Methods of Quality Tests in Malting Barley Breeding

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Malting barley breeding in Japan has been promoted to develop quickly the varieties of malting two-rowed barley of good quality which are characterized with early maturity, stiffness of culms, practical adaptability for mechanized cultivation, and high resistibility against yellow mosaic of barley and powdery mildew.

Breeding has been carried out at three public institutes (two breeding laboratories and one quality-research laboratory), and in four beer industrial companies.

The promising lines of variety bred by these laboratories are cultivated generally for three years under the same conditions and compared their agronomic characters and qualities with each other.

After these cultivations, some lines of variety which are superior to the popularized commercial ones in their agronomic characters and qualities may be selected as the contract variety (contract cultivation has been carried out between the user and producer).

There have been so many factors which can estimate the quality of malting barley that we absolutely determine which is the best. But the malt extract, malt nitrogen content and diastatic power may be considered as the three important factors.

As for the malt extract amount, it is economically clear that the more there is the better. And that too little or too much nitrogen content is not suitable, it is practically demanded to be at the grade of 9-11%, and the soluble nitrogen content of the wort also must be settled at the optimum value as an important factor to the fermentability.

Regarding the diastatic power, the higher it is the better, because the cereal adjunct has been used.

There exists a negative correlation between malt extract and nitrogen content or diastatic power respectively, and a positive correlation between nitrogen content and diastatic power (Den Hartog et al., 1953[3]; Hsi et al., 1954[5]; Rasmusson et al., 1965[7]; Foster et al., 1967[4]).

Consequently, it may be very difficult to breed out varieties of barley which is characterized by the high grade of malt extract and diastatic power, and by a low grade of nitrogen content at the same time.

The improvement of the agronomic characters has been achieved rather easily but the breeding to get a variety which has the superior or at least the same value of quality in comparison with the popularized practical variety is comparatively difficult by the reason above described.

So the breeding has been brought about in every breeding laboratory by the pedigree method and bulk method giving priority to quality selection. Moreover, artificial mutation breeding has been often applied in some breeding laboratories.

The detailed report on the breeding of malting barley by Meguro (1971)[6] may be available to understand the present breeding in Japan and to know the origins and characteristics of bred varieties.

In this report, the author wishes to describe mainly the method and plan of quality test and on the selection for quality, but we are obliged to touch upon some unfinished points of the study to a certain extent because the method of quality test for malting

Table 1. Progress of selection of malting two-rowed barley breeding
(Pedigree method, 1 cross)

Generation	Cultivated		Selected		Remark
	No. of plants or lines	No. of plants per 1 line	No. of plants or lines	No. of plants per 1 line	
F_1	50～ 60 plants	—	50～ 60 plants	—	
F_2	3,000～4,000 plants	—	200～300 plants	—	
F_3	200～ 300 lines	85	30～ 50 lines	8	
F_4	240～ 400 lines	85	20～ 30 lines	8	Preliminary yield test-1 (non-replicates)
F_5	160～ 240 lines	85	5～ 10 lines	5	Preliminary yield test-2 (replicates 2)
F_6	25～ 50 lines	85	3～ 6 lines	5	Ecological adaptability test (5～10 location, replicates 2)
F_7	15～ 30 lines	85	1～ 3 lines	5	〃
F_8	5～ 15 lines	85	1～ 3 lines	5	Yield test and local test of adaptability (15～25 location, replicates 2～4)
F_9	5～ 15 lines	85	1～ 2 lines	5	〃
F_{10}	5～ 10 lines	85	1 lines	5	〃

barley breeding is not as yet established in our laboratory.

The reference available for quality test are as follows; European Brewery Convention: Analytica-EBC, American Society of Brewing Chemists: Method of Analysis of the American Society of Brewing Chemists.

Outline of quality test on bred lines

The cultivated or selected numbers of plants of one cross in the pedigree method and the generations applied with the yield test appear in Table 1.

The fundamental quality test in each generation is as follows; F_2: The plant is threshed individually and the apparent qualities of kernel (plumpness, kernel sharp, kernel color, finesse of husk, quantity of scab kernels) are investigated, and the individual of which qualities attained to the marked level of breeding is selected.

Especially for the cross bred with the emphasis on quality, we are intending to eliminate the inadequate individuals that have revealed big value of nitrogen content by the result of nitrogen analysis (Kjeldahl method) with a little amount of sample (about 1 g).

F_3: The nitrogen analysis per line is also carried out, and the malt extract and diastatic power are measured on the selected lines by the micro malting (20-25 g) method. Individual selection on the apparent qualities is achieved as well as F_2.

F_4 & F_5: The investigation of the liter weight, 1,000 kernels weight and sieving tests are carried out with product of yield test, and the malting (100-250 g) of selected lines is carried out after the germination test.

The matters of malt analysis are as follows: malt nitrogen content, diastatic power, malt extract, odor of wort, saccharification time, speed of filteration, wort color, wort clarity, wort nitrogen content, Kolbach Index, etc., and after these investigations the superior line is selected.

F_6 & F_7: The following analysis is carried out with the ecological adaptability test products which are gathered as much as possible; the malting (250 g) is carried out after the germination test, and some other matters for analysis (yield of malt, acrospire length, extract difference) are additionally examined besides the above mentioned matters.

F_8 and the successional generations: The malting (250-1,000 g) after the germination

test is carried out with products of yield test and local adaptability test which are gathered from every local experimental farms. Besides the above mentioned analytical matters, apparent attenuation limit is added.

Malting method

The malting process consists of the following three main procedures:

1. **Steeping process:** The procedure that steeps kernels into water so as to acquire sufficient moisture (43%) for germination and successive growth.

2. **Germinating process:** The procedure that activates the contained enzyme and modifies moderately the contents of kernels to make green malt.

3. **Kilning process:** The procedure to make preservable malt which possesses the characteristic odor and color caused by high temperature kilning after low temperature kilning which had been operated so as to avoid inactivation of enzyme.

In our laboratory, the temperature during these processes are kept as follows;

During the steeping process: 15°C. Germinating period: 12°C (for former 3 days), 15°C (for middle 3 days), 17°C (for later 1 day). Kilning period: 40°C (former 12 hours), 60°C (succeeding 3 hours), 85°C (next 5 hours).

All the processes are completed during 10-12 days.

In our laboratory two kinds of malting apparatus are used. One is manufactured by Seeger Company for 1 kg use and can treat eight samples at the same time; the other is the modification of this apparatus (modified by Ohnishi Netsugaku Company). The latter can deal with the malting of 250 g, 100 g and 25 g and can treat 40, 90, 195 samples at one time respectively. The vessel for 250 g malting is metallic similar to that of Seeger's. However, the vessels for 100 g and 25 g malting are made of glass cylinder of which both ends are covered with net.

The reports of Reiner (1963)[8] and of Whithouse (1964)[10] are quoted as references for the micro-malting method.

Investigation and analysis of malt

In our laboratory the investigation and analysis of malt have been carried out according to the Analytica-EBC method.

Malt extract: The EBC mill is employed for milling and the wort is prepared by the EBC mashing method. The specific gravity measuring apparatus in 25 g malting is the Gay-Lussac type pycnometer(about 10 ml), and 5 g of ground malt is used for the measure.

As for the 100 g and 250 g malting, 25 g and 50 g of ground malt are used respectively for the specific gravity measure by the glass ball (about 16 ml).

In Fig. 1, the relation between the malt extract in 25 g malting (mashed with 5 g of ground malt) and that in 250 g malting (mashed with 50 g of ground malt) are shown. A correlation to a certain degree between them can be recognized.

The measurement of specific gravity of wort is considerably laborious and requires

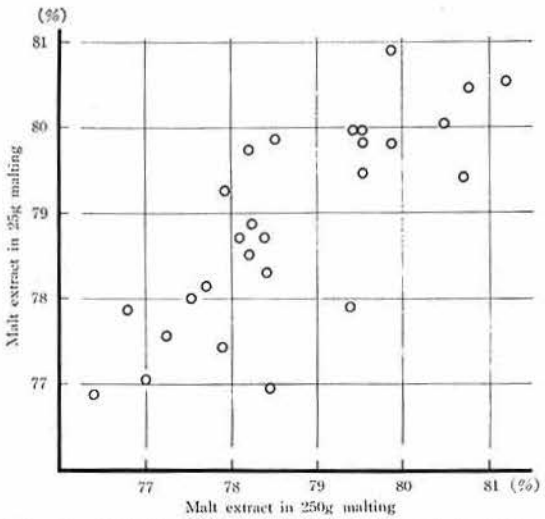

Fig. 1. Relation between malt extract in 250 g malting and malt extract in 25 g malting

much time so we are intending to inquire on the practicability of the gradient method (Atkin et al. 1948)[1] and the refractometer method (Ulonska et al. 1966)[9] using the air-tight mashing method (which shall be detailed in the diastatic power measurement) for the specific gravity measurement of wort in early generations.

Wort color: It is measured by Hellige Neo—comparator.

Soluble nitrogen content in wort: It is measured by the Kjeldahl method with 10 ml of wort.

Diastatic power: This test by the EBC method is to prepare the extract with 20 g ground malt of pale malt in 480 ml cold distilled water, and to keep the weight of contents at 520 g after extraction. In our laboratory, the extract is prepared with 4 g ground malt of pale malt in 100 ml cold distilled water contained in a Erlenmeyer's flask (200 ml) and during the extraction evaporation is prevented by a air-tight glass plug. This method is more efficient because there is no necessary operation to keep the weight of contents at a constant value. The former method is an open system extraction and the latter (our method) may be called as a closed system extraction.

The saccharification and titration are carried out by the EBC method, but there could not be detected any significant difference of the blank in every line so we operate the tests in the proportion of one blank to three main tests and the mean value of blank is adopted (20-25 main tests per day).

Recently, we have succeeded in measuring the diastatic power by the Auto-Analyzer. The relation between the diastatic power value measured by manual procedure (modified EBC method) and that of Auto-Analyzer is shown in Fig. 2. A high correlation between them can be seen so from now we are intending to carry out the diastatic power measurement of lines by the Auto-Analyzer. Bendlow (1963)[2] has reported on a simple method of diastatic power measurement.

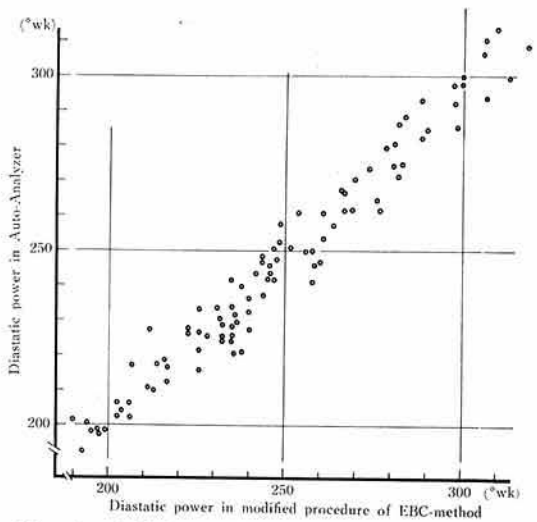

Fig. 2. Relation between diastic power in modified procedure of EBC method and diastic power in Auto-Analyzer

Apparent attenuation limit: This is carried out by the Industrial Beer Test Method (Bakushu Kogyo Shikenhō), and the measurement of specific gravity is the same as that of wort.

Basic standards for quality selection

The definition of malting quality of barley cannot be given easily as it varies according to the malting method, brewing process and the type of beer in demand. These conditions are different by the country and sometimes, it cannot be applied generally even in the same country. And the definition of good quality malt is also variable by the amount of raw barley produced in the country.

Consequently, the matters for investigation on the malting barley quality must be variable according to the environmental conditions so the standards for quality selection could not be settled invariably.

At present, our standards for selection are as follows;

The high malt extract and high diastatic power are necessary and the nitrogen content

must be low as described above. The quality selection must be always promoted in comparison with the qualities of popularized commercial variety of malting barley. The selection has been carried out to meet the demands of Industrial Beer Brewers.

Each investigated characteristic of malting barley quality is weighed and graded respectively. It is given malting marks by a certain standard (0-10) and evaluated finally by the sum of rated marks. At present, the weight of investigated characteristics is as follows

2 **marks:** malt extract and malt diastatic power/malt total nitrogen.

1 **mark:** yield of malt extract, malt total nitrogen, wort soluble nitrogen, Kolbach Index and apparent attenuation limit.

The other investigated characteirstics are consulted as additional references for the evaluation.

These, the above mentioned, are our general method for the examination of malting barley quality and its selection.

References

1) Atkin, L., Stone, I. & Gray, P. P.: Use of the specific gravity gradient tube for brewery control. *Wallerstein Laboratories Communications*, 11, 281-288 (1948).

2) Bendelow, V. M.: Modified procedure for the determination of diastatic activity and α-amylase activity. *Jour. Inst. Brew.*, 69, 467-472 (1963).

3) Den Hartog, G. T. & Lambert, J. W.: The relationships between certain agronomic and malting quality characters in barley. *Agron. J.*, 45, 208-218 (1953).

4) Foster, A. E., Peterson, G. A. & Banasik, O. J.: Heritability of factors affecting malting quality of barley. *Crop. Sci.*, 7, 611-613 (1967).

5) Hsi, C. H. & Lambert, J. W.: Inter-and intra-annual relationships of some agronomic and malting quality characters of barley. *Agron. J.*, 46, 470-474 (1954).

6) Meguro, T.: Breeding of malting barley varieties in Japan. *Barley Genetics* II, 604-608 (1971).

7) Rasmusson, D. C. & Glass, R. L.: Effectiveness of early generation selection for four quality characters in barley. *Crop Sci.* 5, 389-391 (1965).

8) Reiner, L.: Eine vereinfachte 15g-Mikromalzungmethode zur Bestimmung der Brauqualitat an geringen Kornmengen von Gerstenzuchtmaterial. *Brauwiss.* 16, 353-360 (1963).

9) Ulonska, E., Fritz, A. & Lene, W.: Die Kleinmälzungsanlage der Brangerstengemeinschaft an der Bayerischen Landessaotzuchtanstalt Weinhenstephan, ihre Einrichtungen und Arboitsmethoden. *Brauwiss.* 19, 217-233 (1966).

10) Whithouse, R. N. H.: Breeding for malting quality. *Barley Genetics.* I, 325-334 (1964).