

Developing Entrepreneurism: *Student Training and Involvement*



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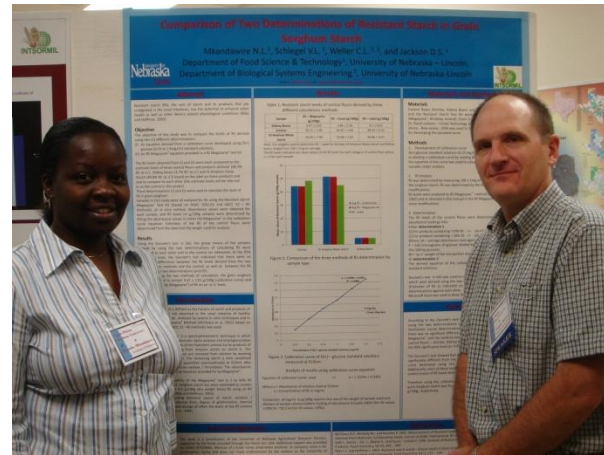
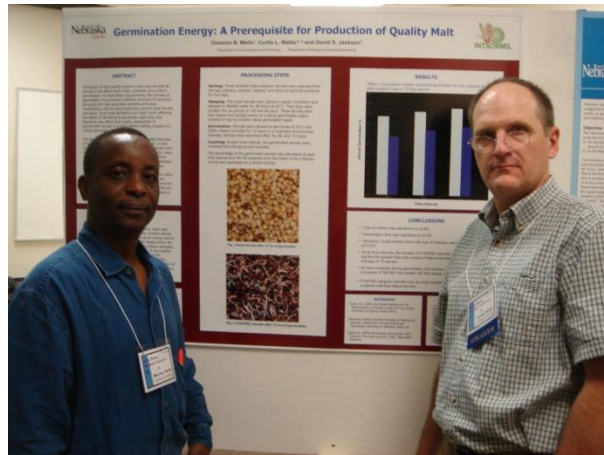
Objectives

- **Student training is an important component of INTSORMIL UNL-SUA-UNZA project**
- **Current students and their backgrounds**
 - **Onesmo Mella is a Researcher with the Tanzania Food and Nutrition Centre in the Ministry of Health and Social Welfare working on his MS degree**
 - **Nyambe Mkandawire is a Lecturer with the University of Zambia Department of Food Science and Technology working on her PhD degree**



Current Projects

- **Summary of progress for current projects**
 - **Effects of malting and fermentation pretreatments on properties of grain sorghum flour and sorghum-containing products (OM)**
 - **Starch and fiber digestibility for tannin-containing grain sorghums (NM)**
 - **Digestibility of pure isolated starches (NM)**



Measurement of Starch Digestibility in Starch and Flour from Tannin containing Sorghum

Mkandawire N.L., Weller C.L., Rose D. J., and Jackson
D.S.

Grain Sorghum

- ▶ ***Sorghum bicolor* (L.) Moench**
- ▶ **5th most important grain**
- ▶ **Important as a feed grain (US) and food (Asia and Africa)**
- ▶ **Low digestibility**
- ▶ **Classified* as**
 - ▶ **Sorghum**
 - ▶ **Tannin Sorghum**
 - ▶ **White sorghum**
 - ▶ **Mixed sorghum**

*FGIS – GIPSA, 2008



Tannin sorghum

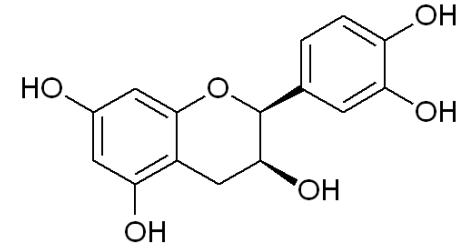
- ▶ **Some sorghums have a pigmented testa**
- ▶ **Condensed tannins – present in inner integument of kernel**
- ▶ **Reported levels of condensed tannins in sorghum - 68 mg catechin equivalent (CE) / g**

Awika and Rooney, 2004

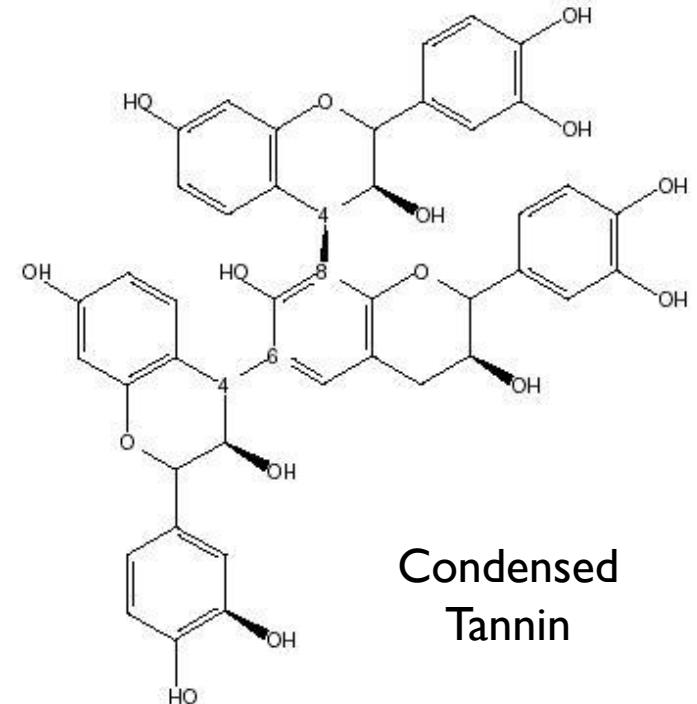


Condensed Tannins

- ▶ **Proanthocyanidins, procyanidins (syn.)**
- ▶ **Polymerized flavan-3-ol and or flavan – 3,4 – diol**
- ▶ **C4-C8 and C4-C6 interflavan bonds**
- ▶ **Polymer units**
 - ▶ **Catechin – terminal units**
 - ▶ **Epicatechin – extension units**
- ▶ **High molecular weights with variable lengths**



Catechin



Condensed Tannin

Importance of CTs

- ▶ **Tannins complex with macromolecules : Proteins, polysaccharides, minerals,**
- ▶ **Reduction of digestibility (Proteins and others)**

BUT

- ▶ **Excellent *in vitro* antioxidant properties**
- ▶ **Low digestibility – good for humans**

Awika et al, 2003; Dykes and Rooney, 2006;



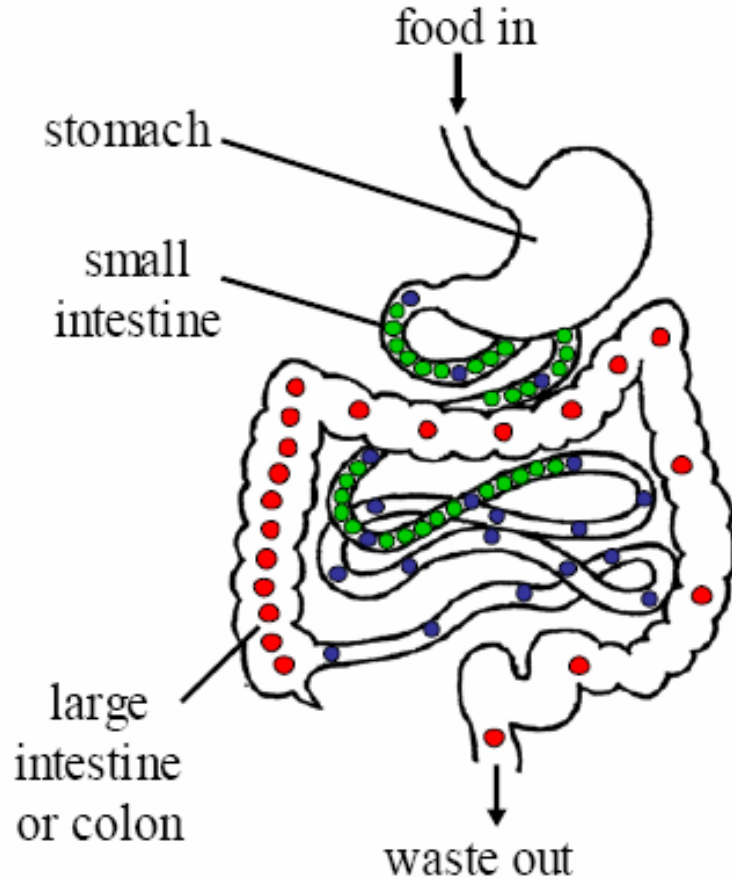
Relationship of CTs to Polysaccharides

- ▶ **Tannins + Proteins (also enzymes) → reduced protein and starch digestibility**
- ▶ **Some polysaccharides prevent protein – tannin interaction → Xanthan, Pectin, gum arabic, carragenaans**
- ▶ **But not carob, guar and tara gums**
- ▶ **Tannins reported to complex proteins, carbohydrates / polysaccharides, minerals, alkanoids etc → reduced digestibility**

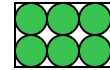
Awika and Rooney, 2004; de Freitas et al, 2003; Carvalho et al, 2006



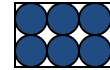
In vivo digestion



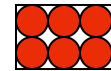
Digested – Rapidly



Digested - Slowly



Resistant to digestion



Rate of digestion of Starch in humans

In vitro digestion

- ▶ **According to Englyst et al, 1992**
- ▶ **Rapidly digested starch (RDS)**
 - ▶ Amount of glucose released after 20 minutes
- ▶ **Slowly digestible starch (SDS)**
 - ▶ Amount of glucose released between 20 and 120 minutes
- ▶ **Resistant starch**
 - ▶ Glucose left after 120 minutes
 - ▶ $RS = \text{Total Starch} - (\text{RDS} + \text{SDS})$



Table 1. Resistant starch types, definitions and examples

Resistant Starch Type	Definition	Example
1	Physically inaccessible (<i>e.g., surrounded by plant cell wall material</i>)	Coarsely ground wheat
2	High amylose (<i>long chains, little branching</i>)	High amylose corn starch
3	Retrograded amylose (<i>long chain double helices</i>)	Cooked and cooled potato starch
4	Chemically modified (<i>e.g., heat processing rearrangement of bonding</i>)	Modified maltodextrins

Table 1. Forms of resistant starch. Adapted from Murphy et al. 2008. Resistant starch intakes in the United States. J. Am. Diet. Assoc. 108: 67-78.

Starch digestibility

▶ OBJECTIVE

- ▶ To assess the digestibility of starches and flours obtained from tannin containing grain sorghum
 - ▶ Correlate [Tannin] to starch digestibility levels of flours and starches

▶ HYPOTHESIS

- ▶ Condensed tannins will complex with starch and therefore reduce the starch digestibility leading to an increase in SDS and RS and decrease RDS.



Sorghum Samples

- ▶ **Harvested in the year 2003 and 2004**
 - ▶ **9301 / 9901 - Shanqui Red**
 - ▶ **9303 - Ajabsido**
 - ▶ **9902 - Koro Kollo**
 - ▶ **9304 / 9904 - IS 8525**
 - ▶ **9305 / 9905 - Sumac**
 - ▶ **9306 / 9906 - SCI03 – 12E**
 - ▶ **9308 - Russian Hi starch**
 - ▶ **9907 - SC 599**

 - ▶ **Red sorghum (PI 597981)**
 - ▶ **Macia – White sorghum**
 - ▶ **Sumac 2008**
-





9902 Tannin

9303 Tannin

9308 Tannin

Macia



9306 Tannin

Sumac 2008

9901 Tannin

Red Sorghum



RED SORGHUM



MACIA



9303 TANNINS



SUMAC 2008

Approaches to Objective 1

- ▶ **Determination of starch digestibility in sorghum flours and their isolated starches**
- ▶ **Methods used**
 - ▶ **Modified Englyst method**
 - ▶ **Proximate analysis: Moisture, Ash, Total starch,**
 - ▶ **Vanillin – HCl for quantification of Condensed Tannins (CTs)**
 - ▶ **Other tests: Color, Bleach test**
- ▶ **Starch isolation by table method**

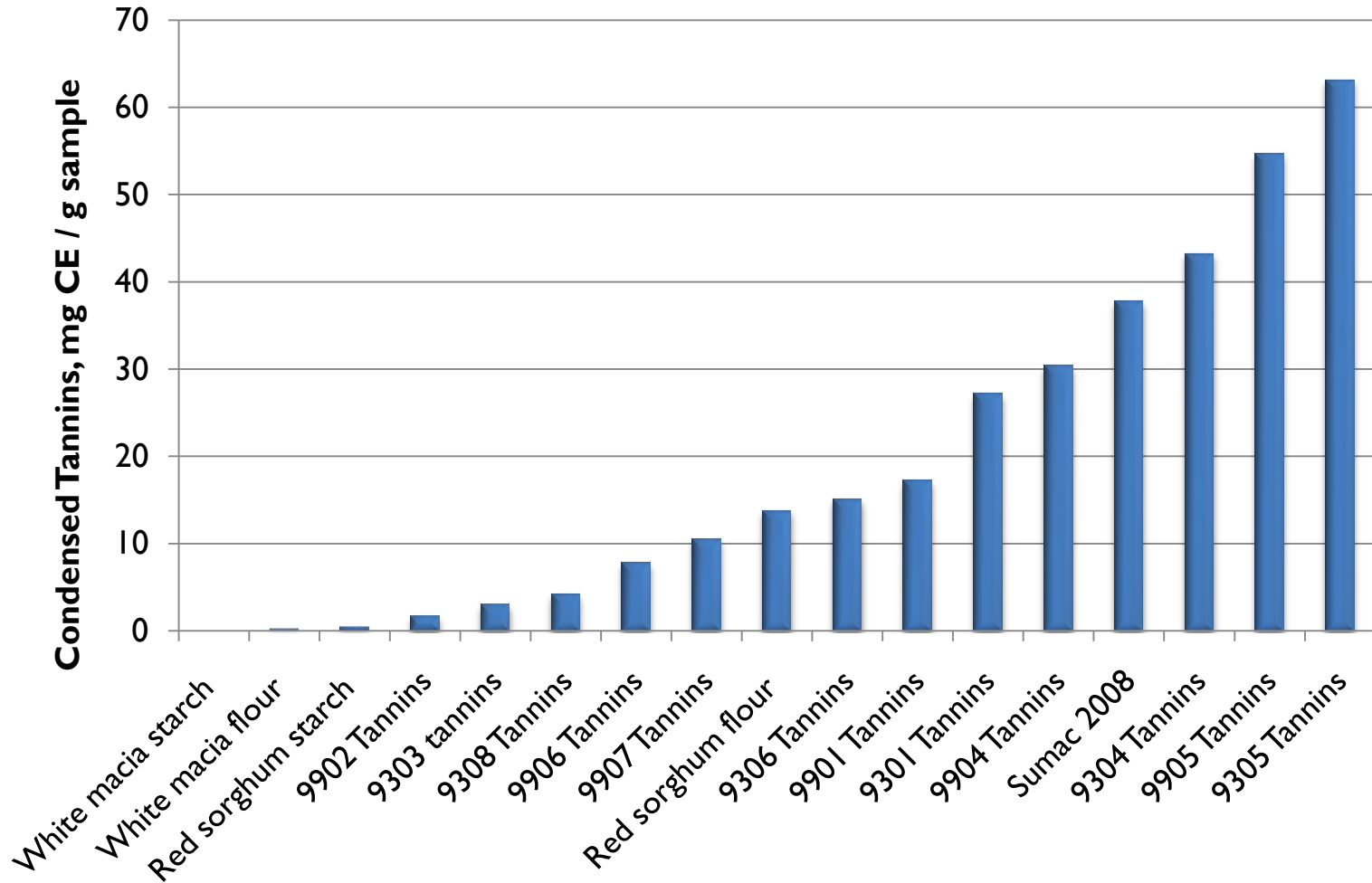
Englyst et al, 1999; Xie and Seib, 2000; Eckhoff et al, 1993; Weller et al, 1988

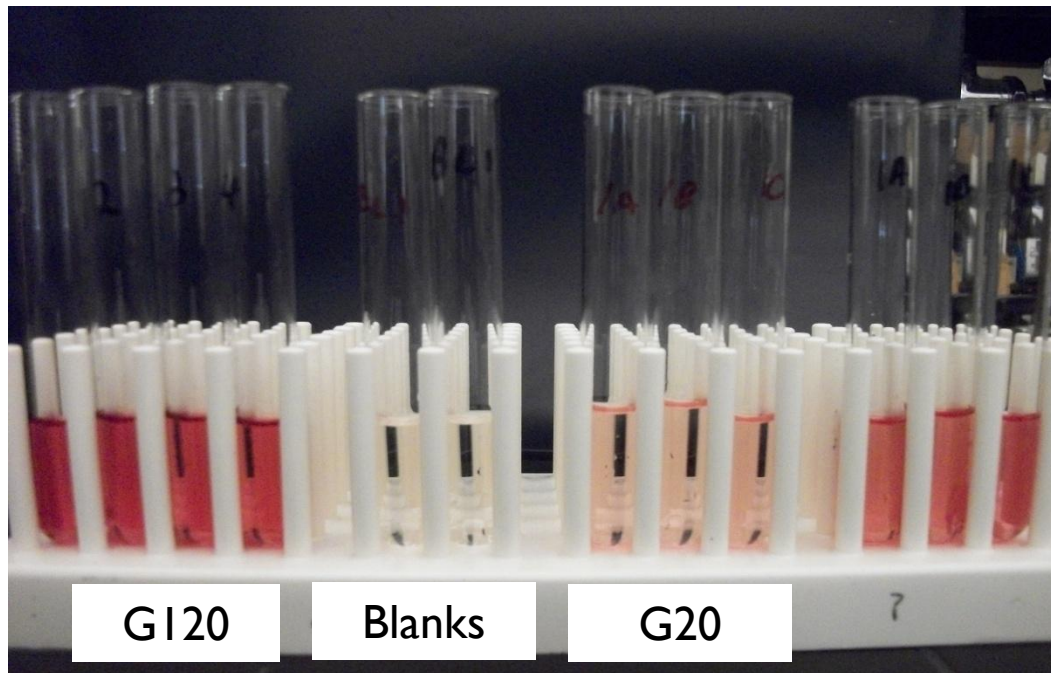
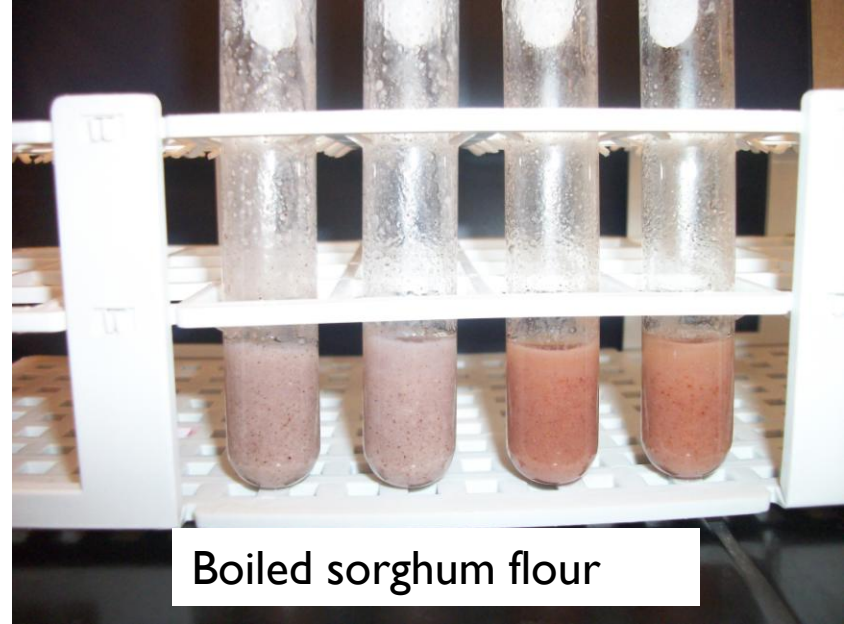
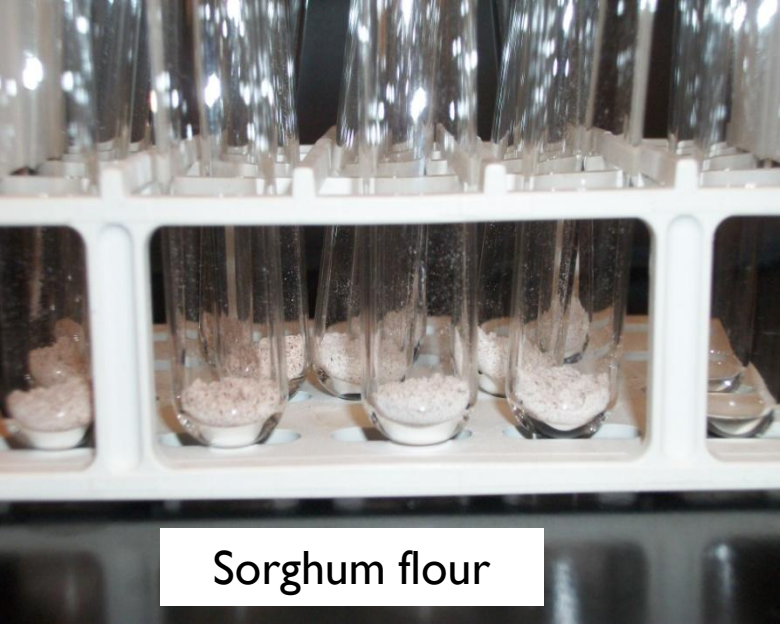


Relationship of Starch Digestibility and Tannin Contents in Sorghum



Condensed Tannins in Sorghum starches and flours







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9x0

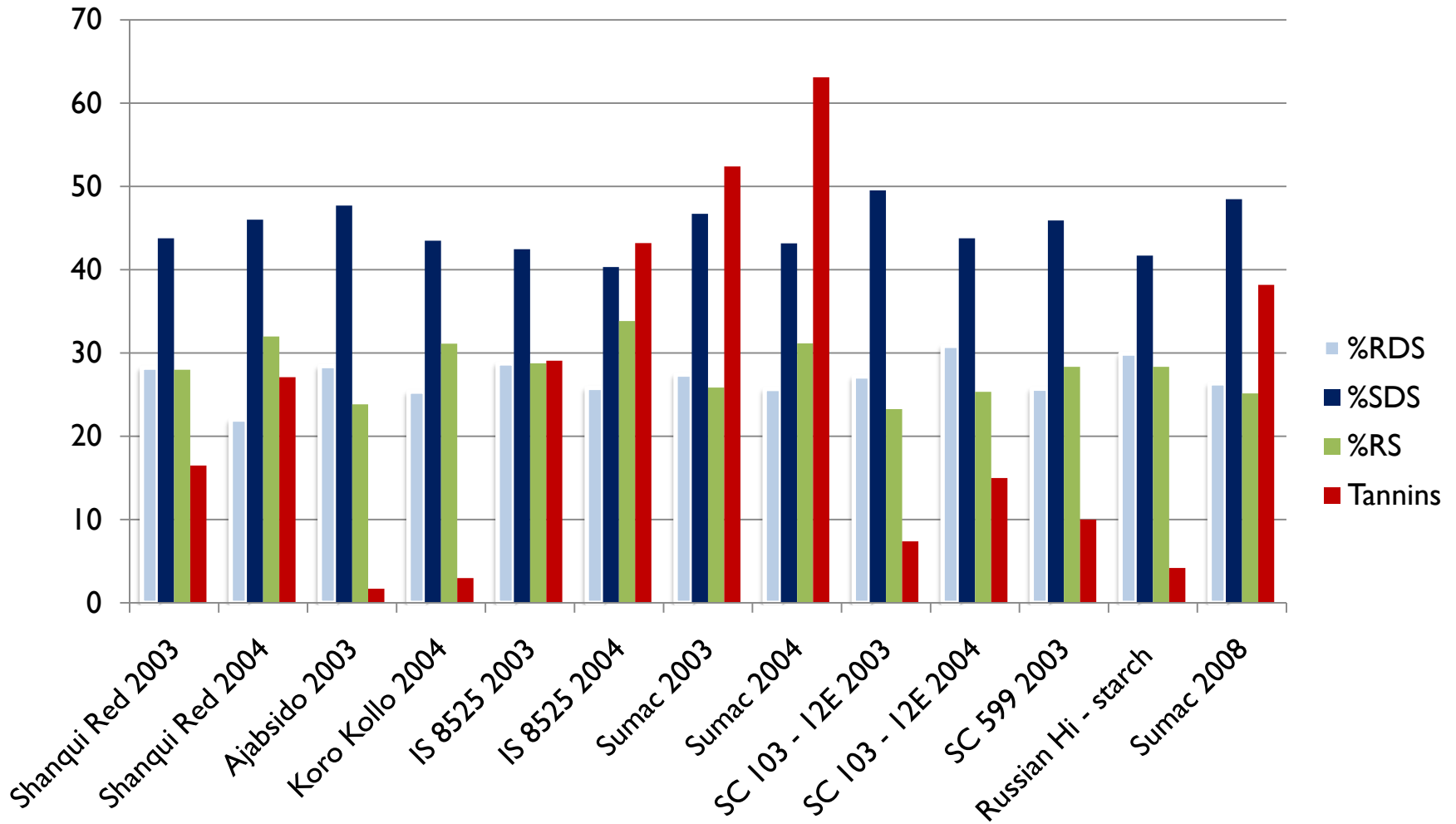


POWER

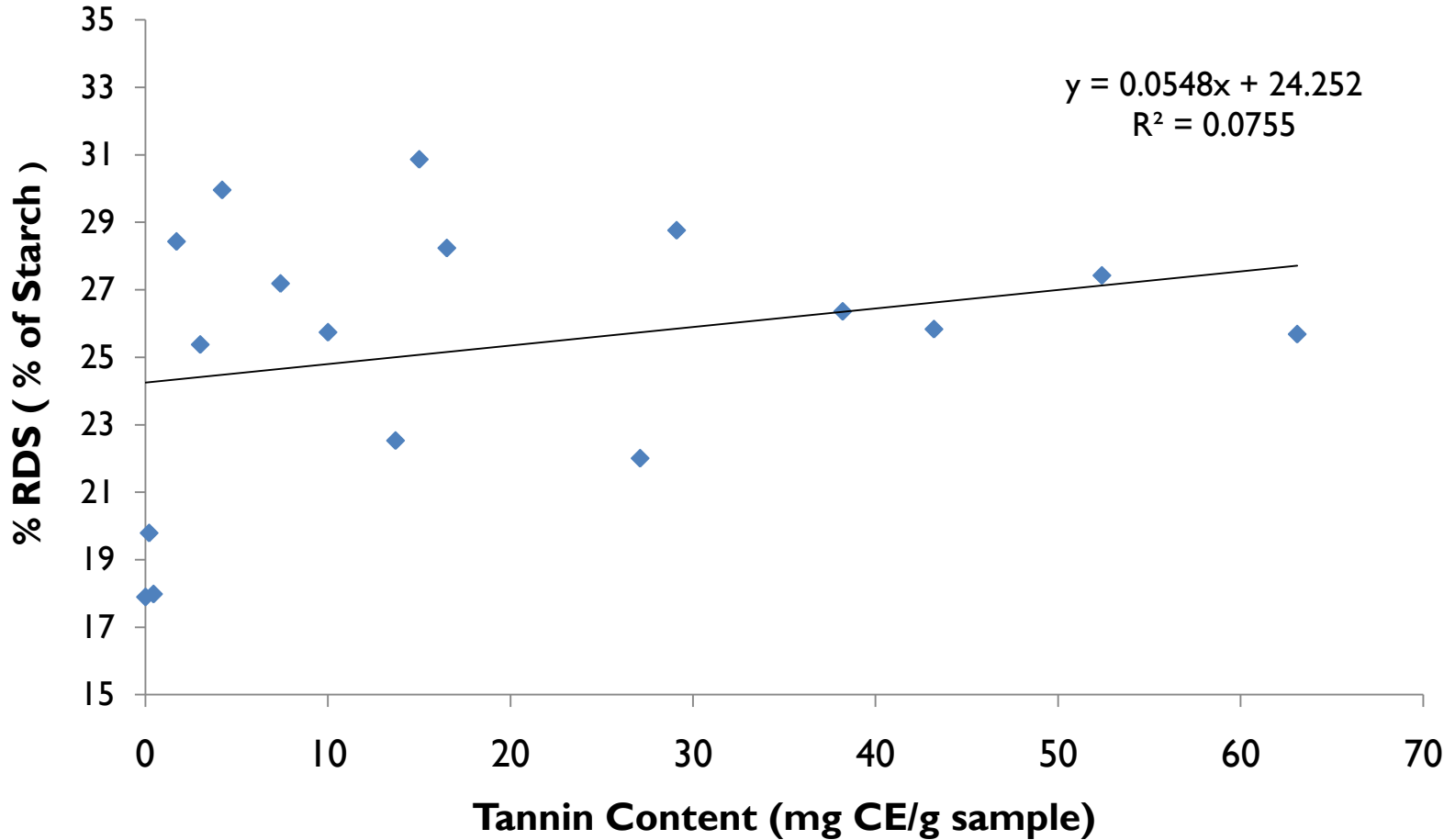
SPEED

TEMPERATURE

Tannin content vs. Starch digestibility

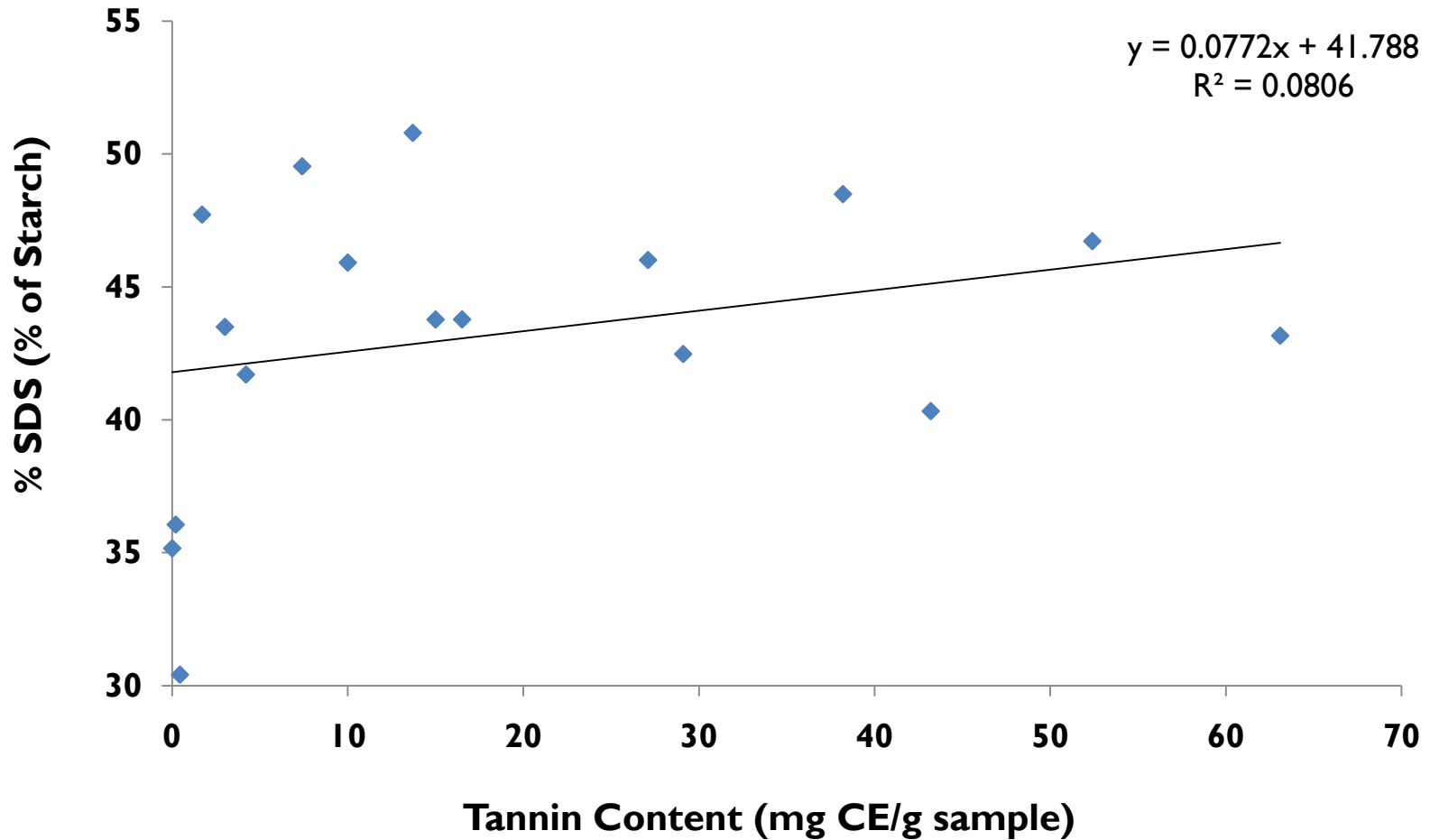


%Rapidly Digestible Starch Vs.Tannin Content



Relationship between Tannin content and RDS; $P = 0.4438$; $P > 0.05$

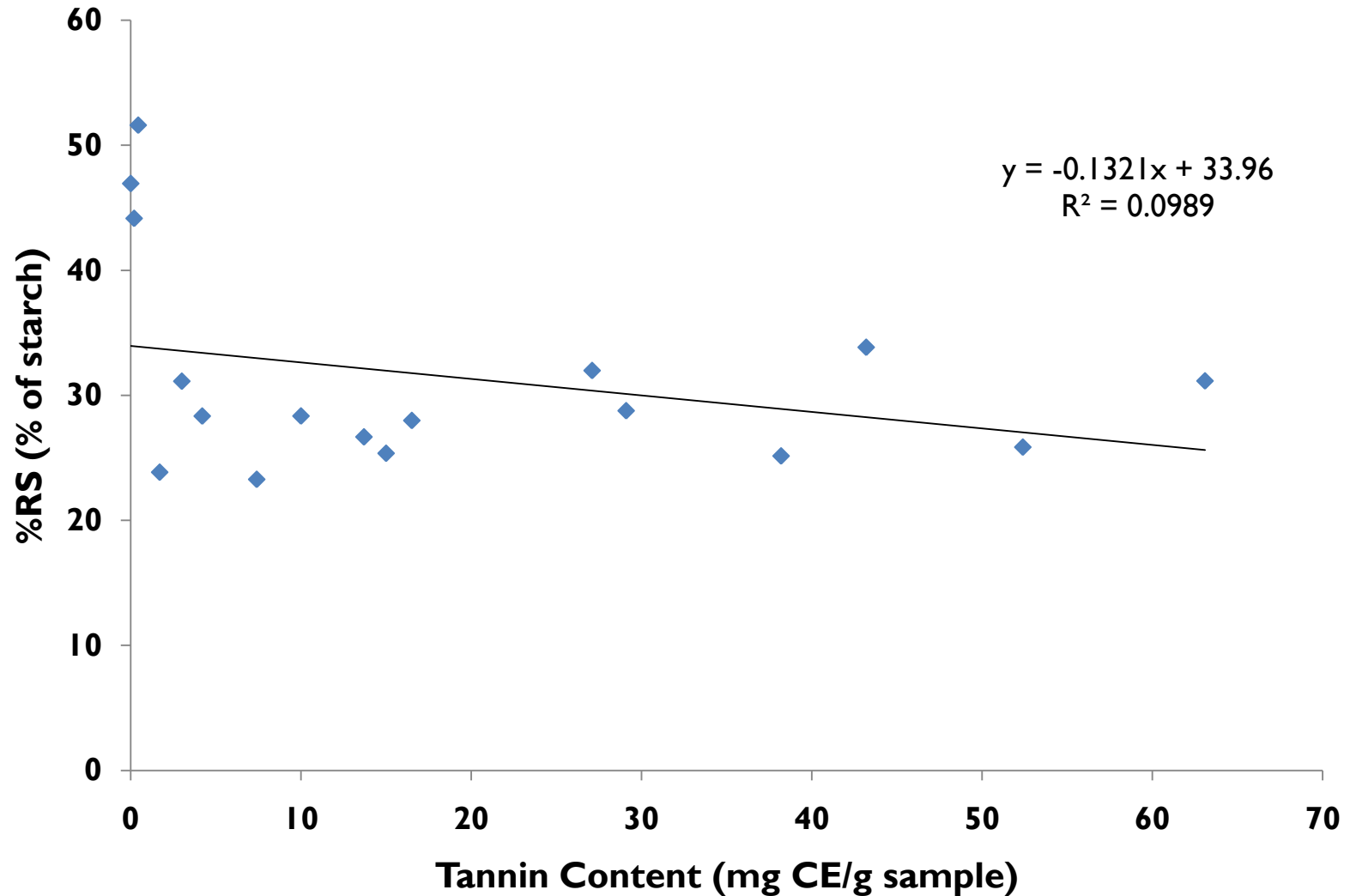
%Slowly Digestible Starch Vs.Tannin Content



Relationship between Tannin content and SDS; P = 0.4159; P > 0.05



% Resistant Starch Vs. Tannin Content



**Relationship between Tannin content and RS; P = 0.3623;
P > 0.05**



Conclusion

- ▶ **No significant correlation between tannin content and starch digestibility**

BUT

- ▶ **Sorghum containing tannins exhibited low starch digestibility overall**
- ▶ **Grains with low RDS and high SDS and RS are desirable**



Digestibility of pure isolated starches

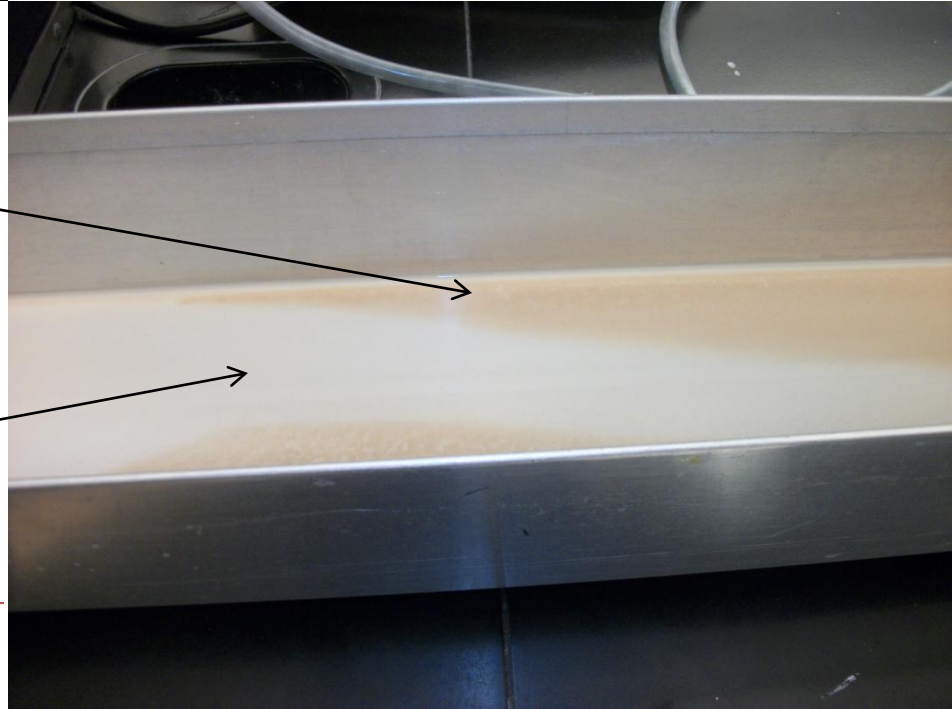




Starch isolation from red sorghum

Brown liquid draining out

Starch separating from brown liquid







**Starch isolated by wet milling
from Sumac grain sorghum**

**Condensed Tannins isolated from
Sumac grain sorghum**



Starch Isolation results






















Method used – starch table method

Sorghum used: Red and Macia Sorghums

Parameter	Macia sorghum	Red Sorghum
Moisture Content (%)	9.4	9.5
Ash Content (%)	0.1	0.1
Color		
L	99.9±0.04	97.65±0.18
a	-0.95±0.06	0.23±0.02
b	0.73±0.04	1.72±0.02
Condensed tannins (mg CE /g sample)	-	0.4
Total Starch Content (mg sample / g sample)	810.5	825.2



Levels of digestibility in different cereal starches

Pure Starch	% RDS	% SDS	% RS	Tannin Content (mg CE / g sample)
Red Sorghum**	18.0 ± 1.15 	30.4 ± 4.79 	51.6 ± 4.56 	0.44
Macia (white) Sorghum**	17.9 ± 1.09 	35.2 ± 5.7 	46.9 ± 4.4 	-
Normal Maize*	84.7 ± 0.62 	8.3 ± 1.85 	6.9 ± 1.23 	
Waxy Maize*	88.5 ± 3.39 	6.6 ± 1.23 	4.9 ± 2.15 	
Rice*	88.0 ± 2.16 	8.1 ± 4.62 	3.9 ± 2.46 	
Wheat*	81.3 ± 3.70 	13.1 ± 2.47 	5.6 ± 1.23 	
Potato*	83.4 ± 2.46 	11.6 ± 4.62 	4.9 ± 2.15 	

*Commercially isolated starch; ** Laboratory Isolated starch
(From Zhang et al, 2008)



Physical and Chemical Characteristics

Physical /Chemical characteristics	Macia Sorghum	Red Sorghum	Sumac
Test weight - kg/m³ (lb/bu)	1400.0 (108.8)	886.8 (67.3)	1386.1(107.7)
True Density g/cm³	0.86	1.21	0.83
TKW(g)	28.4	40.6	16.9
TADD (% weight removed)	30.8	57.2	27.8
Pigmented testa	No	Yes	Yes
Condensed Tannins (mg CE/g sample)	0.2	13.74	37.72
Total Starch of flour (mg starch/g sample)	665.2	620.2	610.0
Ash (%)	1.3	1.51	-



Conclusion

- ▶ **Sorghum has a potential application in food industry as a low glycemic index starch – Healthy option**
- ▶ **Could be used as starch source in diets of individuals sensitive to wheat gluten**
- ▶ **Ongoing research**



Some References

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