Composition of grain sorghum and its use in the feed industry.

October 2025

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Evonik Operations GmbH

Animal Nutrition

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Leading Beyond Chemistry

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> €15.3 billion sales*	**€1.66 billion** adjusted EBITDA*	**€1.17** dividend per share**
10.8% adjusted EBITDA margin*	**~80%** of sales from leading market positions	**~43%** sales from "Next Generation Solutions"
~33,400 employees	**109** nationalities	**€2.26** adjusted earnings per share**

* Fiscal 2023, ongoing activities I ** Proposal to the Annual General Meeting in May 2023

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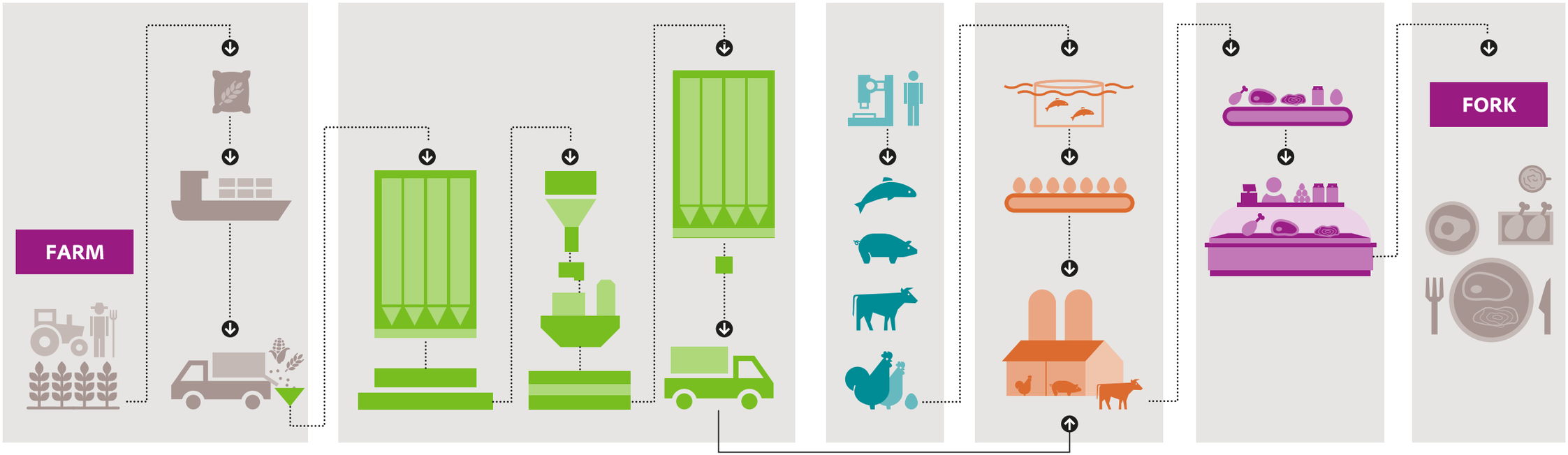

FEED RAW MATERIALS		NUTRITION		HEALTH	FARMING	PROCESSING AND RETAIL	CONSUMER
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SUSTAINABILITY

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ANIMAL NUTRITION

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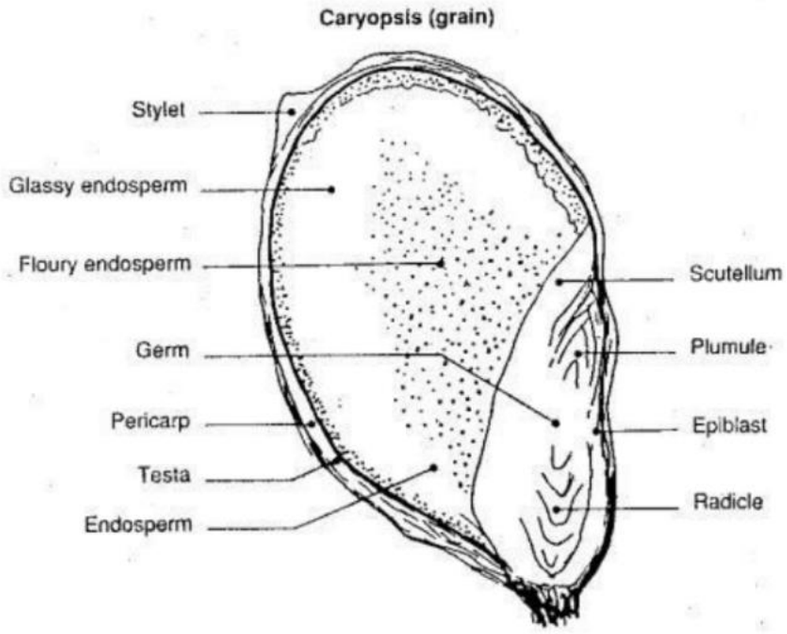
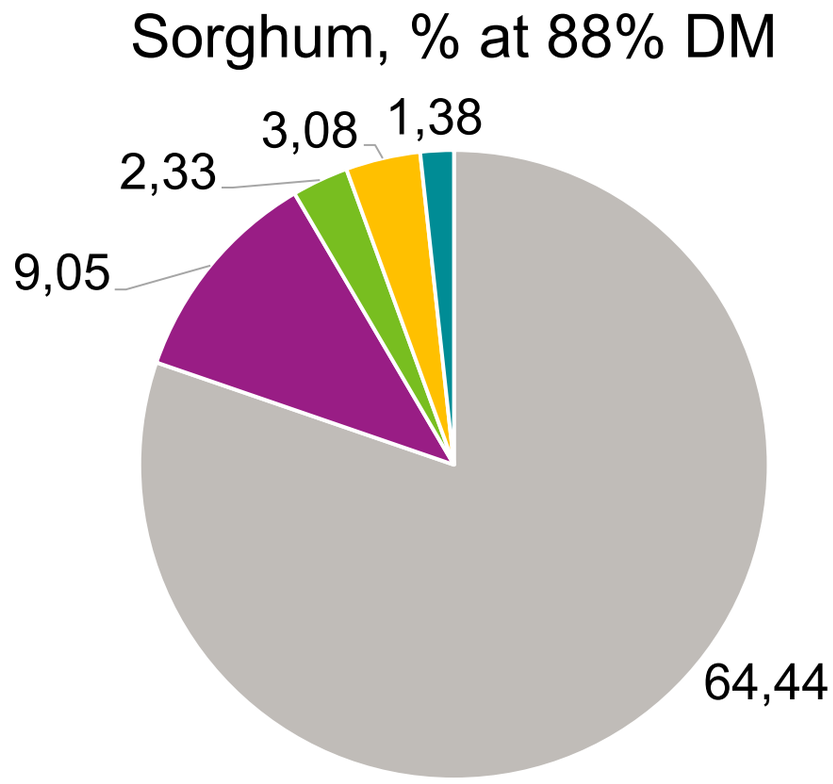
Proximate composition of Sorghum



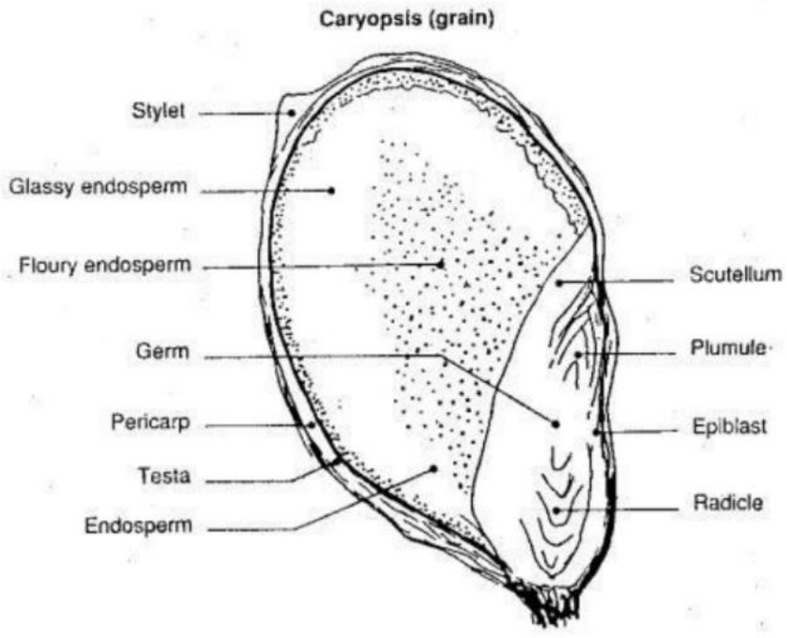
Sautier and O'Deye, 1989



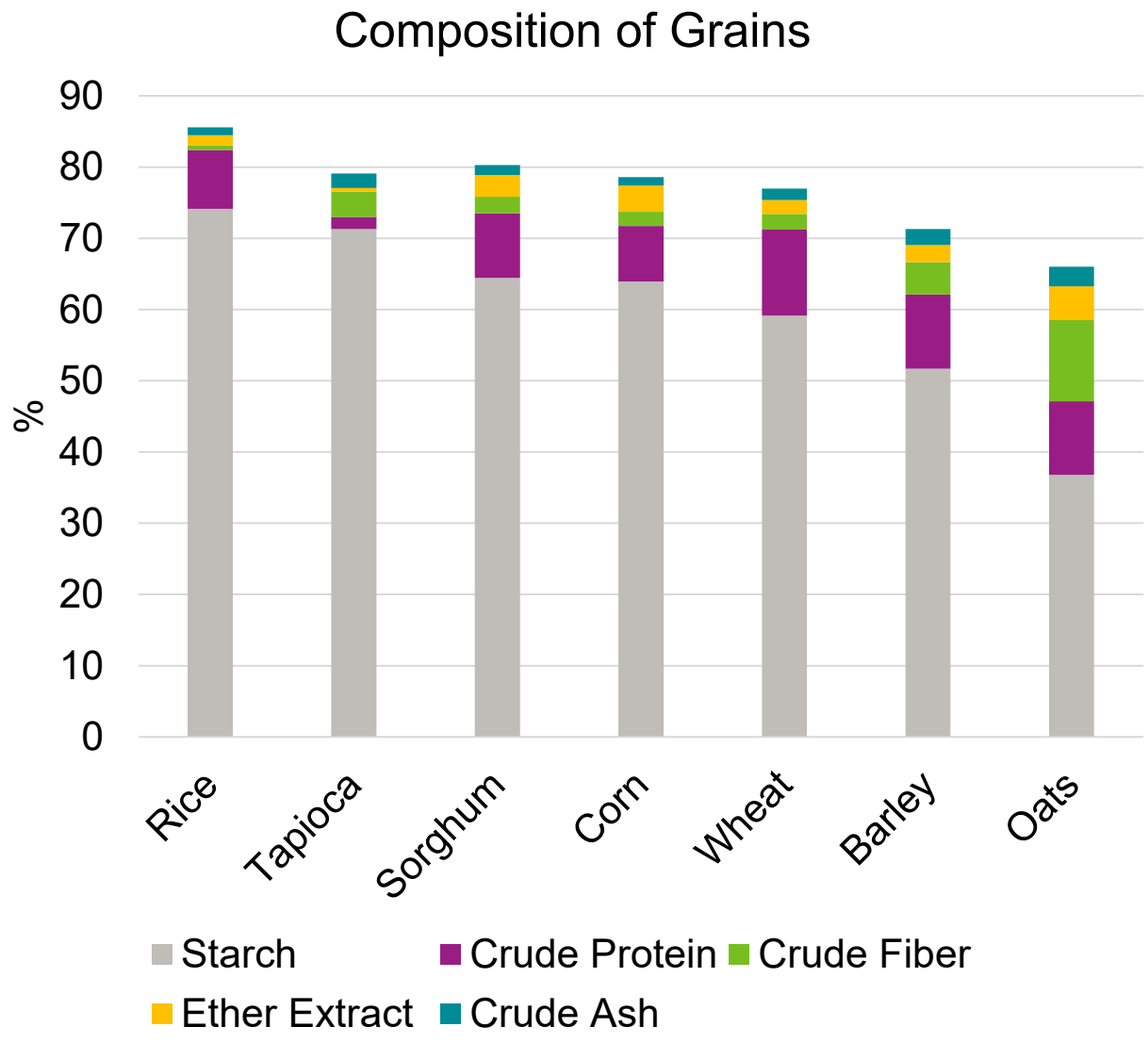
n = 245
2015 – 2020
Wet-chemistry

Source: AMINODat®

Proximate Composition of starch-rich feed ingredients



Sautier and O'Deye, 1989



Source: AMINODat®

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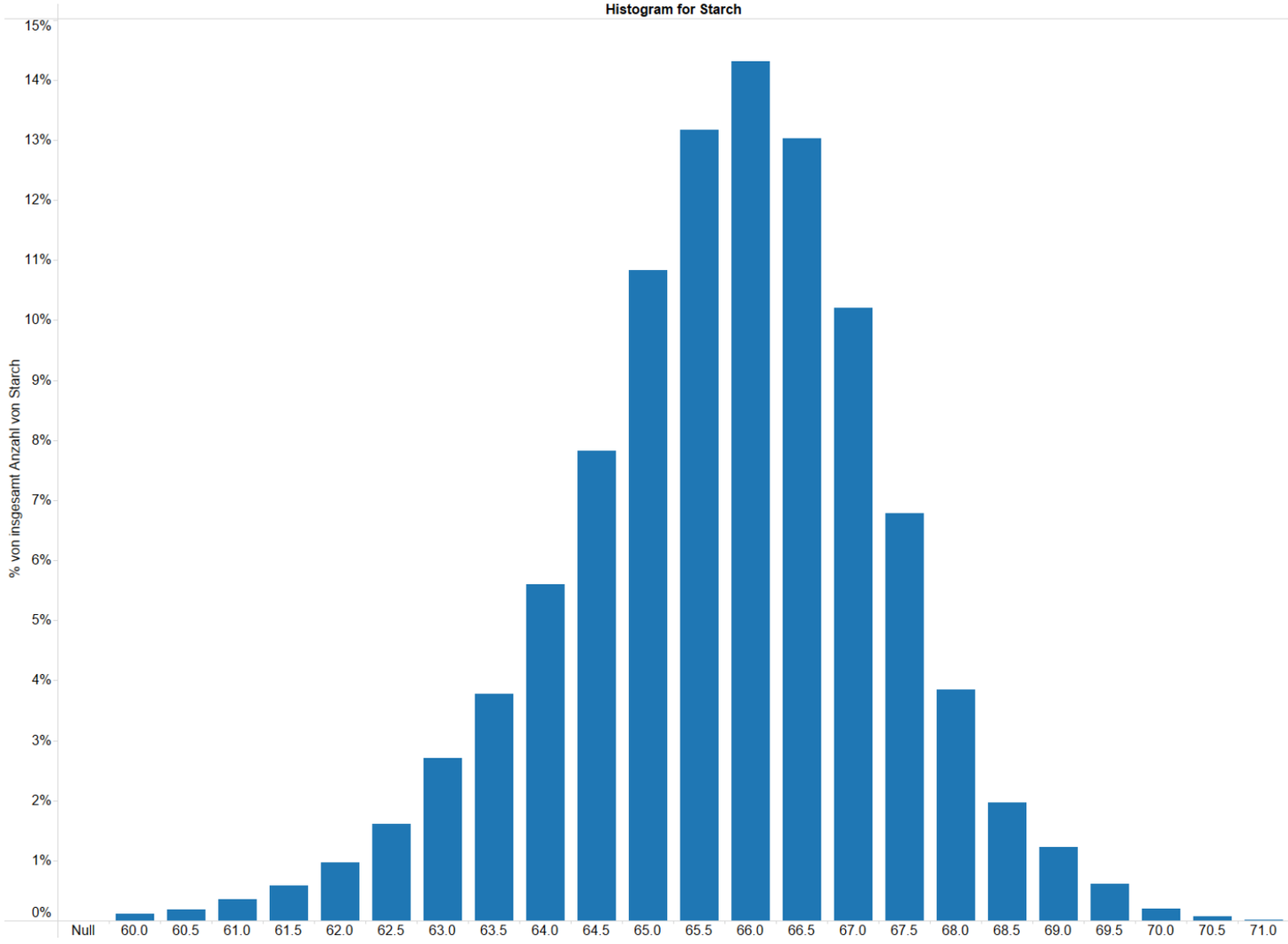
Starch content of Sorghum varies from about 60 to 70%



n = 53 300

Jan 2021 – Sept 2025

NIR

Median: 66.0 %

STD: 1.54

CV: 2.33%

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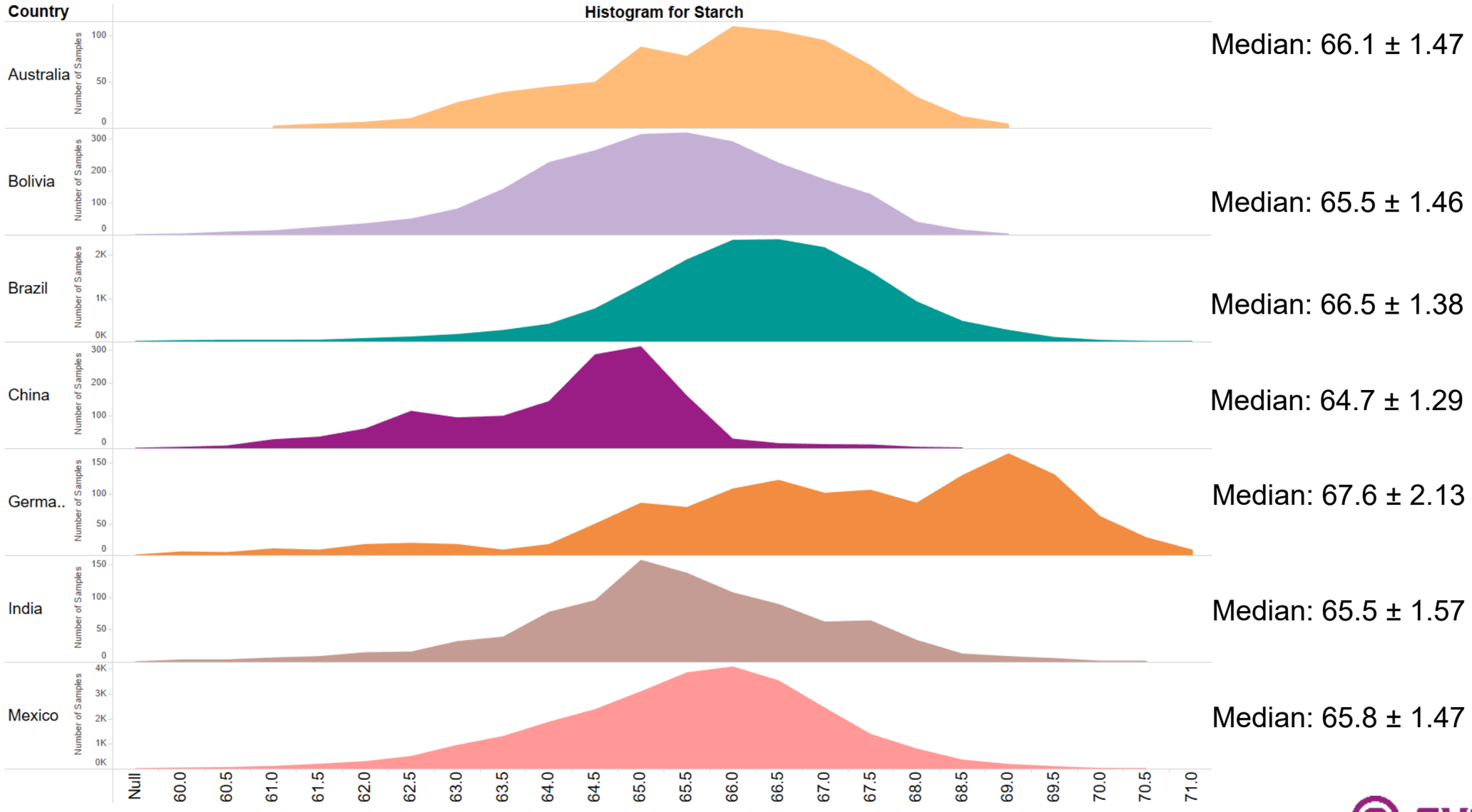
Starch content of Sorghum varies from about 60 to 70% and varies per country



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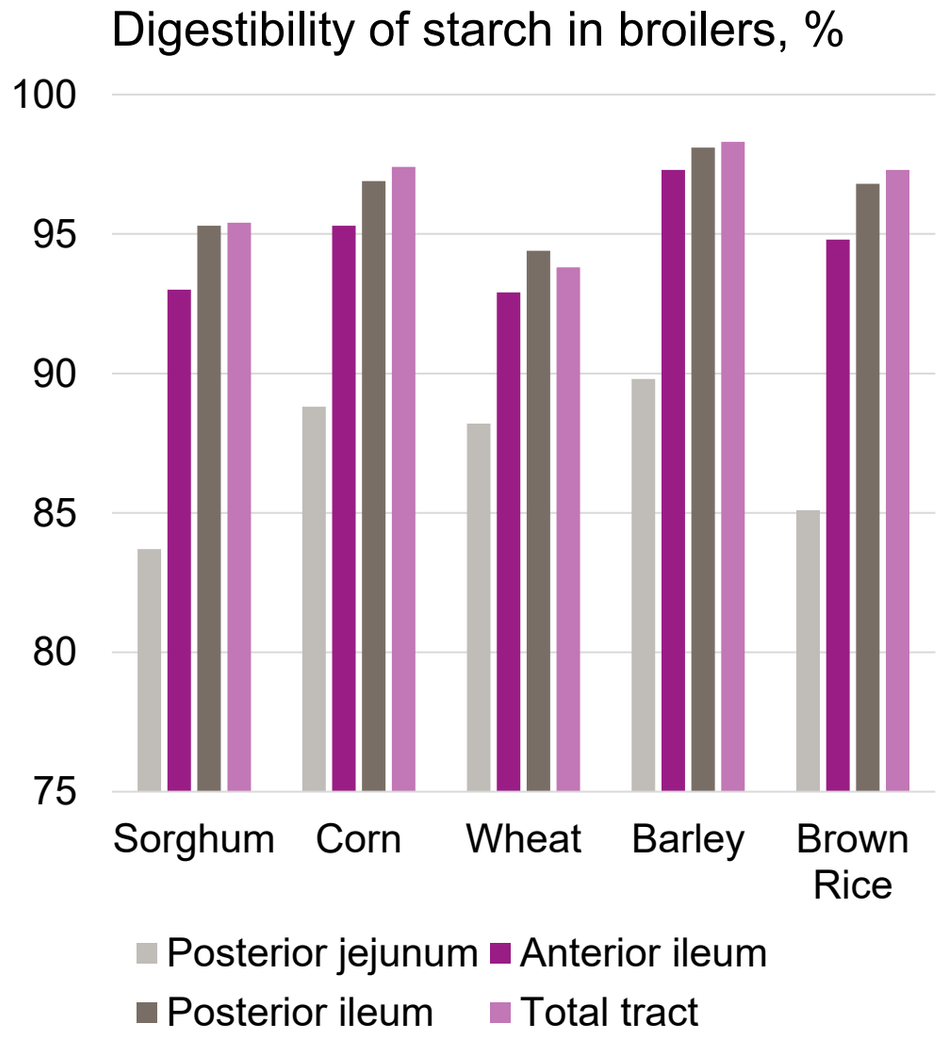
Digestibility of Sorghum starch is about 2-points lower in Broilers than that of Corn starch and digestion is happening more slowly



- Starch digestion occurs mainly in the upper small intestine.
- More than 90% of digested starch of cereal grains is already digested in the anterior ileum.
- There is almost no difference between ileal and total tract digestibility in broilers
- Ileal and total tract digestibility of starch is smaller in Sorghum than in Corn.
- Starch is an energy source for farm animals.

Weurding et al., 2001

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Energetic value of Sorghum is lower compared to that of Corn

	AMEn Poultry (MJ/kg)				
	n	Mean	Min	Max	CV
Sorghum	1384	13.55	13.09	14.19	0.99
Corn	73805	13.91	12.88	14.31	1.39

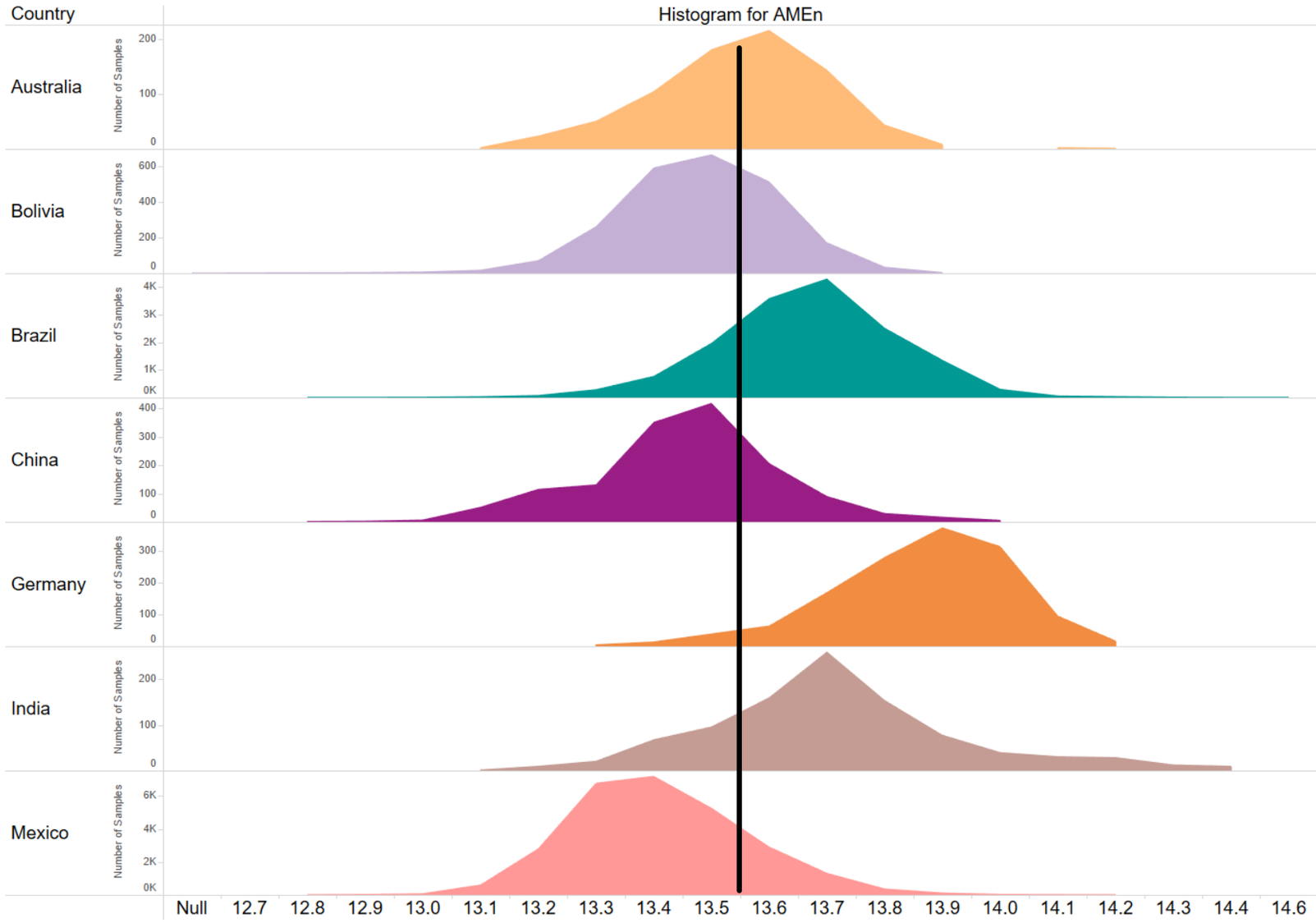
Disadvantage of 9.6 €/ton

	NE gr. Swine (MJ/kg)				
	n	Mean	Min	Max	CV
Sorghum	1384	11.03	10.52	11.47	1.41
Corn	73805	11.33	10.15	11.66	1.55

Disadvantage of 10.5 €/ton

Source: AMINODat®

Energy content of Sorghum varies per country as expected due to the varying Starch content



Total Median: 13.55 MJ/kg

Median: 13.61 ± 0.15

Median: 13.53 ± 0.13

Median: 13.72 ± 0.15

Median: 13.51 ± 0.16

Median: 13.93 ± 0.15

Median: 13.75 ± 0.22

Median: 13.44 ± 0.15

13.72 €/ton

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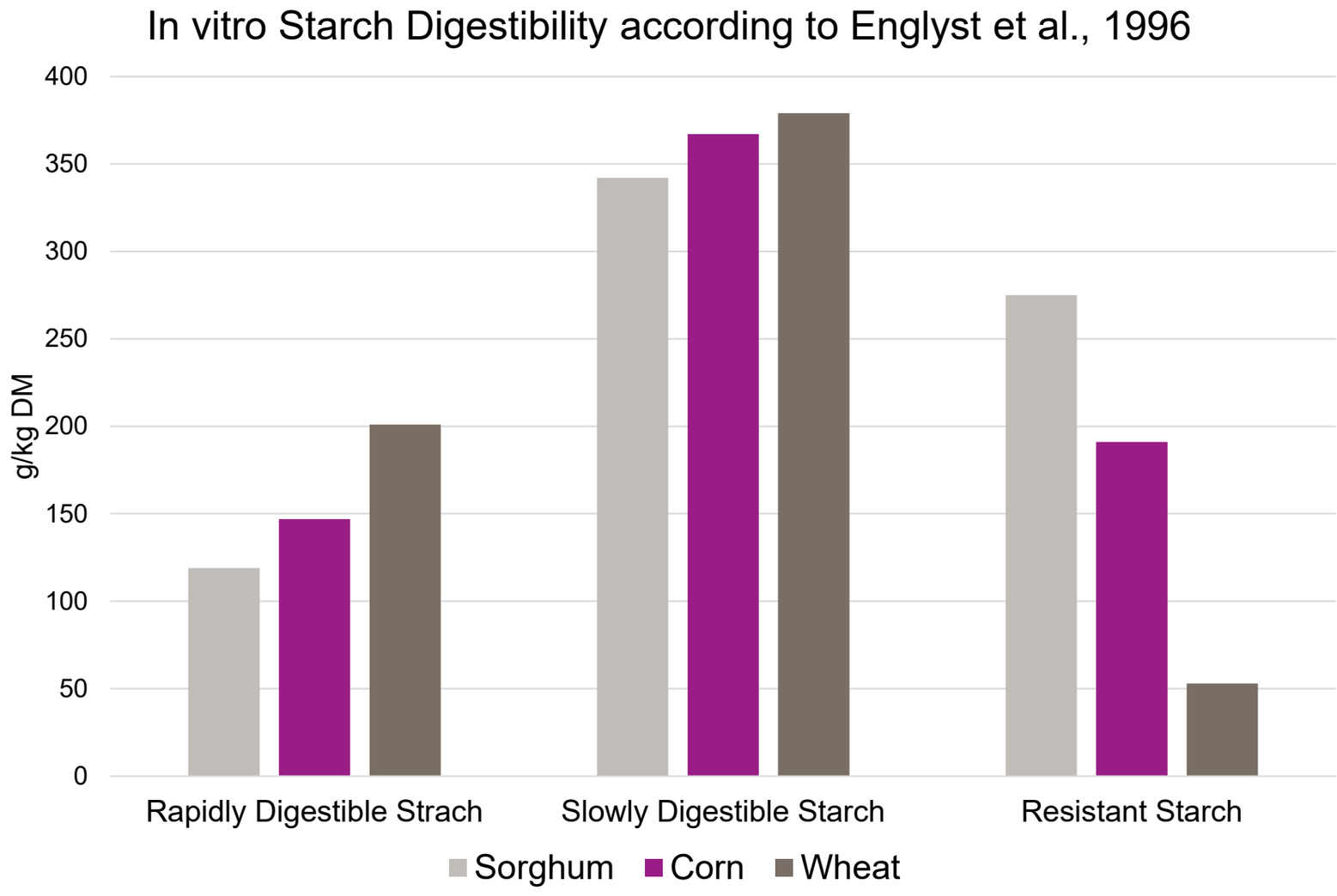
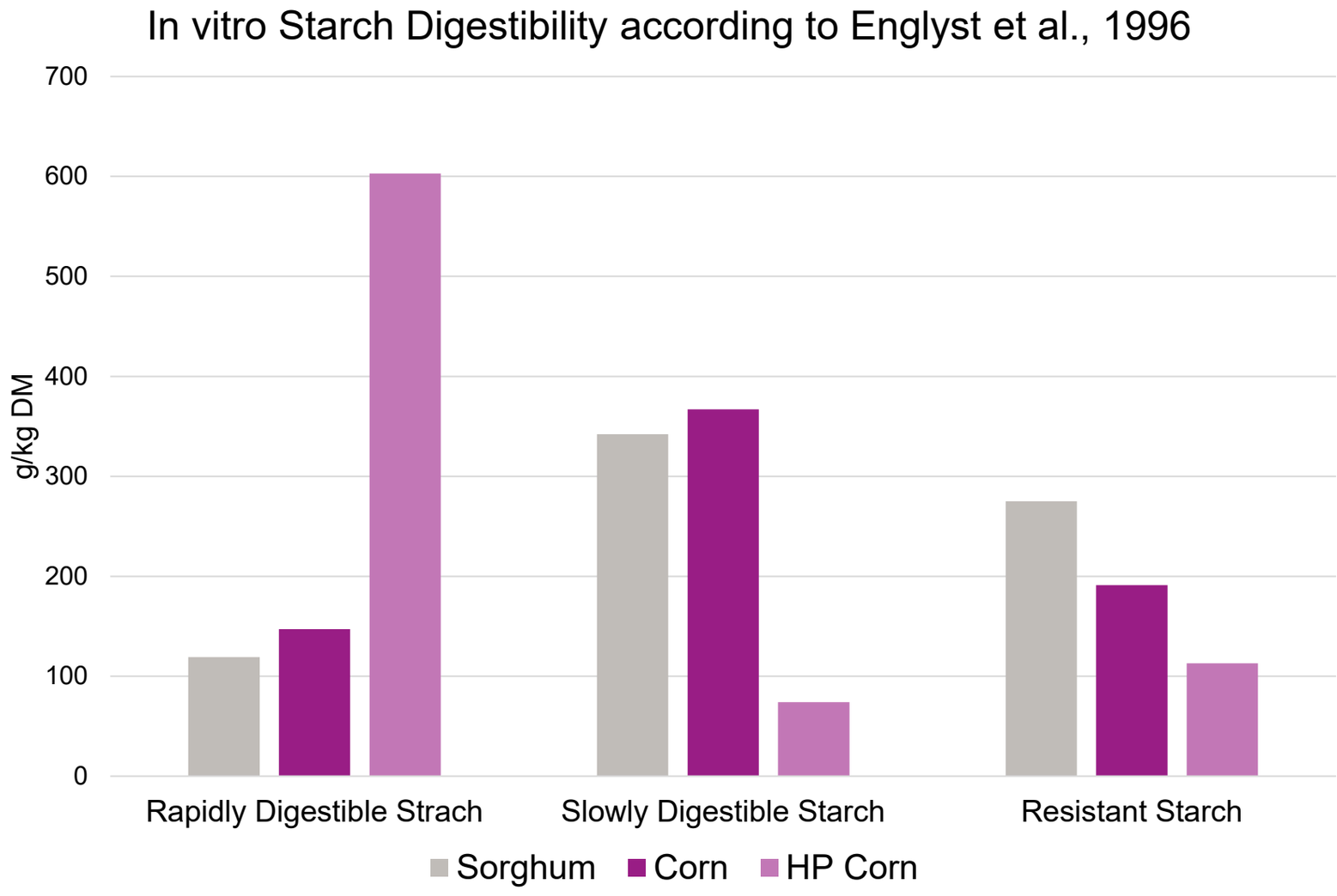
Sorghum is relatively high in resistant starch compared to corn and wheat



Giuberti et al., 2012a

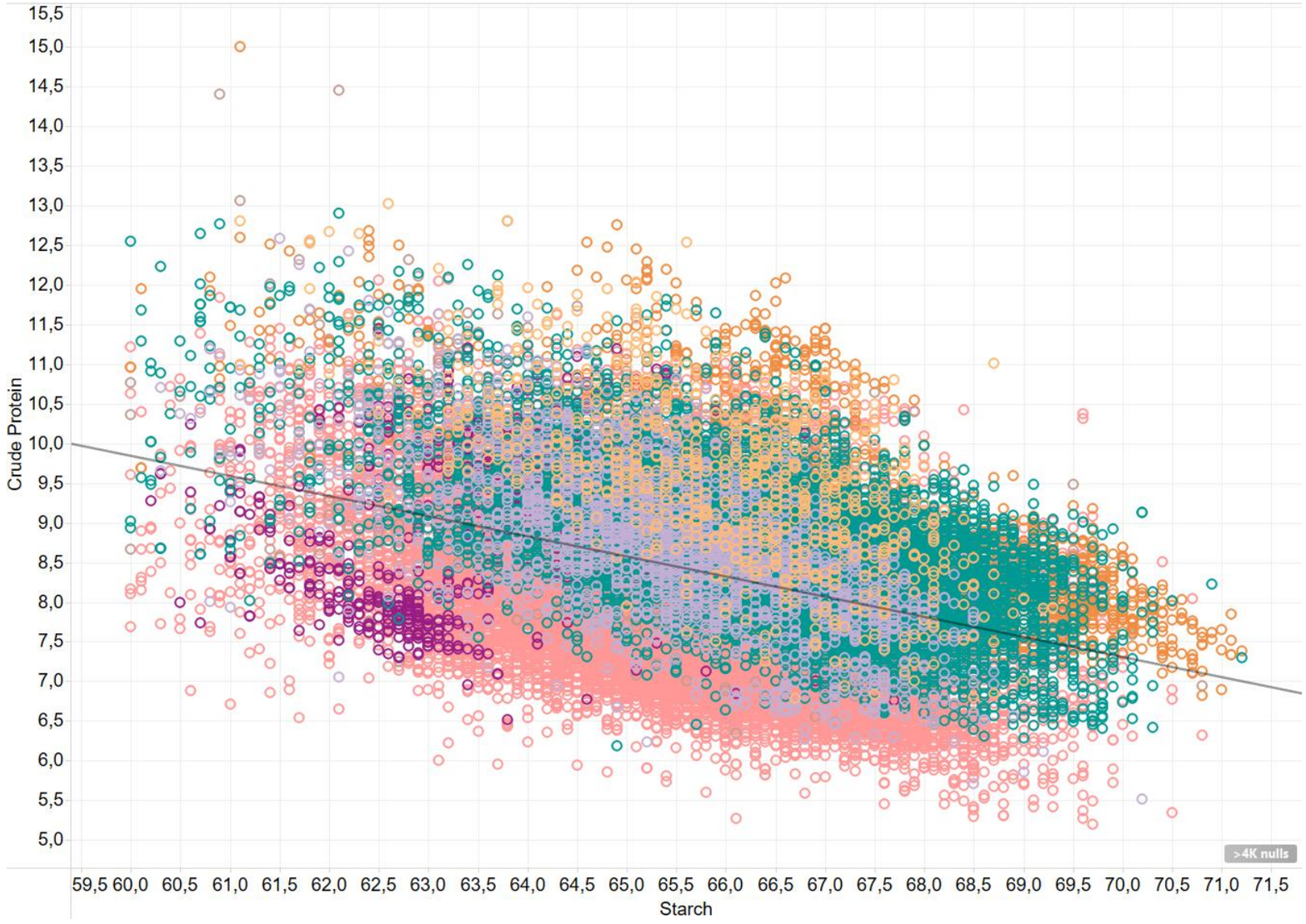
Heat processing can be used to change starch characteristics

Steam-flaking of Corn increased RDS and decreased SDS and RS



Giuberti et al., 2012a

Starch content corrleates negatively with protein content



$R^2 = 0.16$

P-value = <0.0001

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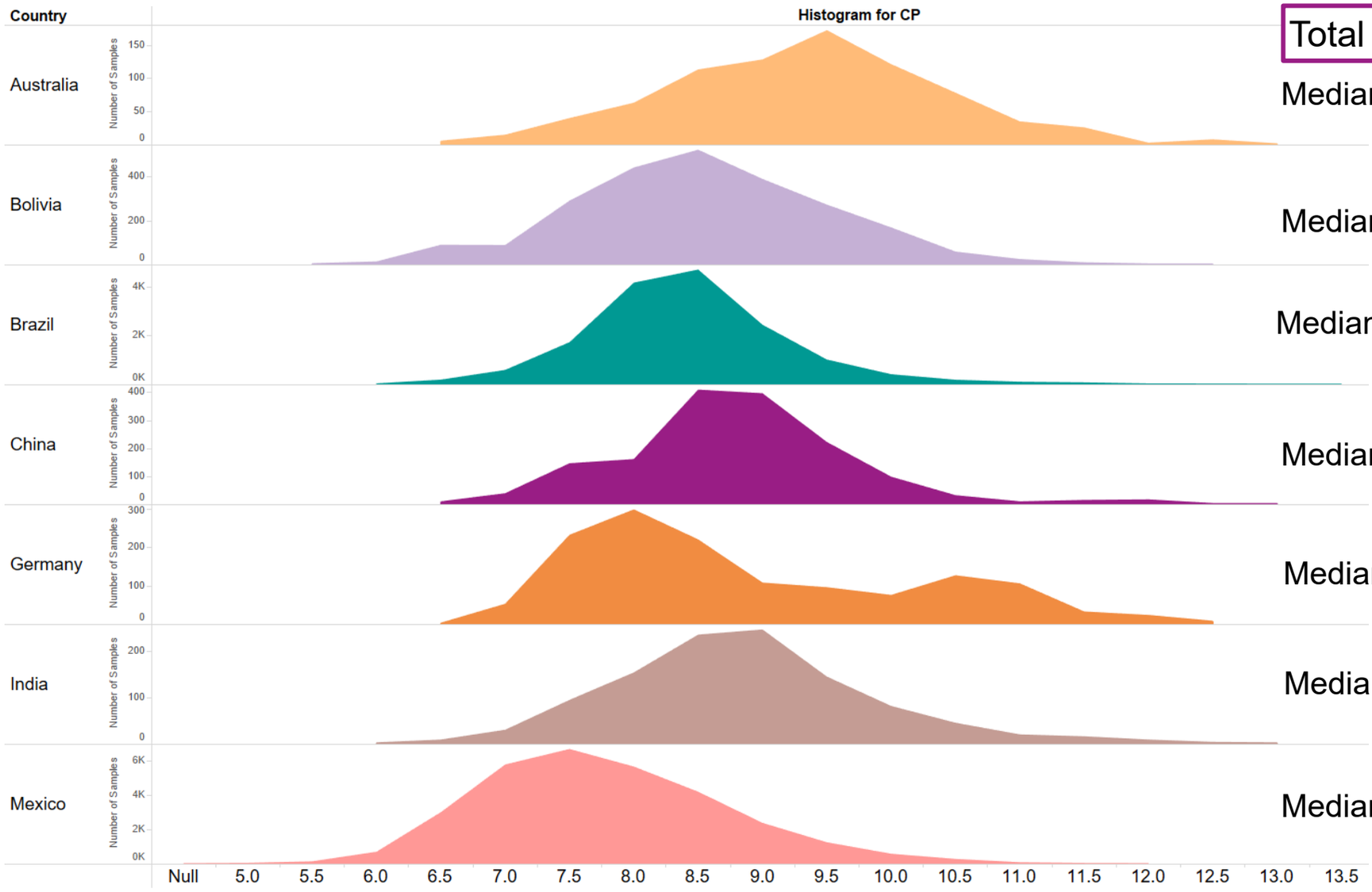
Crude Protein content ranges from about 6 to 12% and varies per country.



Total Median: 8.31 % CP

Median: 9.61 ± 1.07

Median: 8.74 ± 0.97

Median: 8.60 ± 0.76

Median: 9.01 ± 0.89

Median: 8.69 ± 1.31

Median: 9.04 ± 1.04

Median: 7.92 ± 0.92

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Crude protein is a rough parameter, and animals do not have a requirement for crude protein but for amino acids

Crude protein
(Total nitrogen x 6.25)

True Protein

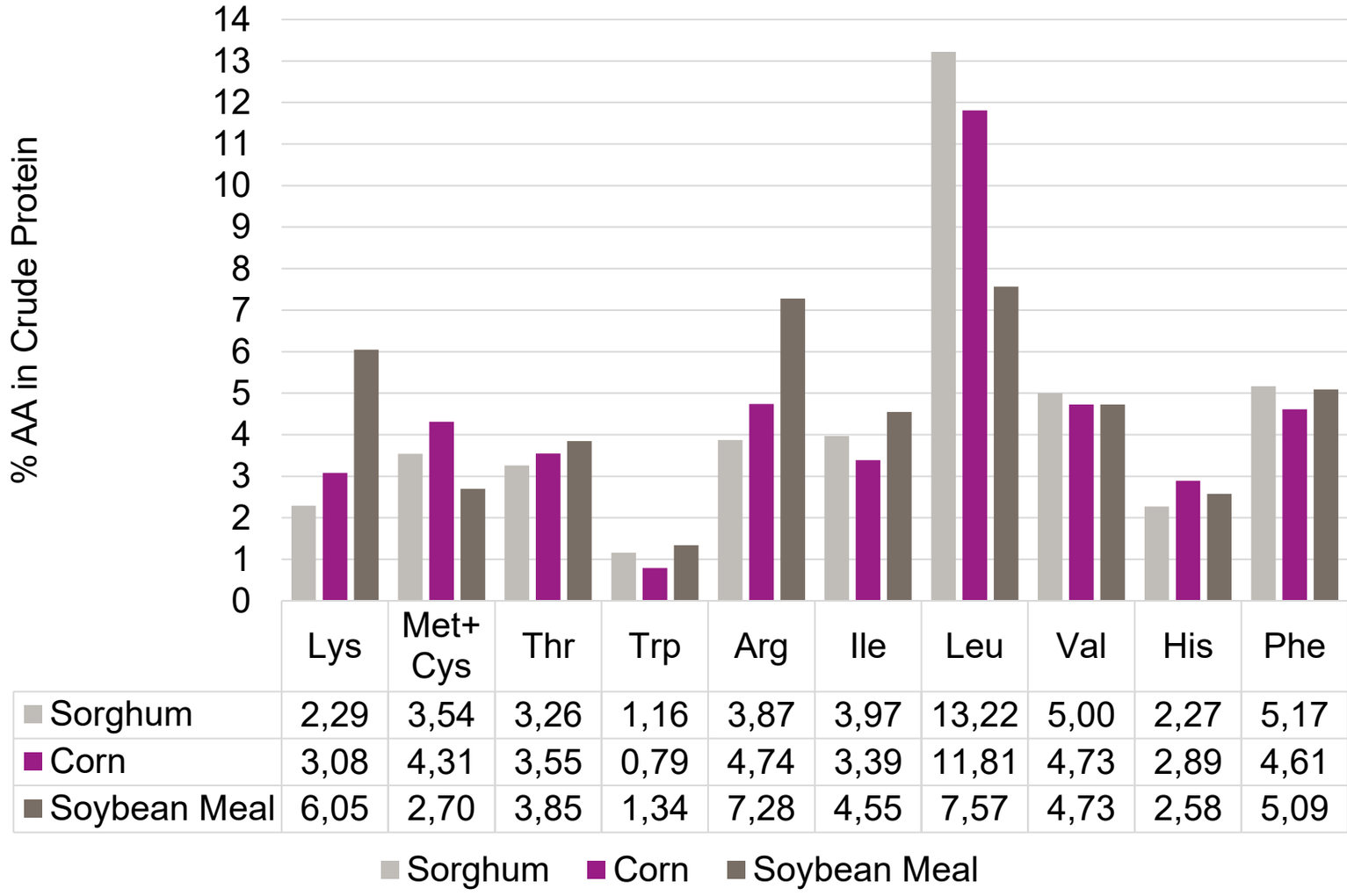
- **Amino acids**

Non-protein nitrogen

- Urea
- Amines
- Amides
- Nitrates
- Nucleic acids (DNA/RNA)
- Betaine
- Choline
-Vitamines

Not retained in the body!

Protein of Sorghum is lower in Lys, Met+Cys and Thr compared to Corn but higher in Trp and Val



	Lys	Met+ Cys	Thr	Trp	Arg	Ile	Leu	Val	His	Phe
Sorghum	2,29	3,54	3,26	1,16	3,87	3,97	13,22	5,00	2,27	5,17
Corn	3,08	4,31	3,55	0,79	4,74	3,39	11,81	4,73	2,89	4,61
Soybean Meal	6,05	2,70	3,85	1,34	7,28	4,55	7,57	4,73	2,58	5,09

First limiting AA

Poultry:

Met+Cys / Lys / Thr / Val

Pigs:

Lys / Met+Cys / Thr / Trp / Val

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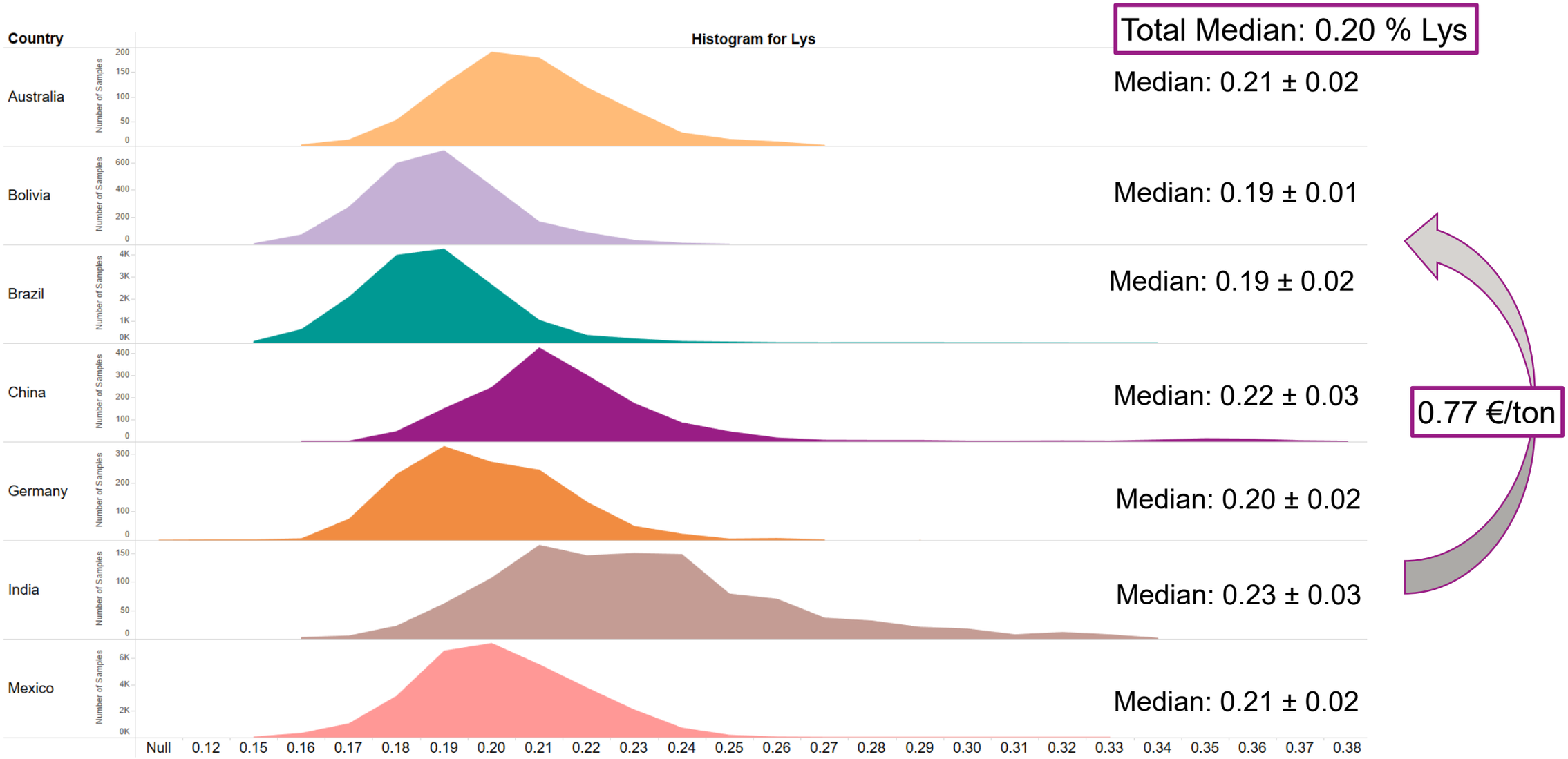
Lysine content varies between countries but much more within the countries



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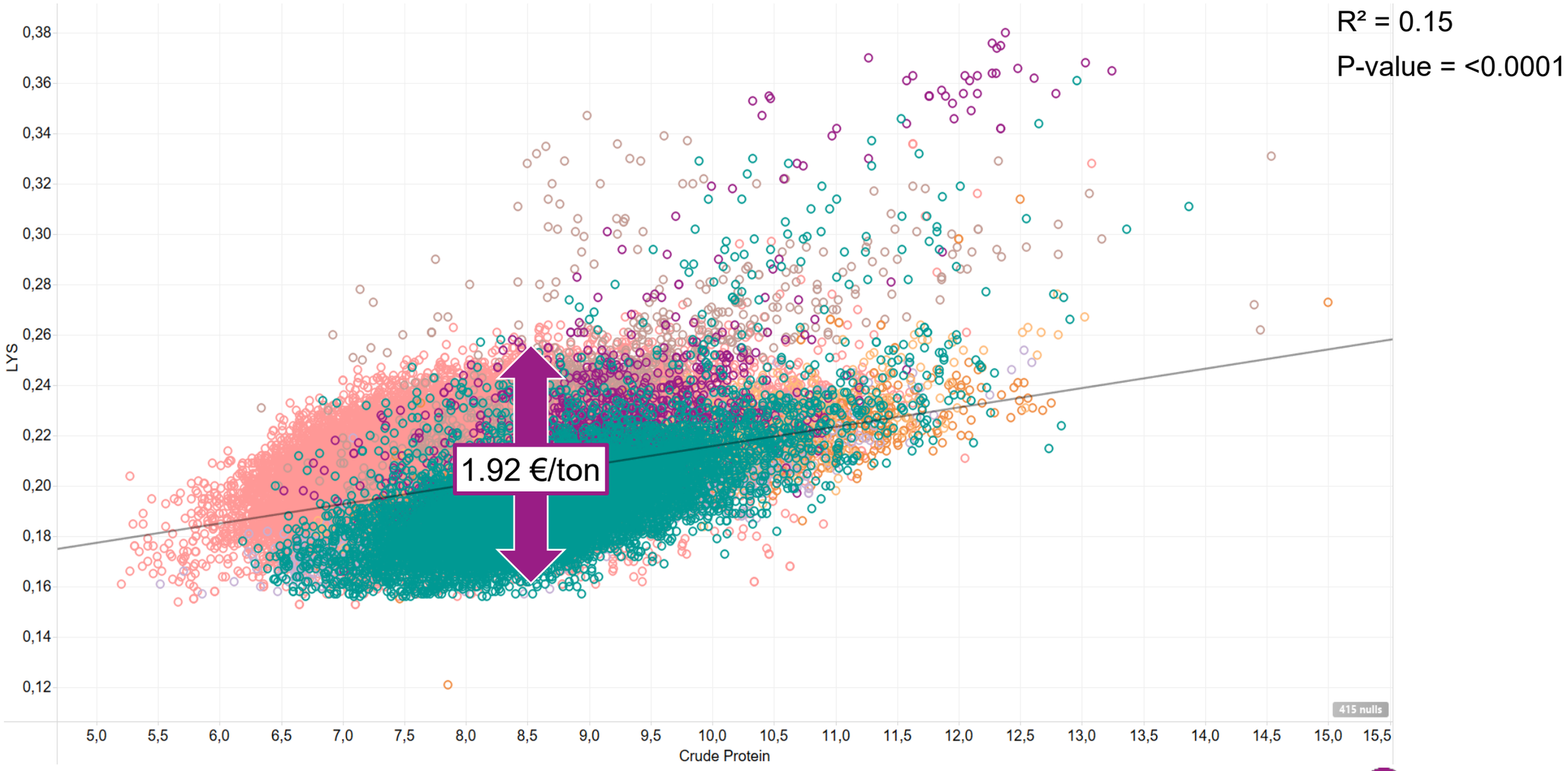
Lysine content is quite variable in Sorghum even at the same protein content



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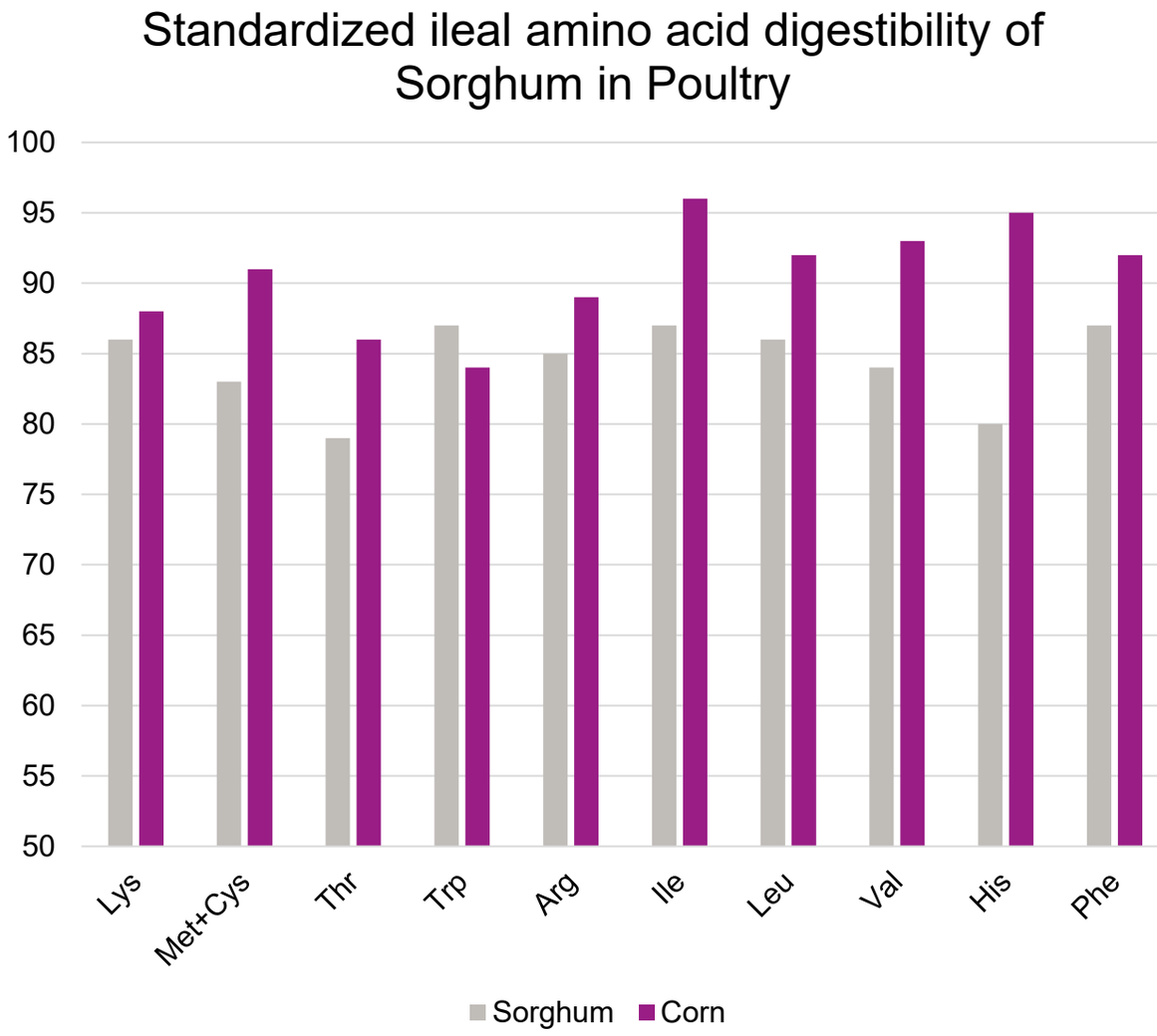
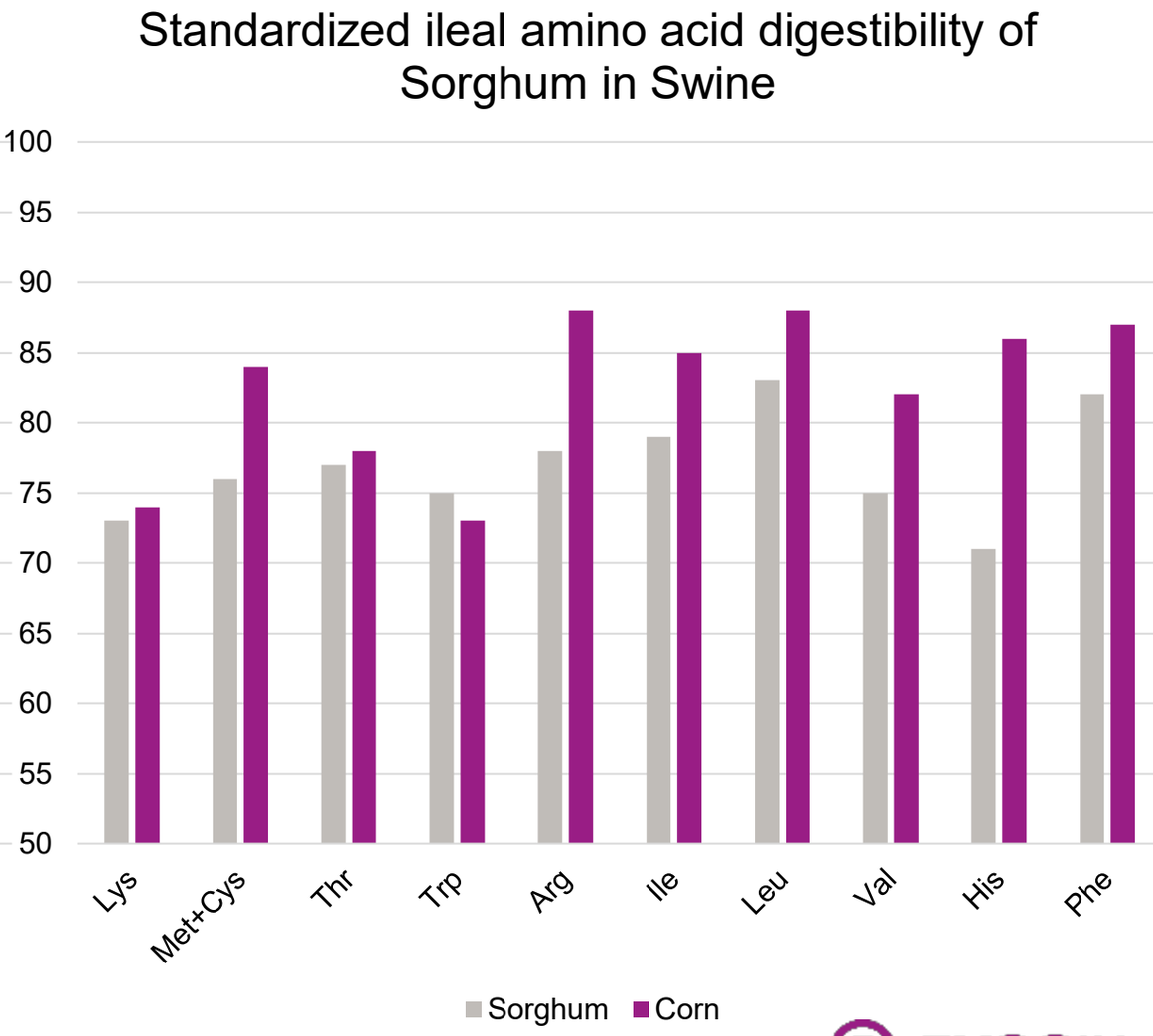
Amino acid digestibility of Sorghum is lower than that of Corn in Poultry and Swine





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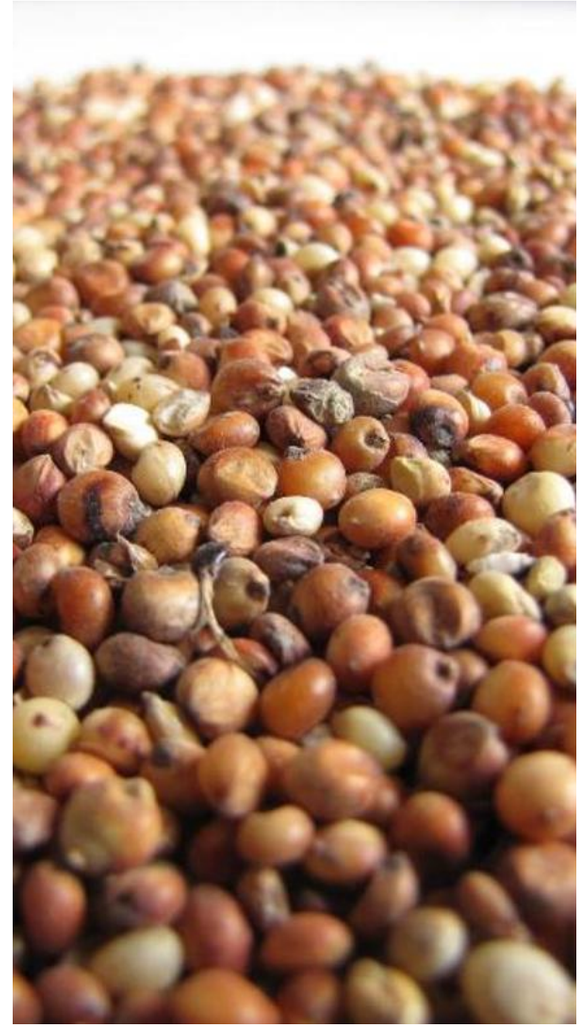
Sorghum price needs to be 10.68 €/ton lower compared to Corn to be used in diets for broilers in this example

Broiler Starter Diet	Corn	Sorghum	
Corn, % (245,00 €/ton)	43,65	-	
Sorghum, %	-	44,67	+
SBM, %	37,47	35,97	-
Wheat, %	12,00	12,00	
Soybean oil, %	2,68	3,24	+
Vit. + Minerals, %	3,59	3,39	
DL-Met, %	0,29	0,32	+
L-LysHCL, %	0,18	0,25	+
L-Thr, %	0,08	0,10	+
L-Val, %	0,06	0,06	
Diet cost*, €/ton	313,88	313,88	
Shadow Price Sorghum, €/ton	234,32		



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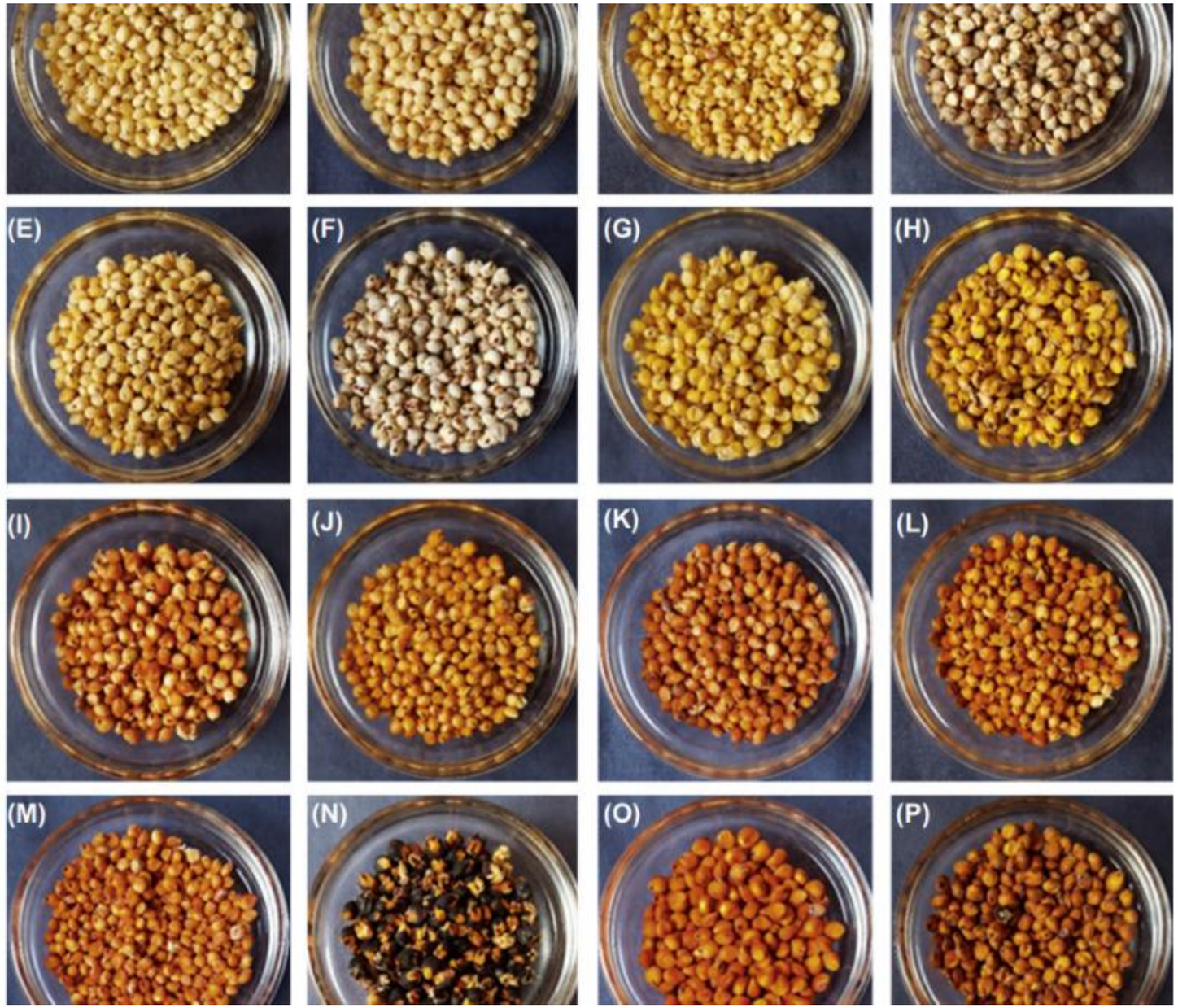
Tannin content of Sorghum



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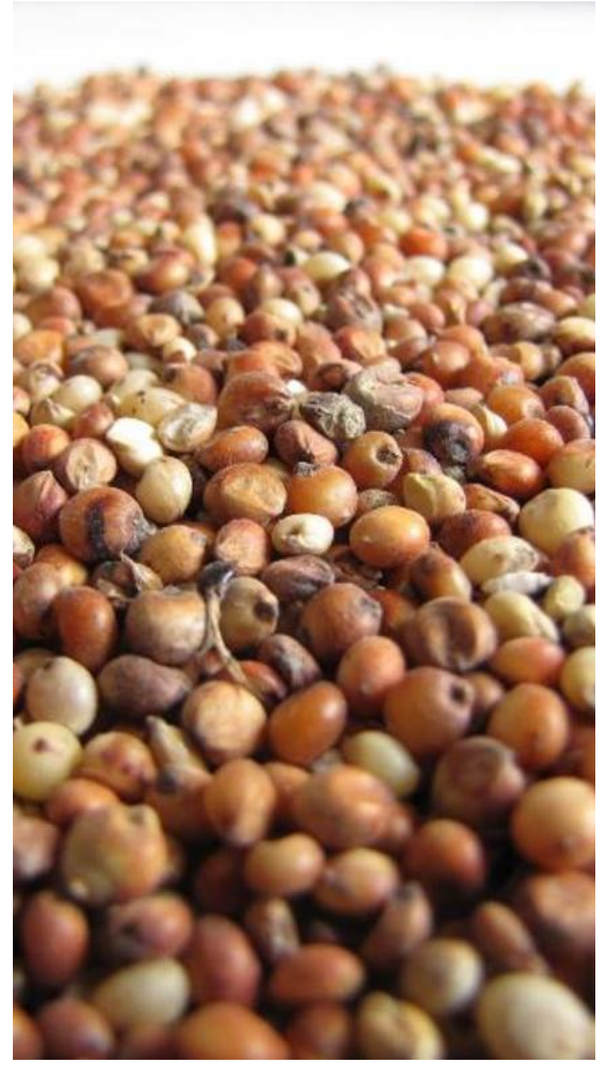
Phenols, Flavonoids, Tannins in Sorghum

- Phenolic compounds in Sorghum
  - Phenolic acids
  - Flavonoids
  - Condensed Tannins

- Phenolic acids:
  - ferulic acid, p-coumaric acid, vanillic acid
  - located in pericarp, tsta, aleurone layer and endosperm; predominantly in bran layer

- Type I Sorghum: non-tannin sorghum
- Type II Sorghum: tannins present in pigmented testa
- Type III Sorghum: tannins present in pigmented testa and pericarp



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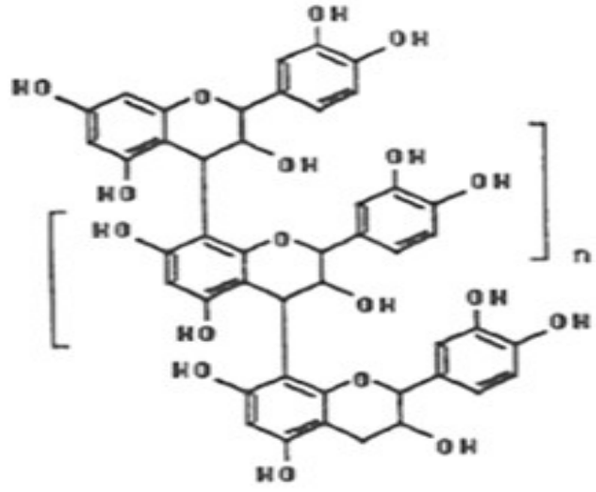
Tannin in Sorghum is an anti-nutritional factor

- Tannins form strong complexes with proteins, carbohydrates, starch, minerals, and digestive enzymes
- Tannins inactivate enzymes and precipitate proteins through complex-forming → thereby reducing feed quality.
- 1% (10 mg/g) Tannins reduces the energy content of sorghum by 7% in pigs and 11% in poultry
- In the EU, only new sorghum varieties that meet the criterion of low tannin content below 0.3% (3 mg/g) can be registered.



Sorghum tannins

Cadogan and Finn, 2010; Liu et al., 2010; Maier et al.,2017

Color of Samples was not an indicator of Tannin content

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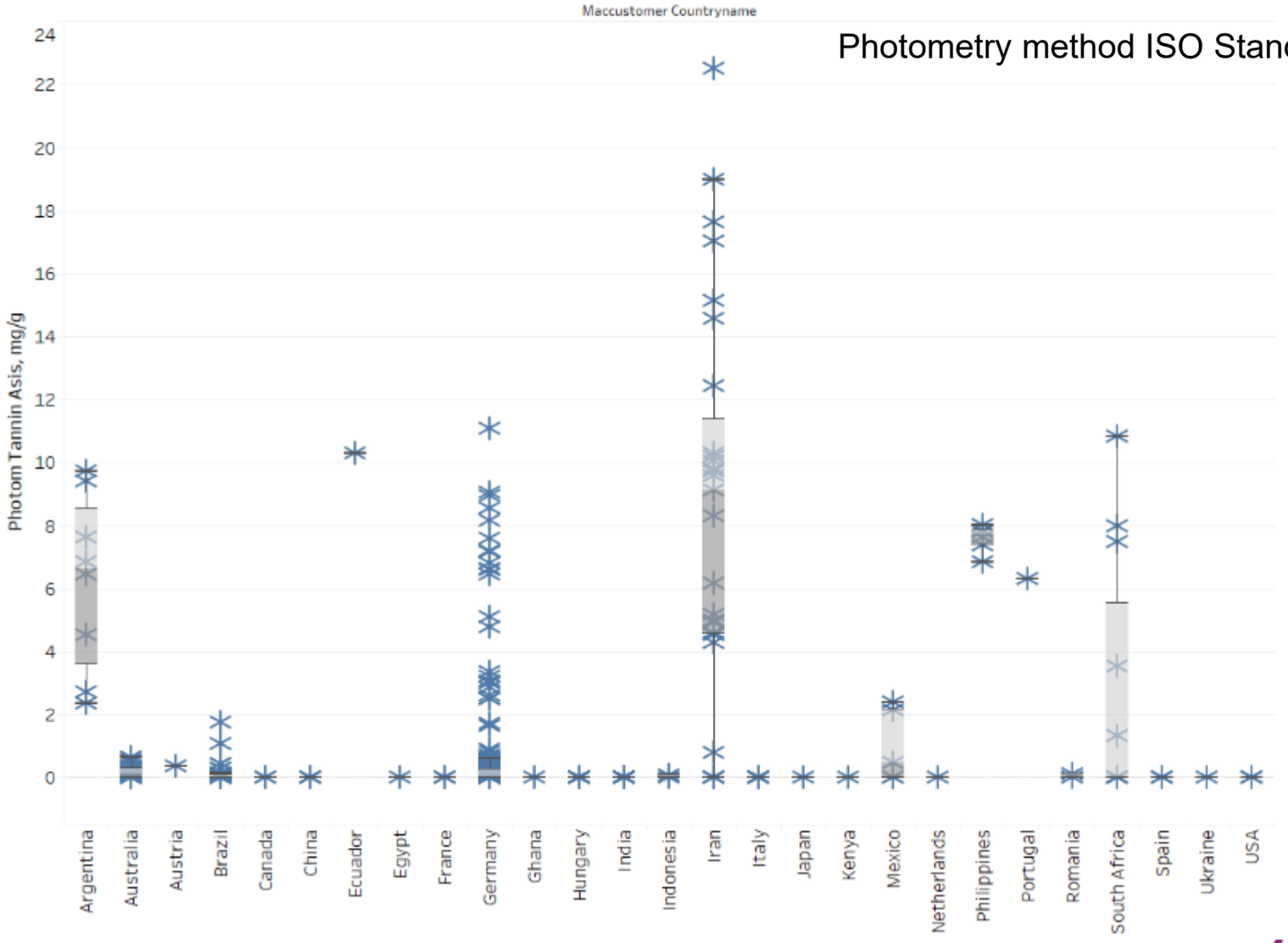
Samples analyzed for Tannins by wet-chemistry (231 samples: Tannin = 0.00 mg/g; 191 samples with detctable Tannin levels)

Maccustom..	
Null	5
Argentina	8
Australia	31
Austria	1
Brazil	54
Canada	2
China	4
Ecuador	1
Egypt	1
France	3
Germany	208
Ghana	1
Hungary	13
India	17
Indonesia	2
Iran	27
Italy	8
Japan	1
Kenya	1
Mexico	5
Netherlands	1
Philippines	6
Portugal	1
Romania	2
South Africa	12
Spain	3
Ukraine	1
USA	3
Grand Total	422



Photometry method ISO Standard 9648:1988

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Summary and Conclusions

1. Low tannin Sorghum is a valuable feed ingredient for monogastric animals
2. Nutritional composition of Sorghum is very similar to Corn
3. Sorghum can fully replace Corn in diet formulation
4. Starch and amino acid digestibility is a bit reduced compared to corn
5. High tannin Sorghum is available in some countries
6. Color is not a reliable indicator for Tannin contents

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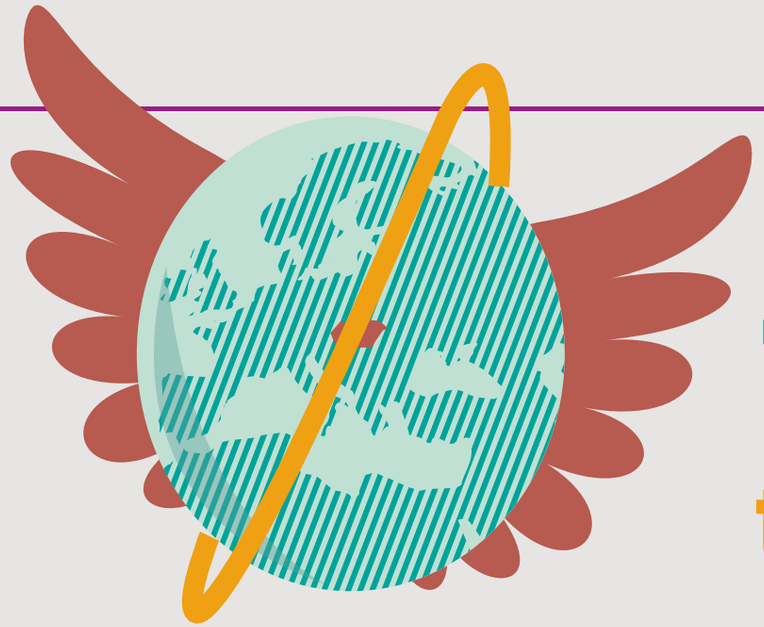

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4th European Sorghum Congress Budapest

October 8th - 9th 2025

Sorghum ID
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