Innovating special nutrition

Dr Schär

OVERVIEW ON THE USE OF PSEUDOCEREALS AND MINOR CEREALS IN GLUTEN-FREE PRODUCTS

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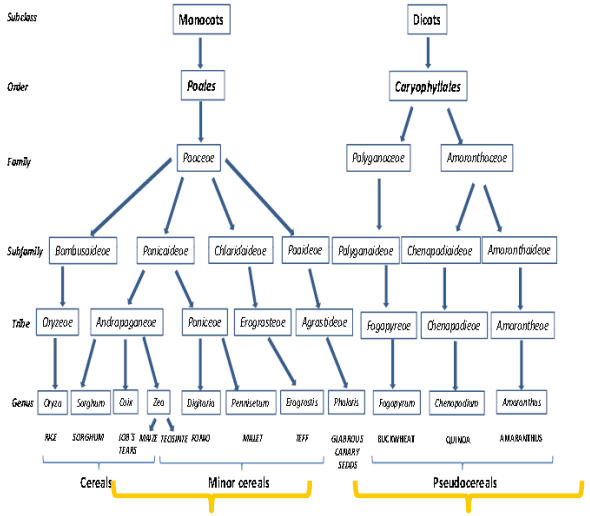
BACKGROUND

- Gluten-free diet characteristics

- Properties and nutritive value of pseudocereals and minor cereals

- Increasing use of pseudocereal and minor cereals in food products

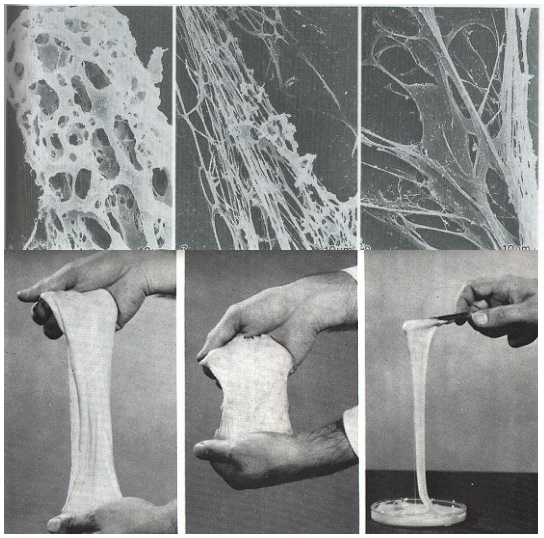
- Overview on the investigations on the application of pseudocereals and minor cereals in gluten-free products



BACKGROUND

DESIGNING AND DEVELOPING GLUTEN-FREE PRODUCTS: A COMPLEX TASK

- Designing gluten–free products is both an **opportunity** and a **challenge**
- Products specifically designed, developed and produced to meet nutritional needs in people suffering from gluten intolerance are demanded
- Gluten presents unique properties
- Obtaining **high quality** gluten free products is a challenge for Food Science and Technology

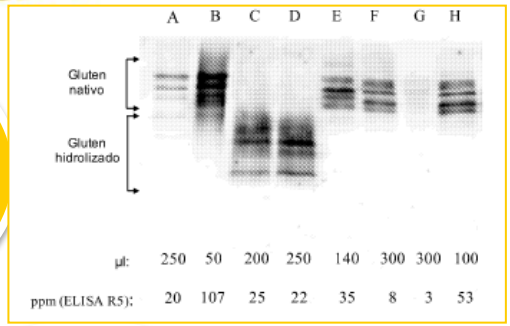


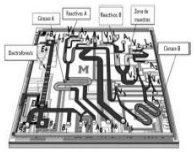
BACKGROUND

QUALITY

Nutritional quality

High safety





Commercial quality

Sensorial quality

BACKGROUND

QUALITY

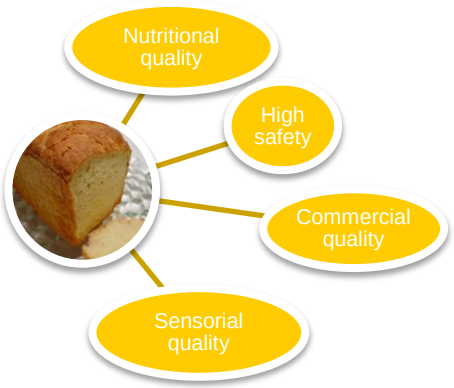
The best designed and carefully calculated diet doesn´t have much use if the person it is intended for, finds it unacceptable.

Eating is not only to satisfy nutritional needs of the body, it is also a pleasure!!!!.

Prof. Grande Covián, 1988

Even if you are celiac……

- **SAFETY** AND **NUTRITIONAL REQUIREMENTS** OF CELIAC CONSUMERS

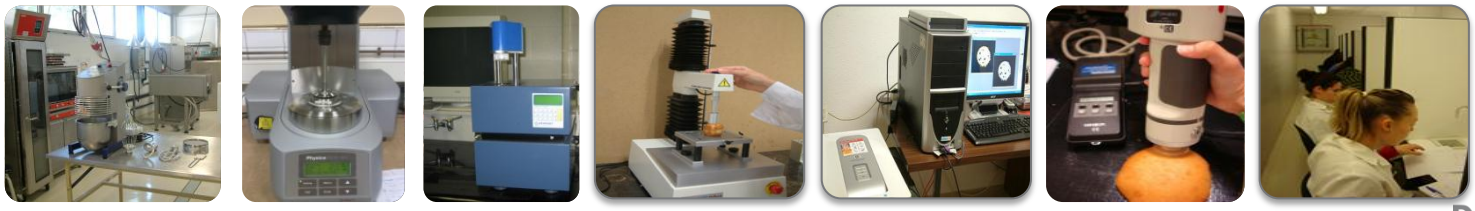


- GF PRODUCTS WITH **HIGH QUALITY STANDARDS**

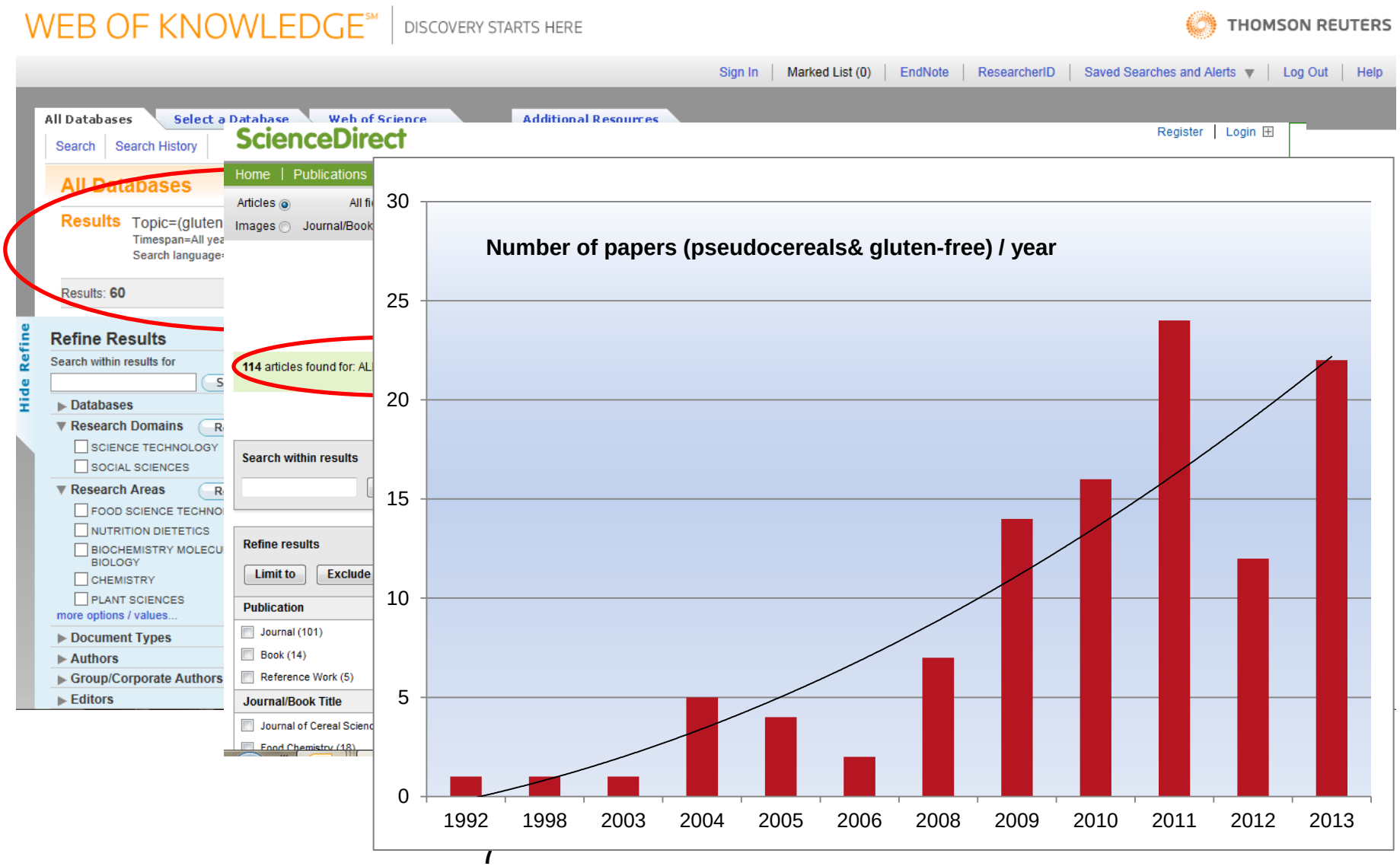
THE PRODUCTION OF **HIGH QUALITY** GF FOOD FROM

PSEUDOCEREALS AND **MINOR CEREALS** REQUIRES

COMPREHENSIVE RESEARCH



SYSTEMATIC REVIEW ON THE RESEARCH ON PSEUDOCEREALS IN GLUTEN-FREE PRODUCTS



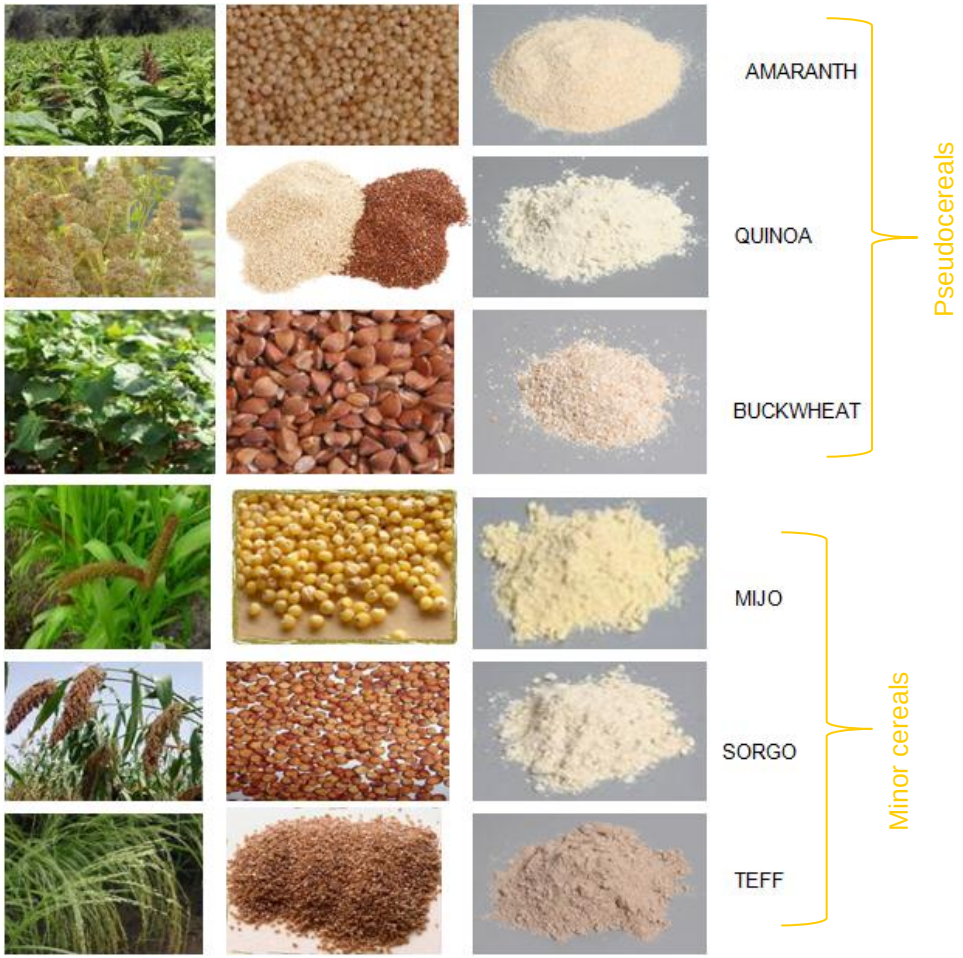
OVERVIEW ON THE INVESTIGATION AND USE OF PSEUDOCEREALS AND MINOR CEREALS IN GF PRODUCTS

- BAKERY PRODUCTS
- PASTA
- SNACKS
- BABY-FOOD
- BEVERAGES

- FLOURS

CHARACTERIZATION OF FLOURS FROM PSEUDO AND MINOR CEREALS

- It is necessary to understand molecular background and behaviour to improve their utilization



TECHNOLOGICAL PROPERTIES OF FLOURS

- Pseudocereals and minor cereals flours differ in technological properties
- Starches differ in size, sha amylose/amylopectin ratio
- Pasting properties are diffe
- Compositional differences exist (proteins, lipids, fibre…)
- Application for each product must be studied and optimized

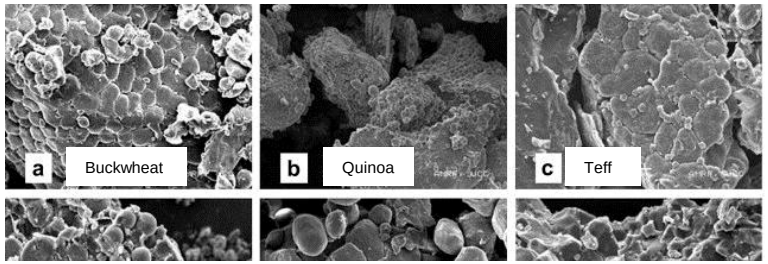


Table 2
Fat content [% (w/w) based on fresh weight] and fatty acid profile of flour samples [% (w/w) of total lipids].*

	Wheat	Wholewheat	Rice	Oat	Quinoa	Buckwheat	Sorghum	Maize	Teff
Fat	1.81 ± 0.05^{d}	3.63 ± 0.104^{c}	0.90 ± 0.06^{e}	6.74 ± 0.80^{b}	8.59 ± 0.25^{a}	4.21 ± 0.74^{c}	3.50 ± 0.31^{c}	2.48 ± 0.46^{d}	4.39 ± 0.26^{c}
Myristic 14:0	1.48 ± 0.014^{a}	0.10 ± 0.000^{f}	0.44 ± 0.002^{b}	0.24 ± 0.001^{c}	0.12 ± 0.000^{e}	0.11 ± 0.000^{e}	0	0	0.22 ± 0.003^{d}
Palmitic 16:0	19.74 ± 0.076^{c}	16.97 ± 0.011^{d}	22.43 ± 0.014^{a}	20.62 ± 0.001^{b}	9.77 ± 0.004^{i}	15.78 ± 0.03^{e}	13.52 ± 0.21^{f}	12.62 ± 0.01^{g}	10.86 ± 0.042^{h}
Stearic 18:0	10.41 ± 0.094^{a}	0.75 ± 0.000^{g}	2.45 ± 0.012^{c}	1.71 ± 0.007^{e}	0.63 ± 0.004^{h}	2.08 ± 0.001^{d}	1.28 ± 0.00^{f}	2.07 ± 0.00^{d}	4.14 ± 0.031^{b}
Oleic 18:1, 9c	31.14 ± 0.006^{d}	12.73 ± 0.007^{i}	40.01 ± 0.019^{b}	41.85 ± 0.004^{a}	23.93 ± 0.004^{h}	36.53 ± 0.012^{c}	30.40 ± 0.05^{e}	26.08 ± 0.01^{g}	29.47 ± 0.320^{f}
Linoleic 18:2 9, 12	23.74 ± 0.034^{i}	60.79 ± 0.020^{a}	29.38 ± 0.003^{g}	26.56 ± 0.011^{h}	52.68 ± 0.012^{c}	33.01 ± 0.010^{f}	49.31 ± 0.13^{e}	54.73 ± 0.01^{b}	49.99 ± 0.183^{d}
α-Linolenic 18:3 9, 12, 15	1.74 ± 0.004^{h}	5.04 ± 0.002^{a}	1.91 ± 0.009^{g}	0.71 ± 0.014^{i}	4.60 ± 0.001^{b}	3.78 ± 0.005^{c}	2.22 ± 0.01^{e}	2.08 ± 0.00^{f}	2.29 ± 0.072^{d}
Eicosenoic 20:1 11	1.61 ± 0.016^{b}	0.72 ± 0.001^{f}	0.53 ± 0.007^{g}	1.06 ± 0.001^{d}	1.56 ± 0.001^{c}	3.27 ± 0.007^{a}	0.32 ± 0.01^{h}	0.26 ± 0.00^{i}	0.78 ± 0.017^{e}
Saturated fatty acids	38.94 ± 0.038^{a}	18.97 ± 0.004^{e}	26.35 ± 0.035^{b}	23.42 ± 0.001^{c}	11.56 ± 0.005^{h}	21.43 ± 0.021^{d}	15.19 ± 0.21^{g}	15.21 ± 0.00^{g}	16.14 ± 0.075f
Unsaturated fatty acids	60.06 ± 0.044^{g}	80.72 ± 0.001^{d}	73.25 ± 0.038^{e}	71.78 ± 0.005^{f}	85.44 ± 0.003^{a}	60.06 ± 0.044^{g}	83.81 ± 0.21^{c}	84.29 ± 0.00^{b}	83.66 ± 0.075^{c}
ω6/ω3	14/1	12/1	15/1	37/1	11/1	9/1	22/1	26/1	21/1

*Values followed by the same letter in the same row are not significantly different ($p < 0.05$).

Table 1
Chemical composition of gluten free and wheat flours (values based on fresh weight of samples).*

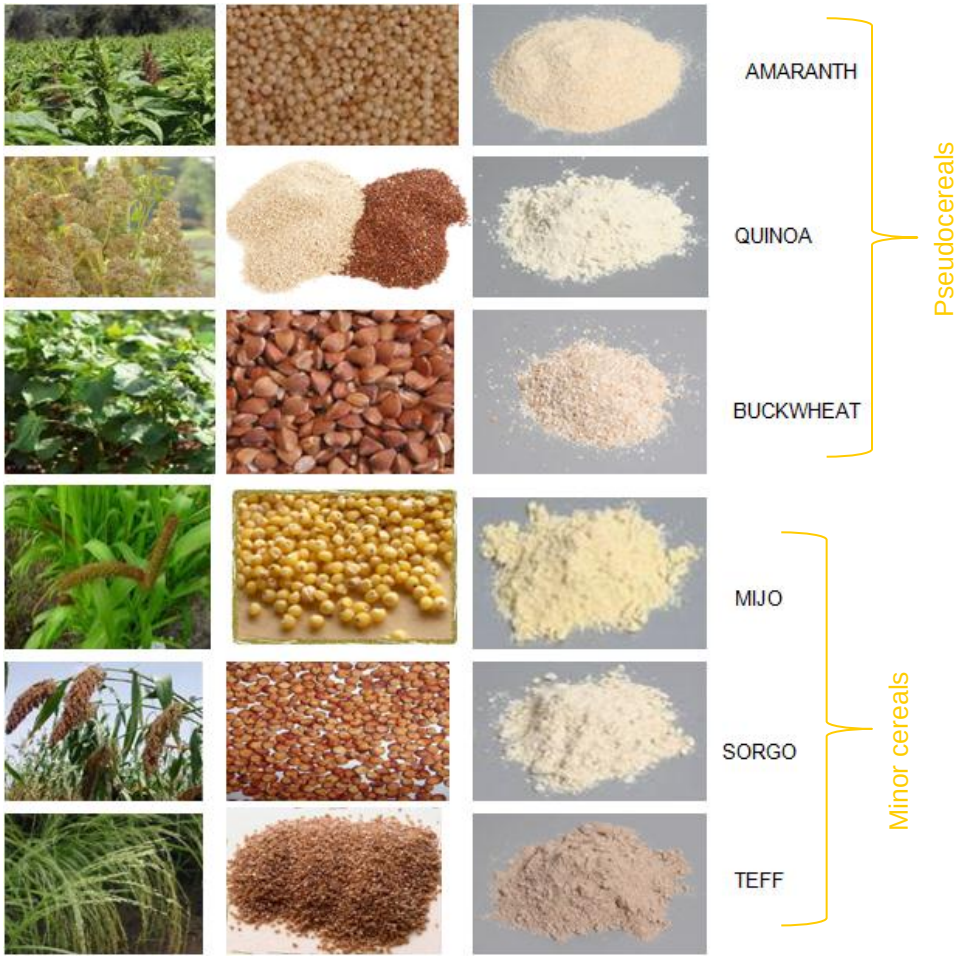
	Wheat	Wholewheat	Rice	Oat	Quinoa	Buckwheat	Sorghum	Maize	Teff
Protein [g/100 g]	11.54 ± 1.07^{c}	9.89 ± 0.17^{d}	7.33 ± 0.03^{e}	6.91 ± 0.08^{e}	13.48 ± 0.04^{a}	12.19 ± 0.38^{bc}	4.68 ± 0.04^{f}	5.50 ± 0.19^{f}	12.84 ± 0.51^{ab}
Total starch [g/100 g]	68.06 ± 2.34^{b}	57.24 ± 0.26^{c}	77.52 ± 0.42^{a}	69.38 ± 1.66^{c}	48.88 ± 2.07^{d}	61.35 ± 2.15^{c}	73.20 ± 1.52^{a}	71.52 ± 0.42^{a}	57.77 ± 5.94^{c}
Amylose [% of total starch]	21.10 ± 1.29^{ab}	21.10 ± 2.08^{abc}	21.38 ± 0.90^{ab}	20.42 ± 2.43^{bc}	4.62 ± 0.83^{e}	15.95 ± 0.61^{d}	18.18 ± 0.55^{cd}	22.91 ± 0.82^{a}	19.72 ± 099^{bc}
Damaged Starch [g/100 g]	7.85 ± 0.41^{b}	4.06 ± 0.68^{c}	15.24 ± 1.53^{a}	4.91 ± 0.06^{c}	4.71 ± 0.70^{c}	2.63 ± 0.25^{d}	4.66 ± 1.03^{c}	4.52 ± 0.30^{c}	2.08 ± 0.22^{d}
Total dietary fibre [g/100 g]	3.44 ± 0.01^{cd}	11.42 ± 1.27^{a}	0.43 ± 0.15^{f}	4.05 ± 0.40^{c}	7.14 ± 0.23^{b}	2.18 ± 0.11^{e}	4.51 ± 0.01^{c}	2.62 ± 0.45^{de}	4.54 ± 0.57^{c}
Soluble dietary fibre [g/100 g]	1.34 ± 0.11^{a}	1.60 ± 0.40^{a}	0.14 ± 0.06^{d}	0.36 ± 0.02^{cd}	1.77 ± 0.14^{a}	0.48 ± 0.17^{cd}	0.72 ± 0.04^{bc}	0.64 ± 0.14^{bd}	0.85 ± 0.17^{b}
Phytate [g/100 g]	0.16 ± 0.03^{e}	0.77 ± 0.01^{b}	0.21 ± 0.01^{e}	0.27 ± 0.01^{de}	1.34 ± 0.00^{a}	0.64 ± 0.06^{bc}	0.49 ± 0.02^{cd}	0.09 ± 0.03^{e}	1.52 ± 0.21^{a}
Polyphenols [mg/100 g]	13.04 ± 0.23^{d}	82.20 ± 0.42^{c}	14.16 ± 2.45^{d}	22.16 ± 0.16^{d}	78.24 ± 0.46^{c}	465.47 ± 22.41^{a}	103.30 ± 6.06^{c}	97.85 ± 0.64^{c}	175.65 ± 1.48^{b}
Calories [kcal/100 g]	361	366	359	393	385	368	376	362	380

*Values followed by the same letter in the same row are not significantly different ($p < 0.05$).

Hager [a], Journal of Cereal Science 56 (2012) 239 247

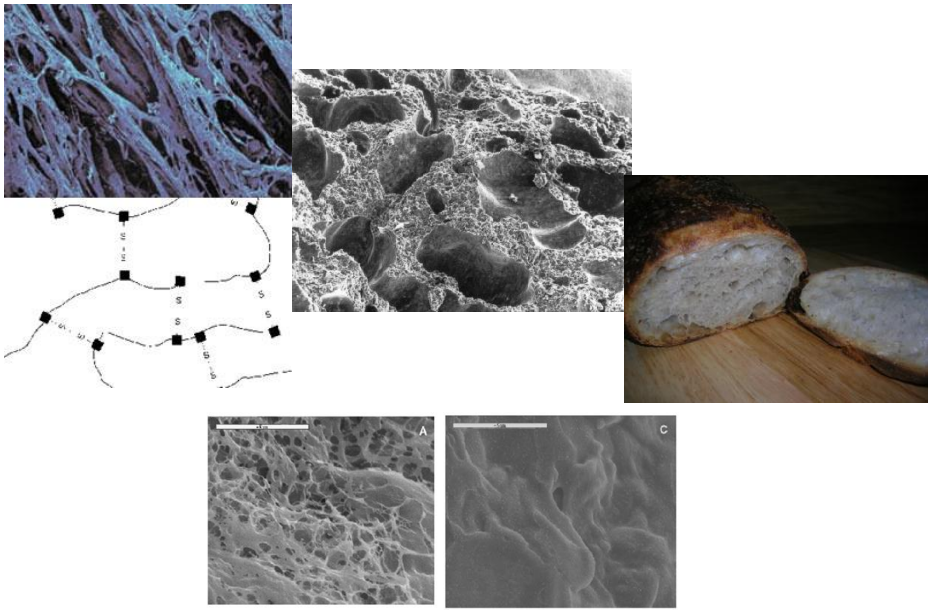
CHARACTERIZATION OF FLOURS FROM PSEUDO AND MINOR CEREALS

- It is necessary to understand molecular background and behaviour to improve their utilization
- Use of flour or fractions
- The effects of processing have also been studied
- Traditional and new technologies under study



USE PSEUDOCEREALS AND MINOR CEREALS IN GF BREAD TYPE PRODUCTS

PSEUDOCEREALS AND MINOR CEREALS IN GF BREAD



- Most studied GF product
- Role of gluten in bread type products is critical
- First efforts of scientists concentrated on rice, maize and oats
- Recent studies show that pseudocereals and minor flours are feasible ingredients in the formulation of GF breads

BREADS

- Successful formulation of pseudocereal-containing gluten-free breads (Gambus et al., 2002; Moore et al., 2004; Kiskini et al., 2007; Alvarez-Jubete et al., 2009; 2010; Mezaize et al., 2009; Torbica et al., 2010; Hager, 2012; Mariotti et al., 2013);

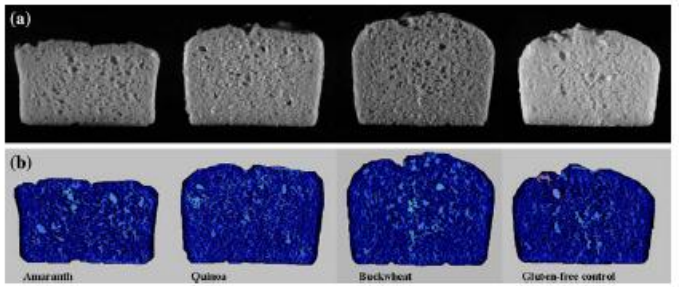


Fig. 3 Raw (a) and cell (b) images of amaranth, quinoa, buckwheat and gluten-free control breads

- Pseudocereals addition resulted in higher loaf volume and softer crumb, lower staling rate and good sensorial quality.

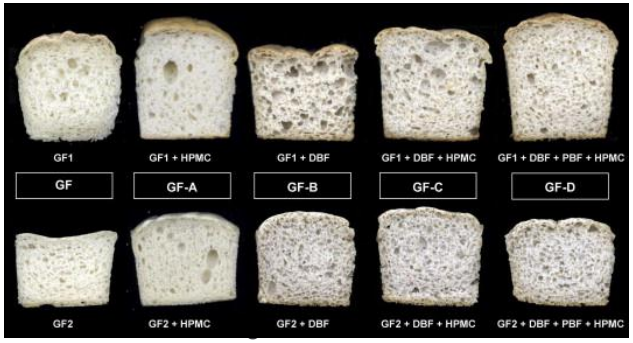
- The resultant breads also had a significantly higher levels of protein, fiber and minerals, higher content of polyphenol compounds and increased in-vitro antioxidant activity.

Table 1: Chemical composition, antioxidant capacity and phenol content of the gluten-free and wheat breads.

Bread type	[1]Protein	[1]Dietary fibre	[2]Antioxidant capacity
GF control	4.18 ± 0.0	7.6 ± 0.9	47.59
Amaranth	11.6 ± 0.0	17.2 ± 0.8	60.6
Quinoa	10.1 ± 0.1	16.1 ± 0.6	71.42
Buckwheat	8.4 ± 0.4	23.3 ± 0.7	147.66
Wheat bread	11.9 ± 0.1	13.4 ± 0.8	81.67

[1] (% dry-weight basis) [2] (mg Trolox/100g DW)

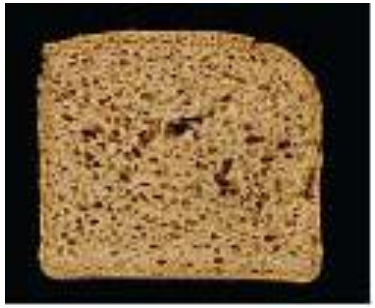
- However, results depend on the pseudocereal, the % of addition and the bread formulation and processing.



BREAD

- Minor cereals have also been studied in GF breads.
- Several researchers have reported on the production of gluten-free bread from sorghum and millets (reviewed in Taylor et al., 2006) and teff (Arendt et al., 2008)
- Good results when combined with sourdough fermentation
  - Teff flour combined with sourdough good results both in fresh and par-baked breads, with high sensorial quality.

SORGHUM



TEFF

Arendt et al., (2008)

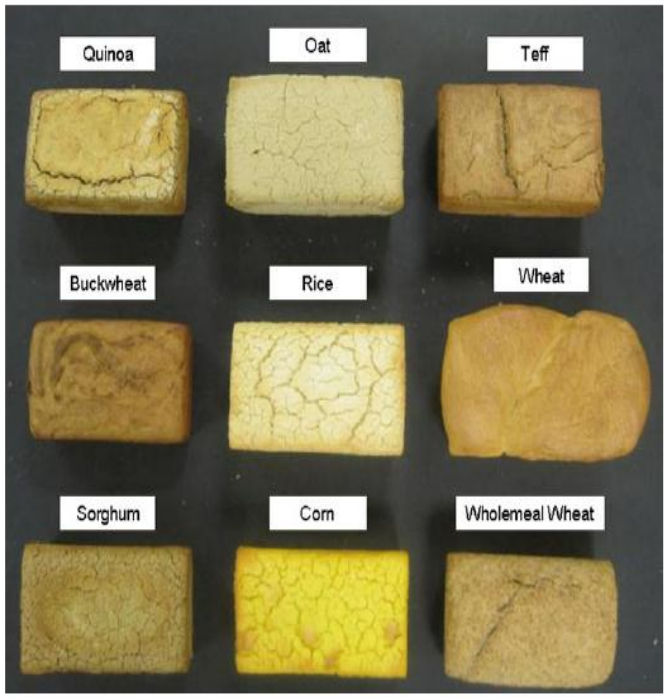
TEFF

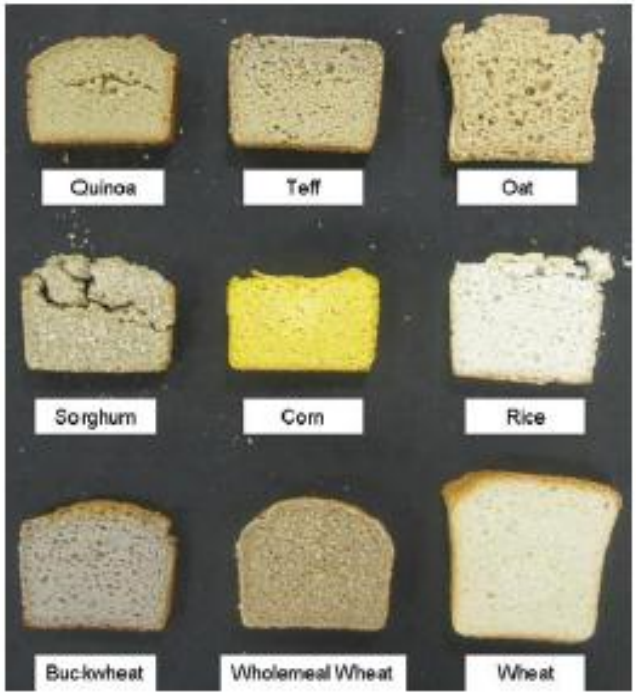
Ferrer-Mairal et al (unpublished)

BREAD

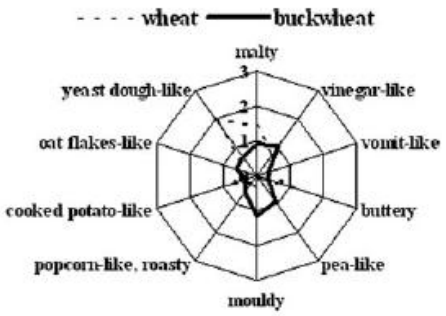
Hager, A.S. et al., (2012)

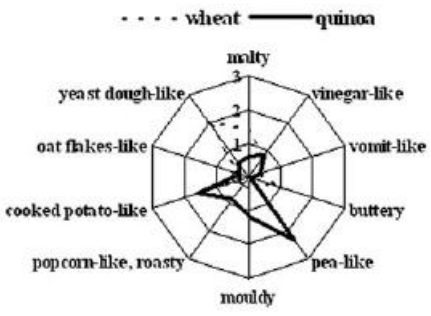
Eur Food Research and Technolgoy 235: 333-344

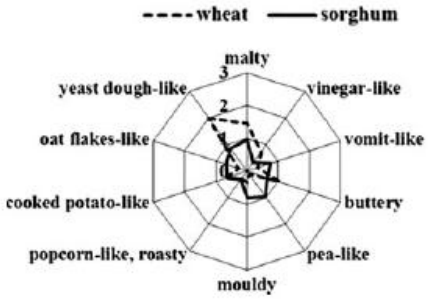


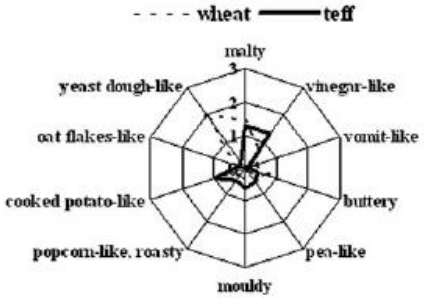


- Pseudo and minor cereals show better suitability than other GF ingredients
- Utilization as part of a composite formulation can lead to product improvement





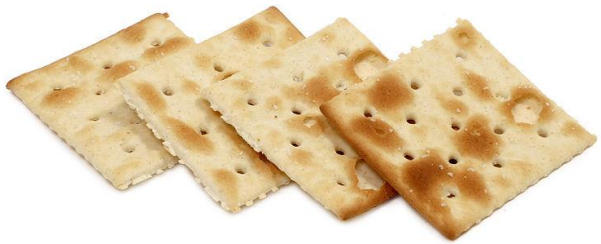




OTHER BAKED PRODUCTS…….

BISCUITS, CAKES, PUFF PASTRY, CRACKERS

- In biscuits
  - Good results for quinoa and buckwheat as the only starch components (Kuhn et al, 1994).
  - Biscuit crispiness was in the order buckwheat > quinoa > amaranth, and biscuits containing buckwheat and amaranth were preferred in a sensory panel (Schoelenchner et al., 2006).
  - Granola bars and muesli with good sensory evaluation with popped or extruded amaranth or quinoa.
- In crackers
  - Buckwheat flours may be used in gluten-free cracker formulation without adversely affecting the sensory properties of crackers (Sedj et al., 2011)
- In general, good results when different cereals, pseudocereals and minor cereals are combined



PASTA

- By combining pseudocereal flours with other flours

  - GF macaroni from blends of quinoa and rice flour obtained by extrusion at 60 and 77 °C successfully produced (Borges et al., 2003)
  - Good quality spaghetti produced from blends of corn, soy, oat, and quinoa (5–15%) flours (Caperuto et al., 2001; Mastromatteo et al., 2011)

  - Incorporation of amaranth to rice flour (25:75 ratio), combined with the cooking-extrusion process, improved the nutritional quality of pasta, while maintaining good cooking behaviour (Cabrera et al., 2012)

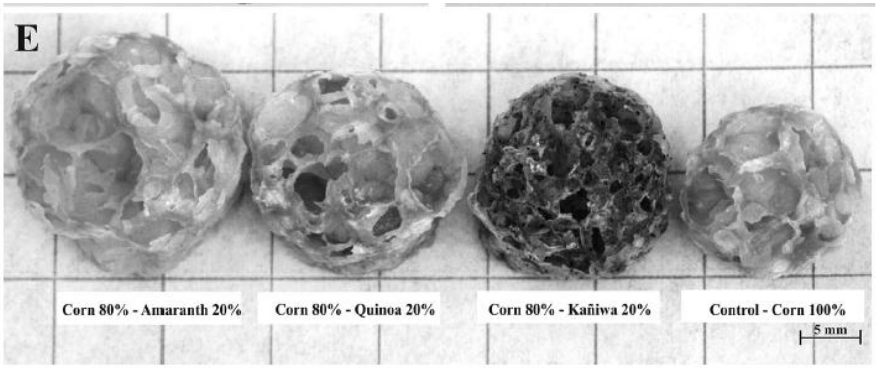
- 100 % pseudocereal flours pasta
  - Amaranth lowers texture firmness, affects flavour and decreases cooking tolerance - Quinoa increases cooking loss – Buckwheat best ability

  - Best results by the combination of amaranth, quinoa, and buckwheat (20:20:60), with 6% of egg white powder and 1.2% of emulsifier (Schoelechner et al., 2010).

- Pasta with pseudocereal flours, low GI (Hager et al., 2013).

USE ON OTHER PRODUCTS

- EXTRUDED PRODUCTS
  - Greater expansion
  - Lower hardness
  - Remarkable stability of lipids



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- TORTILLAS

- NON-DAIRY BEVERAGES

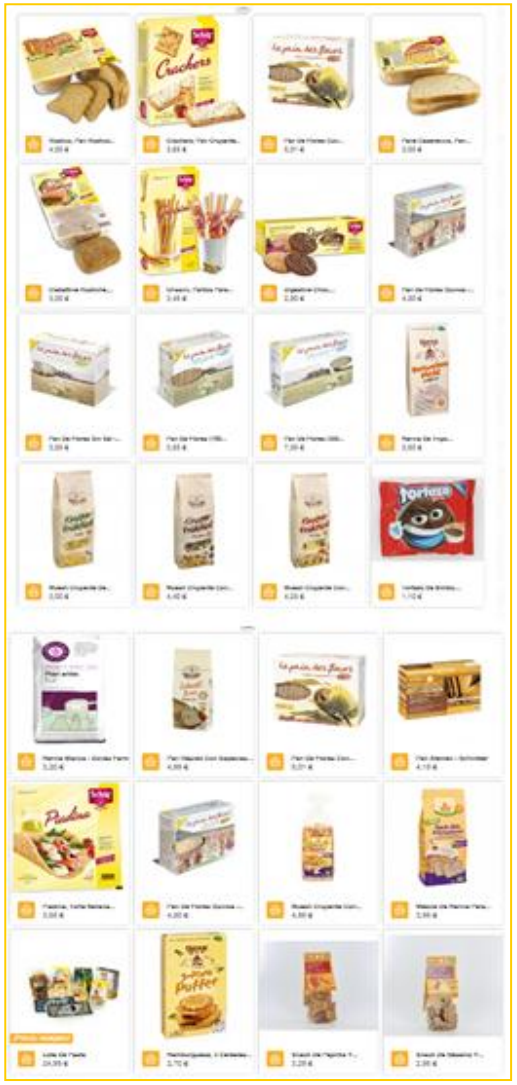
- INFANT FOOD

BEER

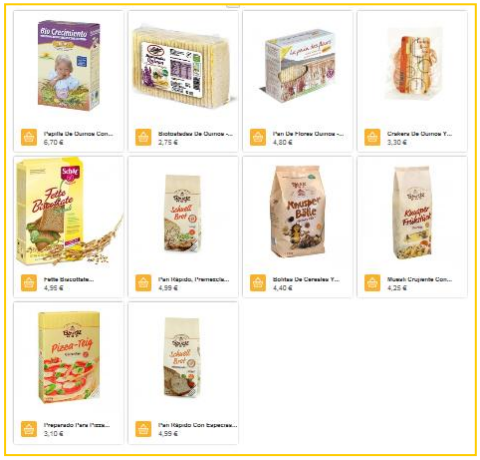
- It is possible to produce beers from sorghum, millet, maize, amaranth, quinoa and buckwheat (Blaize and Arendt, 2008; Meo, 2011).
- Beers differ in foam stability, colour opacity and flavour.
- Combination of different gluten-free materials results in beer, which are closer to conventionally brewed beers.

AVAILABILITY IN THE MARKET

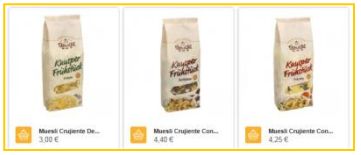
Buckwheat



Quinoa



Amaranth



Millet

Teff

CONCLUDING REMARKS

- HIGH-QUALITY PRODUCTS ARE EVEN MORE IMPORTANT IN A GLUTEN FREE DIET THAN IN CONVENTIONAL DIETS

- INTEGRATION OF PSEUDOCEREALS AND MINOR CEREALS IN GLUTEN-FREE PRODUCTS IS A VALUABLE CONTRIBUTION

- IT IS POSSIBLE TO PRODUCE GLUTEN-FREE PRODUCTS ENRICHED WITH PSEUDOCEREALS AND MINOR CEREALS WITH HIGH NUTRITIONAL AND SENSORIAL QUALITY

- GOOD RESULTS HAVE BEEN OBTAINED BLENDING CEREAL AND PSEUDOCEREAL FLOURS IN PRODUCTS SUCH AS BAKED PRODUCE, PASTA, SNACKS, BEVERAGES AND BABY-FOOD PRODUCTS.






PRESENT AND FUTURE