

Development of chemical composition of grain during growth and ripening

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Abstract. The development of chemical composition of barley and oat grains was investigated in samples taken weekly from the beginning of kernel development to about two weeks over the normal harvesting time.

The chemical composition of both grain species, but especially that of barley, was complete when the colour of crops was turning from green to yellow: the starch content increased from the initial zero level to its maximum, the sugar and crude fibre contents decreased to the low level of ripe grains. Over-ripening decreased the starch content and kernel weight.

Introduction

Cereals are usually harvested at a stage of full-ripeness, when the moisture content has decreased, and the preparation of grain for storage is thereby cheaper. The nutritive value and yield is, however, complete before this. Several authors have shown that deposition of nutrients is completed when the moisture content of grain is 35—40 percent, i.e. at the stage of yellow-ripeness. The over-ripeness, in turn, decreases the volume weight, because respiration requires energy. In a rainy season, also the ear-sprouting wastes the energy depots of grains (GESSLEIN 1959, BENGTTSSON, 1969, 1979, MADSEN et al. 1972, THOMKE 1972).

The purpose of the present study was to investigate the development of chemical composition during the growth and ripening of grains and to what extent the green kernels due

to adventitious green shoots, or early autumn frost diminish the nutritive value of the grain crop.

Materials and methods

The study was performed at the Viikki Experimental Farm (60.2 °N) by taking weekly samples from barley and oat crop from the beginning of kernel growth to the time of harvesting which in this rainy summer was done only at the stage of over-ripeness. The grains were cleaned from chaffs and awns, and samples thereof were dried at room temperature for measuring the 1000 kernel weight, in an oven at 103°C for determination of dry matter, and in a vacuum oven at 50°C for analysis. The ground samples were then analyzed for determinants of Weende system,

for sugars soluble in 80 percent ethanol (SALO 1965) and for starch (SALO and SALMI 1968).

Results and discussion

The analytical data show (Table 1) that the chemical composition of grain is nearly complete when the green colour of the grain crop is turning to yellow. The most drastic change occurs in the starch content, from nearly zero to a 45–55 % level. At the same time, the sugar content falls to the low level of mature grains, and the 100 kernel weight rises. The changes in the protein content are small.

Because starch accounts for over 75 % of the net energy value of low-fat grain species (about 65 % in the high-fat oats), the starch content best characterises the energetic value of grains, as shown earlier (SALO 1978). The content of cell wall substances (100 — (starch + sugar + protein + fat + ash)) characterises the same (Table 1). The nitrogen-free extracts (NFE), the difference group of Weende system, is a poor parameter of nutritive value, because in addition to starch the NFE contain main

part of the cell wall substances of grains. Crude fibre, the common criterion of feed value, is fairly suitable for oats because of its high and variable hull content, but poor for barley, wheat and rye. Therefore it seems to be more reasonable to analyze the grains for starch than for crude fibre. Moreover, the analytical method for starch is more exact.

This study was performed in a very rainy summer (1981), and therefore harvesting was done only about two weeks after the normal threshing time. This delay impaired the nutritive value of grains: the starch content decreased and so did the weight of kernels. The barley was even more damaged by rain than was shown by the analytical data, since the sprouted ears were not included in the samples. The decrease of kernel weight and volume weight of corn due to over-ripeness has been reported by several authors (e.g. GESSLEIN 1959, BENGSSON 1979, LARSSON 1980). The cold and rainy summer caused on the whole a diminished feed value of grains, because the starch and protein contents were below normal values.

Table 1. Kernel weight and chemical composition of grain during growth and ripening.

Sam- pling date 1981	Colour of growing crop	Dry matter of grain %	1000 kernel weight g	% of dry matter							
				crude protein	crude fat	crude fibre	ash	N-free extr.	starch	sugars	cell wall contents ¹
<i>Barley (variety Otra)</i>											
16. 7.	green	28	5.2	11.3	1.9	13.9	4.9	68.0	3.2	13.6	65.1
23. 7.	green	29	16.1	10.0	2.7	10.7	3.7	72.9	37.3	7.0	39.3
30. 7.	yellowish-green	39	26.4	10.2	3.0	7.2	3.2	76.4	53.5	2.9	27.2
6. 8.	yellowish	49	32.7	10.9	2.5	6.6	3.1	76.9	53.9	2.5	27.1
13. 8.	yellow	62	37.1	11.8	2.3	5.8	3.0	77.1	55.0	2.6	25.3
20. 8.	grayish-yellow	54	30.0	12.2	2.3	6.3	2.9	76.3	53.0	1.9	27.7
27. 8.	grayish-yellow	68	29.8	11.7	2.3	6.1	2.9	77.0	53.4	2.6	27.1
<i>Oats (variety Sisu)</i>											
23. 7.	green	34	9.5	7.7	1.5	29.8	3.4	57.6	2.8	7.3	77.3
30. 7.	green	39	17.0	8.1	5.5	21.9	3.8	60.7	20.0	5.8	56.8
6. 8.	green	47	25.5	8.5	6.7	16.3	3.3	65.2	37.9	2.9	40.7
13. 8.	light green	53	33.0	8.5	6.5	13.3	3.2	68.5	42.8	1.5	37.5
20. 8.	light yellow	57	36.5	8.3	6.2	12.5	3.4	69.6	44.1	1.1	36.9
27. 8.	light yellow	62	37.0	9.2	6.1	11.7	3.0	70.0	44.6	0.8	36.3
3. 9.	light yellow	66	32.5	10.1	6.0	12.1	3.2	68.6	45.4	0.9	34.4
10. 9.	light yellow	77	31.0	10.5	5.8	12.9	3.1	67.7	42.6	1.4	36.6

¹ 100 — (starch + sugars + protein + fat + ash)

A preliminary study was performed the previous year, but samples were taken less frequently and regularly. That summer was, in turn, warm and favourable, ripening of crops was rapid and the nutritive value of grains good. The chemical composition of grains was, however, even that year complete far before the normal harvesting time. The samples taken from spring wheat indicated that like oats wheat grain developed to complete nutritive value somewhat faster than barley.

In conclusion, the nutritive value of grains is complete when the crop still looks very under-ripe. If the grains are preserved for feed as silage, the crop can be harvested at the stage of yellow-ripeness or a little before that. The high moisture content, 40—45 %, is an advantage in the silage preservation of crushed grains. If, however, drying or some other more common preservation technique is applied, it is reasonable to let the crop dry up, but not over-ripen.

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SELOSTUS

Jyvän kemiallisen koostumuksen kehitys viljan kasvun ja tuleentumisen aikana

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Ohran ja kauran jyvän kemiallisen koostumuksen muotoutumista seurattiin näytteistä, joita otettiin viikottain jyvän kehityksen alusta viljan puintiin, mikä sateiden vuoksi siirtyi pari viikkoa normaalia puintiaikaa myöhemmäksi.

Jyvien kemiallinen koostumus oli lopullinen jo kelta-

tuleentumisen alussa, ohran vähän kauraa varhaisemmin. Tärkkelyspitoisuus oli silloin noussut maksimiarvoonsa ja sokeri- ja kuitupitoisuus laskenut kypsän viljan tasolle. Valkuaispitoisuus muuttui kasvu- ja tuleentumiskautena vain vähän. Ylituleentuminen alensi jyvien tärkkelyspitoisuutta ja 1000 jyvän painoa.