



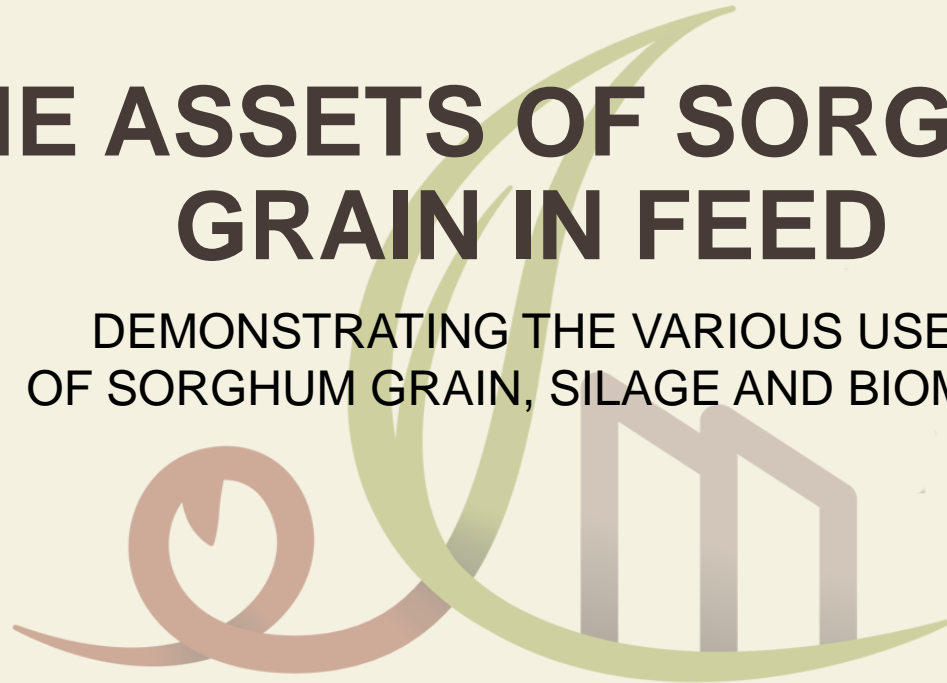
1ST EUROPEAN SORGHUM CONGRESS

WORKSHOP

FROM ENERGY PRODUCTION TO FOOD AND FEED

THE ASSETS OF SORGHUM GRAIN IN FEED

DEMONSTRATING THE VARIOUS USES
OF SORGHUM GRAIN, SILAGE AND BIOMASS



COMPANY DESCRIPTION

PART OF NEOVIA GROUP FRANCE

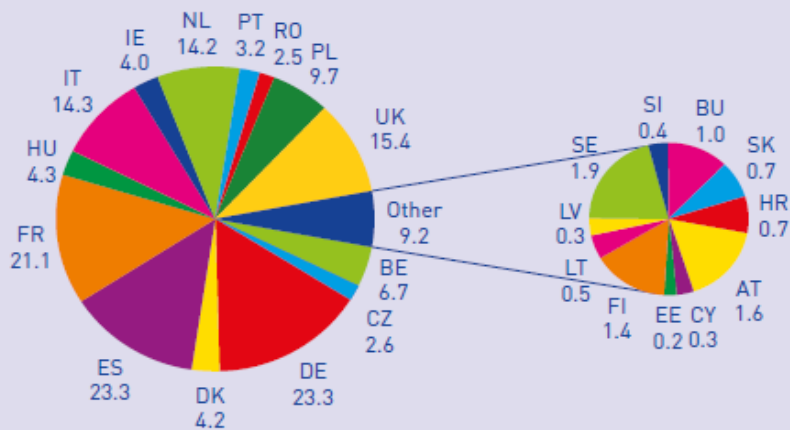
- Subsidiary of **neovia** by **invivo**
- Presence in Romania since 1993.
- 2 companies, 2 factories, with national coverage and products for all major animal species.
- Guyomarc'h Romania with one factory in Ciolpani (IF), since 1997 for vitamin-mineral premix and specialties, production.
- Evialis (G-A Nutritie Animala) with one factory in Brad (BC) since 2009 for compound feed production.



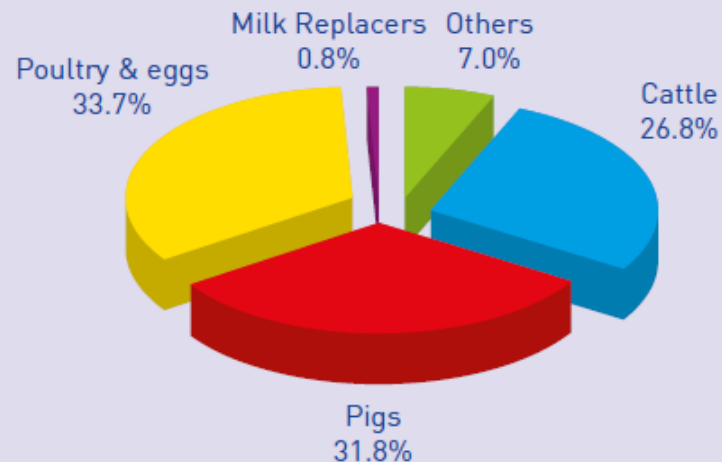
EU-28 FEED PRODUCTION

158 MILLION TONS IN 2015

EU-28 compound feed production in 2015
(158 mio. t / +1%) (Source: FEFAC)



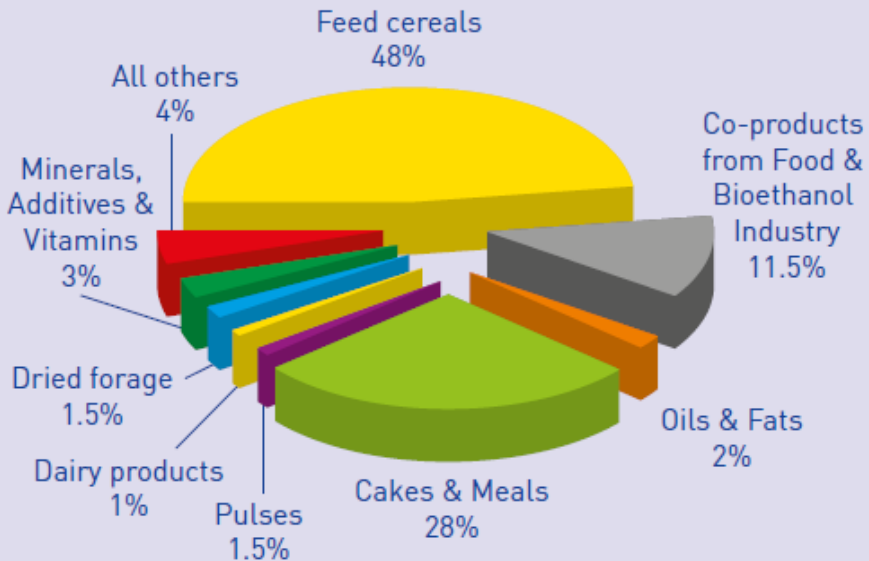
Industrial compound feed production in EU-28 per category in 2015 (Source: FEFAC)



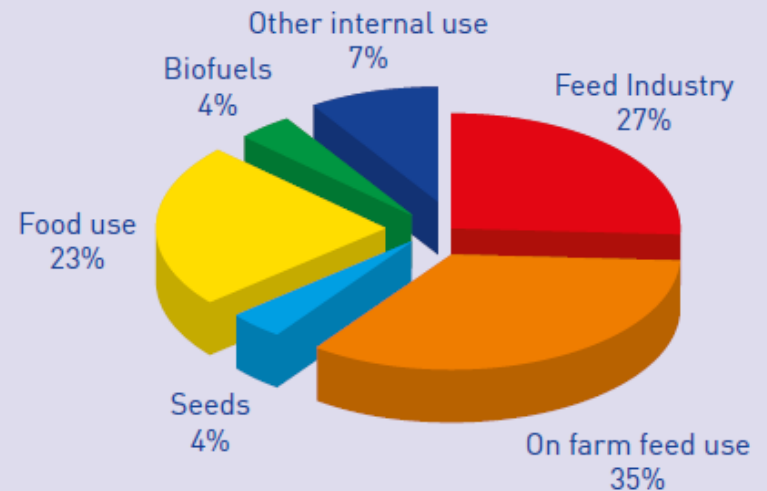
EU-28 FEED PRODUCTION

CEREALS MAIN FEED MATERIAL

Feed material consumption by the compound feed industry in 2015 in the EU-28 (Source: FEFAC)



Usage of cereals in the EU-28 in 2015-16 (Source: DG AGRI - FEFAC)



INTRODUCTION

FIFTH MOST IMPORTANT CEREAL

- Cereal belonging to the Gramineae family.
- Fifth most important cereal in the world.
- Nutritional profile similar to maize.
- Presence on tannins.
- Used both in animal and human nutrition.
- European production used mainly for feed (Fourth most common cereal used in Spain)



VARIETIES

2 VARIETIES FOR ANIMAL NUTRITION

- Sorghum genus, comprises 20 species, the most important being 2:
 - Sorghum bicolor for grain
 - Sorghum sudanense for fodder
- Nutritionally they are divided into 3 groups (based on tannin content)
 - Low tannin content: $< 0.2 \%$
 - Medium tannin content: $0.2-0.6 \%$
 - High tannin content: $> 0.6 \%$

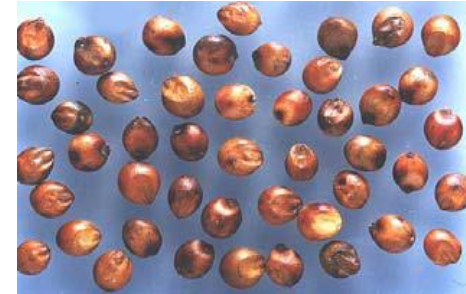


VARIETIES

GRAIN COLOR VARIATION

- Grain color can be white or pigmented (red, brown, yellow, black).
- Varieties used in feed can be white or pigmented.
- White varieties have a low tannin content with higher nutritional value.
- Brown varieties **usually** have a higher tannin content, but are more resistant to birds, diseases and adverse weather conditions.

NB: Today, many brown varieties have low tannin content



Red sorghum

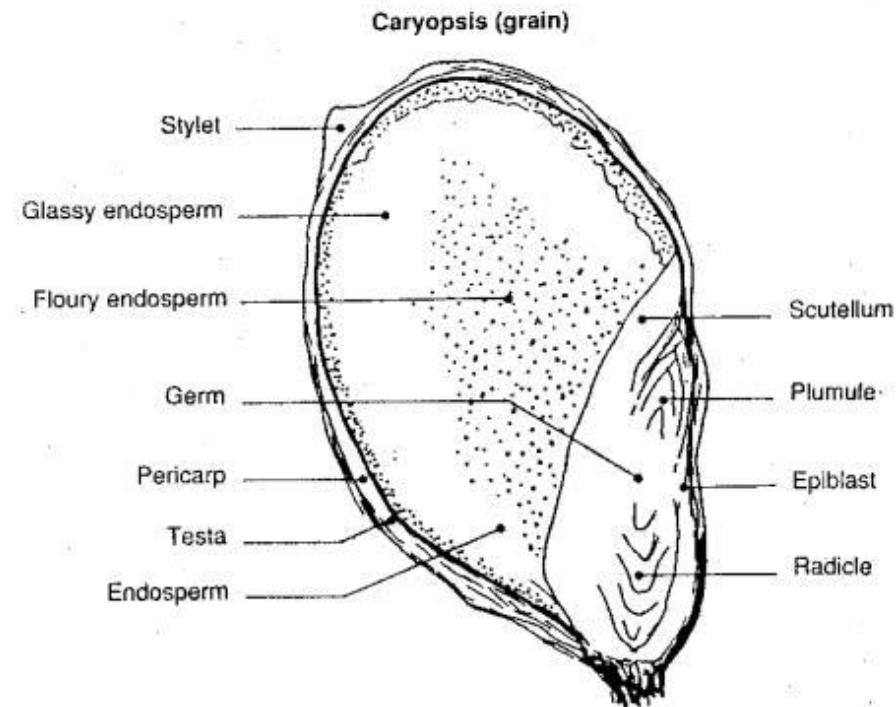


White sorghum

GRAIN STRUCTURE

TYPICAL STRUCTURE FOR CEREAL GRAIN

- Caryopses type.
- 4-8 mm diameter, 25-35 mg weight
- 3 distinct anatomical structures:
 - Pericarp (outer layer) – 6%
 - Germ (embryo) – 9%
 - Endosperm (storage tissue) – 85%
- Tannin varieties have a pigmented testa located between pericarp and endosperm.

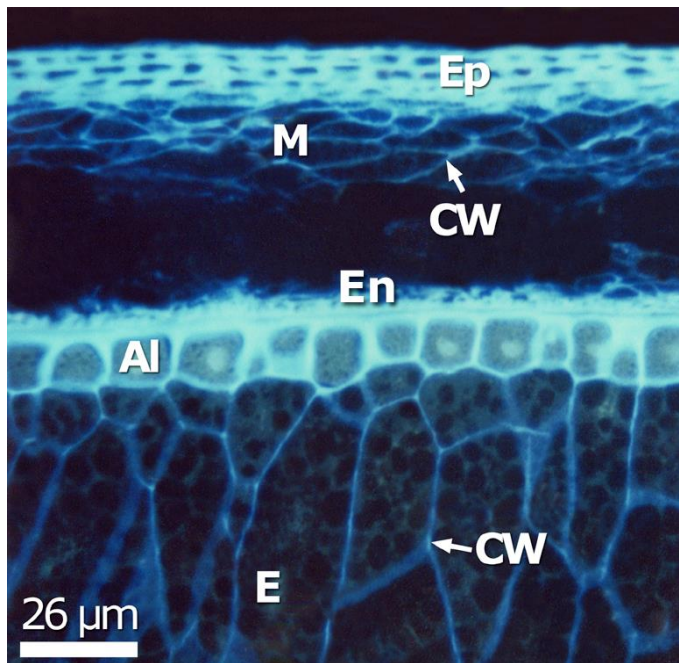


Structure of sorghum grain (Sautier and O'Deye, 1989)

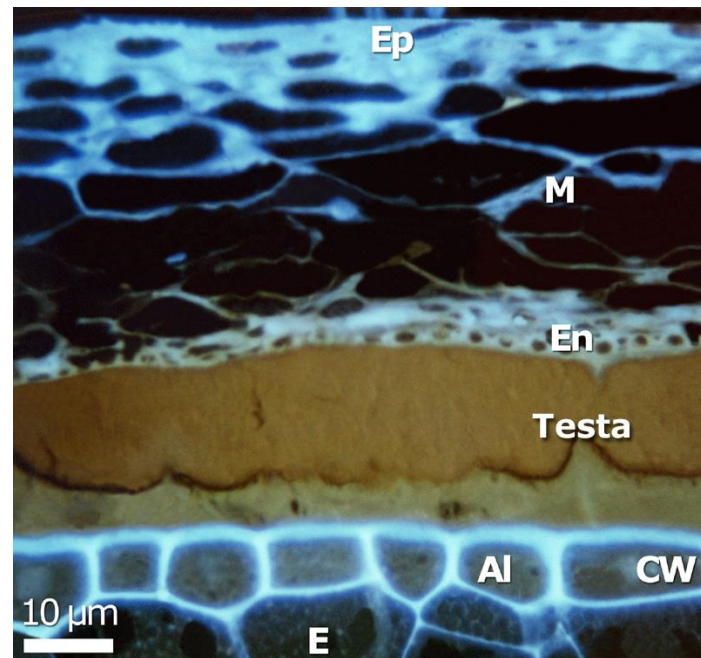
GRAIN STRUCTURE

PIGMENTED TESTA IN TANNIN VARIETIES

Non-tannin sorghum grain



Tannin sorghum grain



Tannins are present in sorghums grain with pigmented testa layer

Fluorescence photomicrograph of cross-sections of a non-tannin (left) and a tannin sorghum kernel (right), Ep- epicarp; M- mesocarp; CW- cell wall; En- endocarp; Al- aleurone; E- endosperm cell (adapted from Earp et al. 2004).

ENERGY SOURCE

- Cereal grain mostly used as an energy source.
- Nutritional composition similar to maize.
- Crude protein content 9 -13% DM but low in lysine.
- Rich in starch with more than 70% DM.
- Low tannin varieties have a higher nutritional value because of better protein and energy digestibility.

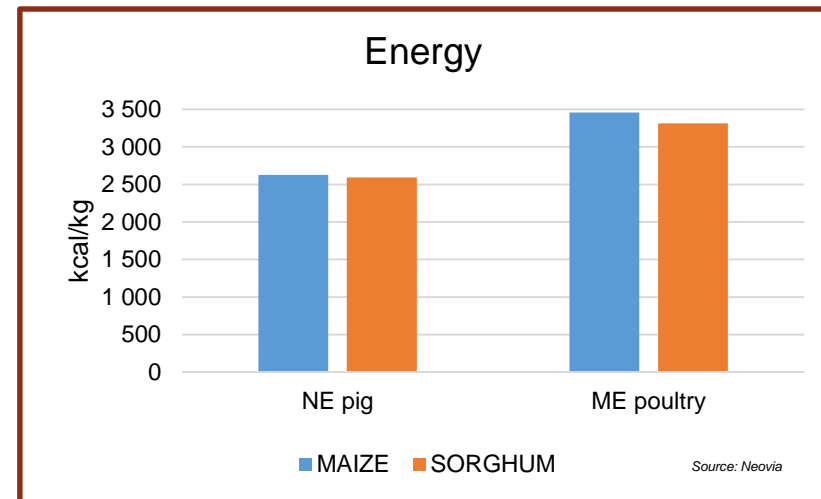
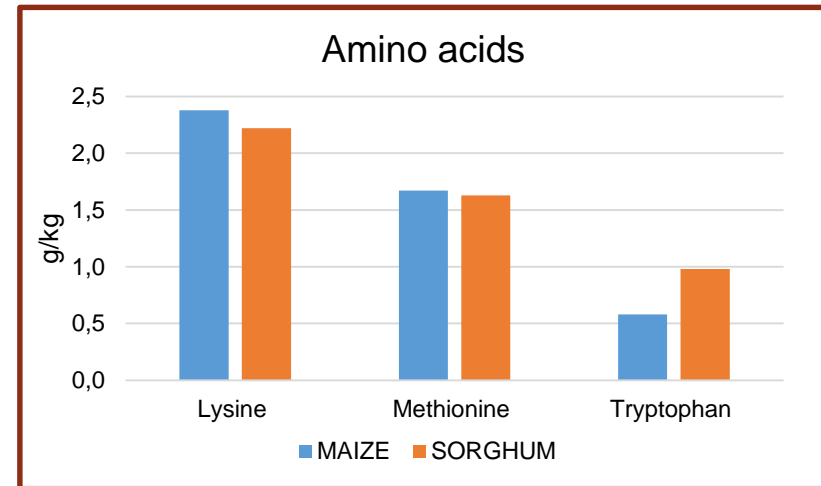
Average nutritional values

Nutrient	Value	MU
Humidity	12.6	%
Crude protein	9.4	%
Crude fiber	2.4	%
Ether extract	3.0	%
Ash	1.8	%
Starch	65.1	%
Calcium	0.26	g/kg
Phosphorus	2.88	g/kg
Lysine	2.08	g/kg
Methionine	1.60	g/kg
Threonine	3.11	g/kg
Tryptophan	0.94	g/kg
ME ruminants	2 820	kcal/kg
NE pig	2 611	kcal/kg
ME broiler	3 280	kcal/kg

NUTRITIONAL PROFILE

SIMILAR TO MAIZE

- Higher protein levels but with higher variability (10.8 vs. 9.4 % DM).
- Higher in tryptophan but lower in lysine and Sulphur aa.
- Similar energy levels.
- Low level of xanthophyll (1.5 vs. 16 mg/kg).
- Lower risk for mycotoxin contamination
 - Production conditions (dry)
 - Type of the flowering (open)



POTENTIAL CONSTRAINTS

TANNINS KAFIRIN PHYTATE

- Tannin, kafirin and phytate content, affects nutritional value, and can reduce the feed efficiency.
- Specific to sorghum is the presence of tannins in the grains.
 - Reduced digestibility of protein and energy
 - Effect on taste & palatability (bitter taste can reduce feed intake)
- Sorghum dominant protein fraction kafirin is poorly digested.
- 70% of its phosphorus content is bound in phytate.
- Low content of xanthophyll affects egg yolk color.



TANNINS

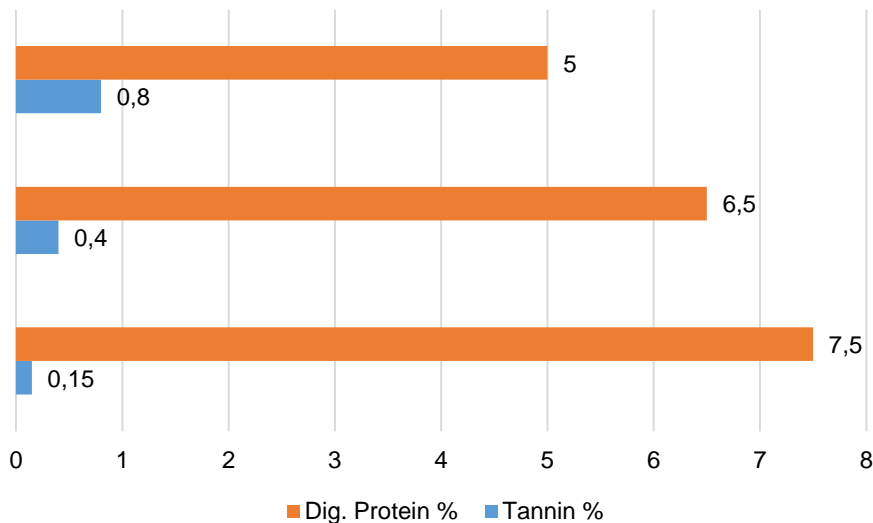
ANTI-NUTRITIONAL EFFECT

- Sorghum is the only cereal that contains tannins.
- They are present in varieties with pigmented testa.
- Natural water-soluble polyphenolic compounds.
- Bind with proteins, and make them unavailable during digestion.
- Reduces digestibility of proteins, carbohydrates and energy.
- Inhibits digestive enzymes and absorption of minerals.
- They are nontoxic and can have an antioxidant effect.

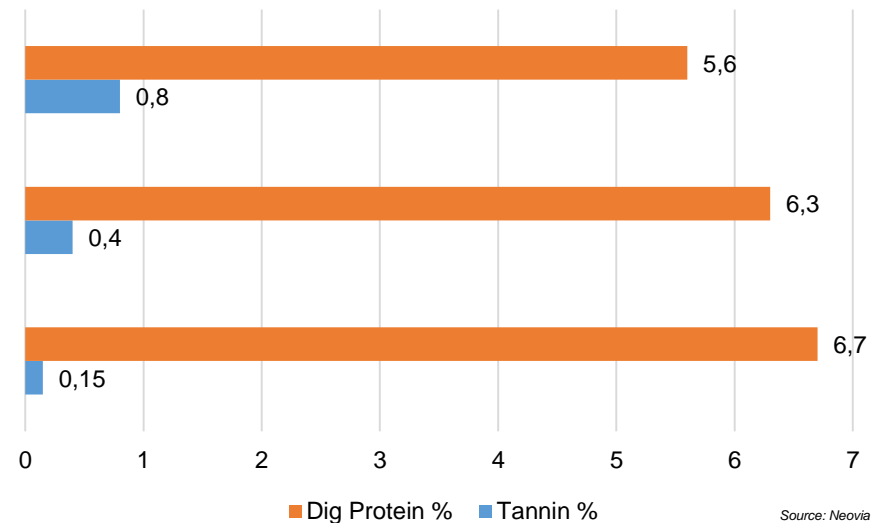


EFFECT ON PROTEIN

Poultry digestible protein based on tannin content



Pig digestible protein based on tannin content

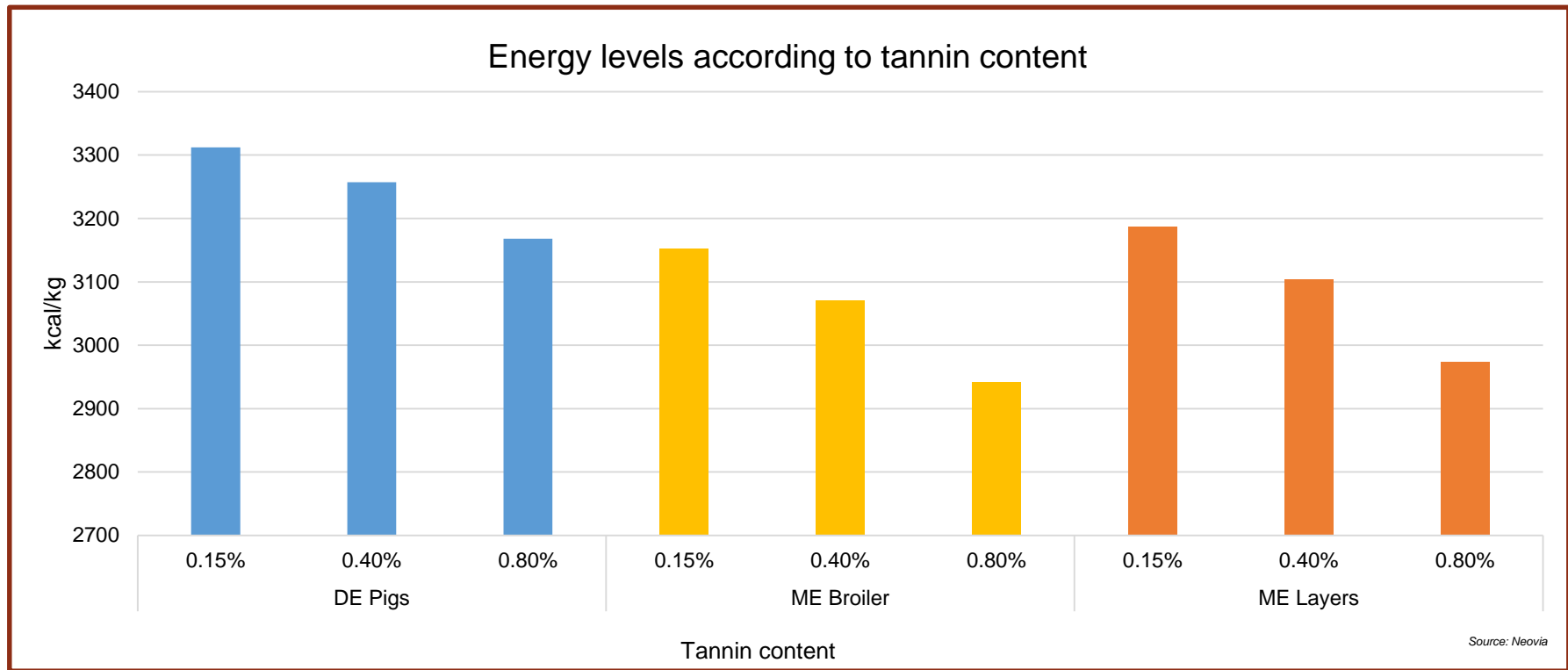


Source: Neovia

High tannin content in sorghum grains affects protein digestibility for poultry and pigs.

TANNINS

EFFECT ON ENERGY



High tannin content of sorghum grains affects energy digestibility for poultry and pigs.

USE IN FEED

MULTISPECIES USE

- Sorghum grain it's used as an energy source in feed.
- Good alternative mainly for maize substitution.
- Suitable feedstuff for poultry, pigs and ruminants.
- High tannin varieties can reduce zootechnical performances.
- Limiting factors tannin content and availability!



WHEAT & MAIZE ALTERNATIVE



- Can be used as main grain in poultry diets
- Low-tannin varieties can replace maize, to a great extent.
- Phytate content may be counterbalanced by P supplementation or phytase
- Low level of xanthophyll may require pigment supplementation (egg yolk).

*Maximum recommended inclusion levels in poultry feeds %				
Broiler STARTER	Broiler GROWER	Replacement pullets	Laying hens	Breeding hens
30	40	40	40	35

**Recommendations valid for low tannin varieties*

SUITABLE FOR FATTENING PIGS



- Low-tannin varieties have an energy level identical to maize one.
- Particle size ~ 650 μm to enhance digestibility.
- High-tannin sorghums may have an effect on meat flavor.
- Not recommended on pre-starter phases (below 12 kg)

*Maximum recommended inclusion levels in pig feeds %			
Piglet STARTER	Fattening PIG	Gestating SOW	Lactating SOW
12	45	45	40

**Recommendations valid for low tannin varieties*

RUMINANTS

LESS DEGRADABLE STARCH



- Good palatability for cattle.
- Less degradable starch compared to wheat and barley.
- Less negative effect of tannins (precipitation by rumen microflora).
- Tannins may have beneficial effects, such as bloat prevention and increasing the amount of by-pass protein.

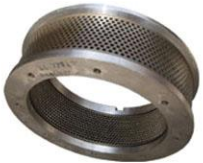
*Maximum recommended inclusion levels in ruminant feeds %				
Breeding Cattle	Milking cows	Beef cattle	Claves	Sheeps
40	35	45	20	40

**Recommendations valid for low tannin varieties*

GRINDING & PELLETING



- Grinding. Hammer mill screen must be adapted to avoid passing entire grains. Reduced particle size increases digestibility.



- Pelleting. Sorghum starch requires higher temperatures for gelatinization (68-75°C).



- Feed color. Compared to maize can be darker depending also on varieties and inclusion rates.

QUALITY CONTROL

USUAL CEREAL CONTROL

- Nutritional quality based on humidity, protein, starch and tannin content.
- Grains must be checked for insects, temperature, mould, impurities, split grains, germinated grains, presence of other cereals and abnormal smell.
- Fat, fiber and ash content are relatively constant for all types of sorghum, but important to be analyzed.



Mouldy sorghum



Germinated sorghum



Split sorghum



Sorghum attacked by insects

LOWER CONTAMINATION IN EUROPE

- Sorghum grains can be attacked by fungi and bacteria, both in field and during storage.
- Usual microbiological analyses: fungi and enterobacteriaceae count, E. coli.
- Usual mycotoxins: **afatoxin**, vomitoxin and zearalenone.

Summary of the chemical, microbiological and mycotoxicological properties of some sorghum samples

ORIGIN	Sorghum USA	Sorghum Argentina	Sorghum Brazil	Sorghum France	Sorghum Spain
CHEMICAL					
Water content	12.3	12.8	11.9	13.5	12.5
Raw protein	9.4	8.3	9.2	8.5	9.1
Raw fiber	2.3	2.4	2.2	2.3	2.3
Starch	65.5	63.7	66.6	66.3	64.3
Ash	1.3	1.5	1.2	1.3	1.4
Tannins	0.12	0.45	0.12	0.12	0.16
MICROBIOLOGICAL					
*Fungi count	0% High	0% High	0% High	0% High	0% High
*Yeast count	15% High	0% High	0% High	0% High	0% High
*Enterobacteriaceae count	19% Average	80% Average	0% Average	0% Average	0% Average
E. coli in 1 gram	0% Positive	0% Positive	0% Positive	0% Positive	0% Positive
MYCOTOXINS					
Aflatoxins	0% > 0.02 ppm	30% > 0.02 ppm	0% > 0.02 ppm	0% > 0.02 ppm	0% > 0.02 ppm
Zearalenone	0% > 2 ppm	20% > 2 ppm	5% > 2 ppm	0% > 2 ppm	0% > 2 ppm
Vomitoxin	0% > 8 ppm	0% > 8 ppm	0% > 8 ppm	0% > 8 ppm	0% > 8 ppm

*Microbiological reference values: High fungi count (250 000 CFU/g). High yeast count (>50 000 CFU/g). Average enterobacteriaceae count (10 000 - 50 000 CFU/g)

QUALITY CONTROL

REJECTION CRITERIA

- Water content $>14\%$.
- Abnormal sensory properties.
- Impurities $>3\%$.
- Protein $< 7\%$ (of DM).
- Tannins $> 0.25\%$.**
- Microbiological and mycotoxicological contamination.



TAKE HOME MESSAGES

- **Sorghum grain it's used as an energy source in feed.**
- **Nutritional profile similar to maize.**
- **Suitable for multispecies use (poultry, pigs, ruminants).**
- **High tannin content can reduce feed efficiency.**
- **Low tannin sorghum grains can be used at high inclusion levels in compound feeds.**
- **Availability and traceability are important points for feed industry.**

