New Methods for the Evaluation of Barley and Malt[1]

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ABSTRACT

The frequent appearance on the French market of new barley varieties, especially two-row and six-row winter types, has caused some delays in adapting malting and brewing procedures. Malting studies with several quantities (10 and 250 g; 2 and 300 kg) of barley have been conducted, and evaluations were made of malt at various malting times. Some of these malts were tested by microbrewing (7 L) and by pilot scale (2,000 L) brewing. The methods of Aalbers/Greif (methylene blue) and of Carlsberg (Calcofluor) were used to measure the modification and the homogeneity of malts. The InfraAlyzer was used to measure modification, but this method does not measure homogeneity. The TEPRAL mashing system was also used. Its advantage is that in addition to the determination of extract, other parameters of industrial importance are measured. The close relationship between filtrability of the TEPRAL mash and filtrability of beer is discussed. The application of these new analytical methods allows better evaluation of barleys and of malts prepared at micro, pilot, and industrial scales.

Key words: *Barley quality, Barley variety, Beer filtrability, Malt analyses, Malt modification*

The cultivation of winter barleys of brewing type continually increases in France, and each year ten to twenty new varieties are introduced to the market. When a variety is accepted by government agencies, the brewer should know its malting and brewing characteristics. We set up a dynamic system for the evaluation of barley and malt in which four different quantities of barley can be used. A further objective was to find markers that can provide, from analyses of barley, the maximum information on the maltability of the barley, the quality of the malt, its behavior in the brewery, and above all the beer produced.

EXPERIMENTAL

Experimental Design

Evaluation of barley varieties starts during their selection process. Table I shows the four tests that we perform on a sample of barley. The objective is to set up a dynamic experimental program aimed at reducing the costs of analyses and of laboratory and pilot-scale trials: the characteristics shown can be amended when research leads to better analytical criteria. The discriminating parameters shown were obtained mainly from experimental results with barleys from earlier years.

As soon as the variety is genetically stable, it is tested. If the barley is satisfactory, it is grown a second year, and test A is repeated. If confirmed, the barley is passed to test B. In the third year, when the variety is grown on several hectares, the results for tests A and B must be confirmed. If these are satisfactory, the barley moves to test C. The best barley varieties eventually pass to test D.

Methods of Analysis

The majority of the analyses used are described in the references given in Table I (2,3,5–7,14,15,20). New methods used are the TEPRAL test, the physiological test, micromalting, microbrewing, and industrial scale malting.

Test for Modification

The TEPRAL method (3) combines the Aalbers (1)/Greif (10) method (4,9) and the Carlsberg (8) method, which were recently described (9). We obtain a correlation coefficient of 0.94 between the methylene blue method of Aalbers/Greif and the Calcofluor method of Carlsberg (Fig. 1). An advantage of the TEPRAL method (3) is that it can be applied to green malt predried in a microwave oven (about 15 min at low intensity). The dried grains

TABLE I
Four Stages of Testing Barleys of the 1981 Crop

Test	Details
A	Extract (NANCY method)
	Total protein
	Sieving test for homogeneity
	Freedom from dormancy
	Water-sensitivity
	10-g physiological test
	Calcofluor test for modification of malted grain
B	Micromalting: 250 g-schedule for spring and winter barleys
	TEPRAL mash. Wort examined for:
	extract yield
	fermentable sugars
	free-amino nitrogen
	volume of filtered wort
	Calcofluor test for modification
C	Micromalting: 2 kg
	malting yield
	Calcofluor test for modification
	Microbrewing: 7 L
	filtration of first wort
	brewing yield
	free amino nitrogen in boiled wort
	tasting
D	Industrial-scale malting: 17 ton (metric)
	Pilot brewing 2,000 L

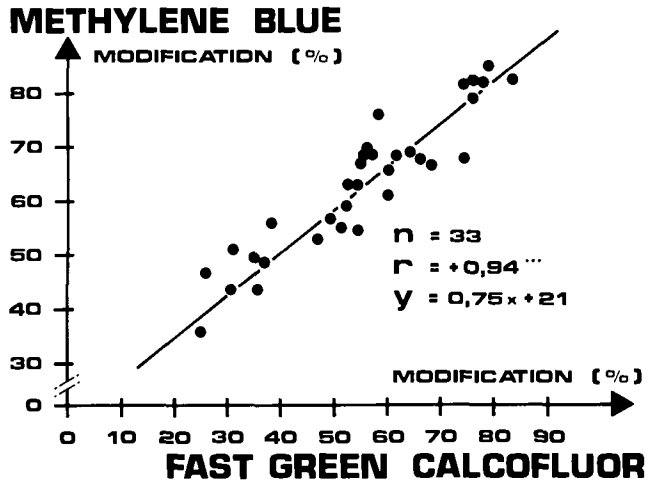

Fig. 1. Tests for modification: comparison of two methods of staining the malt grains.

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are stuck on a glass plate, abraded, colored, and examined for fluorescence from ultraviolet irradiation.

Physiological Test

This test consists of measuring the absorption of water by 10 g of barley after 48 and 72 hr of steeping. After 48 hr, the grain is germinated for five days at 14°C at 100% relative humidity (rh) and is cried under the conditions described under micromalting. For spring barley we obtained 42–50% and for winter barley 40–45% water absorption.

Micromalting

The micromalting procedure has a weekly capacity of 8 × 2 kg of barley. Steeping is preset and controlled by a microprocessor. Germination is done by the method of Versuchs- und Lehranstalt für Brauerei (11) in perforated cylinders fixed on a wheel that turns at one revolution per 4 min in a unit kept at 14°C and at 100% rh. Kilning is done in a Seeger cabinet.

The steeping process is done at 15°C and takes 40 hr; samples are steeped in water for 5 hr and removed for 10 hr, immersed for 7 hr and removed for 10 hr, and reimmersed for 8 hr.

The germination conditions used are the same for winter and spring barleys. Samples are germinated five days at 14°C (100% rh). and the grain is turned continuously.

The kilning process takes 25 hr; samples are kilned for 8 hr at 50°C, and the temperature is raised in 1 hr to 60°C. After 10 hr, the temperature is again raised in 1 hr to 85°C, where it remains for 4 hr.

Microbrewing

Malt (1,575 g) is ground with a Miag roller mill, and the mashing-in is done with 4,725 g of brewing water at 50°C. The brewing schedule is as follows: 20 min at 50°C, raise to 63°C in 13 min, stand for 20 min at 63°C, raise in 12 min to 75°C, and hold for 10 min at 75°C. The mash is then filtered in a lauter vessel.

The first wort and the spargings are collected in a hop kettle, and the pH of the wort is adjusted to 5.4, so as to reach 5.2 at the end of boiling. The wort is bittered using pure hop resin extracts. Cooling of the wort is done in spiral tubes placed in a bath at 0°C, and the cold wort is oxygenated and pitched in Cornelius containers.

Fermentation is conducted at 12°C in a thermostatted bath. Maturation is at 0°C under carbon dioxide pressure. The beer is filtered through a Sartorius filter sheet. Beer filtrability is measured by following the weight of beer collected during the course of filtration.

Industrial Scale Malting

This procedure is done on a 17-ton (metric) scale in a malthouse using steeping vessels, Saladin boxes, and a single-flour kiln.

Conditions Used in Industrial Scale Malting. The steeping process is done in 63 hr. Samples are steeped in water for 4 hr, removed for 13 hr, reimmersed for 4 hr, removed for 25 hr, steeped for 4 hr, removed for 11 hr, and reimmersed for an additional 2 hr.

Winter barleys are germinated in Saladin boxes for a total of six days. The temperature is kept constant at 16 ± 1°C. Gibberellic acid is added at the rate of 0.04 mg/kg 25 hr after casting. Because the moisture content at casting is relatively low, all trials are sprayed twice with water.

Spring barleys are germinated five days without gibberellic acid at 16 ± 1°C.

Kilning is done in a single-deck kiln (Seeger) with natural gas firing, a Seeger burner, and centrifugal high pressure fan.

The duration of temperature stand is as follows: in 1 hr, raise to 52°C; 2 hr at 52°C; in 1 hr, raise to 56°C; 3 hr at 56°C; in 1.5 hr, raise to 65°C; 3 hr at 65°C; in 2 hr, raise to 75°C; 2.5 hr at 75°C; in 1 hr, raise to 82°C; and 3 hr at 82°C.

Pilot Brewery

Milling conditions are modified for each variety of barley and malt so as to obtain a minimum of broken husks, a minimum of fine flour (less than 120 μ) and a maximum of fine grits. This adjustment is particularly important when varieties that have different grain sizes are being tested. The method of mashing used is an infusion mash with a stand of 20 min at 50°C, a raise to 63°C at 1°C/min, a stand at 63°C for 20 min, a raise to 75°C at 1°C/min, and a stand for 5–10 min at 75°C (according to the speed of saccharification). The separation of the mash is made by lautering, using three washings of the grain bed.

The wort is hopped with hop extracts and boiled for 75 min. All the operations of the brewhouse are carried out automatically by a programmable unit. The wort is subjected to passage through a Whirlpool and a plant heat-exchanger, and is oxygenated and pitched. Fermentation and maturation of the beer occur in 1,000-L cylindro-conical tanks. The final beer is filtered on a powder filter, bottled, and pasteurized.

Tasting. This is done by a panel of tasters regularly checked according to the methods recommended by the EBC (5). The results are as follows (1 = bad, 4 = medium, and 7 = good): spring barley, 3.8–4.5; and winter barley, 4.0–4.3.

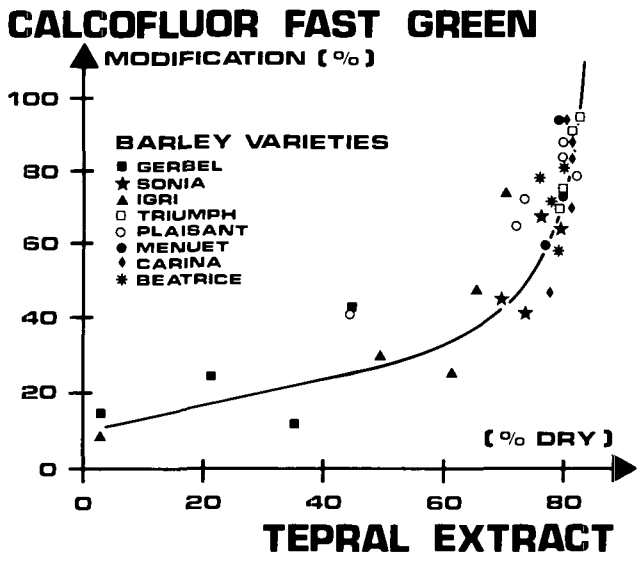

Fig. 2. Relationship between modification and extract yield in the TEPRAL mash.

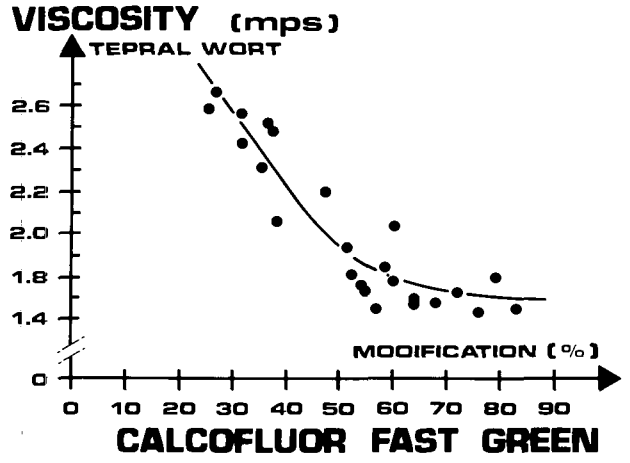

Fig. 3. Relationship between the viscosity of the wort from the TEPRAL mash and percentage modification.

RESULTS AND DISCUSSION

Modification Test

A well modified malt can be distinguished visually from a poorly modified one. An advantage of visual examination is its speed, as it can be completed in less than 1 hr. The information that it gives is equivalent to, if not better than, the information available from conventional methods of evaluation of malt. To illustrate this, Fig. 2 shows the relationship between the degree of modification so obtained and the brewing yield obtained using the TEPRAL mashing method for 35 samples of malt taken at different stages of germination. The relationship is not linear but hyperbolic to an asymptote corresponding to an extract of approximately 81% by the TEPRAL method. An extract lower than 75% indicates that the modification is below 50%.

Figure 3 shows the linear relationship between viscosity, measured with Rheomat 30 from Contraves Co., Zurich, Switzerland, of TEPRAL wort and modification as measured by Calcofluor up to about 50% modification. Above this modification, which corresponds to about 75% TEPRAL extract (Fig. 2), little change in viscosity occurs.

We compared the results of the Calcofluor method with the response given by equipment for measuring the reflectivity in the near-infrared (InfraAlyzer 400 with 19 filters at specific wavelengths). The InfraAlyzer must be calibrated to a particular parameter with a population of values covering the range expected for the samples to be tested. The calibration population often is Gaussian (in Fig. 4 the distribution of the 50 samples used to calibrate for the Calcofluor test is shown); by selecting five filters the regression calculated had a coefficient of simple correlation of +0.96 for the 50 malts examined. When used to examine 30 samples not used in the calibration, the InfraAlyzer gave a result as a function of the calculated regression: Fig. 5 shows the relation between the near-infrared response and the Calcofluor method for these 30 samples (r = + 0.89). As this relationship is good, we can, in the 10 min needed for milling, give a value for the degree of modification of malt with only a small risk of error. Analyses for moisture and protein have been confirmed earlier in a study using the same type of equipment (12); other relationships currently under study will be published later.

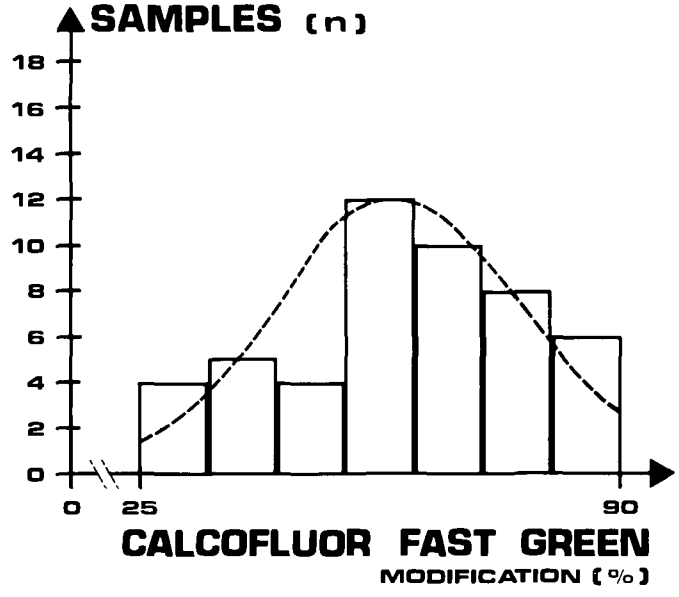

Fig. 4. Distribution of the modification in samples for calibration of the InfraAlyzer.

TEPRAL Mashing Method (13-15)

The brewing yield by this method and wort characteristics are linked to different parameters (other than degree of modification as already discussed) of barley and malt (16–18). The TEPRAL method is also discriminating for the classification of beers by tasting (19).

In this study we demonstrated a relationship between the brewing yield (TEPRAL) and the rate of filtration of beer as shown in Fig. 6: the malts having yields of less than 70% give beers with filtration rates of less than 2 L per hr (microbrewing scale). Winter 2- and 6-row barleys often give beers that filter too slowly.

CONCLUSIONS

We have set up a system for evaluating barley when it reaches genetic stability and before it is released for general cultivation. Four methods are involved, calling for a limited number of

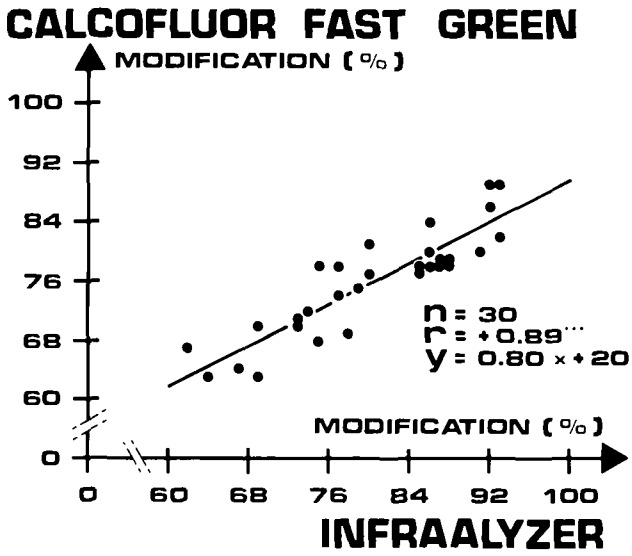

Fig. 5. Test for modification: comparison between results obtained with the InfraAlyzer and by staining of the malt grains.

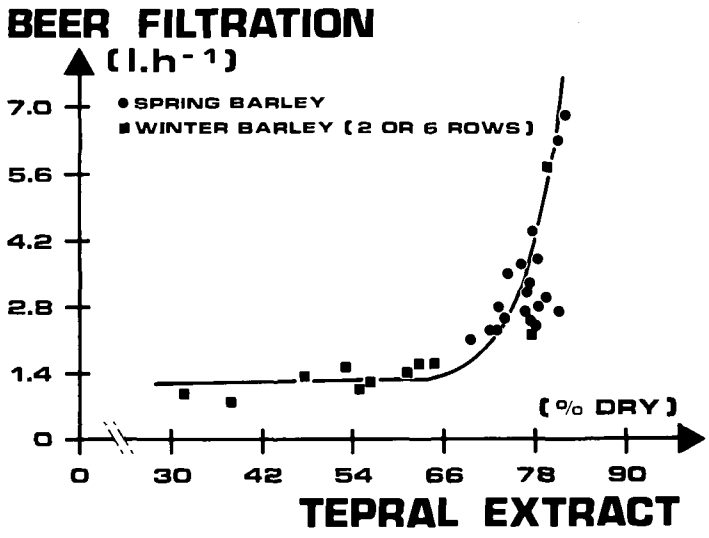

Fig. 6. Relationship between the rate of filtration of beer and the extract yield (TEPRAL mash) from the malt used to make the beer.

analyses; these allow, over four years, recommendations to be made to malters and brewers regarding the choice they should make among new varieties.

Interesting correlations were established between the extract by the TEPRAL mashing method and the filtrability of beer, between extract and the estimate of the modification obtained by staining the germinated grain, and between the estimate of modification obtained by infrared reflectance and by staining.

The results described have an interest for the maltster in following the progress of germination and the optimization of his process. For the brewer, information on the modification and homogeneity of a batch of malt at arrival in the brewery can be obtained.

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