

Nutritional values of the „new“ cereals and pseudo-cereals

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Agenda

- Introduction
- „New“ cereals and pseudo-cereals
- Nutritional value in general
- Nutritional value of:
 - Buckwheat
 - Quinoa
 - Millet
 - Sorghum
 - Teff
 - Oat
- Conclusions

Introduction



- **Gluten free bakery products** tend to have minor volume and fragile crumb -> lack of gluten network



- 3 cereal grains dominate the **world's food supply**: wheat, **rice and maize**^{1,2}
- **Reduced genetic diversity** -> greater risk of catastrophic food crop failure (eg. insect pests, fungal diseases)¹
- Standardly used raw materials in gluten free bakery products: **corn and rice flour** -> lower nutritive value (compared to others)












- Distinguished **alternative** / supplement: **pseudocereals**
- Usually used as **whole-grain flour**
- Can be cultivated in **environments unsuitable for “big three”**

¹ Belton, P. S., & Tylor, J. R. (2002). *Pseudocereals and less Common Cereals - Grain Properties and Utilization Potential*. Berlin: Springer Verlag

² W. Seibel (Hrsg.) (2005). *Warenkunde Getreide*. Spithal: Agrimedia GmbH

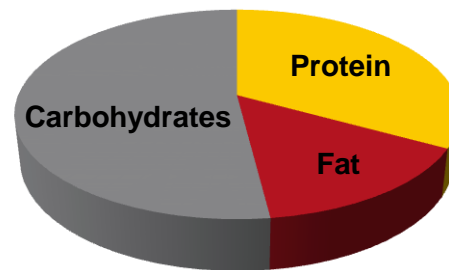
„New“ cereals and pseudo-cereals

- Overview:

„Standard“ cereals			„New“ (pseudo-) cereals		
Gluten free		Rice		Buckwheat	Gluten free
		Maize		Quinoa	
Not gluten free	Bread wheat, Durum, Rye, Spelt, Barley, ... 			Millet	
				Sorghum	
				Teff	
				Oat	

Nutritional value in general

- Key task of food: supplying our body with **energy**
- Energy can be absorbed from:



- Required for various **body functions**:

- Dietary fibre
- Vitamins
- Minerals



- **How much** of those?

- Informations: RDA (recommended daily allowance), RDI (recommended daily intake) -> nutrition facts label
- Reference levels Germany, Austria, Swiss: D-A-CH

Nutritional value in general

- **Fat**

- High **energy** value
- Needed to dissolve **fat-soluble vitamins**
- Essential fatty acids: linoleic acid
- **Healthy**: long-chain polyunsaturated fatty acids



- **Protein**

- Cell-building, eg. **muscles**
- Enzymes
- Immune system
- *Histidine: essential for infants

Essential amino acids	
Valine	Methionine
Leucine	Threonine
Isoleucine	Histidine*
Phenylalanine	Lysine
Tryptophan	Arginin

Nutritional value in general

- **Dietary fibre**

- **Indigestible** materials
- Classified as soluble or insoluble
- Help provide a **feeling of fullness**
-> may help with weight management
- As part of an overall healthy diet:
help reduce blood cholesterol levels, may lower risk of heart diseases
- Recommended daily allowance (RDA): **25 g**



- **Minerals**

- Calcium -> Bones
- Magnesium -> Muscles
- Iron -> Blood



Nutritional value in general

Vitamin	Function
Folic acid	<ul style="list-style-type: none">- Deficiency: birth defects (neural tube defects) and other diseases- RDA: 400 µg
Beta-carotene	<ul style="list-style-type: none">- Provitamin A, fat-soluble- 6 g beta-carotene = 1 g retinol (vitamin A)- RDA: age 25-41: 0,8 - 1,0 mg
Vitamin E	<ul style="list-style-type: none">- Tocopherols, fat-soluble- Antioxidants- Especially in grain seed oils- RDA: age 25-51: 14 mg
Niacin	<ul style="list-style-type: none">- RDA: age 25-51: 13-16 mg- Component of various coenzymes

nutritional value in general

Vitamin	Function
Vitamin B ₁ (thiamin)	<ul style="list-style-type: none">- In grains (whole-grain bread)- RDA: age 25-51: 1,0-1,3 mg
Vitamin B ₂ (riboflavin)	<ul style="list-style-type: none">- Protein metabolism- RDA age 25-51: 1,2-1,4 mg
Vitamin B ₆ (pyridinoxine)	<ul style="list-style-type: none">- Protein metabolism, eg. hemoglobin synthesis- RDA age 25-51: 1,2 - 1,5 mg
Vitamin B ₁₂ (cobalamin)	<ul style="list-style-type: none">- Protein metabolism- RDA age 25-51: 3,0 µg

Buckwheat

Fagopyrum esculentum Mönch



- **Pseudocereal**
- Origin from Chinese gene centre
- In Japan, after rice, one of the **most important grain crops**
- Likes **warm climates**, low requirements for humus, can be **produced on almost all types of soil** (except e.g. sand)
- **Highly nutritious**
- Ranks among plants with **highest protein content**¹
- Potential as a preventive for type 2 diabetes and reduction of cholesterol level¹

¹ Lost Crops of Africa - Vol. 1: Grains (1996)

Buckwheat

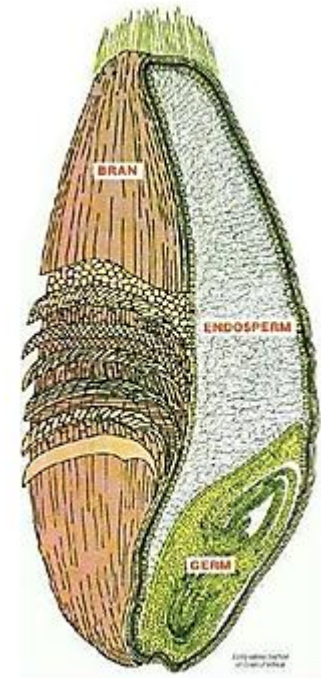


- Contains proteins with a **well-balanced amino acid composition**
- Nutritive value **superior** to millet or even cereals such as rice and wheat
- Relatively high levels of dietary **fibre**, soluble carbohydrates and significant levels of **zinc, copper and manganese**
- High contents of **flavonoids** and **polyphenols**¹ (plant secondary metabolites with antioxidant activity)
 - May be used as a good source of dietary rutin (a flavonoid)

¹ Lost Crops of Africa - Vol. 1: Grains (1996)

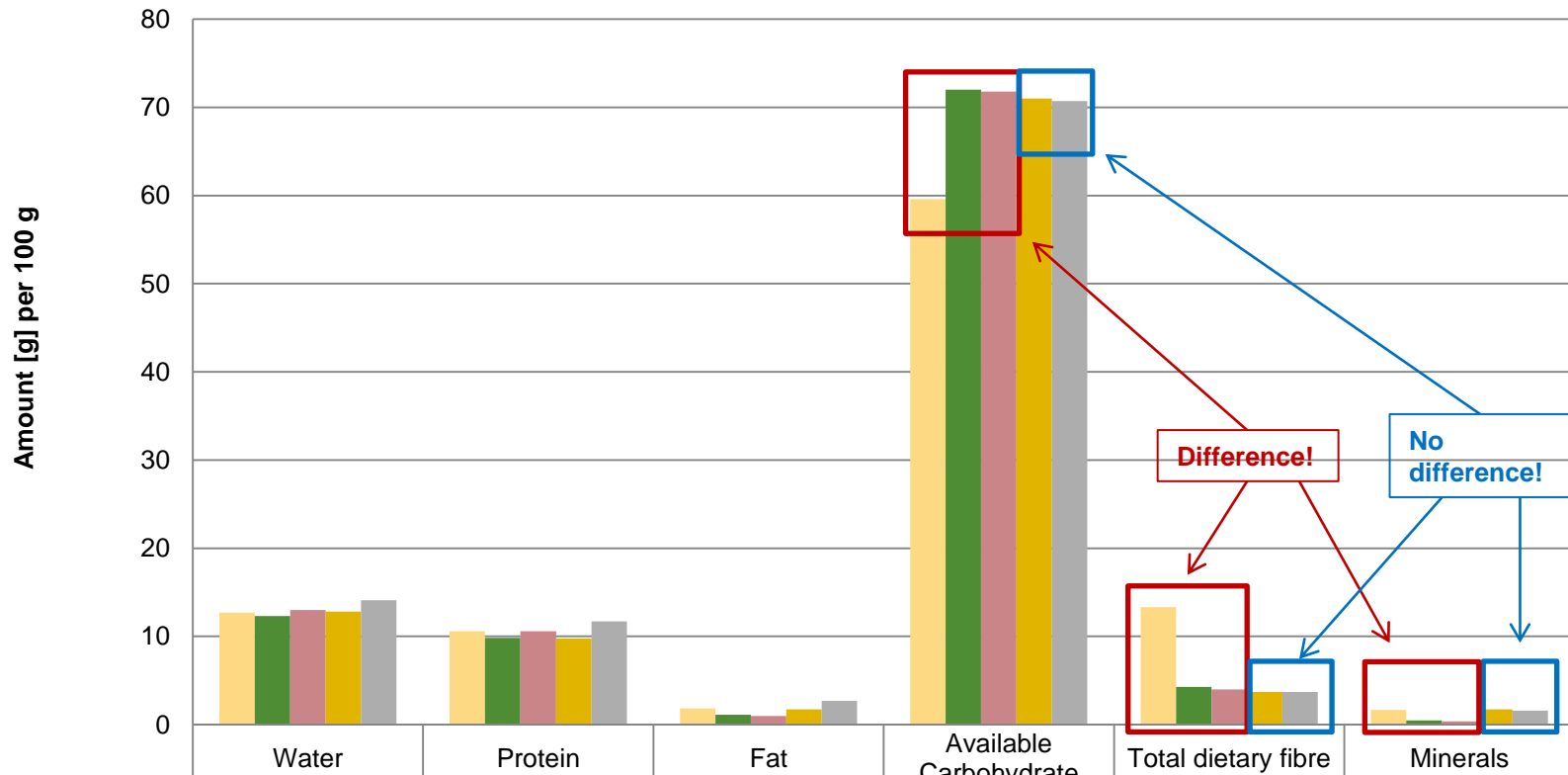
Comparison: (pseudo-) cereals - bread wheat

- In the following: **comparison** between gluten free **(pseudo-) cereals and wheat**
- **Pseudocereal flour**: generally whole-grain flour
- **Wheat flour**: generally **no** whole-grain flour
-> endosperm, no bran
 - „**Type 550**“ = german classification
 - Italy: wheat flour type 0, US: all-purpose flour
 - ~0,55 % ash, ~11 % protein
 - „**Type 405**“ = german classification
 - Italy: wheat flour type 00, US: pastry flour
 - ~0,4 % ash, ~9 % protein



Example: wheat and buckwheat

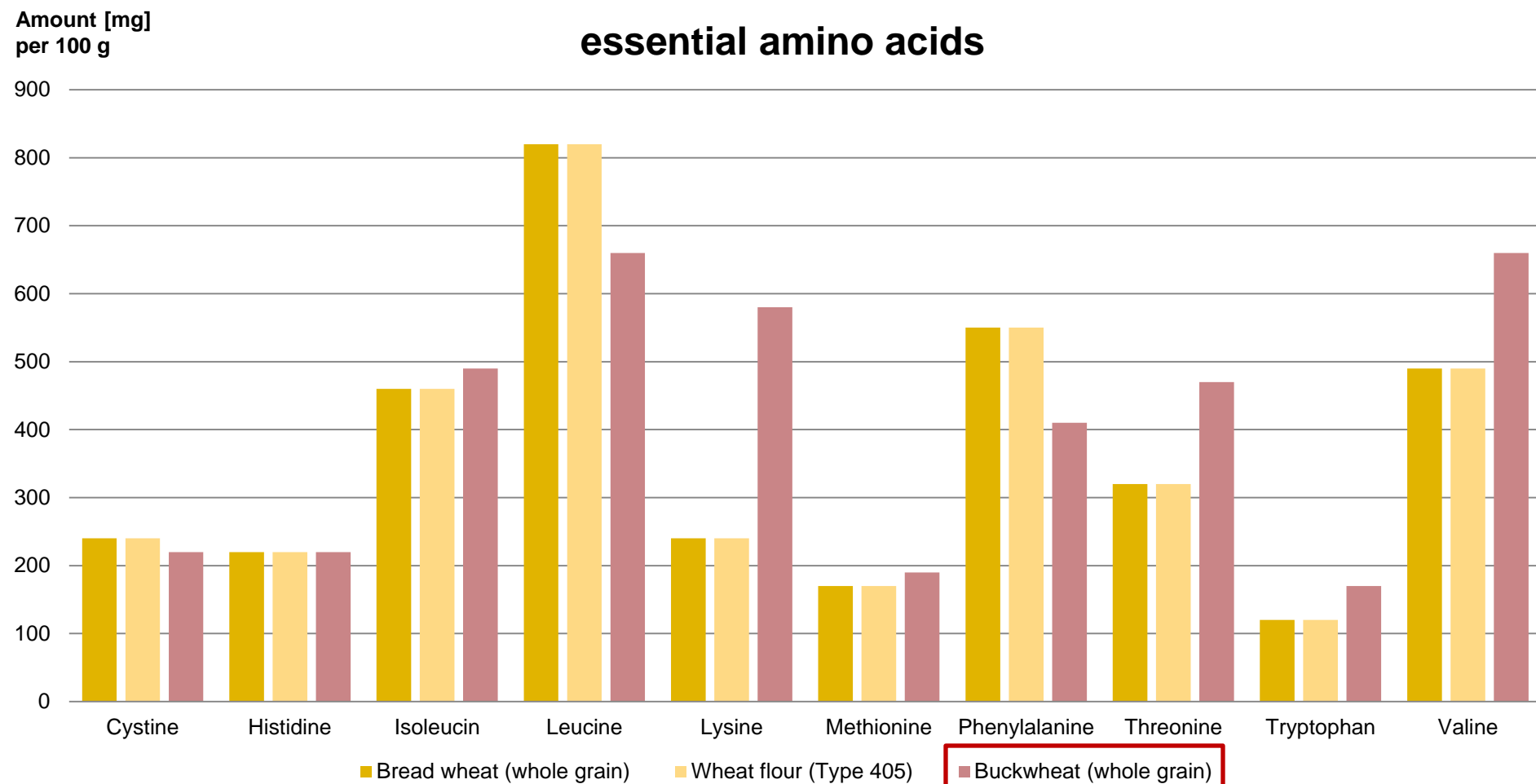
main ingredients



* Protein factor: N x 6,25

Bread wheat (whole grain)
Wheat flour (Type 550)
Wheat flour (Type 405)
Buckwheat (whole grain)
Buckwheat flour (whole-grain flour)

Comparison: buckwheat - wheat



Quinoa

Chenopodium quinoa Willd



- **Pseudocereal**
- Andean region of South America
- **Well adapted**
 - Cultivation in high altitude (2000 - 4000 m)
 - Frost resistant
 - Can be grown in areas with low rainfall (300 - 400 mm)
- Different types of quinoa cultivated in the Andean region
- Small seeds: 1 - 2,5 mm diameter
- Grain enveloped in two-layered pericarp -> contains **saponins** (= bitter substances, must be removed before consumption)

Quinoa



- Considered as **one of the most nutritive grains** used as human food
- Interesting raw material for nutritious gluten-free foods
- High amounts of **lipids**: 4-7 % a great proportion of which is **linoleic acid**
- **Protein** content 14-20 %, quinoa protein is high in lysine
- **Dietary fibre** content 14-20 %
- Good source of **folate, vitamin E, tocopherols**, also contains vitamin c

Quinoa



- Rich in **calcium, magnesium, iron, phosphorus**

but:

- Mineral availability can be affected by “antinutrients”
 - Saponins (bitter substances)
 - Phytic acid
 - Binds with e.g. iron, calcium, magnesium, zinc -> reducing bio-availability
 - Amount: 1 % -> higher level than in other cereals, comparable to oilseeds and soya

Quinoa - compared to other cereals



- | | |
|---|--|
| <ul style="list-style-type: none">• Protein• Fat | <p>More than most other cereal grains</p> <ul style="list-style-type: none">■ Much higher, at least twice as high as in most cereals■ Rich in mono- and polyunsaturated fatty acids |
| <ul style="list-style-type: none">• Dietary fiber• Mineral• Starch• Vitamins | <p>Possibly slightly higher</p> <p>Similar</p> <p>Somewhat lower</p> <ul style="list-style-type: none">■ Similar to other cereals■ Rich in B vitamins■ Containing significant amounts of folic acid■ High levels of tocopherols (vitamin E)■ Unlike other cereals: significant amounts of vitamin c■ In comparison with the RDA, quinoa can be classed as a source of vitamin E, riboflavin, thiamin and folic acid |

Millet

Paniceae sp.



- Small-seeded **grass**
- Oldest cereal: at least 10.000 years
- Important crops in semi-arid and sub-humid zones of Asia and Africa
- Most grown millet: pearl millet
- Other millets (small or minor millets): e.g. finger millet, fonio
- **Nutritionally equivalent or superior to other cereals**
- **Good digestability**

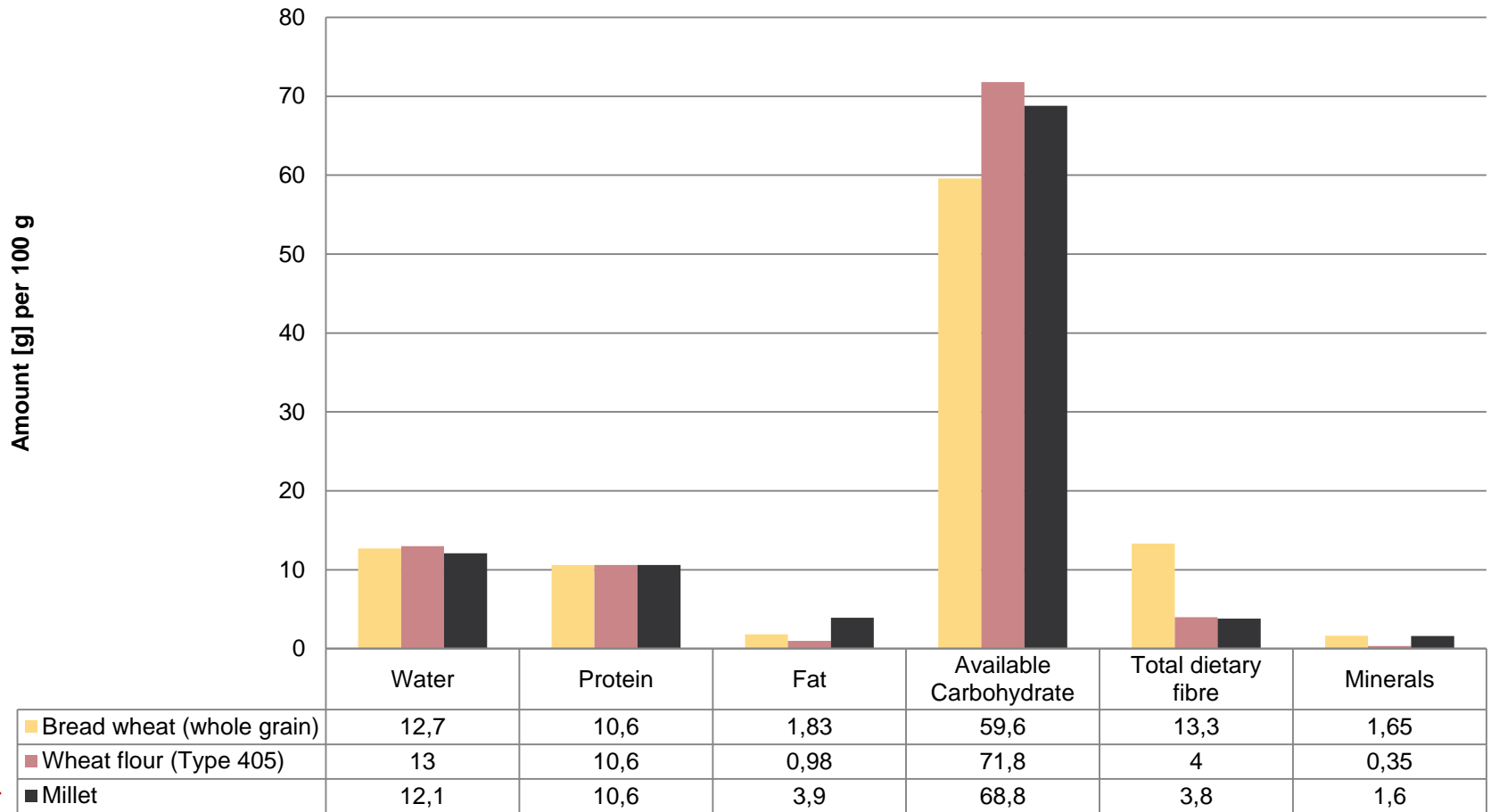
Millet



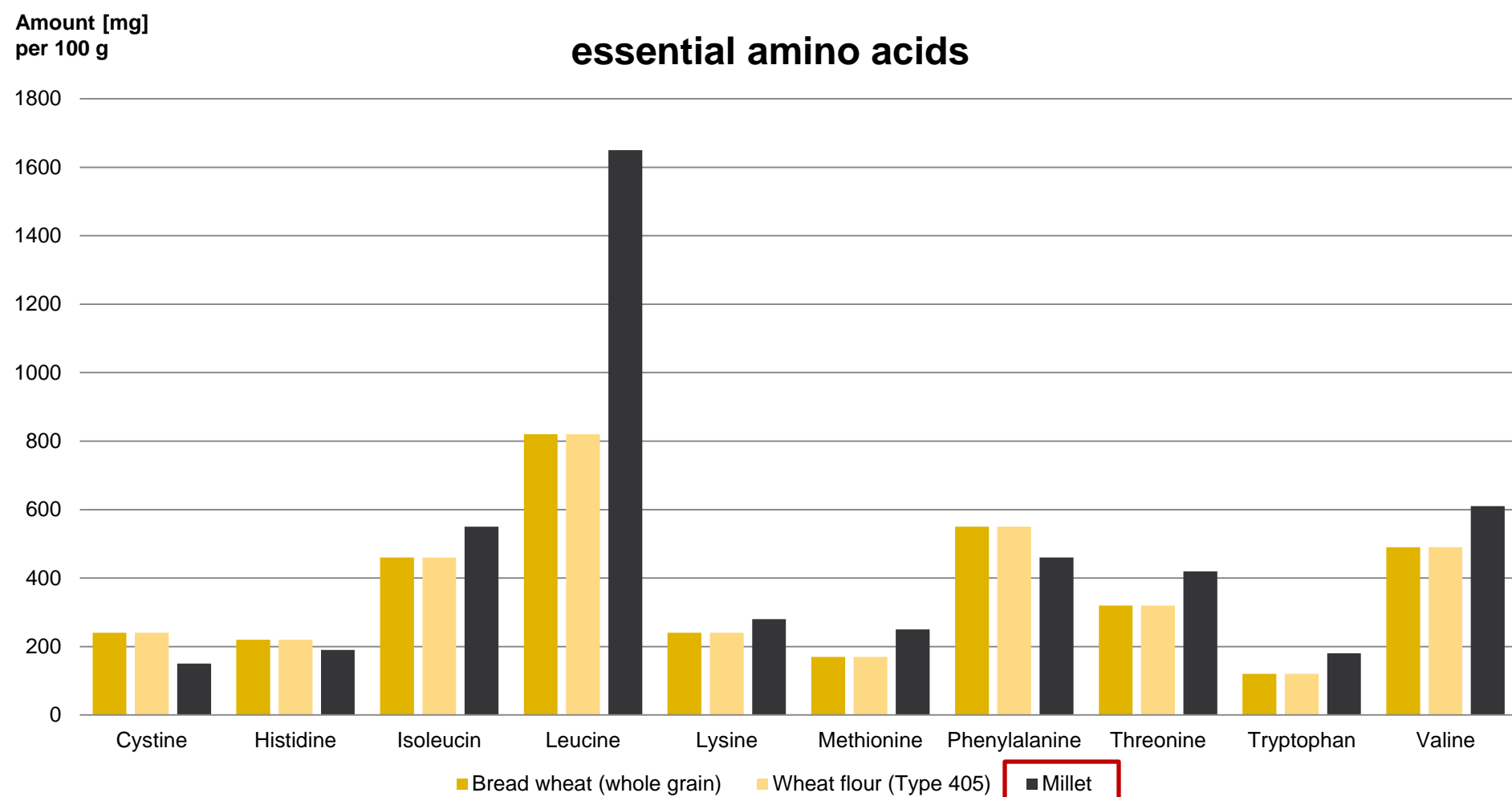
- **High energy, nutritious**
- Recommended especially for infants, lactating mothers, elderly and convalescents³
- Protein contents comparable to those of wheat, maize and rice
- Pearl millet:
 - **Most nutritious** of the common cereals³
- Finger millet:
 - **High quality** (fat, protein)
 - High levels of methionine
 - Substantial **calcium and iron** contents

Comparison: millet - wheat

main ingredients



Comparison: millet - wheat



Sorghum

Sorghum bicolor (L.) Moench



- Tropical cereal **grass**, like rice and maize
- Africa
- Drought tolerant
- Sorghum types:
 - Grain sorghum: Food and feed
 - Forage sorghum: Fodder and grain for livestock
 - Sweet sorghum: Sugar, syrups, alcohol production
 - Strassy sorghum: Grazing silage and hay
- **Vitamin** and **mineral** content very similar to maize
- **Protein**: compares well with other cereals
- **Similar nutritional value to maize** but food processing technologies as malting and fermentation improve its nutritional value significantly

Sorghum



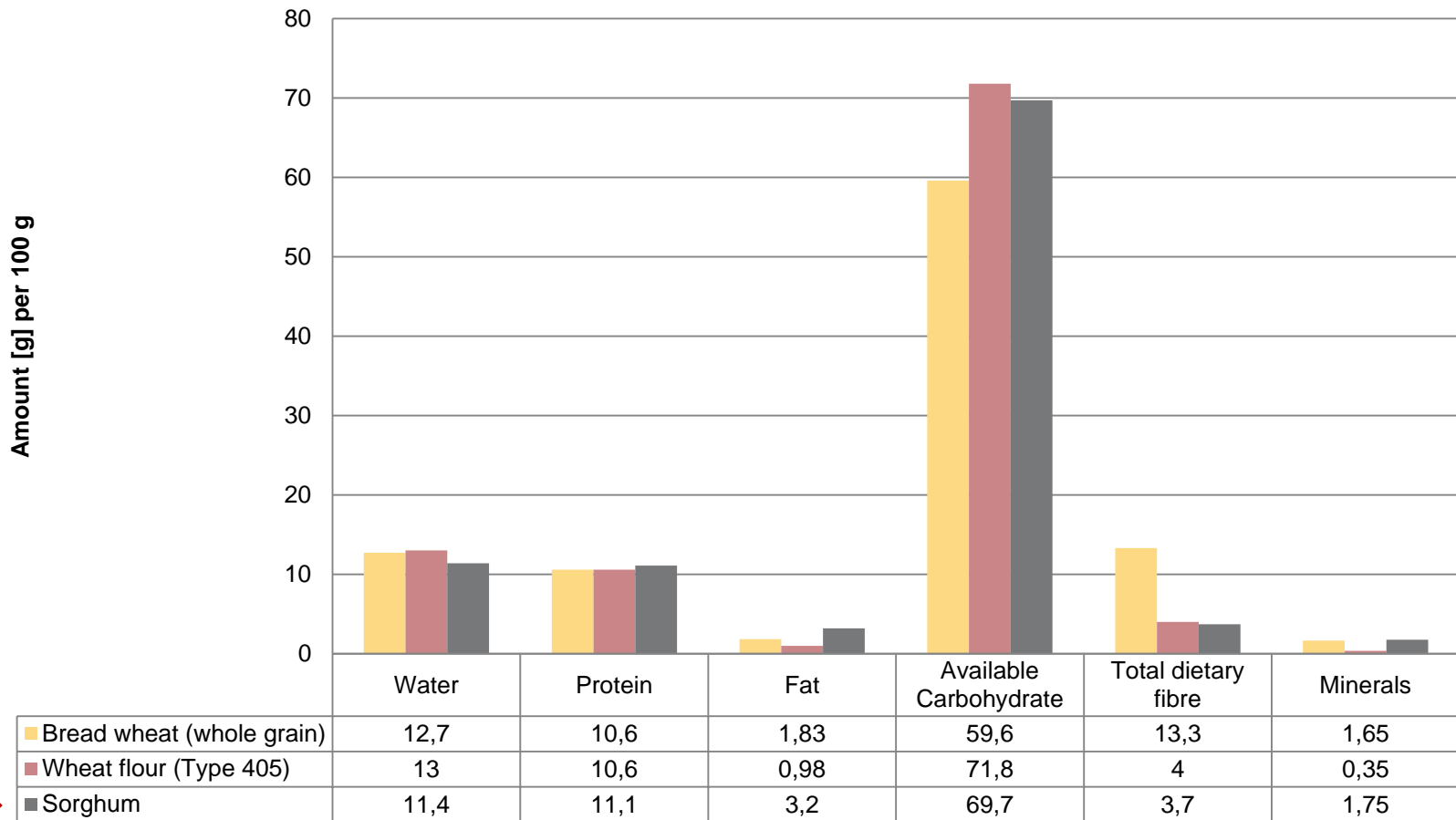
- Phenolic compounds
 - Some sorghums produce significant quantities of **tannins** (most of them located in husk)
 - > antinutritional as they inhibit the digestion of protein
 - > milling for removal

but:

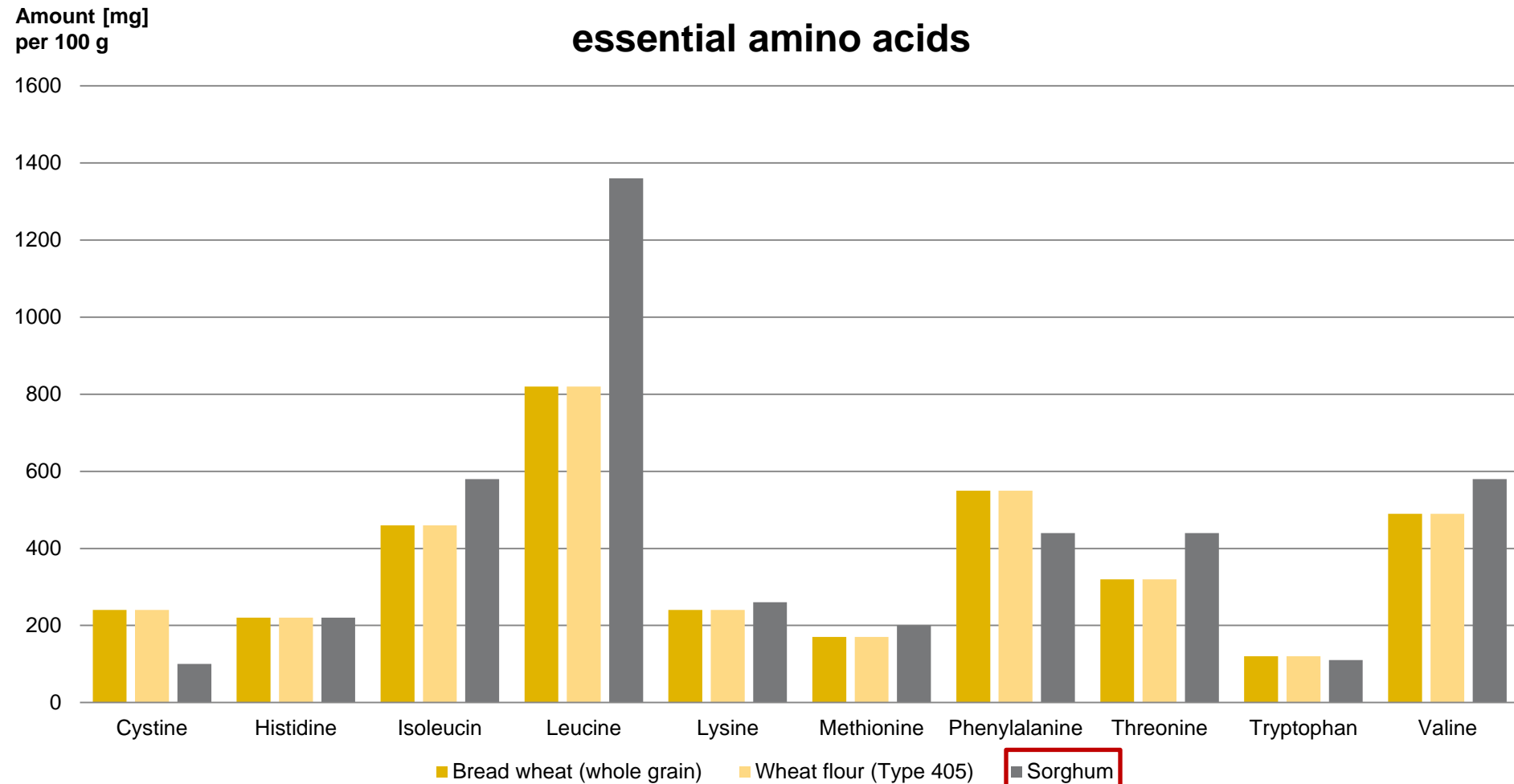
- All sorghums produce **phenolic compounds** such as anthocyanin, anthocyanidin and phenolic acids
 - > healthy (antioxidants)

Comparison: sorghum - wheat

main ingredients



Comparison: sorghum - wheat



Teff

Eragrotis tef



- Significant crop in Ethiopia
- **Stable yield** under varying conditions
- **Good storage properties**
- Always consumed as whole grain, therefore **higher nutritive value** than major cereals, such as wheat, barley and maize
- **High protein digestibility**
 - Probably high because main protein fractions (albumin, glutelin and globulin) are the most digestible types; albumin fraction is particularly rich in lysine

Teff



- **Protein** content 9-11 % -> slightly higher than in sorghum, maize and oats
 - Samples tested in the United States have shown consistently even higher protein levels: 14-15 %
- Good level of **minerals**, average ash content: 3 %
- Teff is reported as rich in certain **minerals**
 - Iron and calcium contents (11-33 mg and 100-150 mg, respectively) higher than those of wheat, barley, or sorghum
 - Contains more Ca, Fe, Mn, Zn than most cereals
 - Less potassium than barley, oat and wheat
- Average vitamin content

Oat

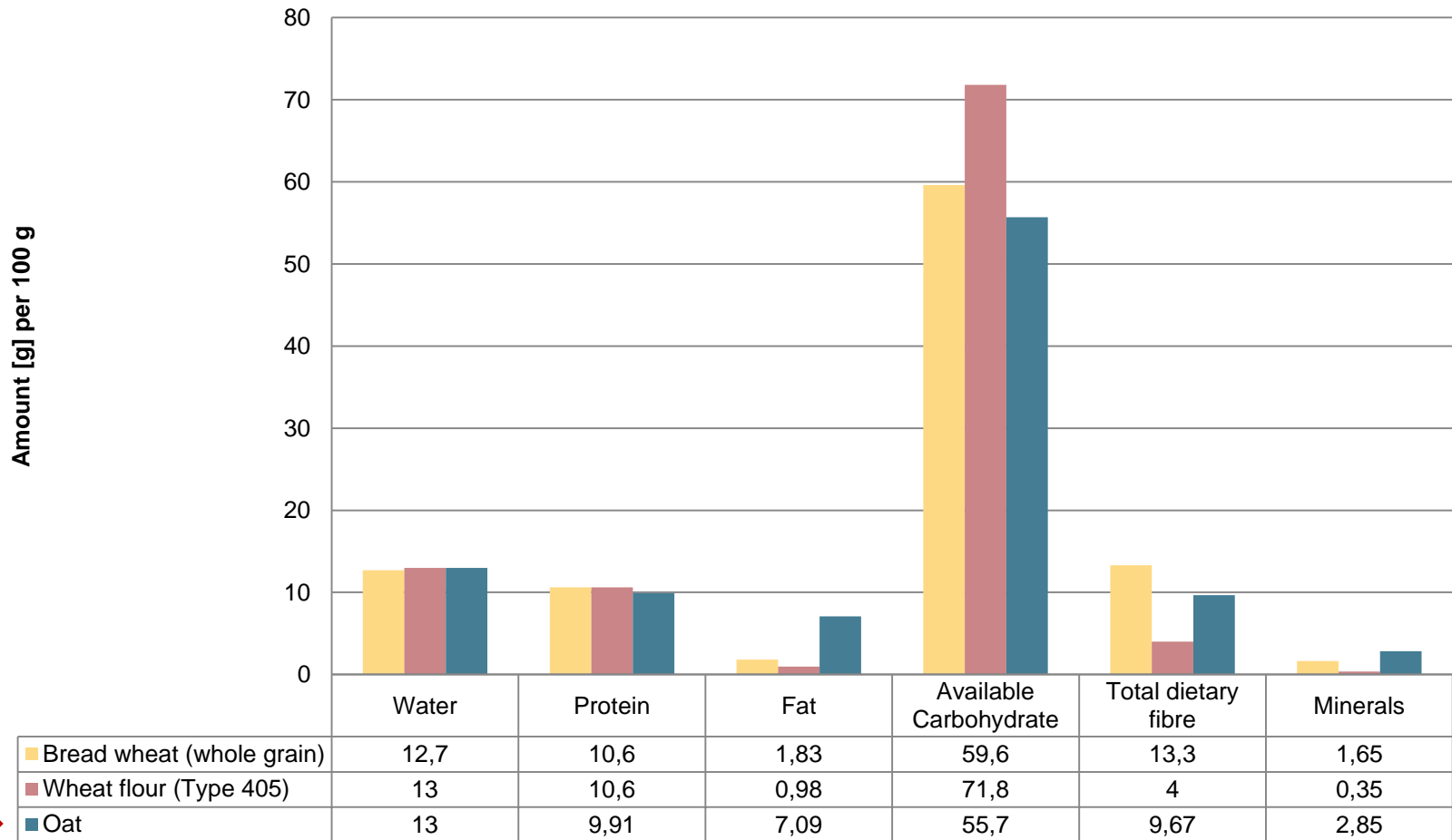
Avena sativa



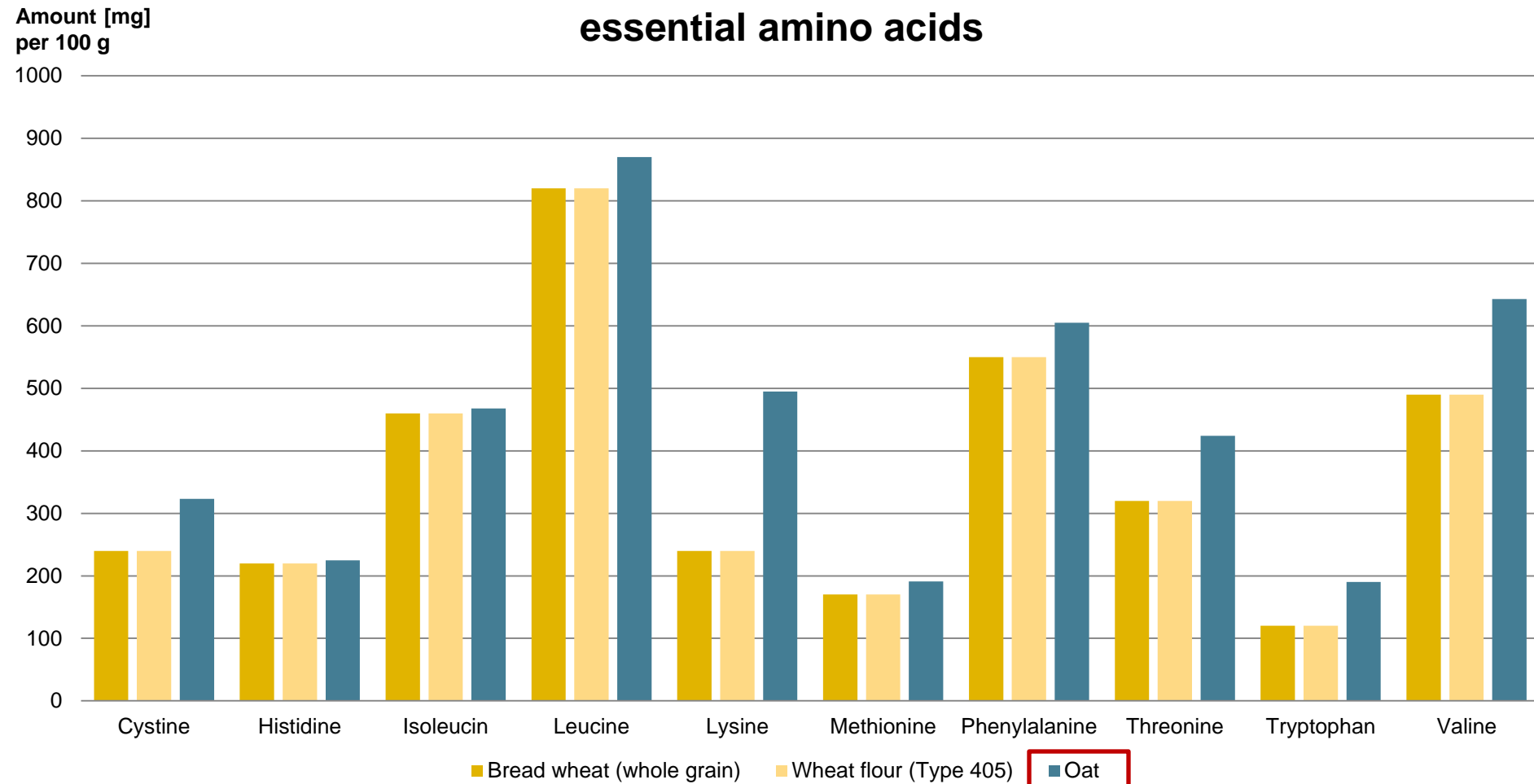
- Used for nutriment and feed
- Not seen as gluten free for a long time -> contamination
- More and more countries include oats in gluten free products
- **Highly nutritious**, much soluble and insoluble fibre (e.g. β -glucan)
- Highest proportion of **soluble fiber** of any grain
- **Good digestability** due to starch structure
- Storability: can become bitter or rancid if not stored correctly

Comparison: oat - wheat

main ingredients



Comparison: oat - wheat



Conclusions

- Pseudocereals buckwheat and quinoa have **high protein contents** and **protein of good essential amino acid composition** when compared to true cereals
- Sorghum and millet: rich in **phenolic compounds** which may have useful **antioxidant** properties
- Buckwheat: possible to make **good quality leavened baked product** from these grains alone
- Other **(pseudo-)cereals**: good additives to receive products with **improved nutritional value**



Thank you for your attention!

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