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The role of red meat in Human diet: Uganda's perspective on Climate-Smart alternative feedstuff

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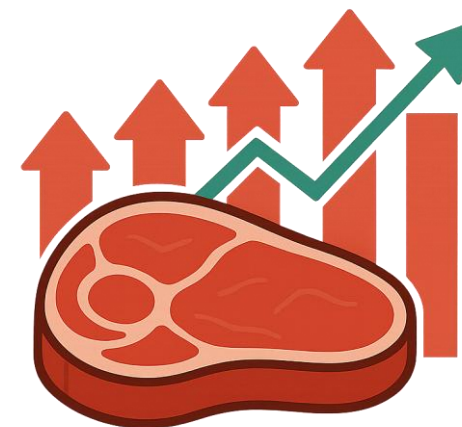


ABI ZONAL AGRICULTURAL RESEARCH AND DEVELOPMENT
INSTITUTE
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The role of red meat in human diet:

Uganda's perspective on climate-smart alternative feedstuff



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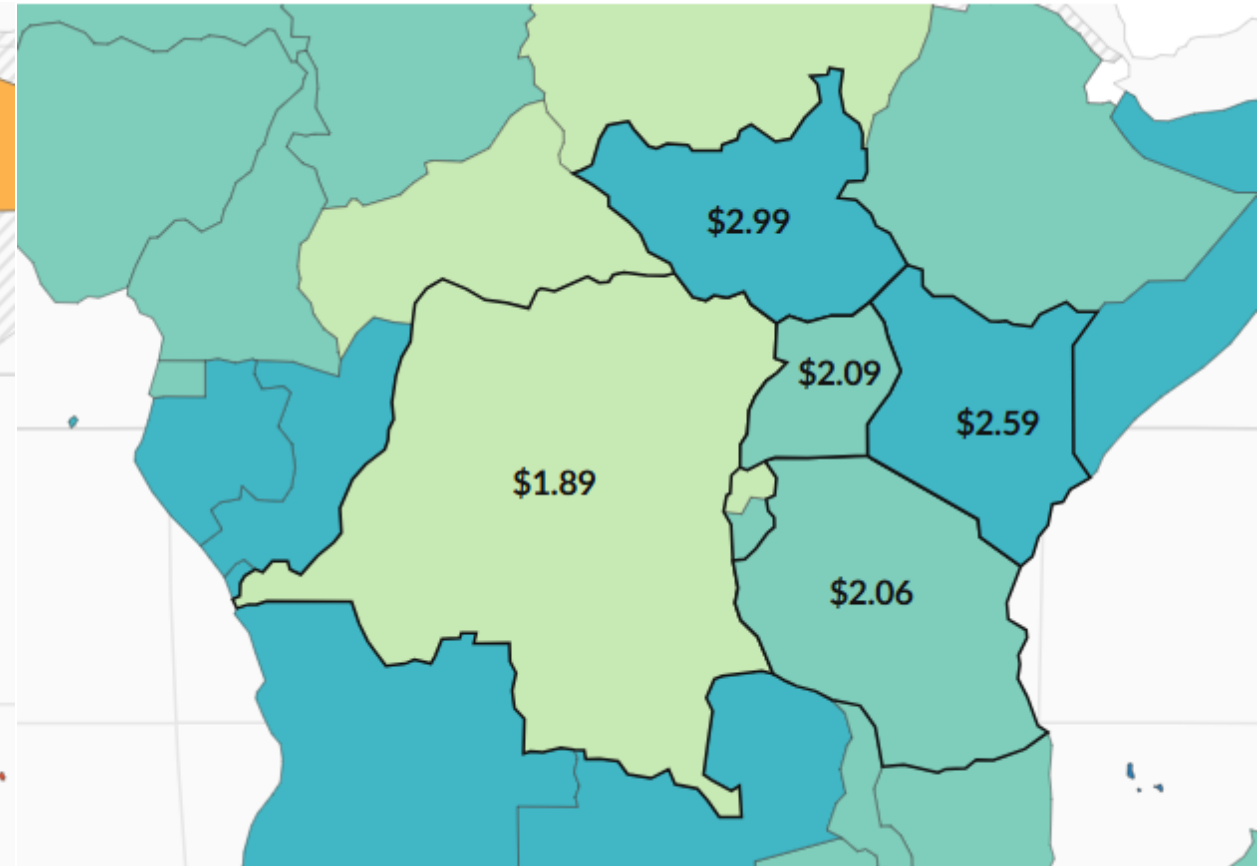
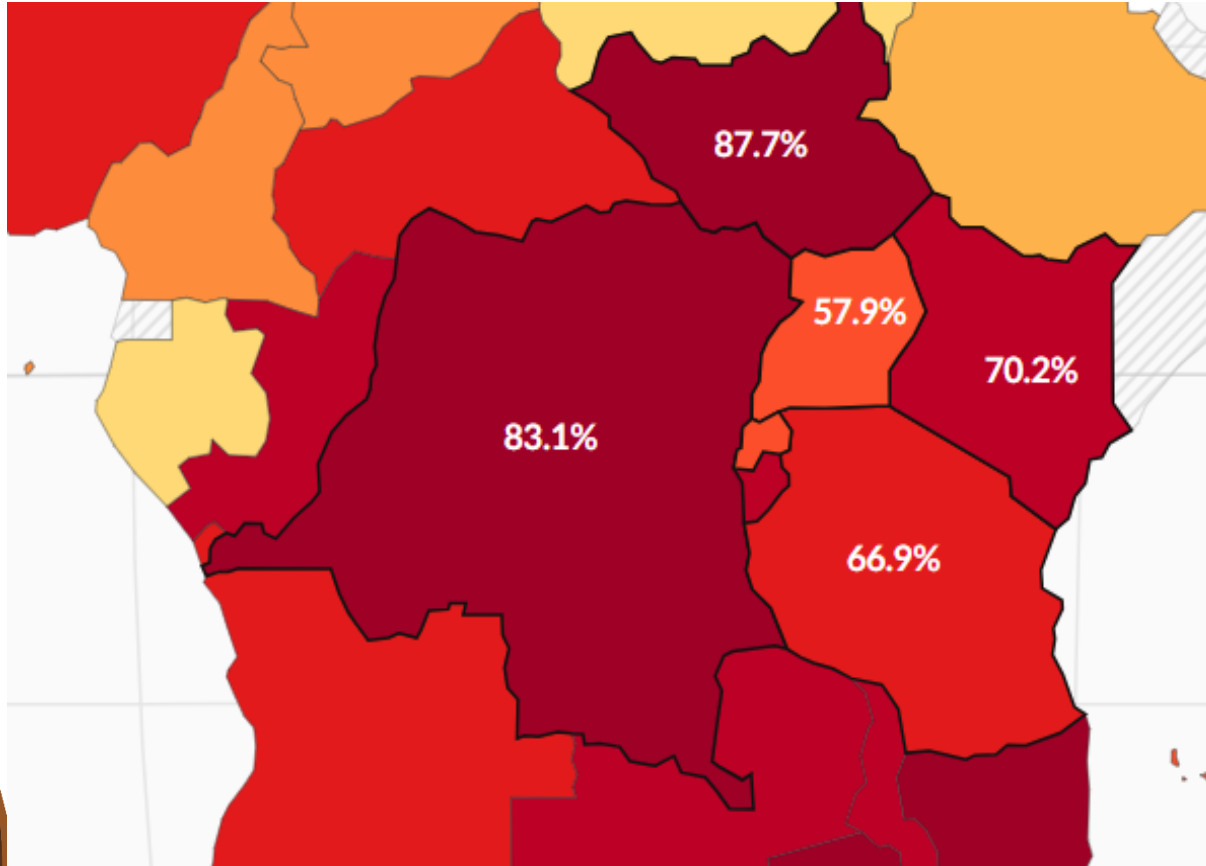
Do we have a food or nutritional problem in Uganda?



Do we?

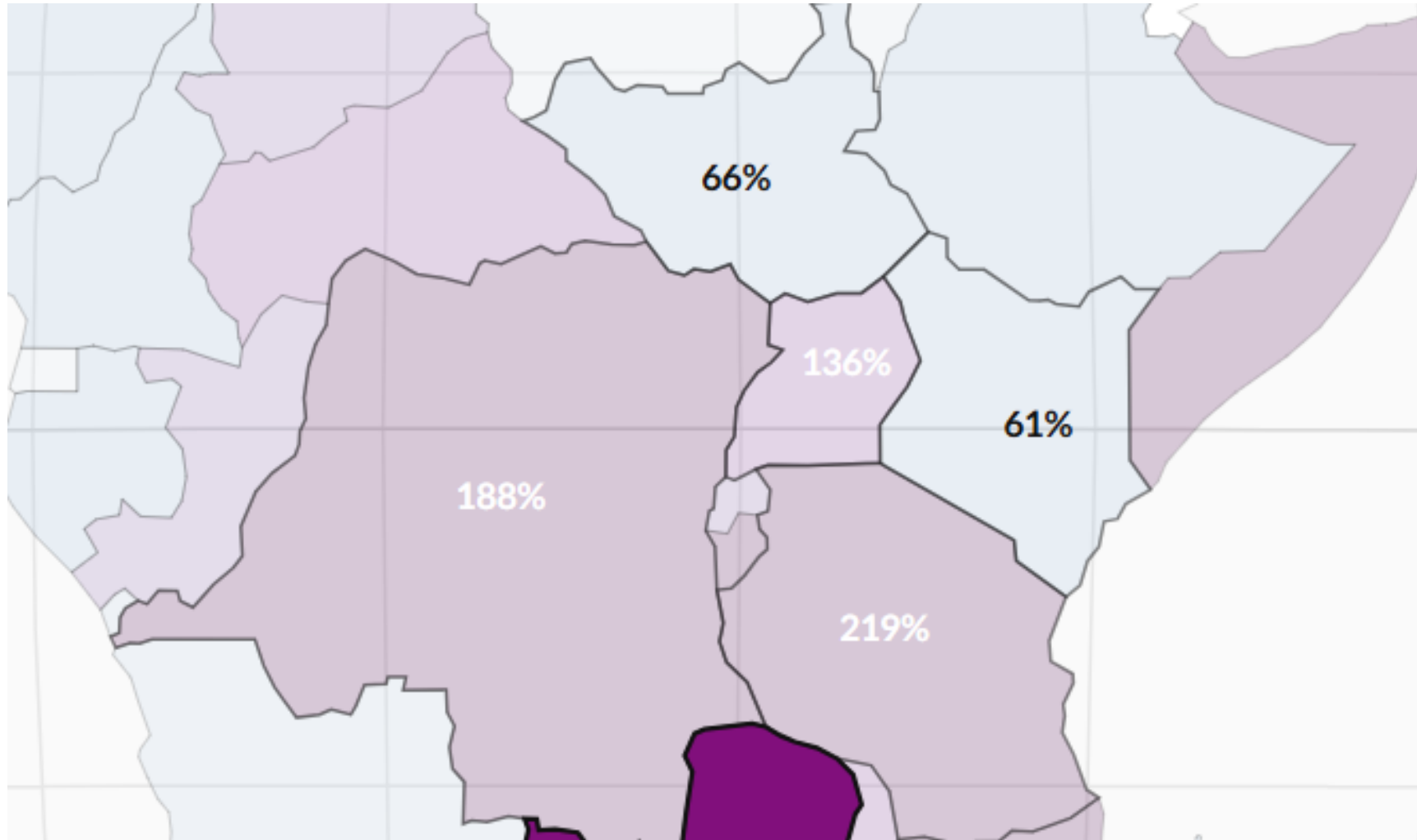
Population affording nutrient adequate food (%)

Average price of nutrient adequate food (\$)



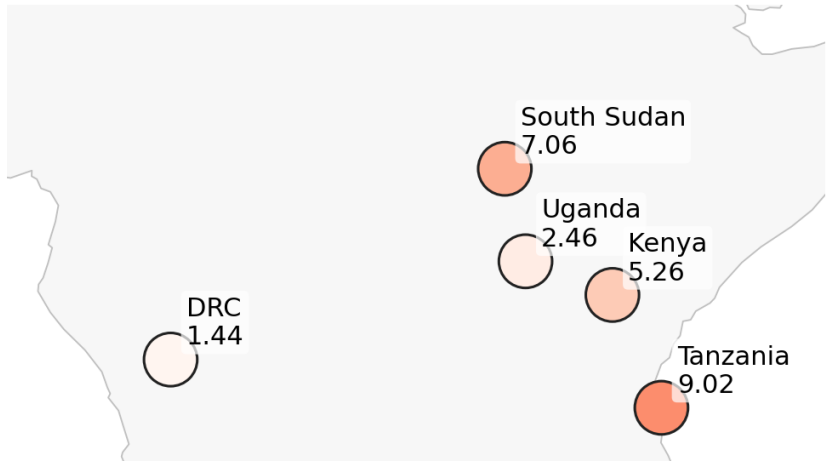
Share of nutrient adequate food

Compared to the average food expenditure (‰)

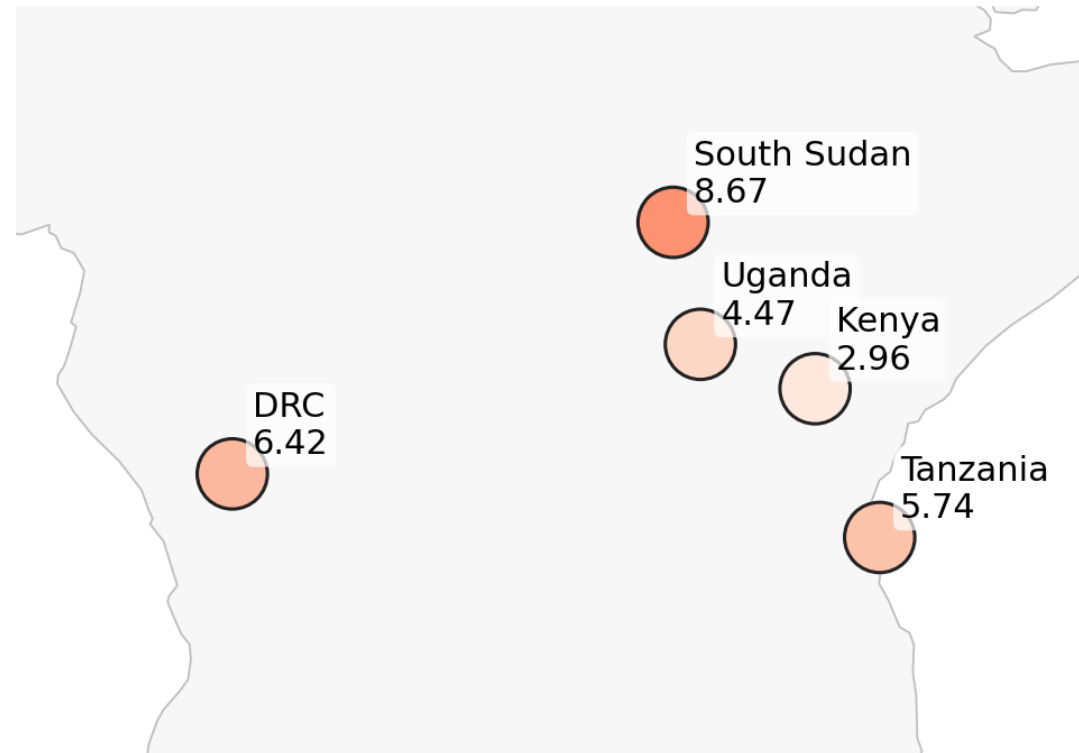


Average price of red meat in East Africa

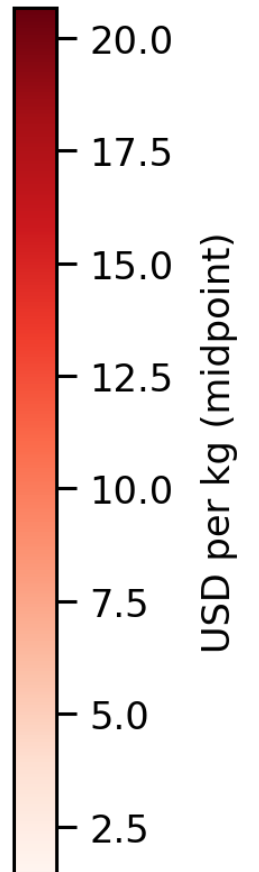
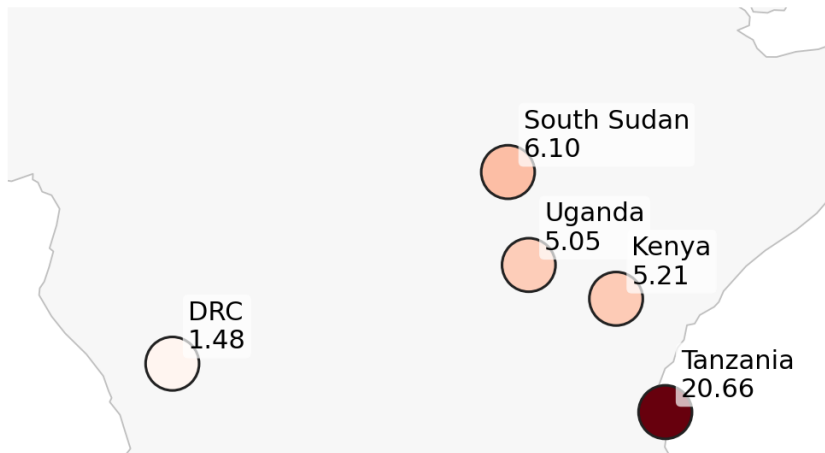
Average retail price: Mutton (USD/kg)



Average retail price: Beef (USD/kg)

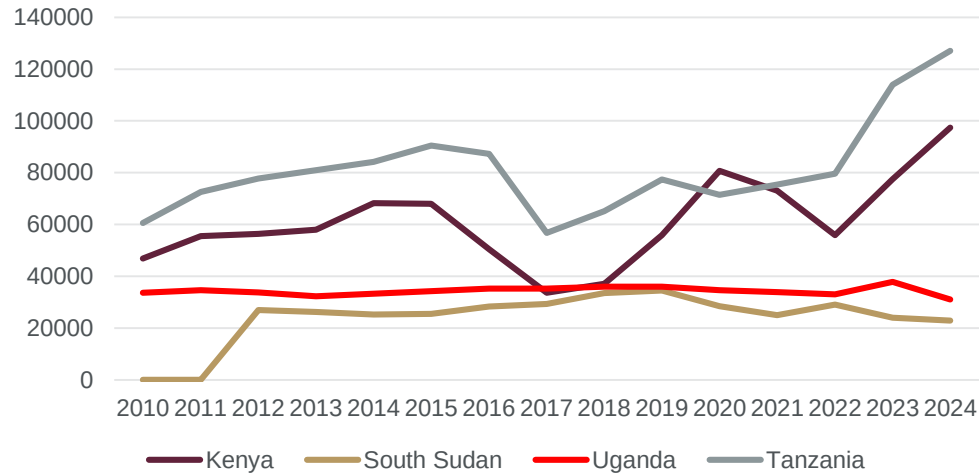


Average retail price: Chevron (USD/kg)

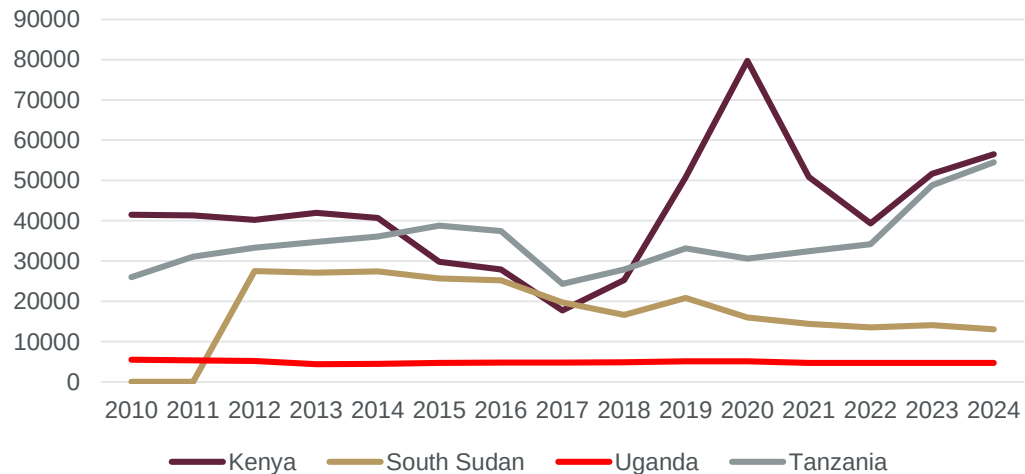


Red meat production

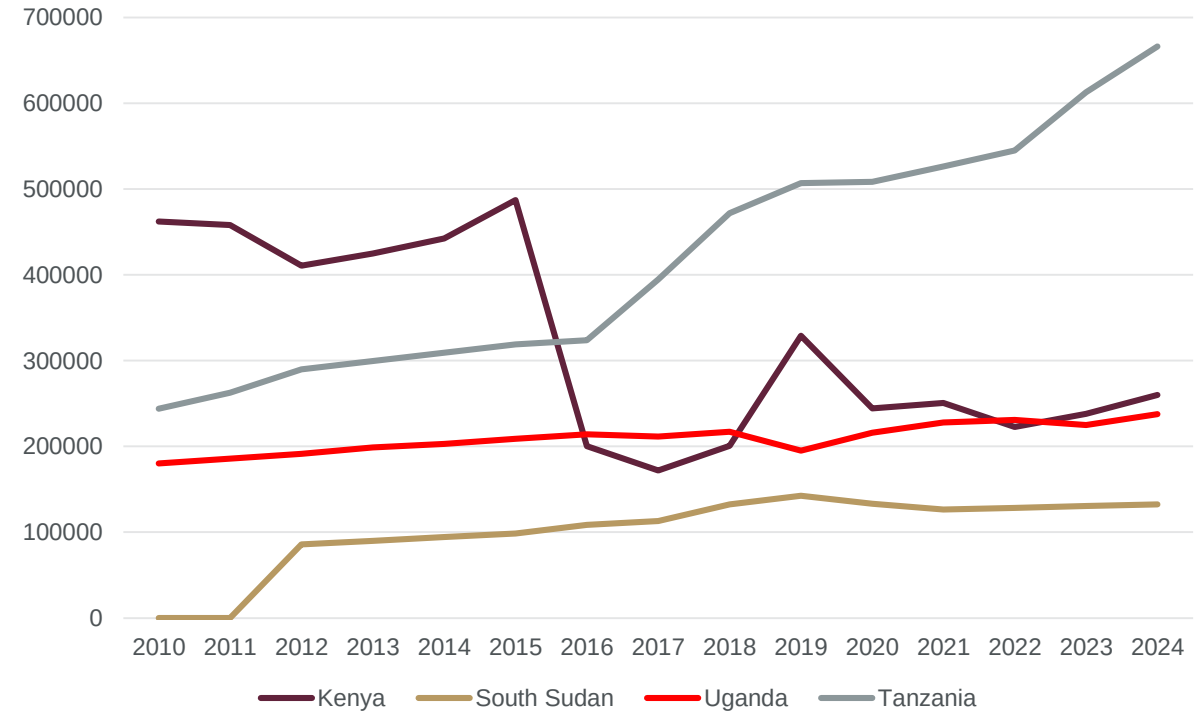
Goat production (tonnes)



Sheep production (tonnes)

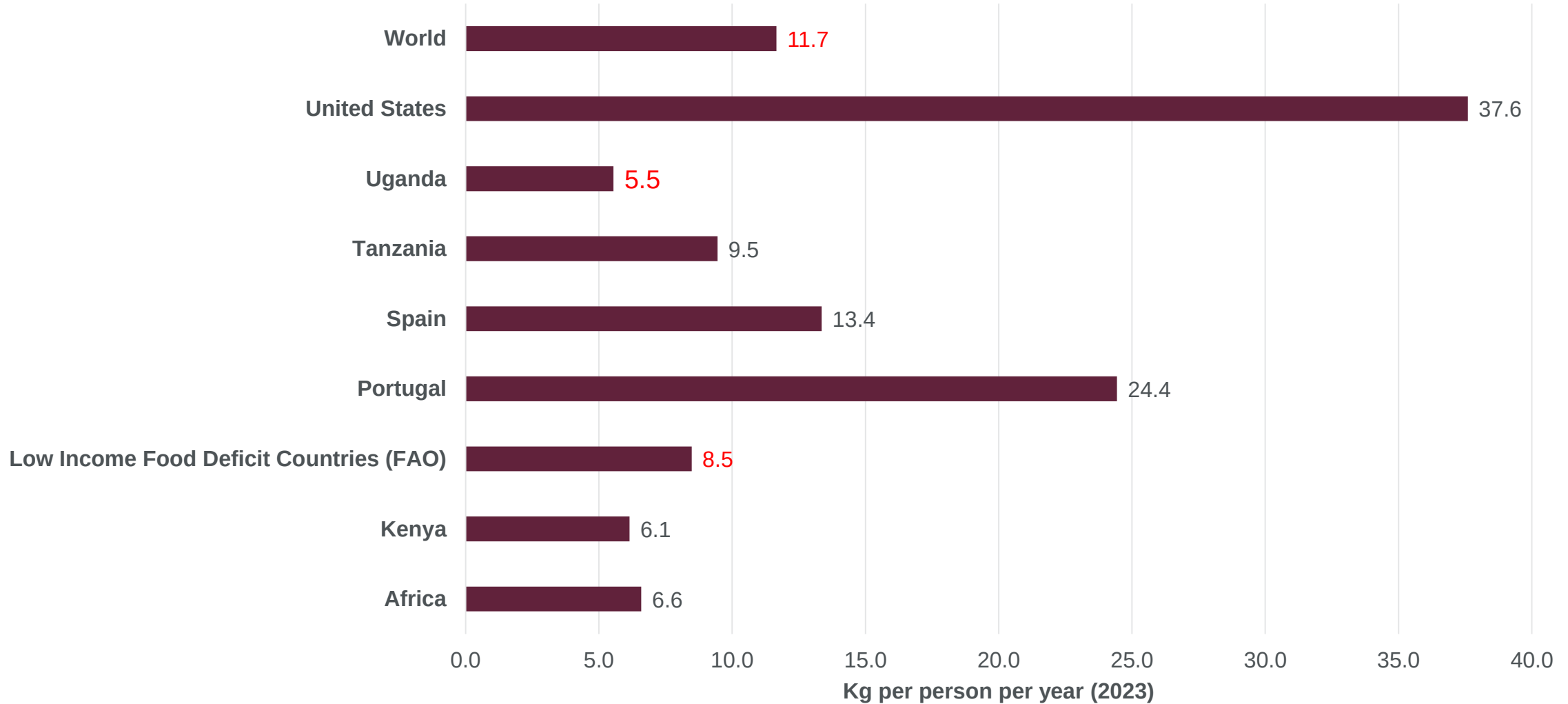


Cattle production (tonnes)





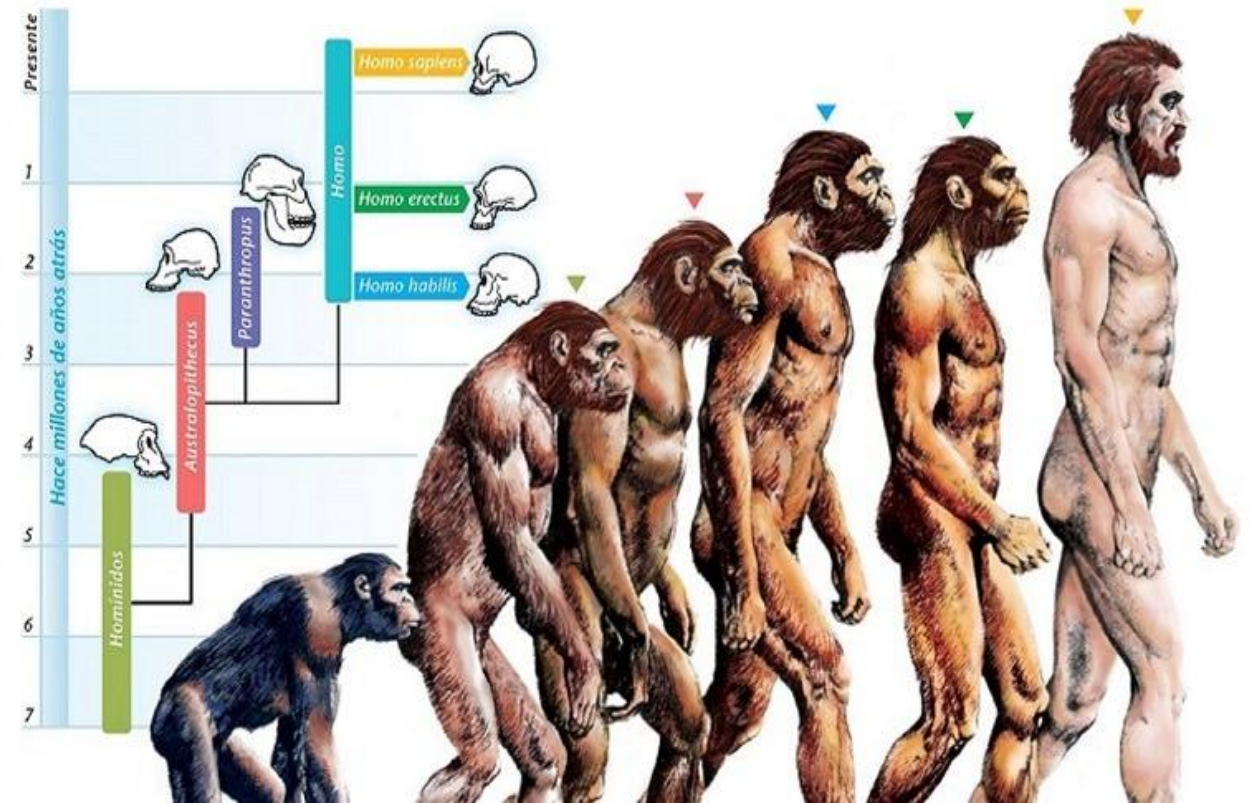
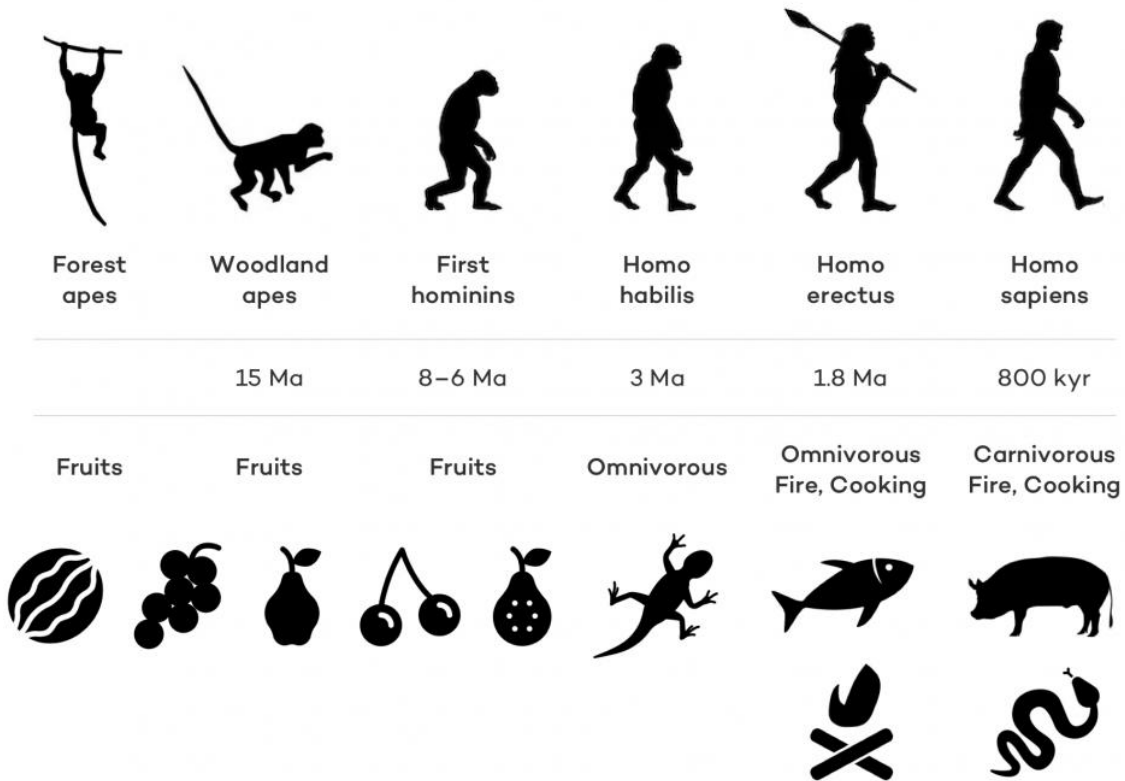
Red meat per capita consumption



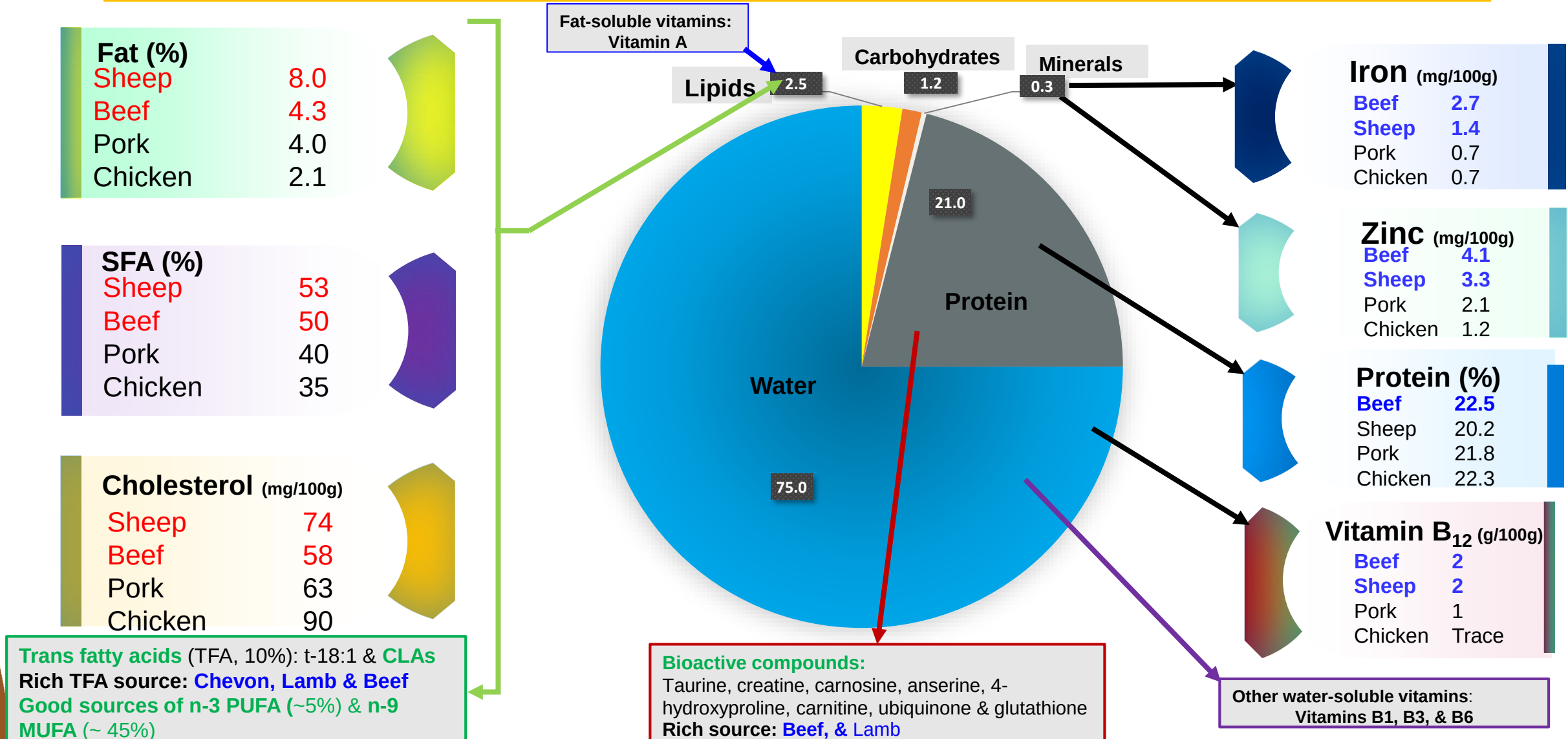
Recommended consumption: 56 grams

FAOSTAT (2025)

Role of meat in human evolution

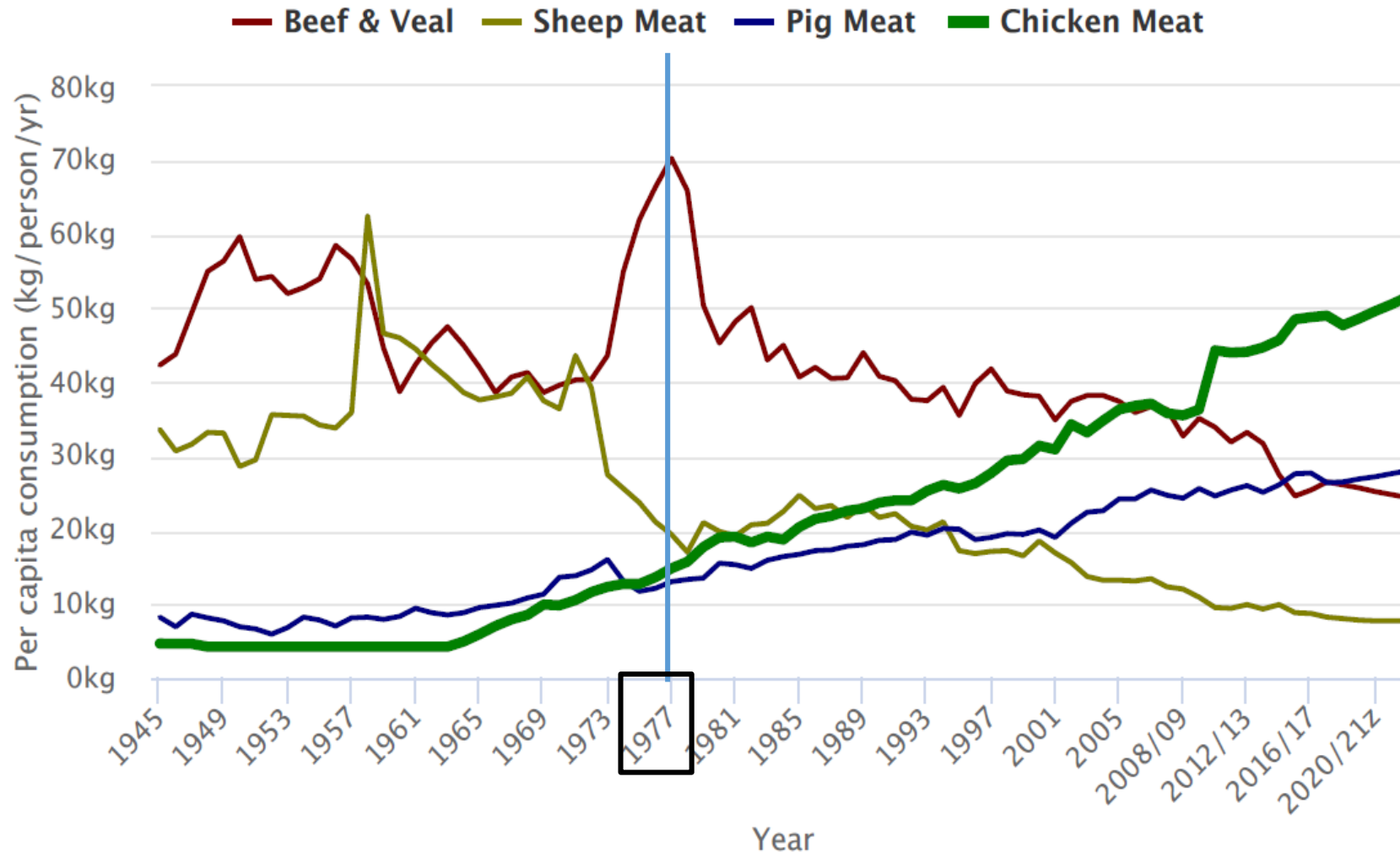


Nutrient content of red meat



Origin of the "myth" of red meat

Global meat consumption per capita trend

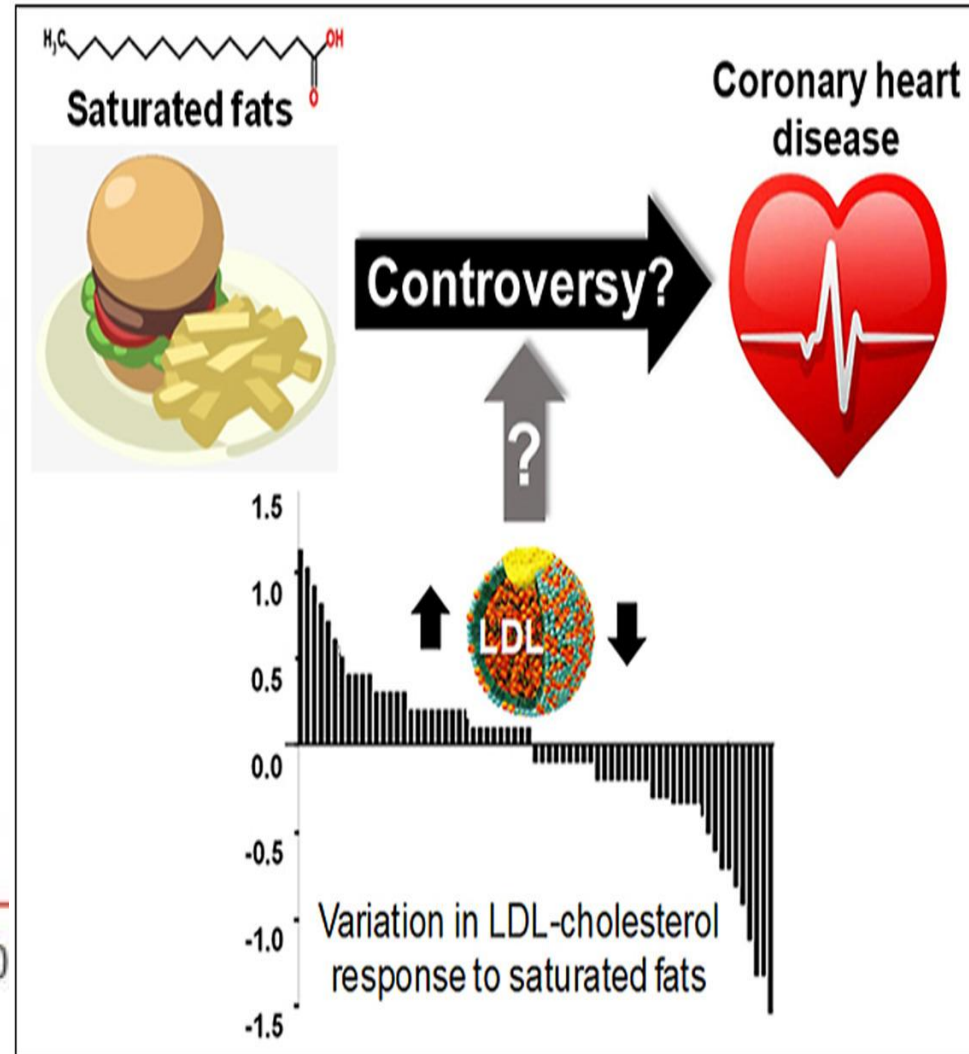
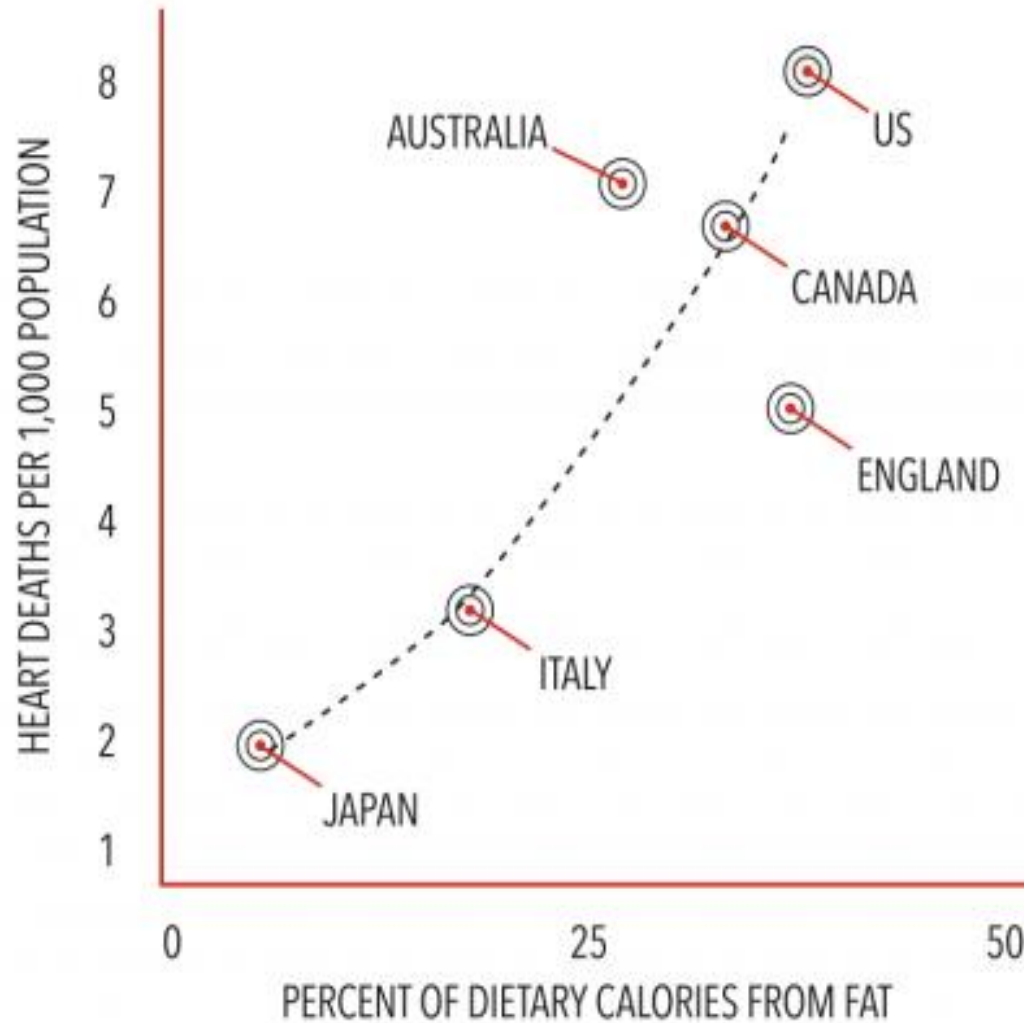


Ancel Keys article 1966

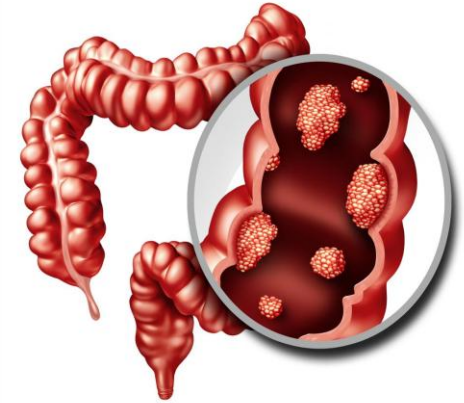


(Jolly, 1983 and Morrison et al., 2003)

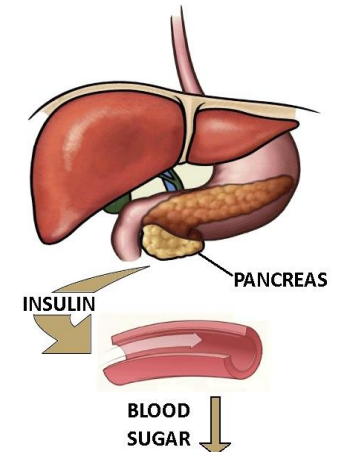
Saturated fat and CHD



Colon cancer



Type 2 diabetes
Insulin resistance



Regulations on dietary fat intake

Nutrition Facts	
8 servings per container	
Serving size	2/3 cup (55g)
Amount per serving	
Calories	230
% Daily Value*	
Total Fat 8g	10%
Saturated Fat 1g	5%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 160mg	7%
Total Carbohydrate 37g	13%
Dietary Fiber 4g	14%
Total Sugars 12g	
Includes 10g Added Sugars	20%
Protein 3g	
Vitamin D 2mcg	10%
Calcium 260mg	20%
Iron 8mg	45%
Potassium 240mg	6%

Dietary intake guidelines

Total Fat
20-30%



SFA
< 10 %



TFA
< 1 %



PUFA
6-11 %



N.B. % of dietary energy

Simple Question

Do we have a red meat
consumption problem in
Uganda



Two faced situation

Africa Edition

Kenya Edition

Uganda Edition

Tanzania Edition

MONITOR

National

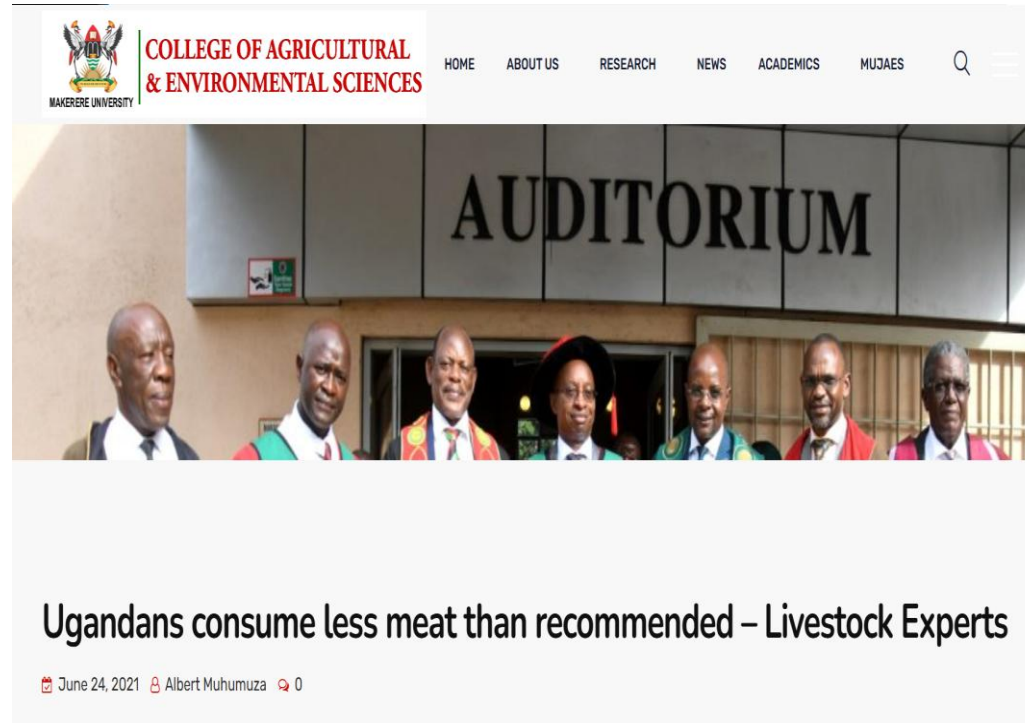
Education

Insight

World

Eating red meat daily could cause early death

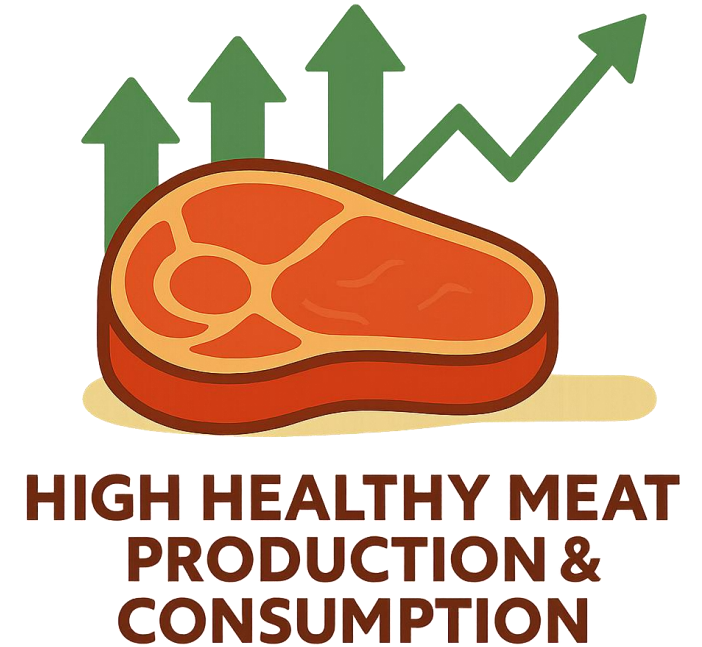
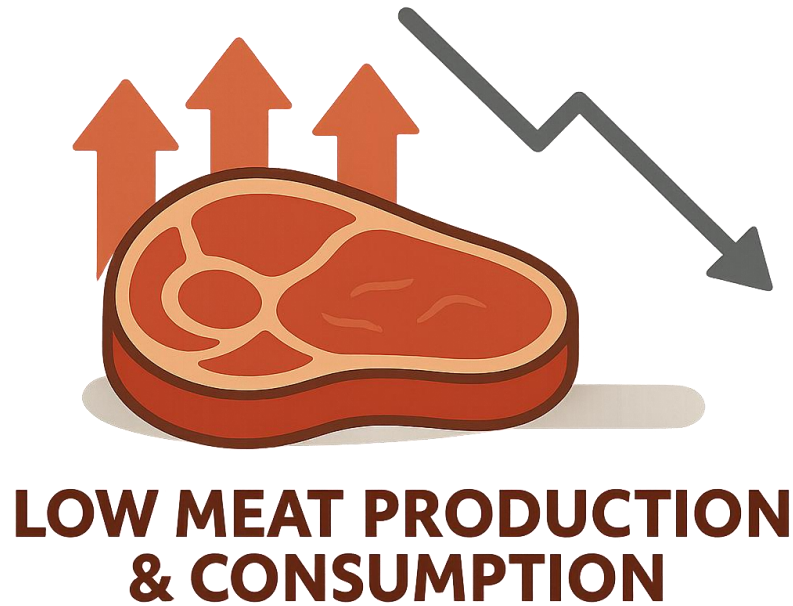
Tuesday, March 13, 2012 — updated on January 22, 2021



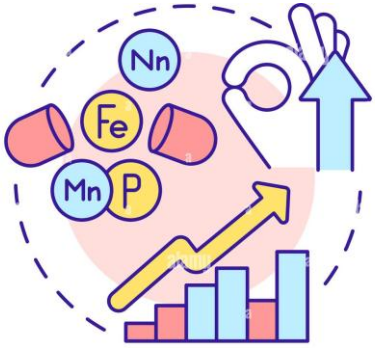
- Low production and consumption
- 95% natural production means a healthy product

Climate-smart feed solutions

Feed sources



Why climate-smart feed alternatives?



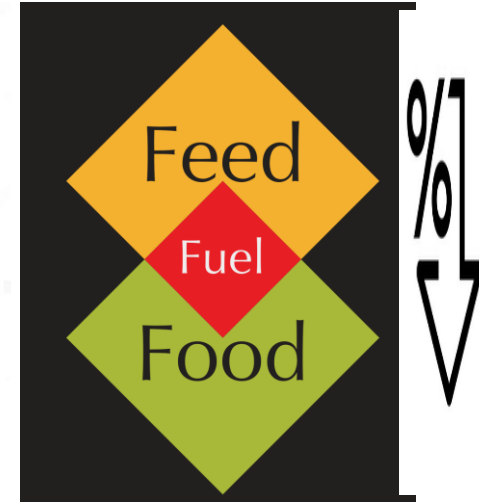
High Nutritional Value



Palatable



Ecofriendly



Locally Sourced



Affordable



uncontaminated



Highly digestible & Gut health

Emerging climate-smart feeds for ruminants?

Terrestrial animal byproducts

Fruit byproducts

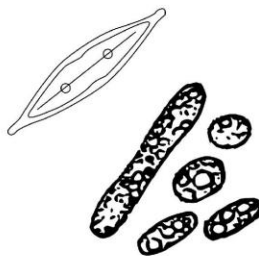


Seaweeds

PRO	CONS
Acceptance	Production Costs

Terrestrial plant byproducts

Single-cells



PRO	CONS
Formulation	Production Costs



PRO	CONS
Production costs	Acceptance



GM Plants

Insect oils/ meals



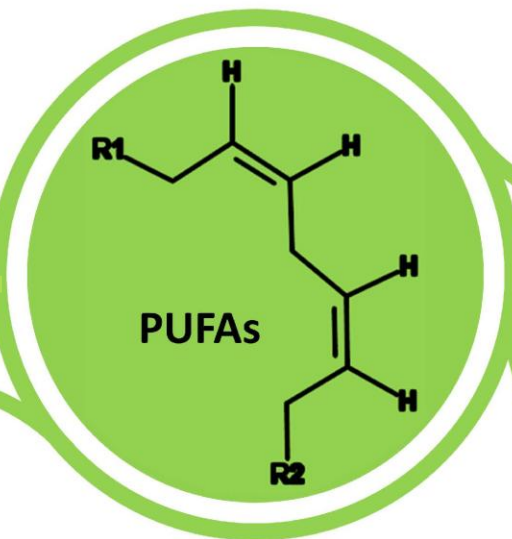
SDA-rich Plants



PRO	CONS
Production costs	Formulation



Aquatic animal byproducts



1) Improved forage grasses

Fibre sources - inclusion levels: up to 60%

- 1) Napier grass (*Pennisetum spp*)
- 2) Signal grass (*Brachiaria spp*)
- 3) Star grass (*Cynodon spp*)
- 4) Bahia grass (*Paspalum spp*)
- 5) Rhodes grass (*Chloris gayana*)
- 6) Buffel grass (*Cenchrus ciliaris*)

Key climate-smart

- Drought tolerant
- Carbon sequestration
- ↑ Biological nitrification inhibition
 - ↑ Soil N retention
 - ↓ N₂O & NH₃ emissions

Key nutritional attributes

- Yield: 5-50.0 DM t/h
- CP%: 5–21
- NDF: 50–70%
- ME: 3–10 MJ/ kg DM
- DMD: 30–70%



Napier grass
(*Pennisetum purpureum*)



Signal grass
(*Brachiaria decumbens*)

Key phytochemicals

- α-linolenic acid
- Flavonoids & phenolic acids
- Essential oils (terpenes)

Key anti-quality factors

- Cyanogenic glycosides
- Steroidal saponins

GHGs, meat production & quality

- ↓ CH₄ & NH₃ emissions
- ↑↔↓ growth & carcass yield
- ↓ Meat colour & tenderness
- ↔↑ Meat fatty acids (FA) profiles
- ↔↑ Meat oxidative shelf life
- **Animal health & welfare?**

2) Alternative cereal grains and byproducts

Starch & fibre sources – inclusion levels: up to 60%

Sorghum
Sorghum bicolor



Teff
Eragrostis tef



Key climate-smart attributes

- Drought & heat tolerant
- Tolerate poor quality soils
- Low input requirements

Key nutritional attributes

- Starch: 30-70%
- CP: 8-23%
- ME: 10-15 MJ/ kg D

Pearl millet
Pennisetum glaucum



Finger millet
Eleusine coracana



Key phytochemicals

- Flavonoids & phenolic acids
- Phytosterols & carotenoids

Key anti-quality factors

- Cyanogenic glycosides
- Nitrates

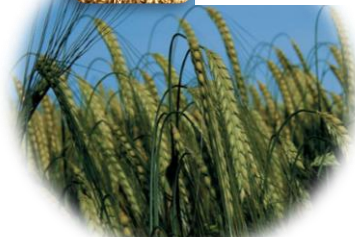
GHGs, health, meat production & quality

- ↓ CH₄ & NH₃ emissions
- ↔ ↓ Worm burdens
- ↔ ↑ Growth & carcass yield
- ↔ Meat quality
- ↔ ↑ Meat oxidative shelf life

Amaranth
Amaranthus spp



Oats
Avena sativa



Byproducts: Distillers grain + solubles

3) Root, tuber crops and their byproducts

Starch & fibre sources - inclusion levels: up to 60%

Roots

Key climate-smart attributes

- Drought tolerant
- Tolerate poor-quality soils
- Carbon sequestration
- Waste reduction

Key phytochemicals

- Phenolic acids & flavonoids
- Essential oils & saponins

Key anti-quality factors

- Cyanoglucosides: linamarin
- Glycoalkaloids: solanine

Key nutritional attributes

Yield: 10-45t/ha/yr

Attribute	Roots	Leaves	Peels
CP%	2.5-8	14-40	2-8
ME%	9-15	6-10	8-12
DMD%	60-90	50-76	40-70

GHGs, health, meat production & quality

- ↔↓ CH₄ & N emissions
- ↓ Worm burdens
- ↔↑ Growth & carcass yield
- ↔↑ Meat chemical profiles
- ↓ Meat oxidative spoilage
- ↔↑ Meat sensory quality

Tubers

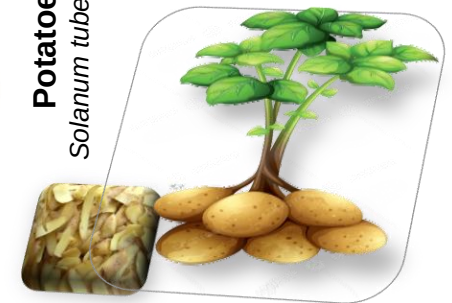
Taro
*Colocasia
esculenta*



Yam
Dioscorea



Potatoes
Solanum tuberosum



Cassava
Manihot esculenta



Sweet potato
Ipomoea batatas



Sugar beet
Beta vulgaris



4) Alternative grain and herbaceous legumes

Fibre and protein sources - inclusion levels: up to 30%



Key climate-smart attributes

- Drought tolerant
- Nitrogen fixation
- Utilize poor-quality soils

Key nutritional attributes

- CP: 10-35%
- NDF: 33-56%
- ME: 7-13 MJ/ kg DM



Key phytochemicals

- α -linolenic & linoleic acids
- Polyphenols & saponins
- Phytosterols & alkaloids

Key anti-quality factors

- Cyanogenic glycosides
- Protease inhibitors

GHGs, health, meat production & quality

- $\downarrow$ CH₄ & N emissions
- $\leftrightarrow$ $\downarrow$ Worm burdens
- $\leftrightarrow$ $\downarrow$ Bloat incidences
- $\leftrightarrow$ $\uparrow$ Growth & carcass yield
- $\leftrightarrow$ $\uparrow$ Meat chemical profile
- $\leftrightarrow$ $\uparrow$ Meat FA profile
- $\leftrightarrow$ $\downarrow$ Meat oxidative spoilage



5) Alternative oilseeds and byproducts

Protein and/or energy + PUFA sources – inclusion levels: $\leq 10\%$

Oilseed meal/ cakes



Chia

Salvia hispanica



Carinata

Brassica carinata



Key climate-smart attributes

- Drought tolerant
- Waste reduction

Key nutritional attributes

- CP: 24-50%
- NDF:10-25%

Key phytochemicals

- α -linolenic & linoleic acids
- Polyphenols & essential oils
- Carotenoids & tocopherols

Key anti-quality factors

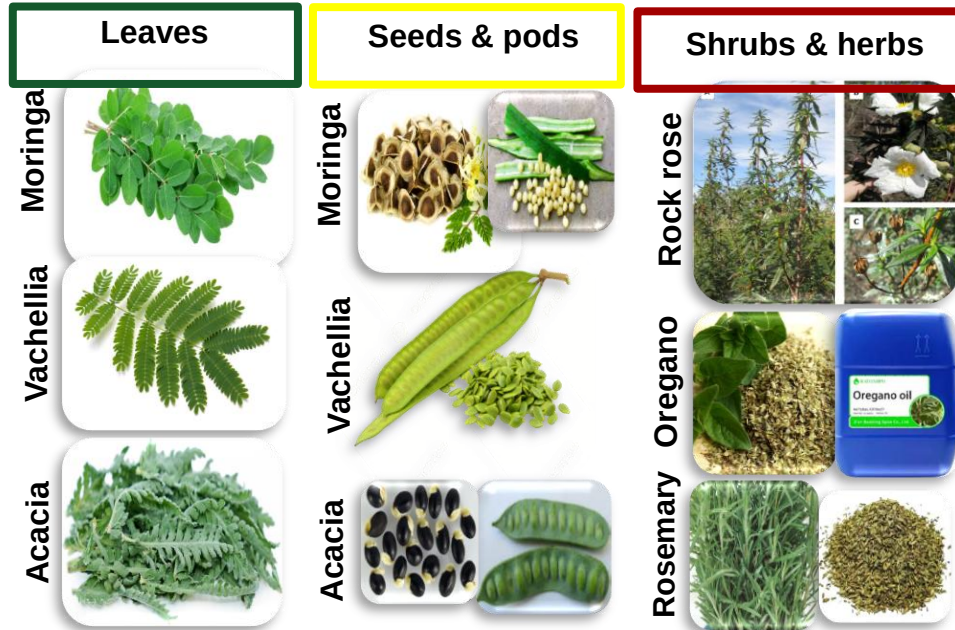
- Glucosinolates & erucic acid
- Sinapine & trypsin inhibitors

Meat production & quality

- $\leftrightarrow$ $\uparrow$ Growth & carcass yield
- $\leftrightarrow$ Carcass attributes
- $\uparrow$ Healthy enhancing FA
- $\leftrightarrow$ Haematological
- $\leftrightarrow$ Immune response
- GHG emissions ?
- Meat production & quality?

5) Tree, shrubs & herbs

Fibre, protein & PUFA sources - inclusion levels: Up to 30%



Climate-smart attributes

- Drought, heat & salt tolerant
- Legume trees – N fixation
- Adapted to poor quality soils
- Carbon sequestration

Key nutritional attributes

- Yield: 5-40 DM t/ha
- CP: 8-35%
- NDF: 22-57%
- ME: 7-10 MJ/ kg DM

Key phytochemicals

- α -linolenic & linoleic acids
- Polyphenols, terpenes, saponins & alkaloids

Key anti-quality factors

- Phenols, oxalates, lignin, thorns & spines

GHGs, health, meat production & quality

- $\leftrightarrow$ $\downarrow$ CH₄ & N emissions
- $\downarrow$ Worm burdens & oxidative stress
- $\leftrightarrow$ $\uparrow$ Growth & carcass yield
- $\leftrightarrow$ $\uparrow$ Meat proximate & FA profiles
- $\downarrow$ $\leftrightarrow$ $\uparrow$ Meat sensory quality
- $\uparrow$ Meat shelf life

6) Woody byproducts

Fibre sources - inclusion levels: < 10%

Bark meal



Key climate-smart attributes

- Waste reduction
- Promote circular economy
- Affordability

Sawdust



Key phytochemicals

- Polyphenols

Key limitations

- High cellulose & lignin
- Low digestibility

Shavings



Key nutritional attributes

- DM: 50-60%
- CP: 1-2%
- NDF: 80-90%
- Cellulose: 40-45%
- Hemicellulose: 20-30%
- Mg: 35-99 mg/kg

GHGs, meat production & quality

- ↓ CH₄ emissions
- ↔ Growth & carcass yield
- ↔ Meat proximate & sensory

7) Fibre crop byproducts: oils and oilseeds

Protein and/or energy + PUFA sources - inclusion levels: oils up to 6%, meal/cakes up to 20%



Hempseeds

Seed oil & cake



Flaxseeds

Seed oil & cake



Cotton seeds

Seed oil, cake or meal

Key climate-smart attributes

- Drought tolerant
- Phytoremediation
- Problematic lands utilisation

Key phytochemicals

- n-3 PUFA & linoleic acids
- Flavonoids & tocopherols
- Terpenes & cannabinoids

Key anti-quality factors

- Cyanogenic glycosides
- Protease inhibitors
- Gossypol (cotton)

Key nutritional attributes

- CP: 16-50%
- NDF: 25-55%
- ME: 10-18 MJ/ kg DM

GHGs, health, meat production & quality

- ↔↓ CH₄ emissions
- ↔↑ Immunity & oxidative status
- ↔↑ Growth & carcass yield
- ↔↓ Feed costs
- ↔ Meat physiochemical quality
- ↑ Meat FA profiles
- ↔↑ Meat sensory quality
- ↓ Meat oxidative spoilage

8) Fruit byproducts

Fibre sources - inclusion levels: up to 25%

Pomace



Key climate-smart attributes

- Waste reduction
- Promote circular economy
- Affordability

Key nutritional attributes

- CP: 4-12%
- NDF: 20-75%
- ME: 4-12 MJ/kg

Key phytochemicals

- Linoleic & oleic acids
- Polyphenols & essential oils
- Carotenoids & tocopherols

Key limitations

- High moisture content
- Nutrient variability

GHGs, meat production & quality

- ↔↓ CH₄ emissions
- ↑ Growth & carcass yield
- ↔↓ Feed costs
- ↔ Meat proximate & sensory quality
- ↑ Meat FA profiles
- ↑ Meat oxidative stability
- Animal health & welfare?

Other byproducts:

- Seeds & seed oils
- Peels, skins & pulp

9) Halophytes

Protein, fibre & mineral sources - inclusion levels: up to 20%

Saltbush
(*Atriplex spp.*)



Kochia
(*Kochia scoparia*)



Key climate-smart attributes

- Salt & drought tolerant
- Desalination
- Phytoremediation

Key nutritional attributes

- Yield: 3-13 t/ha DM
- CP: 5-25%
- NDF: 20-65%
- ME: 2-8 MJ/ kg DM

Key phytochemicals

- α-linolenic & linoleic acids
- Polyphenols & tocopherols
- Saponins & alkaloids

Key anti-quality factors

- Ash & oxalates
- Nitrates & NPN
- Fibre

Meat production & quality

- ↓↔↑ Growth & carcass yield
- ↑ Meat mineral & vitamins
- ↑ Meat FA profile
- ↑ Meat oxidative shelf life
- ↔ Meat sensory quality
- GHG, animal health & welfare?

Sea spinach
(*Tetragonia decumbens*)



Wild cabbage
(*Trachyandra ciliata*)



10) Xerophytes and byproducts

Succulent xerophytes: energy & water - inclusion levels: up to 30%



Spineless cactus
(*Opuntia ficus-indica*)

Key climate-smart attributes

- Drought tolerant
- Heat & radiation tolerant
- Phytoremediation



Aloe (*Aloe vera*) waste

Key phytochemicals

- Linoleic & α -linolenic acids
- Polyphenols & essential oils
- Saponins & alkaloids

Key limitations

- Highly perishable
- Toxicity - oxalates
- Spines

Key nutritional attributes

- DM: 6-15%
- CP: 2-8%
- ME: 2-11 MJ/ kg DM

GHGs, meat production & quality

- $\downarrow$ CH₄ emissions
- $\downarrow \leftrightarrow \uparrow$ Growth & carcass yield
- $\downarrow$ Feed costs
- $\leftrightarrow$ Meat physicochemical quality
- $\uparrow$ Meat FA profiles
- $\leftrightarrow$ Meat sensory quality
- $\uparrow$ Animal health & welfare



Century plant (*Agave*)



African milk bush (*Euphorbia*)



Common ice plant
(*Mesembryanthemum crystallinum*)

Browse xerophytes data ??:
Colophospermum mopane
Dichrostachys spp.
Ziziphus spp.

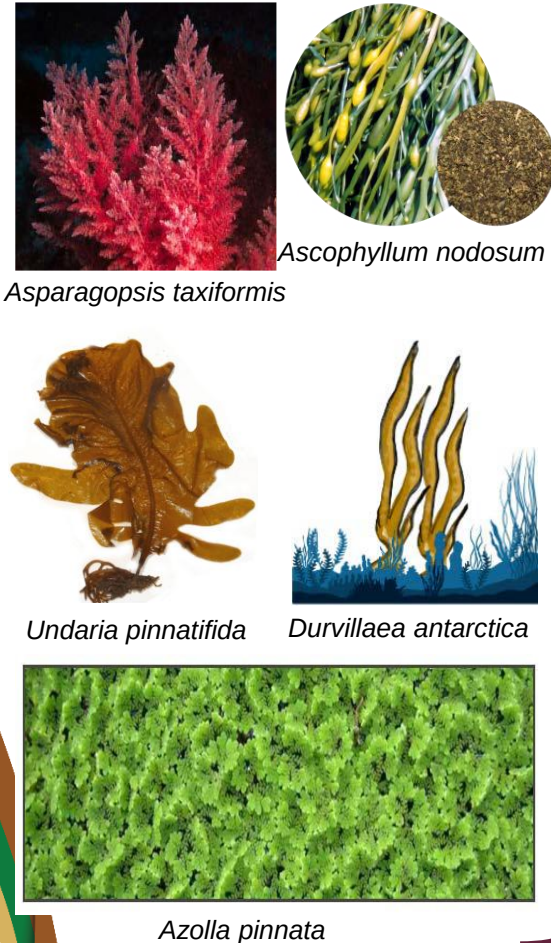


Pineapple (*Ananas comosus*) waste

11) Algae and byproducts

Protein, n-3 PUFA & anti-methanogenic compounds CH₄ - inclusion levels: 0.2-25%

Macroalgae (seaweeds)



Microalgae (phytoplankton)



Key climate-smart attributes

- Carbon sequestration
- Saline tolerant
- Waste reduction

Key nutritional attributes

- Yield: ~80t/ha/yr
- CP: 10-60%
- NDF:14-42%

Key phytochemicals

- Long chain n-3 PUFA
- Halogenated compounds
- Phlorotannins

Key limitations

- Bromoform toxicity
- High cost
- Nutrient variability

GHGs, meat production & quality

- ↓ CH₄ emissions (up to 99%)
- ↓↔↑ Growth & carcass yield
- ↑ Meat FA profiles
- ↔ Meat nutritional quality
- ↔↑ Meat sensory quality
- ↑ Meat oxidative stability
- ↔↑ Animal health & welfare



12) Former food products (FFPs)

Protein, energy n-3 PUFA & anti-methanogenic compounds - inclusion levels: up to 30%



Key climate-smart attributes

- Carbon sequestration
- Waste reduction

Key nutritional attributes

- CP: 7-14%
- NDF: 2-23%
- EE: 4-15%
- Starch: 50-60%
- ME: 14-17 MJ/kg

Key phytochemicals

- Polyphenols
- Theobromine

Key limitations

- Nutrient variability
- Safety concerns



GHGs, meat production & quality

- ↓ CH₄ emissions **up to 45%**
- ↔ Growth & carcass yield
- ↔ Meat nutritional quality
- ↔ Meat sensory quality
- ↔ Meat oxidative stability

13) Animal byproducts

High bioavailable CP (up to 95%) – e.g., fish, meat, feather, rumen digesta etc: inclusion levels: up to 30%



Key climate-smart attributes

- Carbon sequestration
- Waste reduction

Key phytochemicals

- n-3 PUFA
- Polyphenols
- Volatile fatty acids

Key limitations

- Nutrient variability
- Safety concerns

Key nutritional attributes

Rumen digesta:

- DM: 13-92%
- CP: 13-46%
- NDF: 59-78%
- EE: 3-8%
- ME: 14-17 MJ/kg

GHGs, meat production & quality

- ↓ CH₄ emissions
- ↔ Growth & carcass yield
- ↔ Meat nutritional quality
- ↔ Meat sensory quality
- ↔ Meat oxidative stability

14) Insects

Protein and Fibre sources - inclusion levels: up to 30%



Nutrient composition of BSF larvae meal (LM)

Comp*	Full-fat	Partially defatted	Defatted
DM %	88–97	47	94–97
CP %	35–48	59	41–60
Fat %	36–48	9	8–12
NDF %	16	20	13

Key climate-smart attributes

- Carbon sequestration
- Waste reduction

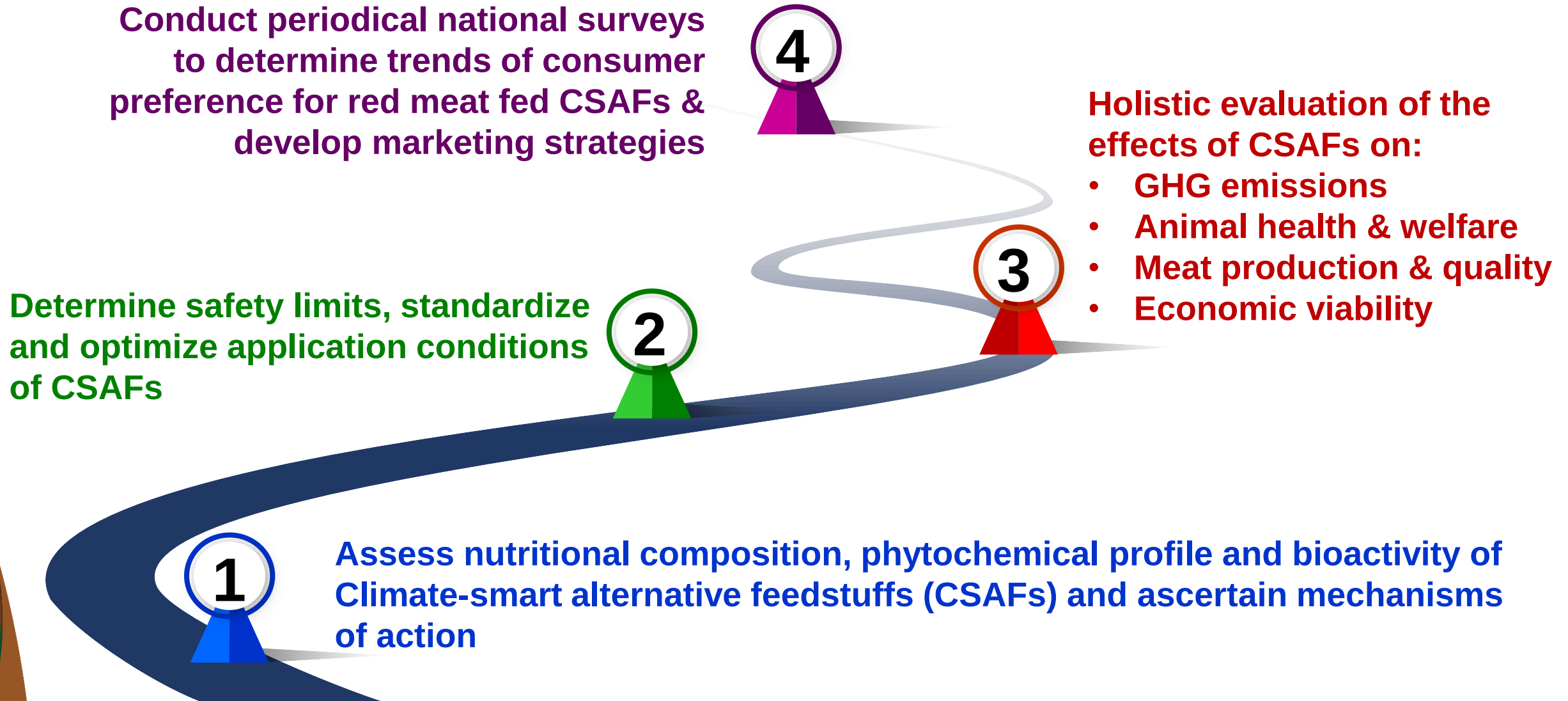
Limitations:

- High EE & chitin contents
- Data on ruminant production
- Scale-up production technologies
- Product safety & consumer acceptability
- Accidental release of non-native spp
 - Possible effects on biodiversity

GHGs, meat production & quality

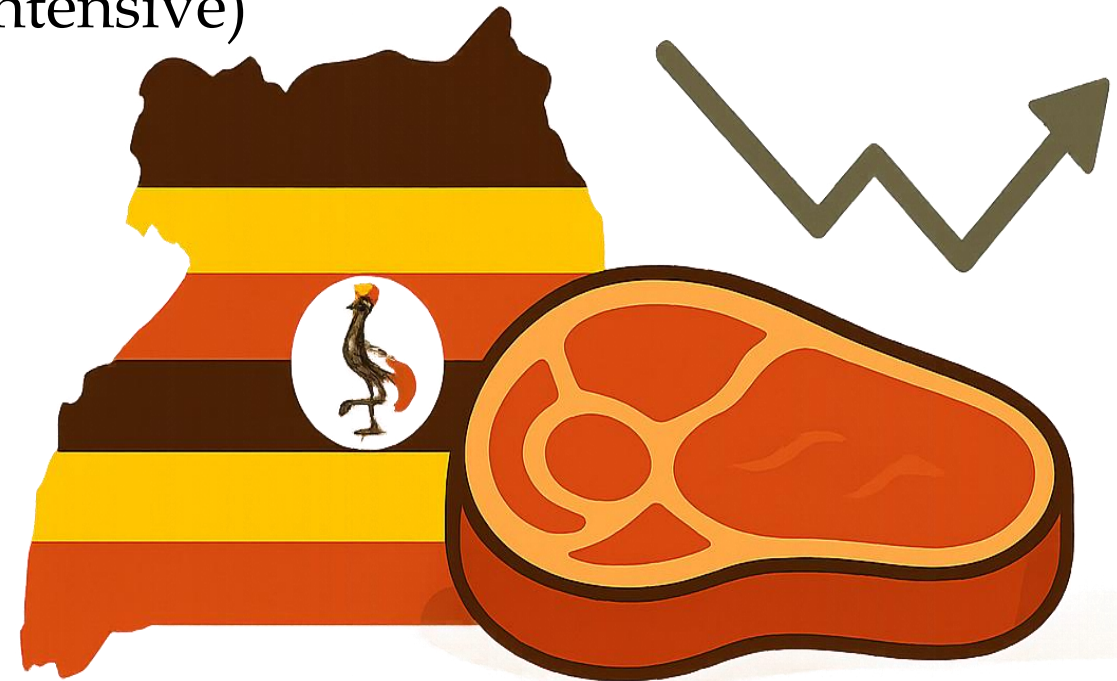
- ↓ ivCH₄
- ↓ 30% BSF: ↔ DMI, ↓ DMD

Proposed research directions



Potential impact on Uganda's red meat industry

- Reduction in feed costs
- Enhanced feed quality
- Shifts in production systems (semi and intensive)
- Increase red meat production
- Enhanced health value of red meat
- Affordable red meat
- Enhanced food and nutrition security



Any Questions

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