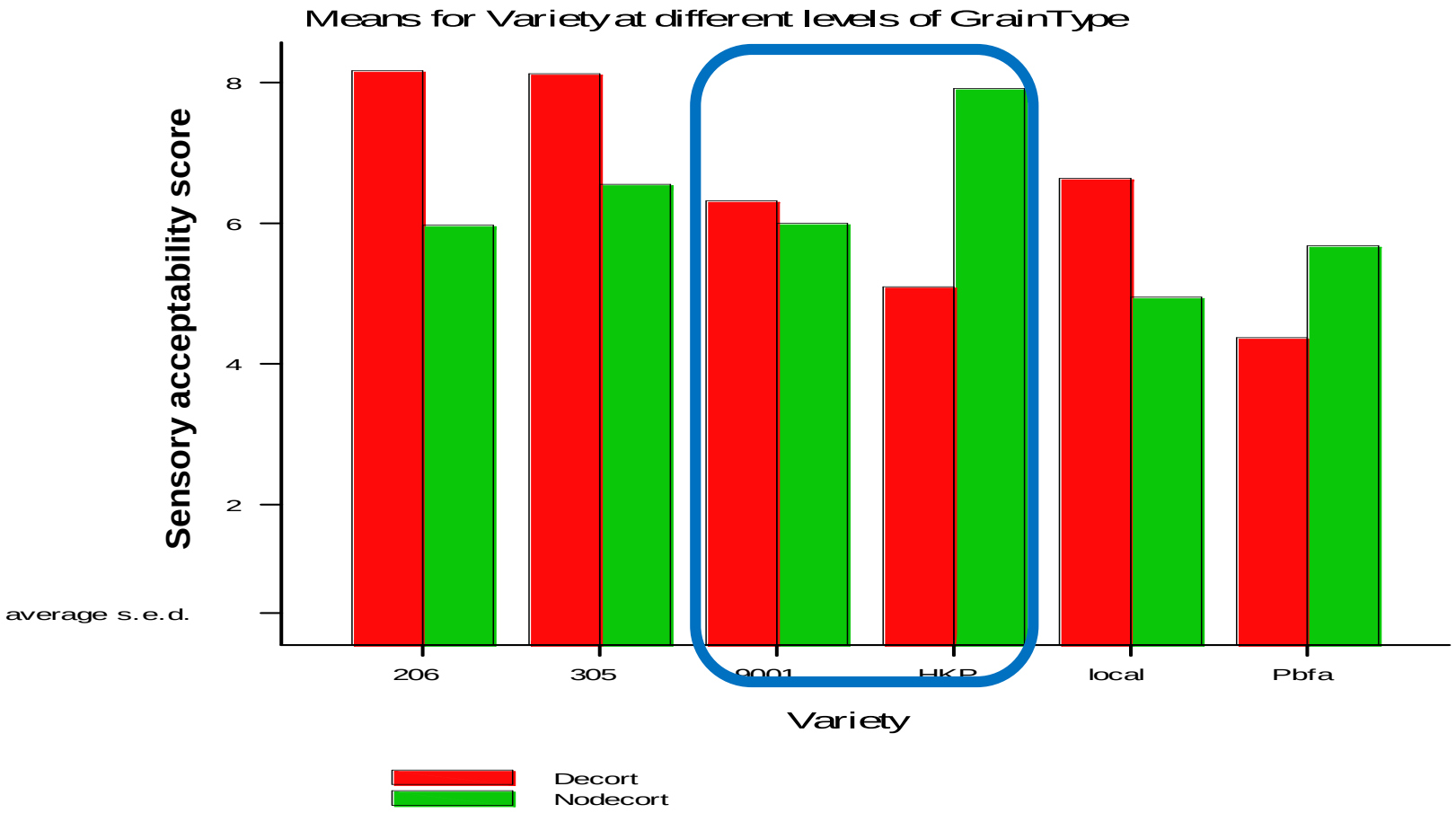

Size-exclusion chromatography (Normalized RI versus Time) patterns of sample extract. Extruded couscous (orange color) and conventional couscous (blue color).
Note: low peak area for extruded couscous indicates process-induced amylopectin fragmentation

# Decorticated vs whole grain extruded couscous – decorticated is somewhat more preferred




Box Plot of consumer overall liking/acceptability (taste, color, odor, texture) of extruded millet couscous) made from decorticated and whole millet grains in Niger. Values are means of panelist scores analyzed at ($P<0.05$) using GenStat statistical method.

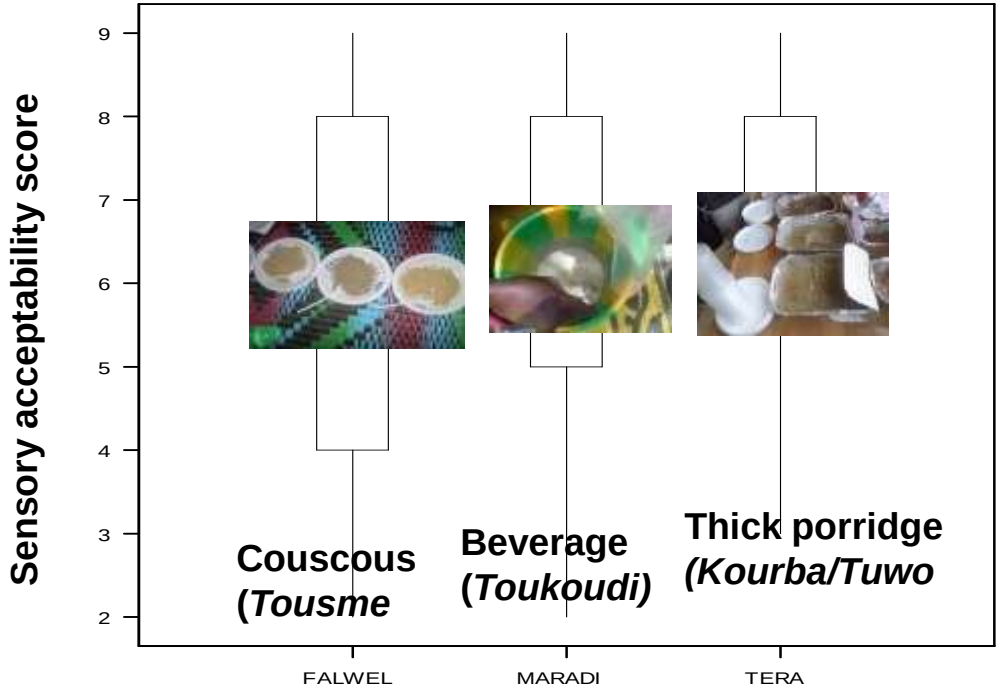
# Differences between decorticated vs whole grain by varieties – some have equal acceptability




Values are means of panelist scores analyzed at (P<0.05) using GenStat statistical method.

# *Test and evaluate various types of millet foods made using the Single Screw Extruder*

***Consumer overall liking/acceptability*** *(taste, color, odor, texture) of 3 extruded millet foods (couscous, beverage, and thick porridge) made from millet grains SAMPLES grown and tested in Falwel, Tera and Maradi.*




Values are means of panelist scores analyzed at (P<0.05) using GenStat statistical method.

# Conclusions

- Using a small-scale single screw extruder technology, production of highly acceptable couscous was 10 times higher than that made manually

- This study reveals the potential of developing and diversifying millet foods using the extrusion technology

- The single screw extruder is an effective means of diversifying uses of millet grains and boosting performance level of processed millet foods

# Ongoing  Work

1-Market study to learn about market potential of extruded foods in Niger

2- Fortification by co-extrusion using natural fortificants

Acknowledgement of funding

Feed the Future Innovation Lab
Collaborative Research on Sorghum and Millet

INRAN

COLLABORATIVE CROP RESEARCH PROGRAM
HELPING SMALLHOLDER FARMERS FEED THEIR WORLD
THE McKNIGHT FOUNDATION

KANSAS STATE UNIVERSITY

PURDUE UNIVERSITY

ICRISAT
Science with a human face

# THANK YOU

FUMA GASKIYA
MARADI

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