FACULTY OF BIOSCIENCE ENGINEERING

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NUTRITIONAL PROPERTIES OF ANCIENT WHEATS AVAILABLE ON THE BELGIAN MARKET

Introduction

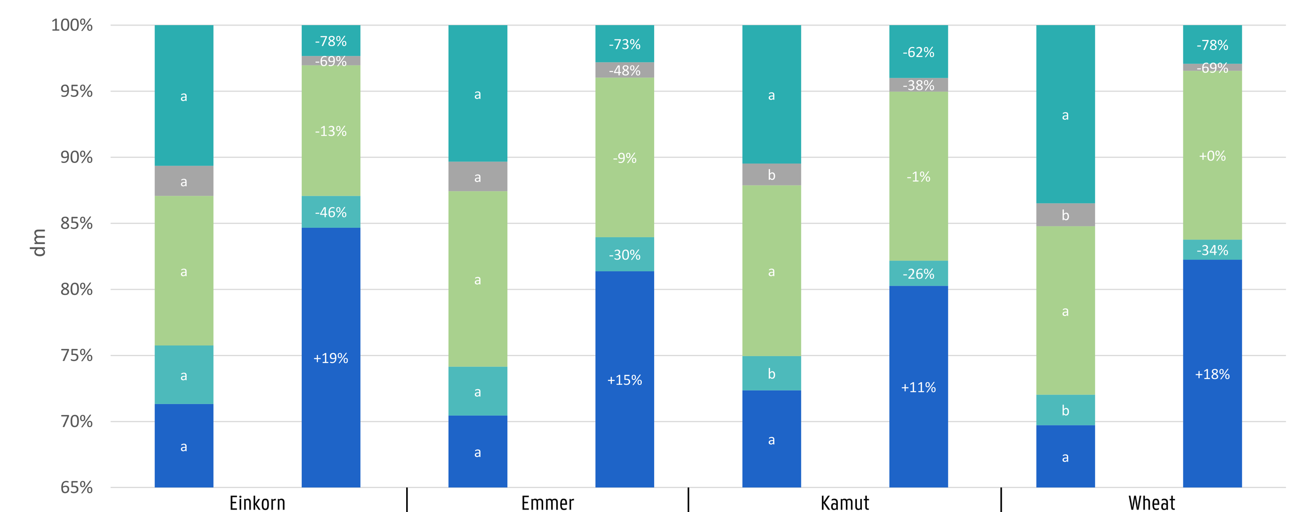
There is an increasing interest in ancient wheats from farmers, companies and consumers. To be able to apply these ancient wheats in bakery products, more knowledge is necessary on the quality, processability and nutritional properties of the cereals and derived meal or flour. The ancient wheats are believed to have a superior nutritional composition to the modern ones due to the "yield dilution phenomenon" causing lower micronutrient contents. However, information on the quality aspects and nutritional properties of ancient wheats in Belgium is scarce, especially of refined flour. In Alterbake, a research project, the application possibilities of ancient wheats are being investigated. A sample set of ancient wheats including einkorn (*T. monococcum*), emmer wheat (*T. dicoccum*) and khorasan wheat (Kamut, *T. turgidum spp. turanicum*) was purchased from local suppliers. The aim of this study was to compare the nutritional composition of the ancient wheats to bread wheat and gain insight on some functional properties, digestibility and the influence of milling.

Methods

Einkorn, emmer and Kamut kernels or whole meals (n=3) were purchased from the Belgian market. Refined flours (n=2) were milled with a Bühler pilot mill. Macro- and mineral composition were determined on each sample once and vitamin composition on 2 samples per ancient wheat (2 whole meals and 2 refined flours). Therefore, no statistics could be performed on refined flours and vitamin composition. Macronutrients were determined according to standard methods: protein content (Dumas N x5,7; ISO 16634-1), crude fat (ISO 6492), total dietary fibre (AOAC 985.29) moisture content (ICC 110/1) and ash content (ICC 104/1). Carbohydrates were calculated by difference. Mineral composition was measured with ICP-AES (ISO 11885). Vitamin B1 (NBN EN 14122), B2 (NBN EN 14152) and E (NBN EN 12822) were evaluated as vitamins in 2 whole meal and 2 refined flours per species. Nutritional properties of the ancient wheats were compared with wheat data found in usda database (n=3). Some functional properties of the refined flour were also analysed (Zeleny sedimentation (ICC 116/1), wet gluten content and quality (Glutomatic, ICC 155) and damaged starch (SD matic Chopin, ICC 172) and compared with a commercially available flour (Epi B, Paniflower NV). In vitro- starch digestibility was determined using an assay kit GOPOD-format K-GLUC 09/14 (Megazyme International Ireland Ltd), the in vitro protein digestibility (IVPD) was performed by a multi-enzyme system, as described by Hsu et al. (1977).

Results

Macro composition



	Einkorn		Emmer		Kamut		Wheat	
	Kernel (n=3)	Refined flour (n=2)	Kernel	Refined flour (n=2)	Kernel (n=3)	Refined flour (n=2)	Kernel (n=3)	Refined flour (n=2)
Fiber	10.65±0.43	2.33±1.85	10.33±1.95	2.81±1.41	10.47±3.75	4.00±0.54	13.48±1.21	2.92±0.15
Minerals	2.27±0.10	0.70±0.04	2.23±0.15	1.17±0.32	1.65±0.18	1.03±0.13	1.73±0.04	0.54±0
Protein	11.33±0.90	9.89±1.31	13.28±1.52	12.08±1.54	12.93±1.51	12.80±1.80	12.76±1.57	12.78±1.05
Fat	4.42±0.20	2.41±0.24	3.69±0.10	2.58±0.42	2.59±0.46	1.91±0.10	2.31±0.38	1.51±0.40
Carbohydrates	71.33±0.54	84.67±0.74	70.46±1.23	81.37±2.74	72.36±2.77	80.26±2.57	69.72±0.78	82.25±1.31

Fig. 1 : Macro composition of ancient wheat kernels and refined flours, compared with common wheat (usda,2019). Carbohydrates were calculated by difference.

Einkorn and emmer showed significant higher values for ash- and fat content compared to Kamut and bread wheat, all other values were not statistically different (p>0.05). Milling (to refined flour) reduced fat, dietary fiber, mineral and protein content. Einkorn suffered from the greatest losses for fat, protein and mineral content (-45%, -13% and -70%, respectively).

Minerals

All ancient wheats appear to have higher mineral content than bread wheat. However, this could not be statistically proven for all analyzed minerals. Only einkorn has a significant higher content of Ca and K, while emmer has a higher P content (p<0.05). Furthermore, the ancient wheats have statistical significant higher sodium contents (p<0.05). Intensive selection and cultivation of bread wheat could have lead to the 'yield dilution phenomenon'. Also, because of the dwarfing gene in common wheat (which is not present in the ancient wheats), the roots have a lower capacity to collect minerals from the soil. Among the ancient wheats, the highest mineral losses can be found in einkorn. Because of the soft texture of einkorn kernels it was extremely difficult to mill using a roller mill. The refined einkorn flour is very sticky and regularly clogged the mill. As a result the flour yield was low and large parts of the endosperm were lost with the bran. Because minerals are mainly located in the bran, the larger losses for einkorn could be explained.

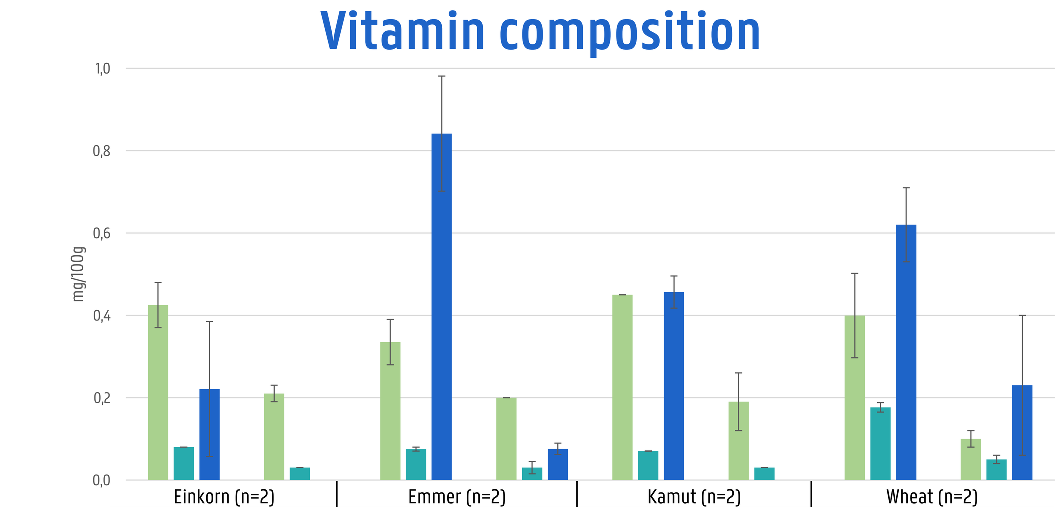
Table 1 : Mineral content of ancient wheats and common wheat (usda, 2019) whole meal (n=3) and refined flour (n=2). Values between parentheses indicate mineral losses due to milling.

	Einkorn		Emmer		Kamut		Wheat	
mg/kg dm	Kernel (n=3)	Refined flour (n=2)	Kernel (n=3)	Refined flour (n=2)	Kernel (n=3)	Refined flour (n=2)	Kernel (n=3)	Refined flour (n=2)
Calcium	570±24[a]	332±28 (-42%)	423±66[ab]	357±27 (-16%)	345±112[ab]	213±26 (-38%)	371±12[b]	172±1 (-54%)
Potassium	5715±171[a]	2259±103 (-60%)	5308±197[ab]	3598±1283 (-32%)	4926±975[ab]	2896±215 (-41%)	4448±292[b]	1185±30 (-73%)
Magnesium*	1516±141	316±63 (-79%)	1671±163	1093±532 (-35%)	1505±406	752±75 (-50%)	1300±208	269±19 (-79%)
Phosphor	5236±326[ab]	1594±95 (-70%)	5489±550[b]	3702±1362 (-33%)	4205±790[ab]	2478±321 (-41%)	3871±133[a]	1173±53 (-70%)
Copper*	6.2±0.6	3.8±0 (-39%)	6.6±1.9	5.6±1.4 (-15%)	7.0±0.7	7.4±1.9 (+6%)	4.7±0.6	1.9±0.2 (-60%)
Iron*	41±3	26±4 (-36%)	61±7	44±11 (-28%)	43±13	29±4 (-32%)	44±4	12±1 (-73%)
Sodium	106±12[a]	102±4 (-4%)	143±42[a]	105±5 (-26%)	117±7[a]	136±17 (+16%)	26±6[b]	23±0 (-13%)
Zinc*	46±2	18±1 (-61%)	52±10	36±14 (-31%)	38±8	20±5 (-47%)	33±3	9±1 (-73%)

* No statistical difference could be detected between mineral content in the kernels (p<0.05)

[ab] Different letters in the same row indicate statistical differences for kernel values (p<0.05)

Vitamin composition



	Einkorn (n=2)		Emmer (n=2)		Kamut (n=2)		Wheat (n=2)	
	Kernel	Refined flour	Kernel	Refined flour	Kernel	Refined flour	Kernel	Refined flour
Vitamin B1	0.43±0.06	0.21±0.02	0.34±0.06	0.20±0	0.45±0	0.19±0.07	0.40±0.10	0.10±0.02
Vitamin B2	0.08±0	0.03±0	0.08±0.01	0.03±0.02	0.07±0	0.03±0	0.18±0	0.05±0.01
Vitamin E	0.22±0.16	nd	0.84±0.14	0.08±0.01	0.46±0.04	nd	0.62±0.09	0.23±0.17

Fig. 2 : Vitamin composition of ancient wheat kernels and refined flours, compared with common wheat (usda, 2019). nd = not detected

Vitamin B1 content was similar in einkorn, Kamut and bread wheat (ca. 0.4mg/100g), while emmer had a slightly lower content (0.3 mg/100g). Vitamin B2 content was similar for all ancient wheats (0.08 mg/100g), but lower than the vitamin B2 content of bread wheat. Vitamin E content was low in einkorn and kamut kernels and high in emmer kernels, compared to common wheat.

Functional properties

Table 2 : Functional properties of ancient wheats and common wheat (refined flour, n=2)

	Zeleny sedimentation (ml)	Gluten index (%)	Wet gluten content (%)	Damaged starch (%)
Einkorn	<11	*	*	3.08±0.08
Emmer	13.00±0.43	45.08±0.49	33.13±1.22	6.74±0.07
Kamut	13.25±0.43	53.07±3.76	25.50±0.28	6.91±0.10
Wheat	38.25±0.43	94.89±0.68	28.88±0.37	5.20±0.12

* Gluten index and wet gluten content could not be determined for einkorn

Protein content of the ancient wheats was high. However, high protein content does not guarantee good protein quality. Zeleny sedimentation values of einkorn were < 11 ml, emmer and Kamut had higher values, yet still much lower than bread wheat (38 ml). Wet gluten content (WGC) and gluten index (GI) could not be determined for einkorn. This does not mean einkorn does not contain gluten, it does however suggest that the gluten present can't form a network. GI of emmer (43%) and Kamut (53%) were much lower than for common wheat (95%), while WGC was similar. Finally damaged starch content of einkorn was lower because of their soft texture, while emmer and Kamut, who are closely related to durum wheat, have higher contents.

In-vitro digestibility

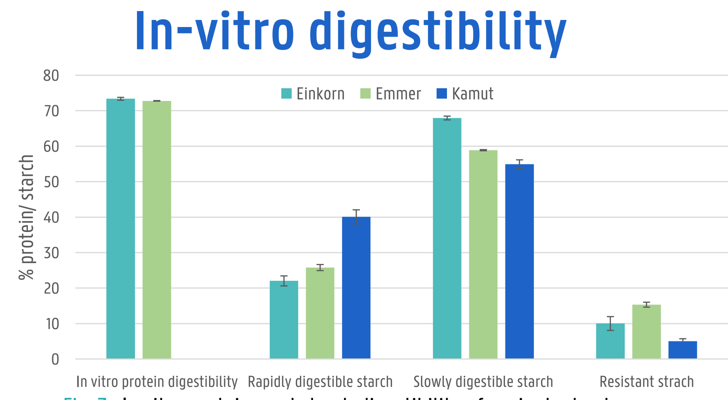


Fig. 3 : In vitro protein- and starch digestibility of ancient wheats

Emmer showed the highest fraction of resistant starch (RS; 15.3% starch), while Kamut showed a low fraction of RS (5%). Resistant starch is fermented in the large intestine, releasing short fatty acids which are considered as beneficial. Kamut consists of a high portion of rapid digestible starch (RDS), which causes a rapid increase in blood glucose level after ingestion. Slowly digestible starch on the other hand, releases glucose slowly and consistently over and extended time. Einkorn showed the highest values for this parameter of starch digestibility. No statistical difference could be found in protein digestibility between einkorn and emmer.

Conclusion

Ancient wheats commercially available on the Belgian market were investigated for their nutritional profile. It was shown that differences with normal bread wheat were limited. Einkorn and emmer have higher ash- and fat content. Vitamin B1 content of einkorn and Kamut was superior to bread wheat, while vitamin E content in emmer was higher than in bread wheat. When introduced into an normal diet, these small differences will not have great health beneficial effects. The differences in (in-vitro) digestibility do not necessarily mean they are healthier, as the digestibility depends on the structure of the end product (e.g. baking and storage time, compact vs airy,…). Einkorn in specific, but the ancient wheats in general, have weak protein quality (compared to bread wheat), which makes it difficult to use them for Belgian breads. Other techniques, e.g. sourdough, poolish, overnight proving, cold doughs,… could be used to produce breads with an aerated, more open crumb structure and good volume.

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