# Nutritional water productivity

## An emerging approach for tackling malnutrition in South Africa

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# What is malnutrition?

**Malnutrition** indicates a **poor nutritional status.**

**Nutritional status** is the physiological state of an individual, which results from:

- the relationship between nutrient intake and requirements, and
- the body’s ability to digest, absorb and use these nutrients.

# Distinguish between malnutrition and under-nutrition:


**Malnutrition**

deficiencies or excesses of specific nutrients, or

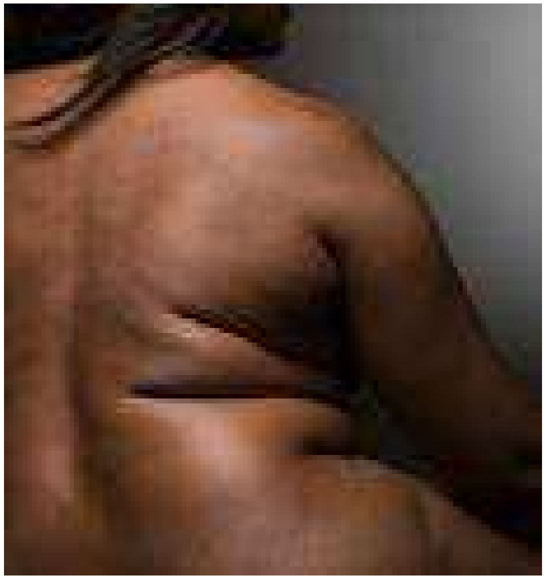
diets lacking diversity (wrong kinds or proportions of foods).

**Under-nutrition**

the outcome of insufficient food.

caused primarily by an inadequate intake of energy from food.

# The “double burden” of malnutrition



In SA, and other developing countries, under- and over-nutrition occur simultaneously

**Over-nutrition**

**Under-nutrition**

# Micro-nutrient malnutrition

- Called "**hidden hunger**", as effects often unnoticed for a long time.
- ***Vitamin A, iron*** and ***zinc*** are the core micronutrients of concern.
- Multiple signs are associated with hidden hunger:
  - ***Vitamin A*** deficiency may present as eye lesions.
  - Fatigue is typical of ***iron*** deficiency.
  - ***Zinc*** deficiency may result in skin changes.

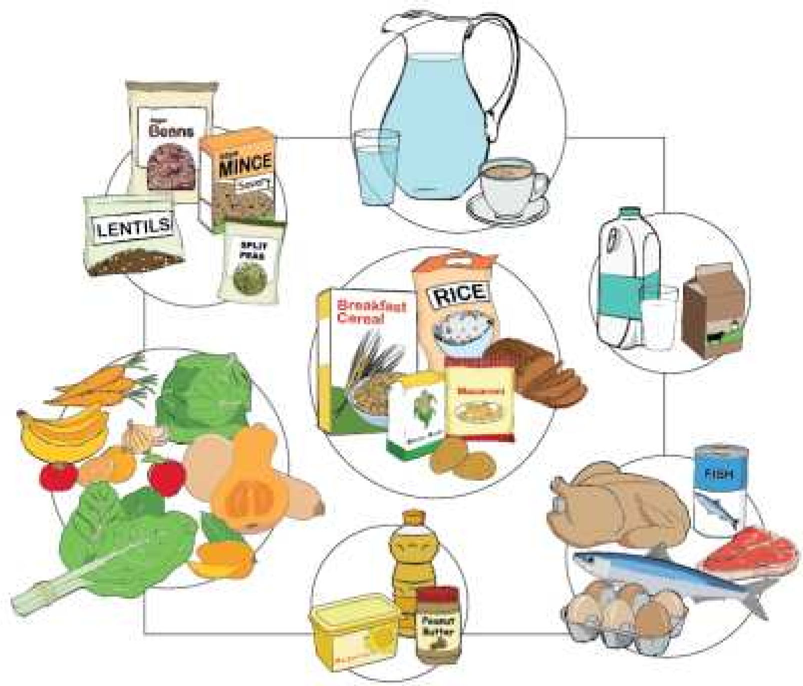
## Nutritional problems of South Africans can be summarised in terms of the following:

1. Energy and macronutrient (protein) status
2. Micronutrient malnutrition
3. Dietary diversity
4. Nutrient density

# FOOD for Health

## A healthy diet is:

- ***Balanced*** (in line with Food Based Dietary Guidelines).
- ***Varied*** (different foods are consumed from the various food groups).
- ***Moderate*** (to prevent over-nutrition).



# Energy and macronutrient (protein) status

## Energy:

- ***Children***: Overall intakes are inadequate, but at the same time childhood obesity is increasing.
- ***Adults***: Obesity common among women in rural areas.

## Protein:

- Overall intakes adequate, but biological value (of mainly plant source protein) may be of concern.

# Micro-nutrient status

Among 1-9 year old SA children:

- 64% have low serum retinol levels (low **vit A** status)
- 45% have low **zinc** status
- 28% are anaemic and 13 % have poor **iron** status.

Thus ***hidden hunger*** is a major cause of concern.

Source: *National Food Consumption Survey – Fortification Baseline 2005*

# Dietary diversity

- Overall South Africans consume monotonous diets: their diets lack diversity
- Intake of fruit and vegetables is low

# Nutrient density

- Nutrient density refers to amount of (micro)-nutrients relative to energy content (or volume) of the diet or of a food.
- Porridge (from maize meal) and bread are staples for many South Africans.
  Both have low micronutrient density.



Nutritional status is influenced by

**multiple and interrelated factors.**

| FOOD | HEALTH | CARE |
| --- | --- | --- |

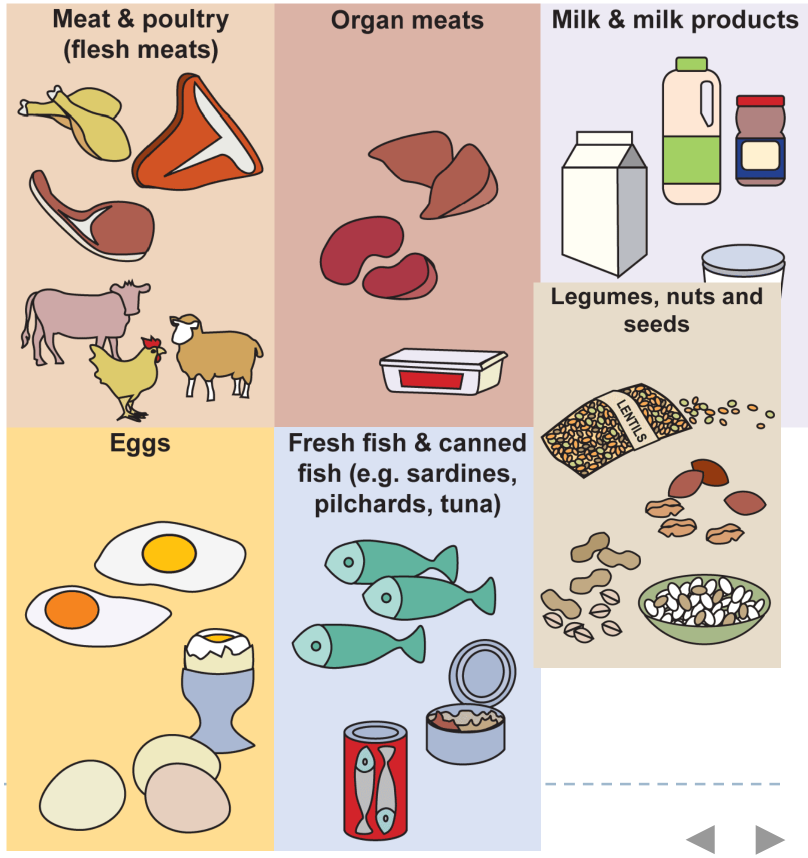
**Poverty** is the root cause of **malnutrition.**

In South Africa people in rural areas most affected

# Foods rich in PROTEIN

## Animal source foods:

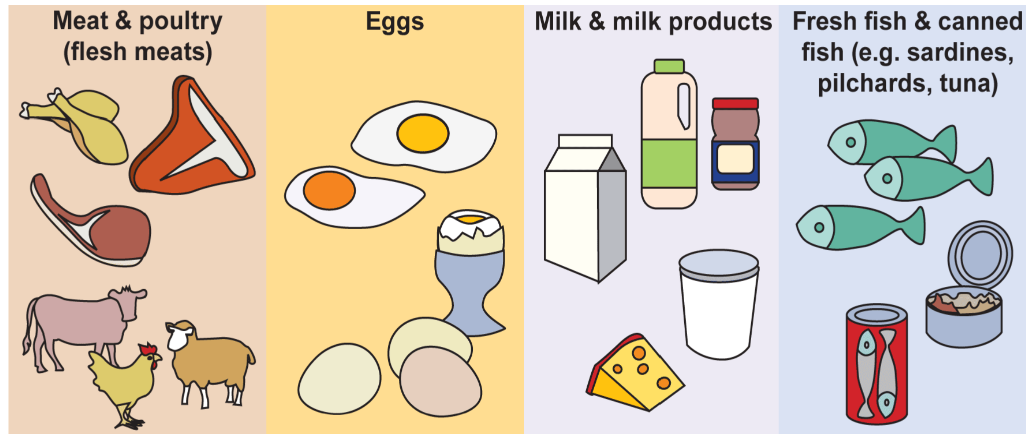
- Lean meat (mutton, goat, beef, pork)
- Poultry
- Eggs
- Milk
- Fish




## Plant source foods:

- Legumes (dry beans, split peas, cowpeas, soya, groundnuts)

# Foods rich in VITAMIN A

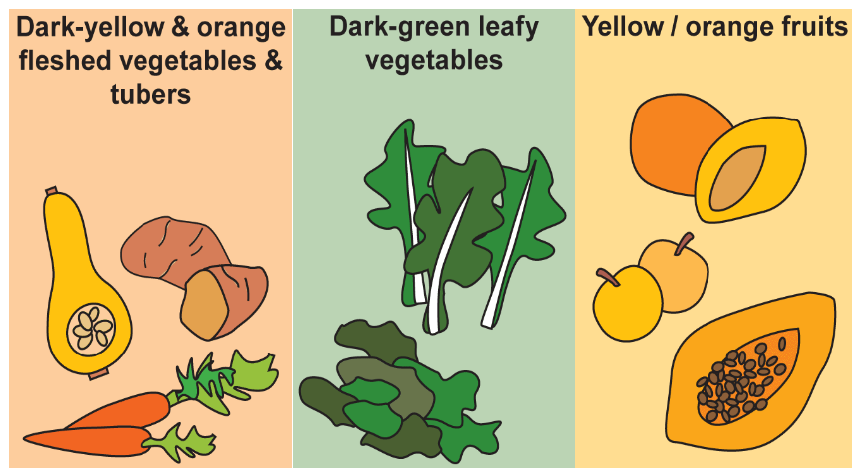



## Animal source foods:

Lean meat, Poultry, Eggs
Milk and Fish

## Plant source foods:

**(*contain pro-vit A, converted in human body to vit A)***

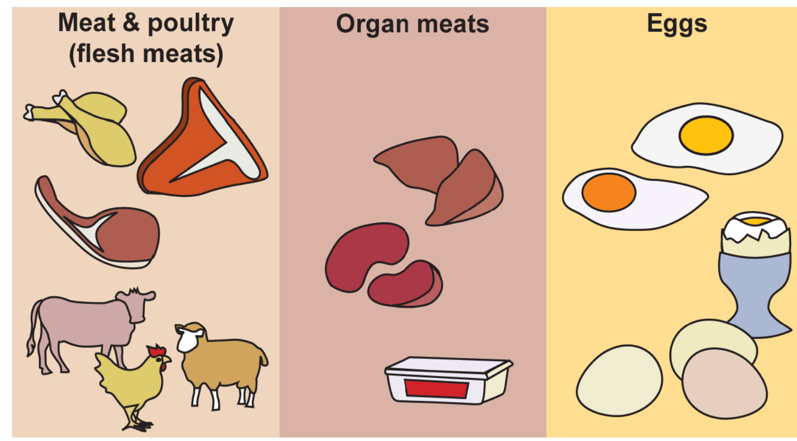



Good sources include :
Yellow/orange vegetables
Dark green leafy vegetables
Yellow/orange fruit (excl citrus)

# Foods rich in IRON

## Animal source foods:

- Lean meat (mutton, goat, beef, pork, darker fleshed cuts of poultry)
- Organ meat
- Egg yolks



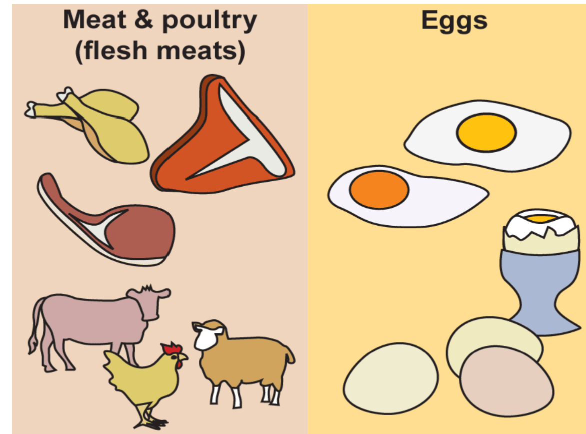

## Plant source foods - Fe not as bio-available as for animal sources:

- Dark green leafy vegetables

# Foods rich in ZINC

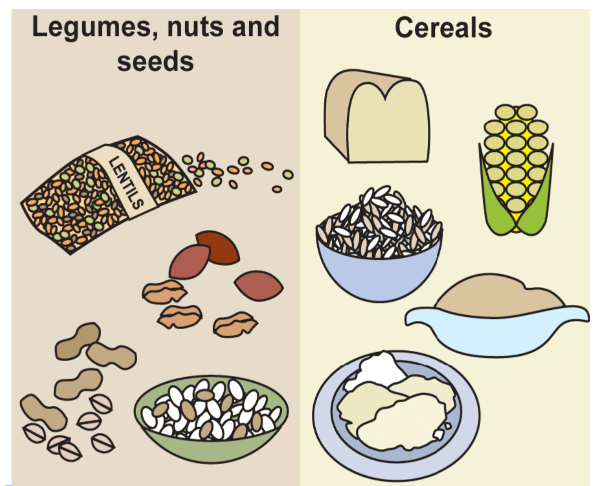
## Animal source foods such as:

- Lean meat (mutton, goat, beef, pork, poultry)
- Eggs




## Plant source foods limited to:

- Legumes, nuts and seeds
- Whole grains



# Human nutritionists / Crop scientists

**Clearly an important topic**

Can make a big contribution if we better nourish our people

**Macro/micro-nutrient concentrations**

of unprocessed foods of importance in the diet of rural poor

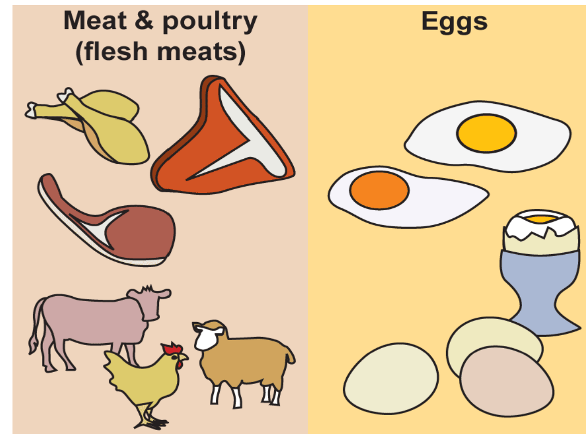
**Variation in nutritional value**

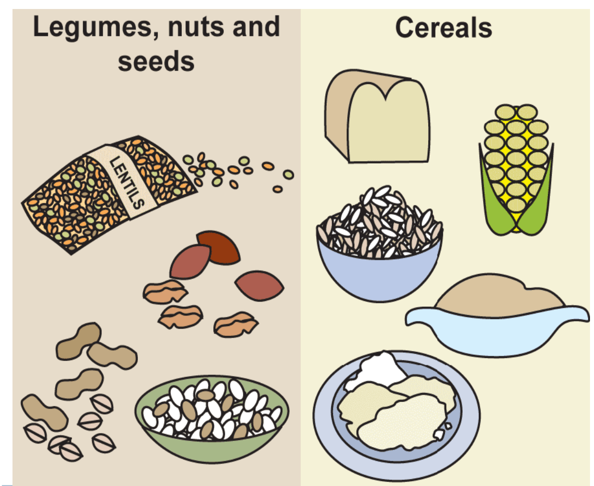
Moisture %

**Nutrients**

Crop science – N, P, K etc

Human nutrition – Protein, energy, fat



# WATER in food production

Water is essential for the agricultural production of plant and animal-source foods.

# WATER in crop production

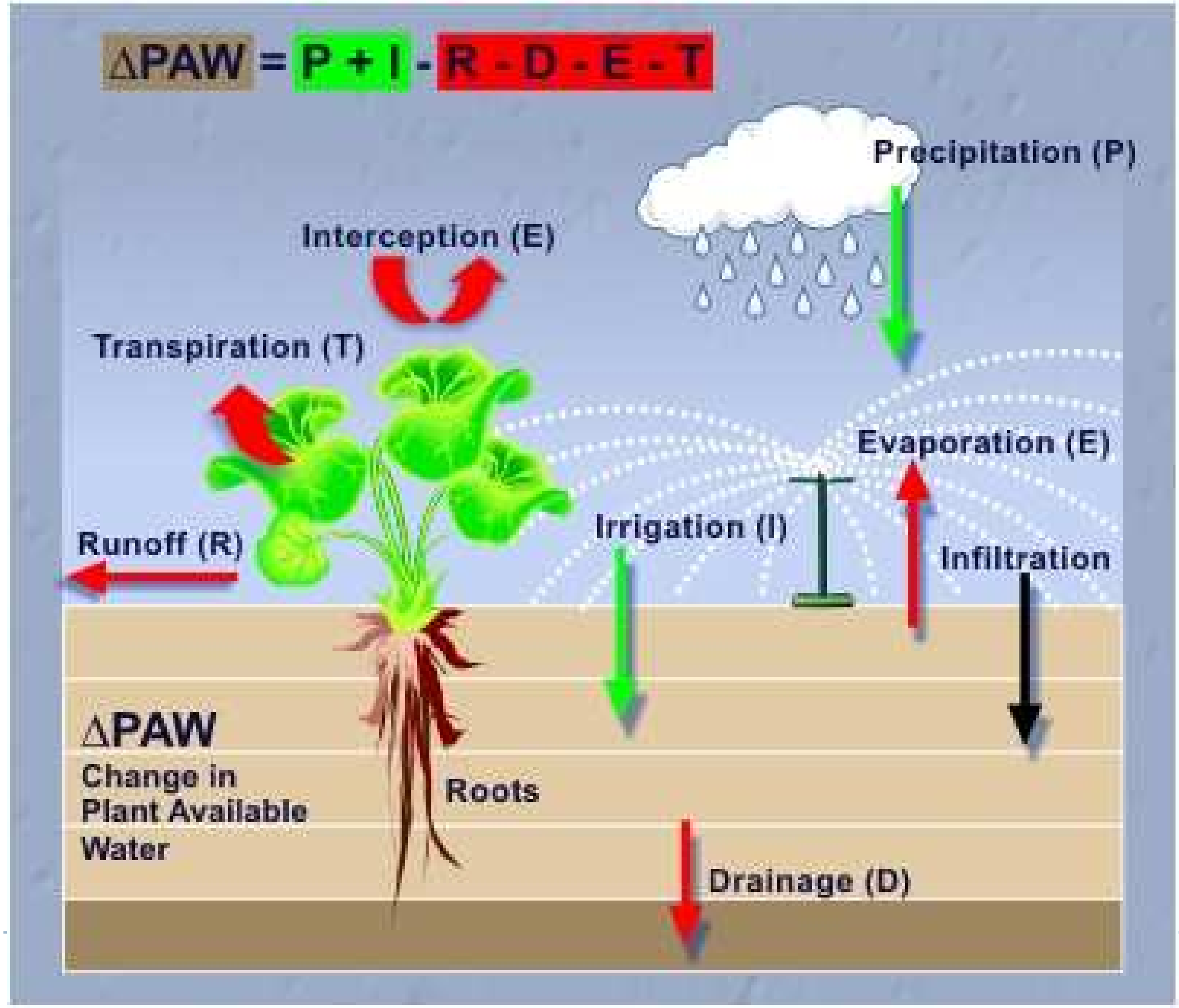
Crop water productivity - yield relative to water used to produce it

Water from rainfall – ***green water***

Irrigation from surface or groundwater – ***blue water***

Units: kg crop per $m^3$ or kg $ha^{-1}$ $mm^{-1}$

# SOIL WATER BALANCE



# Water productivity is influenced by

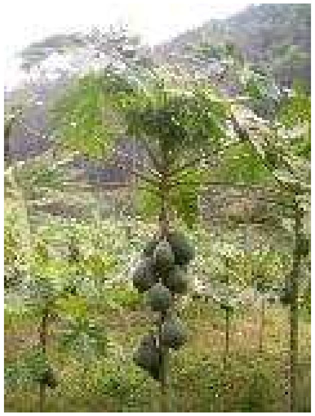
# **multiple and interrelated factors**.

**CLIMATE**

- Radiation
- Wind speed
- Temperature
- VPD

# CROP factors affecting WP

- Photosynthetic mechanism - C3, C4 or CAM



- Harvest index - Fraction of DM consumed
- Composition - 1 g glucose →

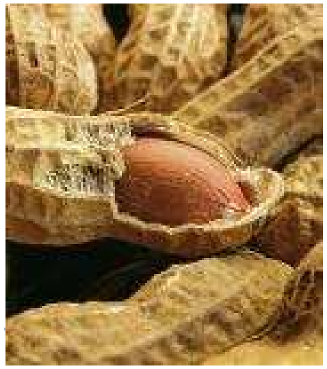
0.86 g cellulose / starch

0.45 g protein

0.36 g lipids (fats)

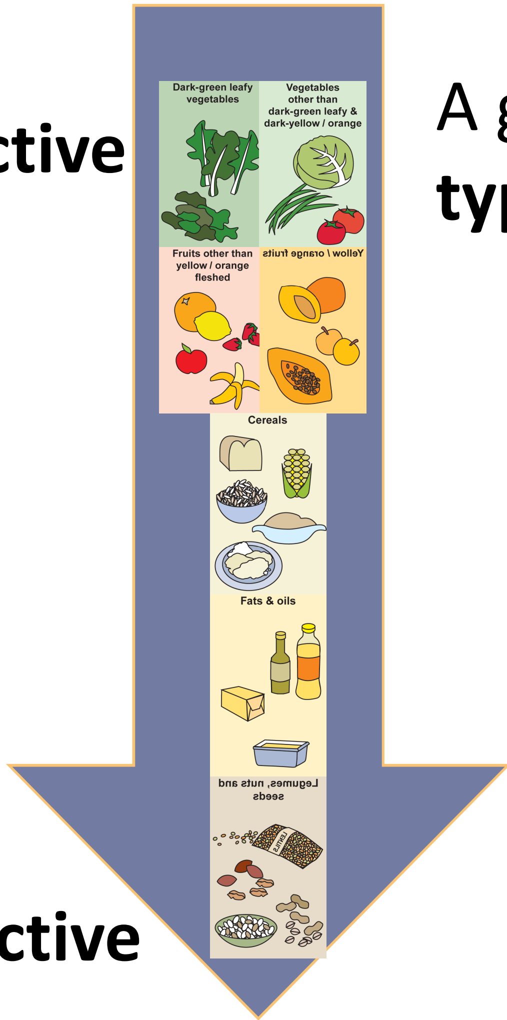
- Other factors limiting growth

Nutrient deficiencies, plant diseases, weed and insect control, soil cultivation etc.



# WATER in crop production

**Most productive**

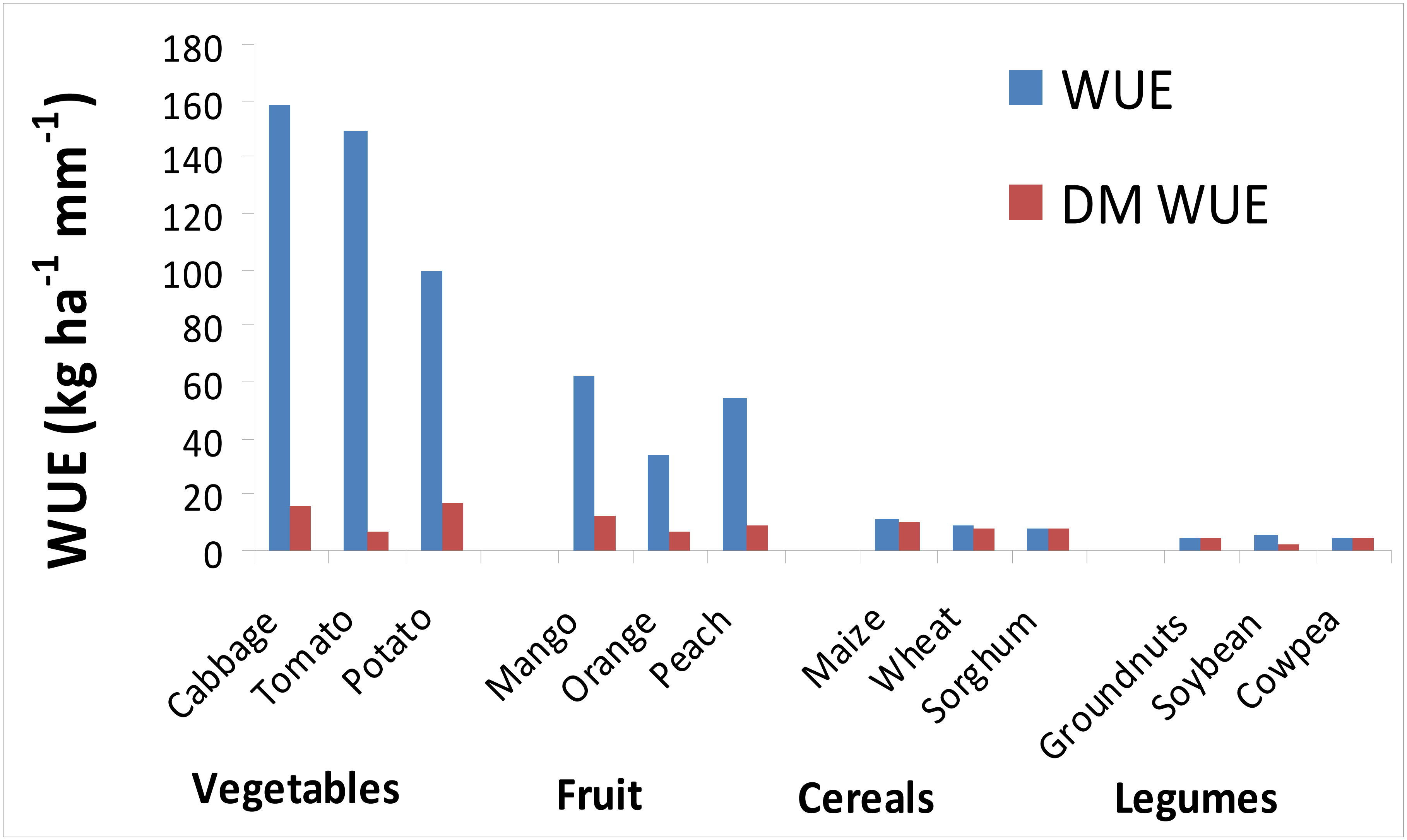



**Least productive**

A general ranking of WUE of **food crop types** from most to least efficient:

1. from vegetables
2. to fruits
3. then to cereals,
4. oil crops and
5. lastly legumes.

# Fresh and dry mass water productivities



# Yield, water use & WUE – yellow/orange veg

| Product | Yield* | Water use | WUE* | Source | Locality |
|---|---|---|---|---|---|
| | t $ha^{-1}$ | mm | kg $ha^{-1}$ $mm^{-1}$ | | |
| **Butternut** | 16.4 | 370 | 44.3 | Fanadzo (2009) | Fort Hare, SA |
| **Carrots** | 67.4 - 103.6 | - | 19.4 - 28.3 | Quezada et al. (2011) | Chile |
| | 57.6 | 390 | 148 | Annandale & Jovanovic (1999a; 1999b) | Roodeplaat, SA |
| | 30.3-64.7 | 201-493 | 131-148 | Nortje (1988) | South Africa |
| **Sweet potato** | 10.8-25.8 | 500 | 21.6 – 51.6 | Beletse et al. (2011) | Roodeplaat |
| | 13-47 | 182-1400 | 33.4 - 71.1 | Laurie et al. (2009) | South Africa |
| | 20.1-34.2 | 350-850 | 42.8 - 57.4 | Gomes and Carr (2003) | Mozambique |
| | 40 - 55 | 400-500 | 70 - 130 | Bok et al. (2000) | South Africa |
| **Pumpkin** | 36 – 43 | 162 | 222 - 266 | Zotarelli et al. (2008) | Florida, USA |
| | 57 - 66 | 258 - 410 | 160 - 220 | Fandika (2011) | New Zealand |

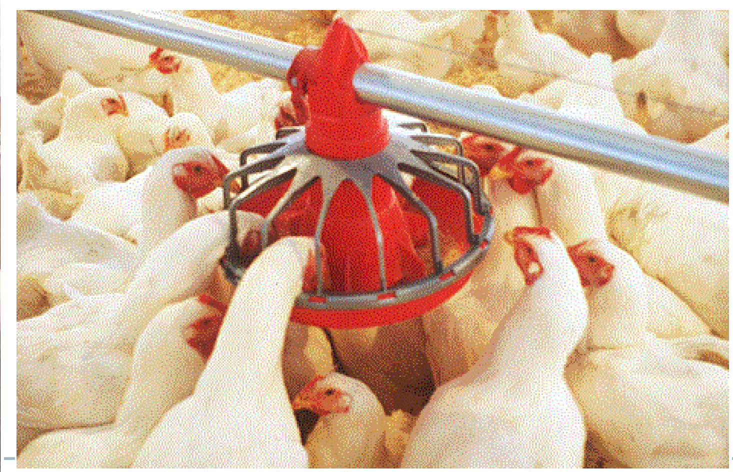
# WATER in livestock production

Animal-source foods - negligible amount used for drinking

Most used for production of feed

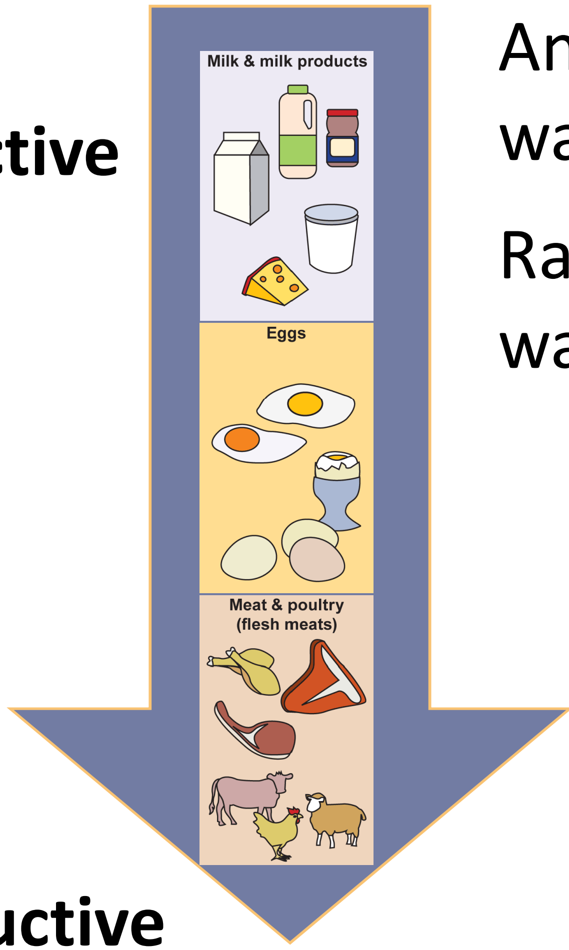
(considerations on plant water productivity apply)

Processing carcasses also depletes water.



# WATER in livestock production

**Most productive**



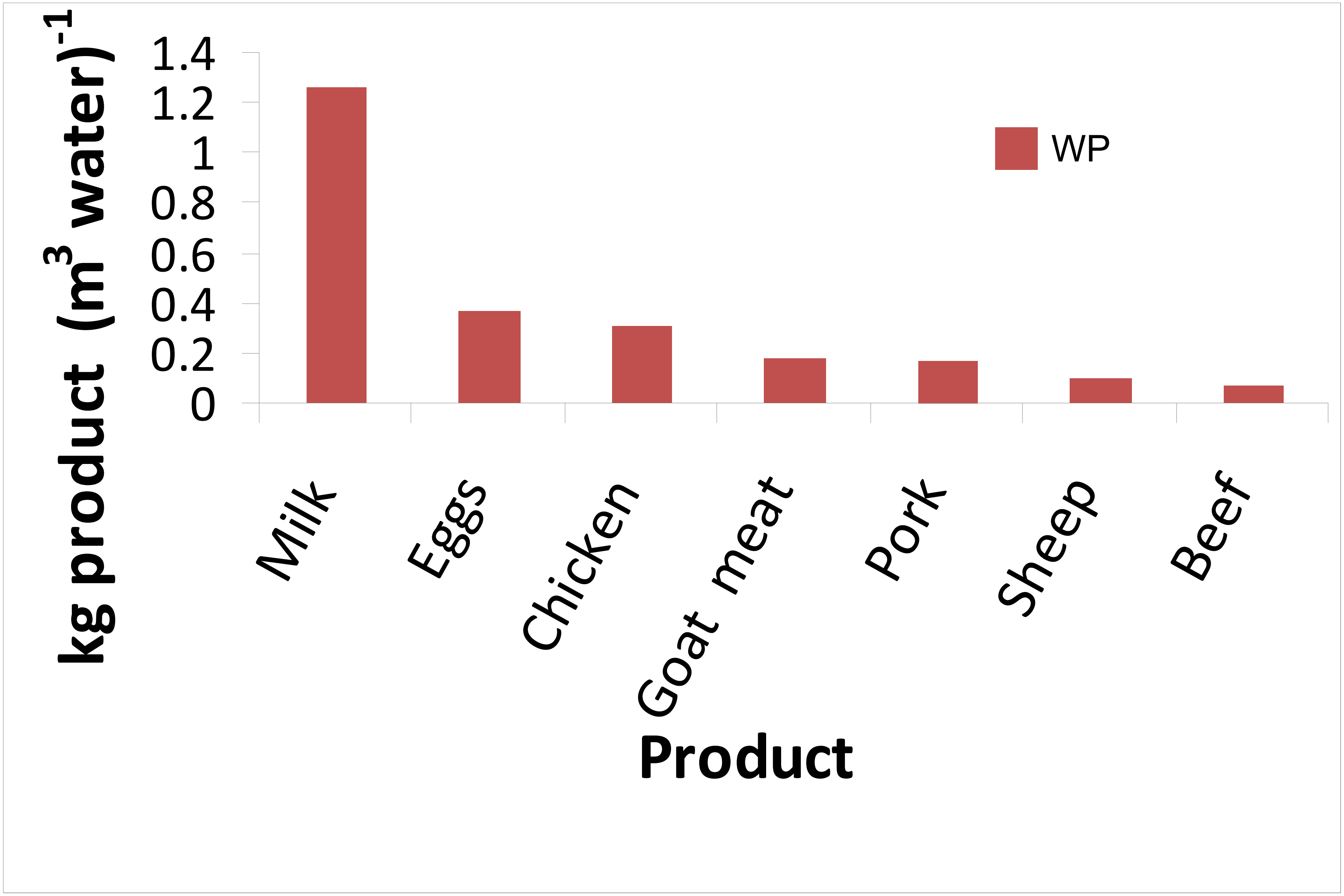

**Least productive**

Animal-source products are less water efficient than crop products

Ranking from highest to lowest water productivity:

from milk and eggs,
to chicken and pork,
to small stock (sheep/goats),
and lastly to beef

# Animal food products - WP



# What is nutritional water productivity?

- This novel concept combines knowledge of the **composition of foods** in terms of nutrients (e.g. protein or vit A content) with knowledge of the **water productivity** of the food product.

- The result is an **index** for a given food which includes nutrient-based output per unit water use

- An example is µg β-carotene in spinach per $m^3$ water used to produce this food.

# NWP example calculation – Sweet potato

A **water productivity** of **5.2 kg $m^{-3}$** is reported from a study on sweet potato

Sweet potato has a **nutrient content** of:

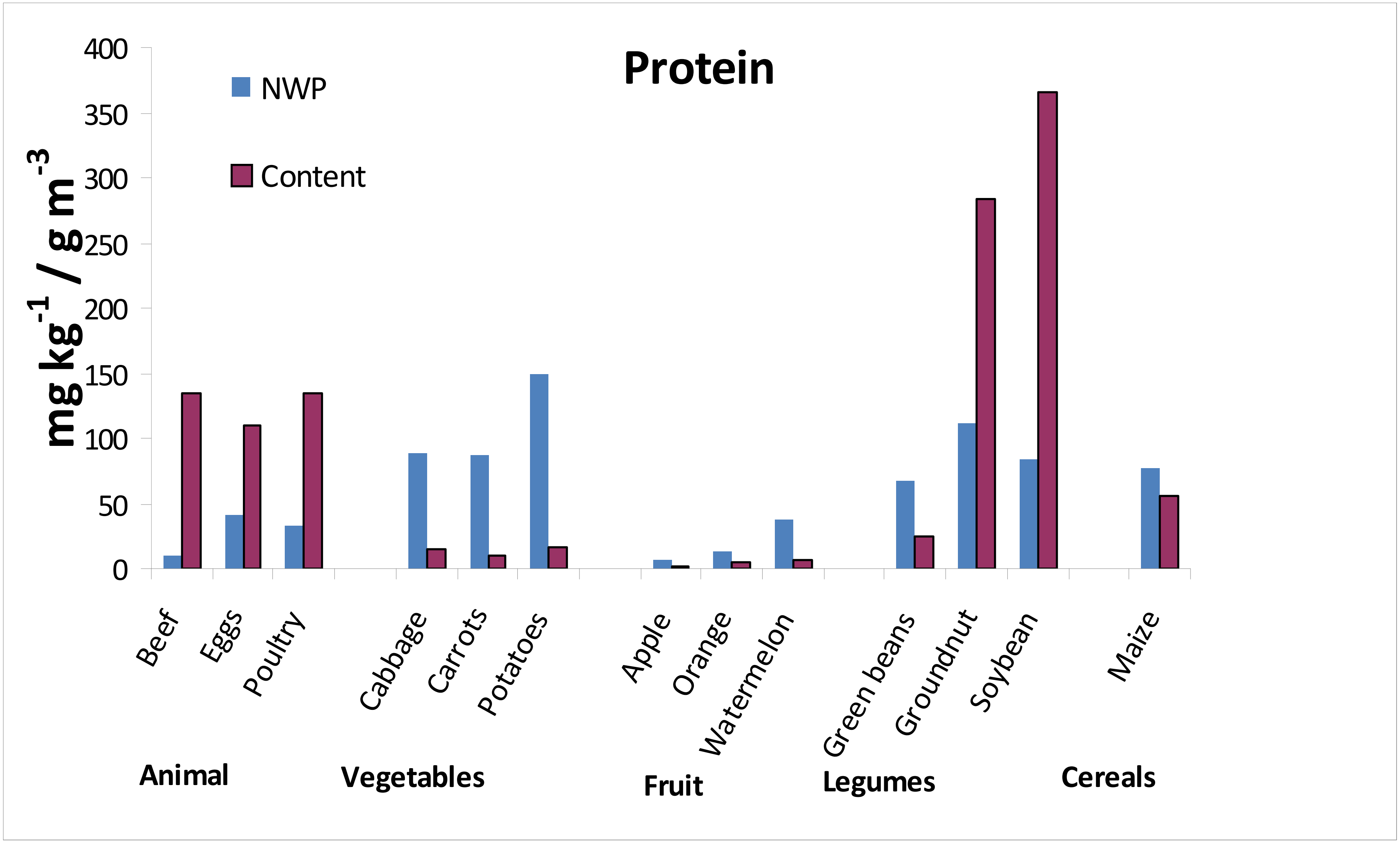
**Energy: 4.5 MJ $kg^{-1}$**
**Protein: 17 g $kg^{-1}$**

**Nutritional water productivity** would thus be:

**Energy: 23.4 MJ $m^{-3}$**
**Protein: 88 g $m^{-3}$**

**→ Per $m^3$ water used, sweet potatoes yield 23.4MJ of energy and 88 g protein**

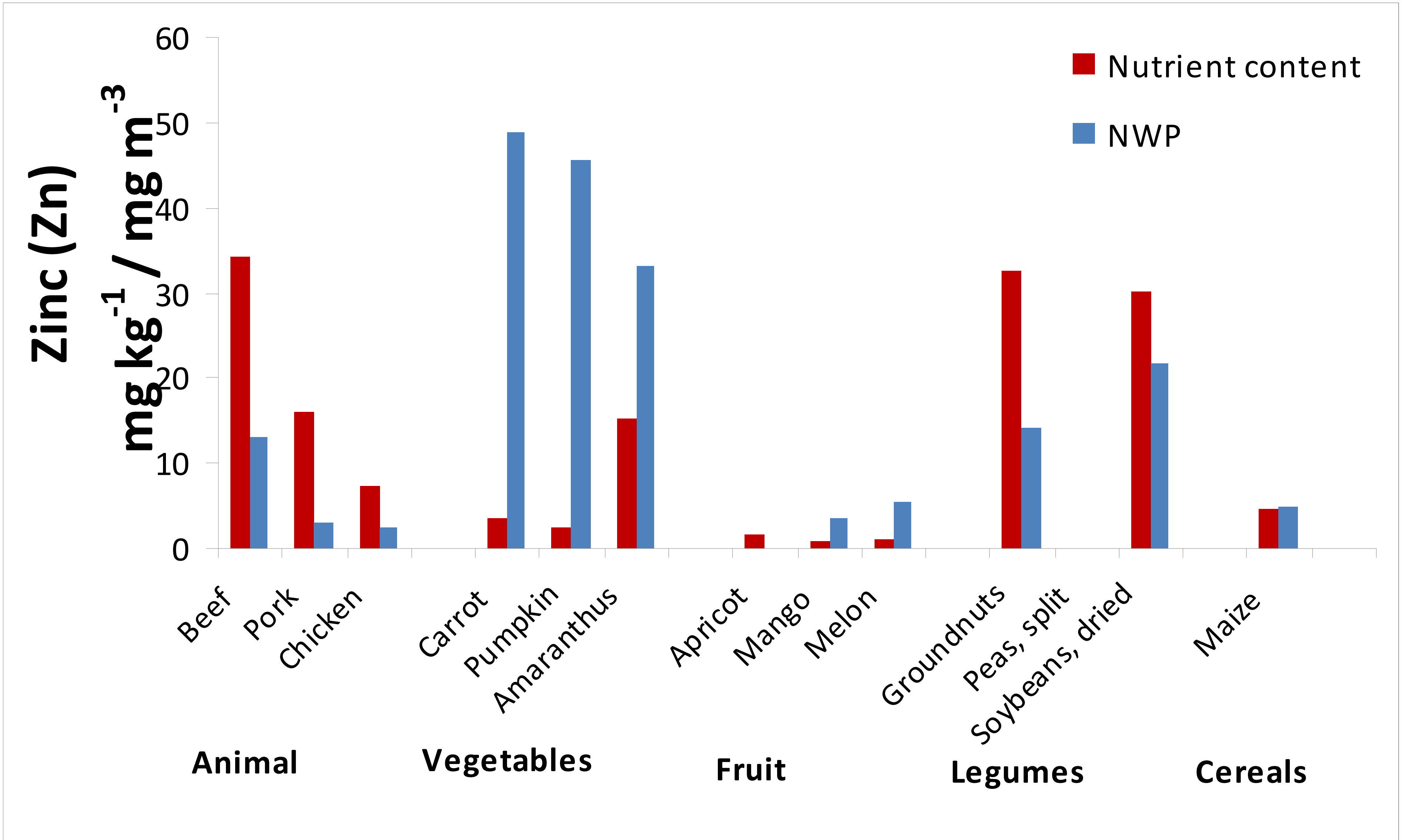
# Macro-nutrient WP - protein



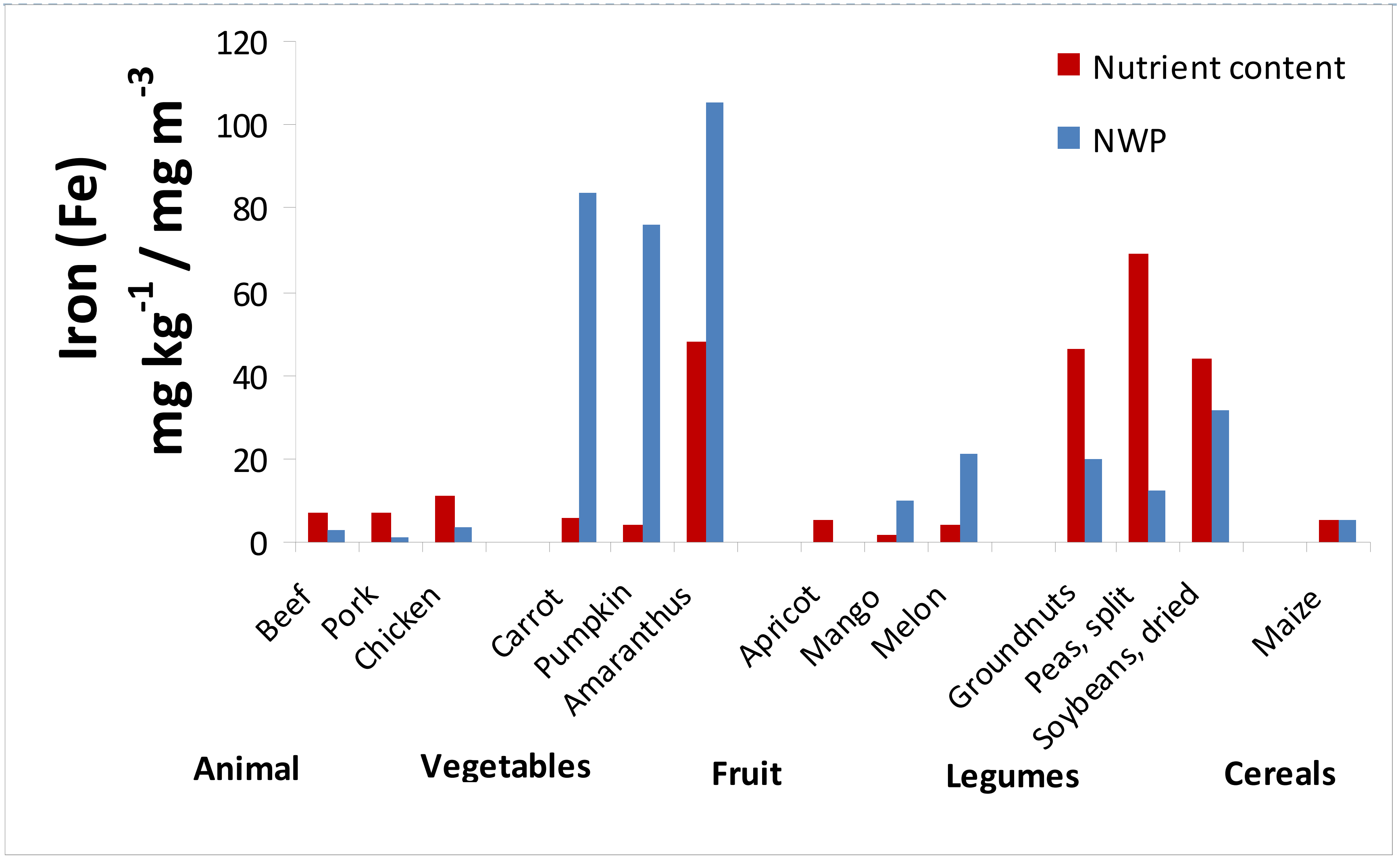
# Macro-nutrient NWP

| Product type | Energy (MJ $m^{-3}$) | Protein (g $m^{-3}$) | Fats (g $m^{-3}$) |
|---|---|---|---|
| **Animal products** | 0.5-3.1 | 12-60 | 4-70 |
| **DGLV** | 1.1-32 | 17-608 | 1.9-76 |
| **Yellow or orange vegetables** | 5.3-24 | 35-152 | 2-19 |
| **Other vegetables** | 0.36-17 | 3-185 | 0.35-12 |
| **Fruit** | 9.2-15 | 31-42 | 5-10 |
| **Legumes** | 2.7-11 | 4.6-177 | 1-212 |
| **Grains** | 17.3 | 132 | 50 |

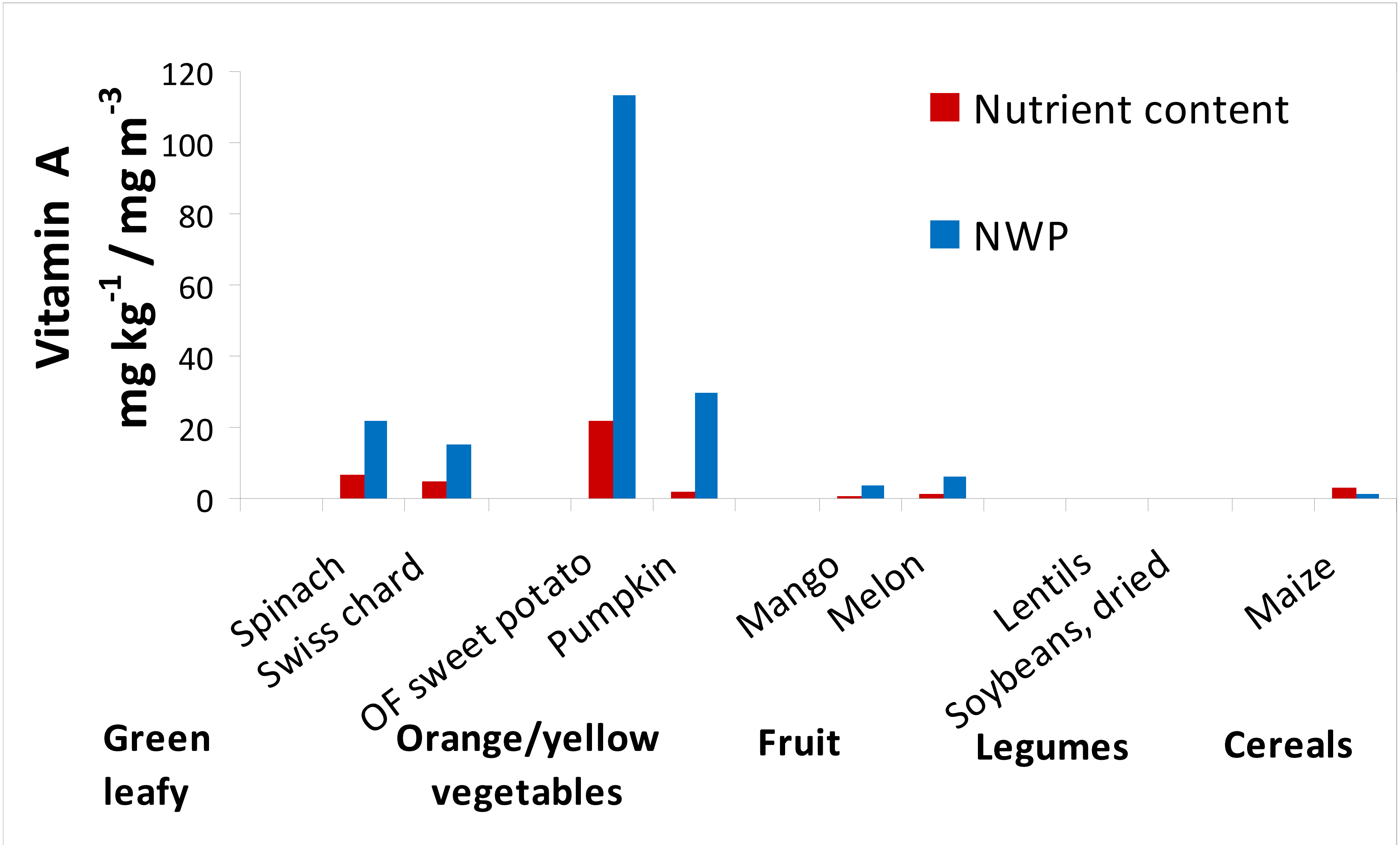
# Micro-nutrient productivity - Zinc



# Micro-nutrient productivity - Fe



# Micro-nutrient productivity – Vit A



# NWP – Fe and Vitamin A

| Product type | Iron (mg $m^{-3}$) | Vitamin A (mg Re $m^{-3}$) | β-carotene (mg $m^{-3}$) |
|---|---|---|---|
| **Animal products** | 1.3-18 | 0.01-1.3 | 0 |
| **Dark Green Leafy Vegetables** | 7.6-316 | 0.17-37 | 0.95-221 |
| **Yellow / orange vegetables** | 9-84 | 3-46 | 12-2226 |
| **Other vegetables** | 3-317 | 0.1-59 | 5-351 |
| **Fruits** | 10-21 | 0.5-6.1 | 2-37 |
| **Legumes** | 12-40 | 0.01-0.11 | - |
| **Grains** | 21 | 1.1 | 0 |

# Nutritional water productivity - conclusion

**NWP** can ***promote production of nutritious foods*** to help close nutrient gaps of vulnerable South Africans while, simultaneously, leaving a sustainable water footprint.

The concept of **NWP** must be ***embedded in an understanding of eating habits*** of the vulnerable groups targeted.

***Variety***, ***balance*** and ***moderation*** remain the pillars of healthy eating.

# NWP – future research

Reliable "***water footprint***" data is lacking for important food crops

Estimates of **NWP** should be made with a ***single reliable data set*** – so crop scientists measuring water balances and doing growth analyses of nutritionally important crops are encouraged to also ***determine nutrient contents***

Need to ***benchmark potential WUE's and NWP's*** so we can identify limiting factors and strive for more efficient production

# Acknowledgements

This PowerPoint presentation is a product of the project titled
"A *baseline and scoping study on water use and nutrient content of crop and animal products for improved household food security"*
initiated, managed and funded by the
Water Research Commission
(WRC Project No. K5/1954//4).

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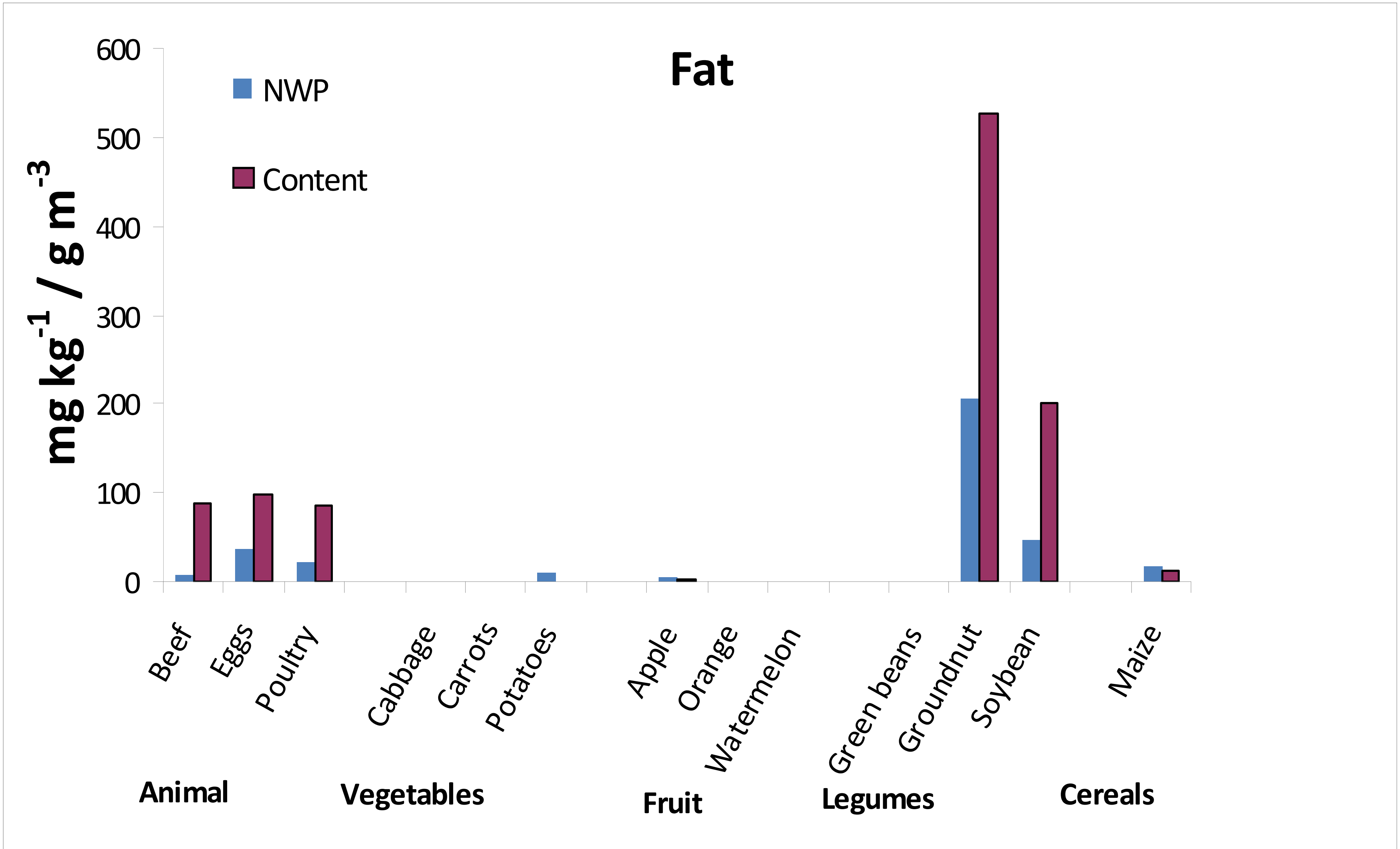
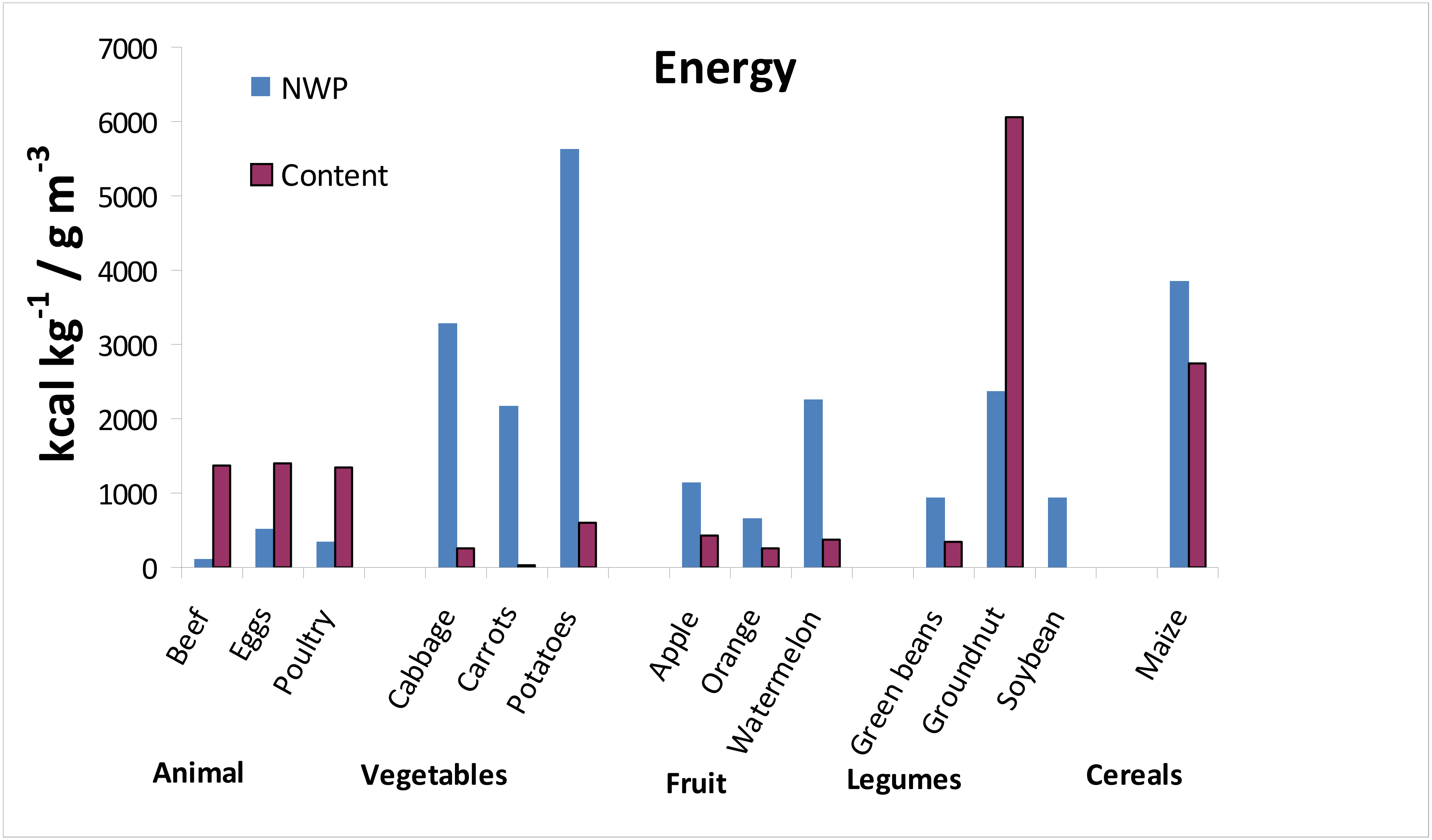
# Macro-nutrient WP - fat



# Macro-nutrient WP - energy



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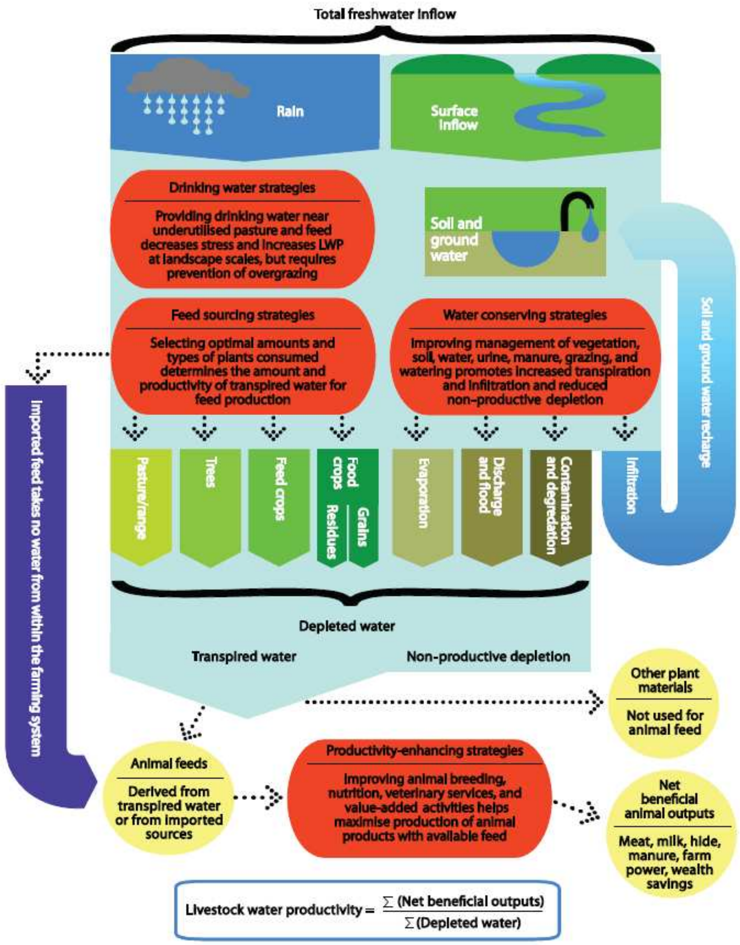
# WATER in livestock production




Water inflows into the system are precipitation, surface water and groundwater. Water is used for biomass production, servicing and processing. Animal outputs are meat, milk, hides, manure, and wealth (Peden et al., 2009).

## Nutritional water productivity

**Example 2: Spinach**

The water productivity of spinach is 3.2 kg / $m^3$

Spinach has the following nutrient content per kg

Energy: 1.3 MJ

Protein: 27 g

The nutritional water productivity would thus be

Energy: 4.1 MJ/$m^3$

Protein: 86 g/$m^3$

→ Spinach yields 4.1 MJ of energy and 86 g of protein per cubic meter of water used.