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Breeding Better Barley

Background, Purpose, Hypothesis

Exploring which way of growing lettuce and broccoli– organically or conventionally– harboured the least amount of bacteria, had the least amount of chemicals, and contained the most vitamin C, produced astounding results, leaving me eager to further investigate. Interest in genetic engineering and growth methods, and how each correlated to the nutritional quality of a product led to "Breeding Better Barley." A professor at the University of Guelph (U of G) who breeds feed barley (grown organically and conventionally) provided me with the opportunity to execute the comparison. How the nutritional content of old and new barley varieties is affected by conventional and organic growth became the purpose of study. A hypothesis of more protein, fat and calories in organic barley was an extrapolation of previous results. The conventional-site herbicides were iron-based, suggesting that conventional samples would have more iron. The focus breeders place on yield, where yield and protein have a negative relationship, suggested that older varieties of barley would have more protein than new varieties. No significant differences in mineral content of new and old varieties were expected.

Procedure

Near infra-red (NIR) transmission technology determined the protein content of ten varieties of barley seeds. Beyond protein testing, experimentation of nutritional value required complicated, and expensive lab work. A local lab, Agri-Food Laboratories, generously provided data for the following specifications: iron, calorie, copper, zinc, fat, and manganese content, and an additional measurement of protein content. Determining mineral content involved a dry-ashing process, where samples were ground and heated to 500˚C. The mineral content was found using a dissolving reactant, spectroscopy, and relative stock solutions. The Dumass method provided the additional protein data.

Results

As hypothesized, organic barley had more protein and more calories. This was not due to a chemical factor, but due to a biological factor. It was determined that biologically, more calories would not have been expected and that there could be a chemical factor affecting calorie content. Newer varieties had less protein, as hypothesized. Differences were noted in mineral content, when comparing growth methods, however, these differences were due

to field history, not a chemical reaction of fertilizers and minerals. A soil test would have ensured that results were representative of samples, not soil. Conventional barley had more iron, due to the iron-based herbicide. The conditions under which seeds were developed can account for the difference in mineral content of old and new varieties.

Conclusions

Certain aspects of barley breeding should be re-evaluated, depending on breeding objectives. Growth method can affect a seed's nutritional value. The newer varieties, for example, displayed lower iron content. Iron is a key mineral in an animal's system, and if a feed does not provide an adequate supply, animals are susceptible to iron deficiency. Older varieties were developed under more stressful conditions and are therefore more eager to absorb available minerals. Newer varieties were developed under more luxuriant conditions and absorb a minimum amount of minerals.

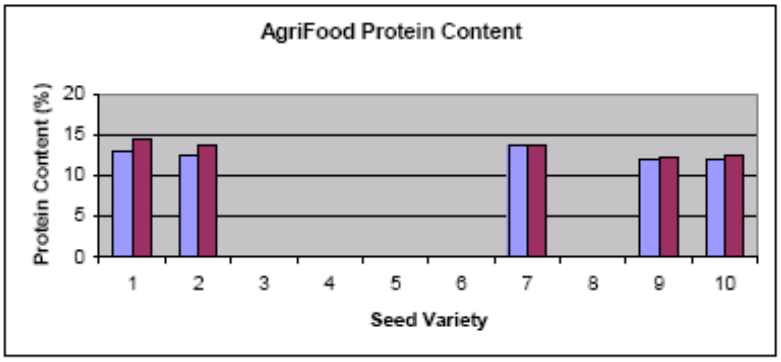
Perspective is critical when determining which growth method to use. A buyer seeks quality (organic) whereas a seller seeks quantity (conventional). Newer varieties have higher calorie and fat contents, but lower mineral contents. Old varieties have lower calorie and fat contents, and higher mineral contents. Determining which is more essential to the nutritional quality of a grain feed is dependent on animal health

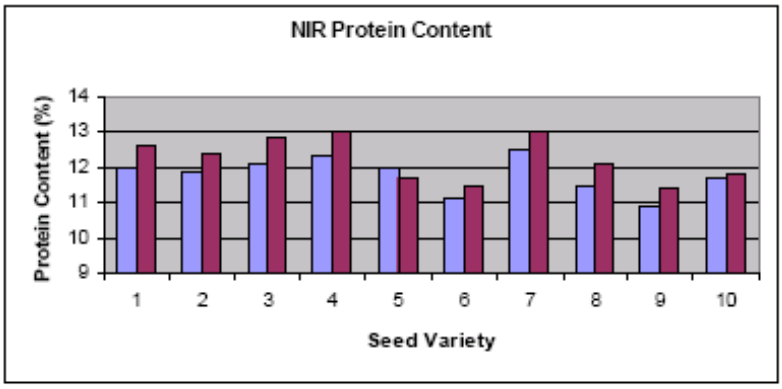
Further investigation would involve determining the chemical processes that may cause differences in mineral content. To ensure greater accuracy, preliminary soil tests would be conducted to eliminate sources of error. Exploring the genetic development of the barley seed while breaking down the breeding process to determine where nutritional quality was most significantly lost would be valuable research. The U of G has incorporated the results of the iron content test into their breeding program and will further address the apparent affects of the breeding process on nutritional quality as a result of this research. Exploring the correlations of conventional growth and human health could determine if the benefits of organic growth are truly worthwhile. Studying the effects of genetic breeding is an expansive field, and will hopefully yield results in the near-future. "Breeding Better Barley" is one small step of the study.

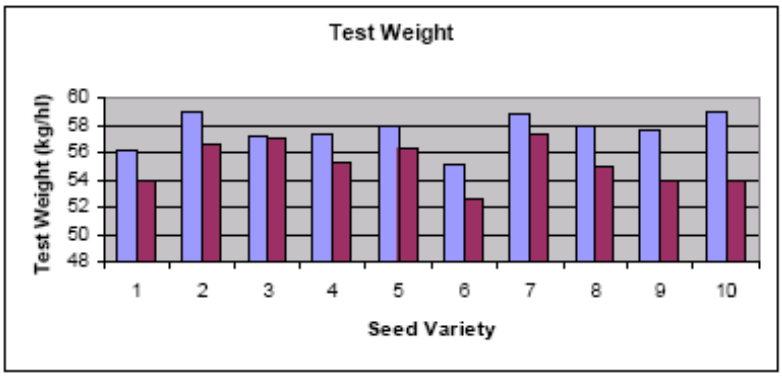
Acknowledgments

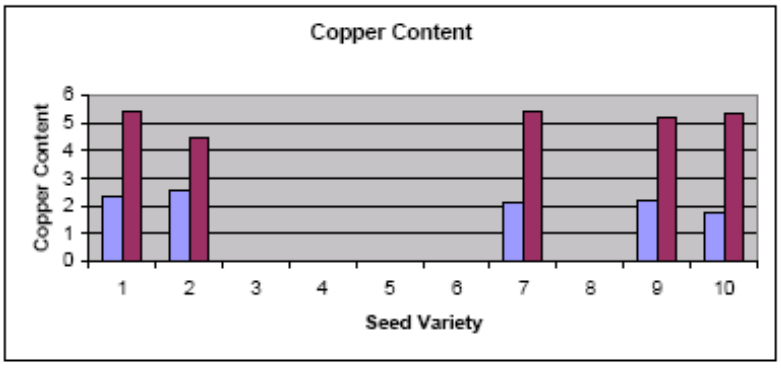
I sincerely appreciate the contributions of Dr Duane Falk, Assistant Professor, Crop Sciences, U of G, and of Agri-Food Laboratories, Guelph.

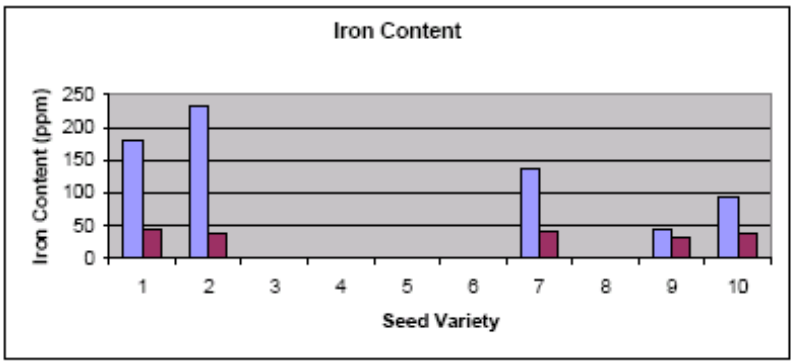
Appendix

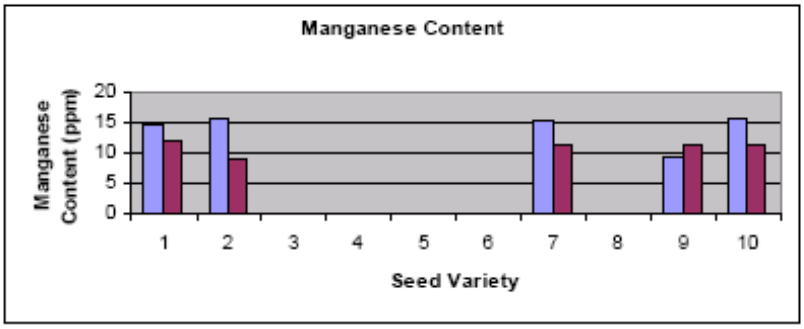

AgriFood Protein Content
Protein Content (%)
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
Seed Variety

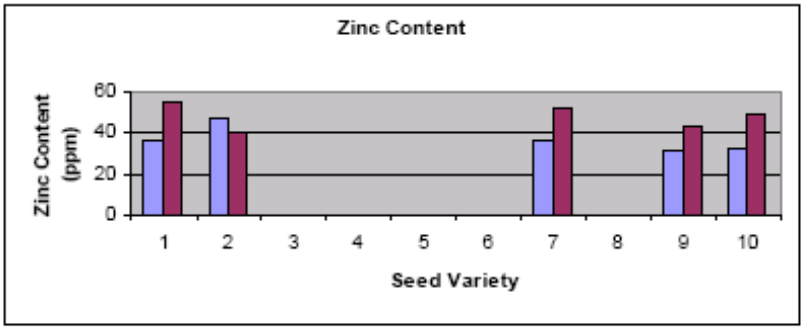

NIR Protein Content
Protein Content (%)
14
13
12
11
10
9
1
2
3
4
5
6
7
8
9
10
Seed Variety

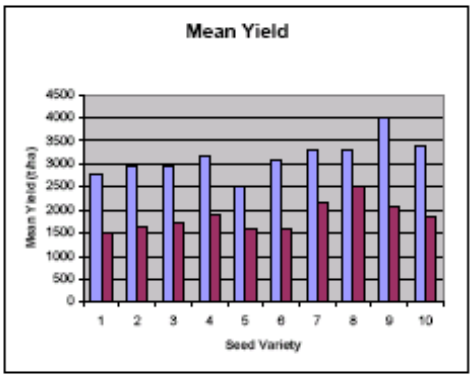

Test Weight
Test Weight (kg/hl)
60
58
56
54
52
50
48
1
2
3
4
5
6
7
8
9
10
Seed Variety

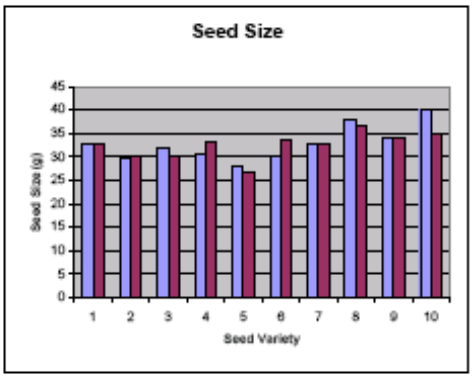

Copper Content
Copper Content
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
Seed Variety


Iron Content
Iron Content (ppm)
250
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10
Seed Variety


Manganese Content
Manganese Content (ppm)
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10
Seed Variety


Zinc Content
Zinc Content (ppm)
60
40
20
0
1 2 3 4 5 6 7 8 9 10
Seed Variety


Mean Yield
Mean Yield (t/ha)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10
Seed Variety


Seed Size
Seed Size (g)
45
40
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10
Seed Variety

Bibliography

Boston Women's Health Collective. (1984). The New Our Bodies, Ourselves. USA: TOUCHSTONE.

Faculty List. (Last updated 09.01.04). Department of Plant Agriculture. Retrieved January 5, 2004. World Wide Web: <http://www.uoguelph.ca/plant/directory/faculty.htm>.

Food and Nutrition. Britannica Student Encyclopedia. Retrieved January 5, 2004, from Encyclopedia Britannica Online. <http://search.b.com/ebi/article?eu=296262>

Glossary. (n.d.) Montana Wheat and Barley Committee. Retrieved January 13, 2004. World Wide Web: <http://wbc.agr.state.mt.us/reference/nutrition/art2.html.>

Helrich, Kenneth. (Ed.) (1990) Official Methods Of Analysis of The Association of Official Analytical Chemists. Fifteenth Edition. Virginia, USA: Association of Official Analytical Chemists, Inc.

Levchuk, Caroline M. (2000). Healthy Living. USA: U.X.L., imprint of Gale Group.

Lundqvist, U. 1986. Barley mutants - diversity and genetics. In: Research and results in plant breeding. Svalof, 1886-1986: 85-88.

Micke, A. 1989. 25 years Plant Breeding and Genetics Section of the Joint FAO/IAEA division. Mutation Breeding Newsletter, 34: 2-3.

Nutrition. (2000). World Book Encyclopedia. (vol. 14, pp.267-268). USA: World Book.

Payne, Wayne A. (1992) Understanding Your Health. USA: Mosby-Year Book, Inc.
Sigurbjornsson, B. 1983. Induced mutations. In: Crop Breeding. Crop Science. Madison. USA.: 25-37

University of Guelph Research. (Last updated 09.01.04). In The News. Retrieved January 5, 2004. World Wide Web: <http://www.uoguelph.ca/research.>