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USABILITY OF BISHOP FORMULA IN EVALUATION OF MALTING QUALITY OF BARLEY GRAIN

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Key words: barley grain, malt, wort, extractivity, Bishop's formula

The purpose of the research was to define the influence of cultivar, growing season and grain largeness on its extractivity, which was determined by Bishop's formula. The experimental material was: barley grain of Rudzik, Brenda and Scarlett cultivars, from growing seasons of 2000-2003, originating from the region of Lower Silesia, taken from raw material supplied to malthouses, as well as grain from 10 cultivars of brewing barley (Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, Stratus), from the growing season of 2005, from Agricultural Experimental Station in Pawłowice In the fractionated barley grain there were determined protein content and thousand grains weight. Malts of Pilzen type were obtained as a result of brewing barley grain malting in laboratory conditions for 6 days. After mashing, there was determined the content of extract in congress worts. On the basis of extract content malt extractivity was calculated. These data were compared with the extractivity of barley grains, determined by Bishop's formula and differences analyzed statistically. It was stated that the application of Bishop's formula in the evaluation of the malting usability of brewing barley grain, especially in multi-year analyses, enables predicting the extractivity of Pilzen type malts with high accuracy. Differentiated cultivar-specific traits, changeable weather conditions during growing seasons as well as grains fractionation in terms of their thickness neither impair nor significantly change the effects of predicting the malting usability of brewing barleys with the formula of Bishop.

INTRODUCTION

Evaluation of the malting usability of barley grain, in Poland carried out by the Research Centre for Cultivar Testing (COBORU), is based on principles elaborated by Molina-Cano commissioned by the European Brewery Convention – EBC. Cultivars are classified to an appropriate brewery group (from medium to very good) or a non-brewery group based on values of the Q coefficient, in the scale of 1 to 9 (1 – the worst value, 9 – the best value). It is a sum of products of quality parameters of malt (extractivity, Kolbach's number, diastatic activity, degree of final attenuation of wort and its viscosity) and weights assigned to them. In reports elaborated by COBORU instead of the Q coefficient often use is made of the following expressions "brewery value in 9-point scale" or "synthetic evaluation of 5 technological indices". The most important parameter in the evaluation of the malting usability of brewing barley grain, assigned the highest weight (0.40), is malt extractivity [Molina-Cano, 1987; Klockiewicz-Kamińska, 1998]. It is treated as a percentage quantity of extractive substances to be obtained from malt produced from a given grain under optimal technological conditions [Kunze, 1999].

Under laboratory conditions, grain extractivity can be determined using traditional methods of Dinklag, Pawlowski or Graf. It can also be assayed by analyzing extract content of wort obtained as a result of congress mashing of malt produced from the grain examined [Dylkowski, 1959, Analityca – EBC 1998].

Extractivity of grain is also calculated with the use of Bishop's formula:

$$E = 84.5 - 0.75\,B + 0.1\,TGW$$

where: E – extractivity of barley grain according to Bishop; B – content of protein in barley grain in% of dry matter; TGW – weight of 1000 barley grains in respect of dry matter; 84.5 – a constant value of distichous spring barley.

The application of Bishop's formula is a more rapid and less expensive method, taking into account a dependency between extractivity and protein content and thousand grain weight of barley [Dylkowski, 1959].

The study was aimed at determining the effect of cultivar-specific traits, growing seasons and thickness of brewing barley grains on the extractivity of grain calculated with Bishop's formula as well extractivity of Pilzen type malts.

MATERIAL AND METHODS

The experimental material was: barley grain of Rudzik, Brenda and Scarlett cultivars, from growing seasons of 2000--2003, originating from the region of Lower Silesia, collected from deliveries of raw material prepared for processing in a malt-house, as well as grain from 10 cultivars of brewing barley (Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bo-

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lina, Philadelphia, Tolar, Stratus), from the growing season of 2005, originating from a plot experiment carried out in the Agricultural Research Station in Pawłowice within Post-registration Variety Testing System (PDO).

The grain was fractionated as well as determined for protein content with Kjeldahl's method and thousand grain weight. From barley grain of all cultivars examined Pilzen type malts were produced under laboratory conditions. Malting was carried out in a laboratory applying conditions of grain soaking, sprouting and drying typical of the production of Pilzen type malts. The soaking and sprouting of grain samples (250 g) was run in perforated foil bags in a conditioning cabinet, in a temperature range of 15-16°C. The soaking cycle of grain spanned for 48 hours. The grain was kept in water and in air atmosphere according to the following scheme: 8 h – in water (w), 11 h – in air atmosphere (a), 5 h – w, 8 h – a, 11 h – w, 5 h – a. As a result of soaking, the grain was brought to moisture content of 43%. Grain sprouting lasted for 6 days. Malts were dried in a laboratory dryer with a ventilator according to the following scheme: 10 h at a temp. of 30°C, 5 h at a temp. of 40°C, 3 h at a temp. of 50°C, 3 h at a temp. of 65°C, and 2 h at a temp. of 82°C. The malts were deprived of radicles, comminuted and subjected to laboratory mashing with the congress method. The worts obtained were determined for extract content which was then used to calculate malt extractivity. Next, it was compared with grain extractivity computed from the Bishop's formula. Results were subjected to a statistical analysis using *Statistica* software package.

RESULTS AND DISCUSSION

Amongst parameters of brewing quality evaluated already at the purchase of barley grain by malt-houses, of key significance is protein content that should ranged from 9.5 to 11.5%. Values both above and below that range are unfavorable [Bathgate, 1987; Garstang & Giltrap, 1990].

The content of protein in grain is a cultivar-specific trait that results in differentiation in the brewing usability of cultivars. At the same time, it is modified to a great extent by environmental factors. Under unfavorable weather conditions (drought), in the period of grain filling and ripening it is difficult to maintain protein content a desirable level even in the best cultivars [Klockiewicz-Kamińska, 1998; Bertholdsson, 1999; Błażewicz *et al.*, 2003].

Specificity of brewing barley cultivation consists in striving for obtaining a high possible yield of well filled grain with strictly specified qualitative parameters enabling the production of normative malts, and then standard brewing worts. The maximization of yielding is linked, most of all, with the application of high doses of nitrogen. High doses of a nitrogenous fertilizer cause a standard-exceeding increase in protein content as well as a decrease in choice quality of grain and malt extractivity, thus diminishing its brewing value [Eagles *et al.*, 1995; Błażewicz & Liszewski, 2001].

Table 1 presents effects of statistical calculations that were aimed at determining the impact of cultivar-specific traits on theoretical and practical extractivity of three cultivars of malting barley (Rudzik, Brenda and Scarlett) analyzed in subsequent growing seasons.

Results compiled in Table 1 and Figure 1 indicate that the theoretical and practical extractivity of grain of the cultivars examined is highly correlated. Attention should be paid to the fact that results of assay cover experimental material from four subsequent growing seasons (2000-2003), of which the season of 2001 was represented by grain samples originating from two separate supplies of raw material to malt-houses, prepared in different regions of the Lower Silesia. Those results enable concluding that the application of Bishop's formula for predicting the extractivity of malts may be of practical use, similarly to predicting the complex malting usability of barley grain acc. to Molina-Cano [Błażewicz & Liszewski, 2004].

Based on data from Table 2, it was stated that cultivation conditions in particular growing seasons exerted a highly dif-

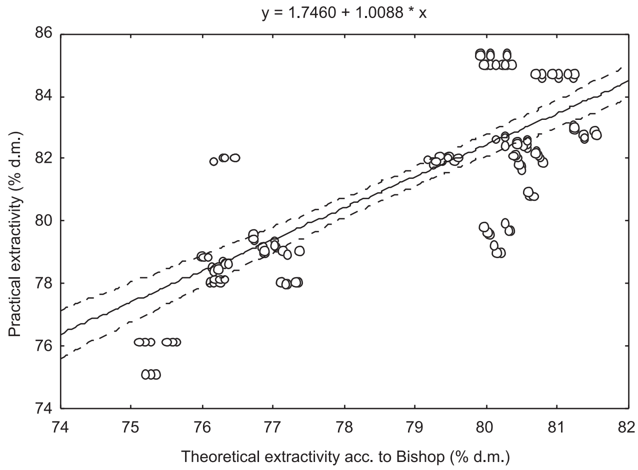

FIGURE 1. Dependency between practical and theoretical extractivity acc. to Bishop (cultivars Rudzik, Brenda and Scarlett, growing seasons of 2000-2003, correlation coefficient 0.76 at p<0.05).

TABLE 1. Effect of a cultivar factor on theoretical and practical extractivity of brewing barley grain of Rudzik, Brenda and Scarlett cultivars from growing seasons of 2000-2003.

Cultivars	Theoretical extractivity (% d.m.)		Practical extractivity (% d.m.)		Coefficient of correlation between practical and theoretical extractivity	
	mean	NIR	mean	NIR	for cultivars	mean
Rudzik	78.56[b]		80.66[a]		0.88	
Brenda	78.86[a]	0.06	80.85[b]	0.11	0.81	0.76
Scarlett	78.90[a]		82.13[c]		0.58	

a, b, c – homogenous groups (α=0.05); NIR / LSD – least significant difference (p=0.05)

TABLE 2. Effect of growing season on theoretical and practical extractivity of brewing barley grain of Rudzik, Brenda and Scarlett cultivars.

Growing seasons	Theoretical extractivity (% d.m.)		Practical extractivity (% d.m.)	
	mean	NIR	mean	NIR
2000	76.24[a]		77.43[a]	
2001A	80.05[c]		81.03[c]	
2001B	76.44[b]	0.76	80.00[b]	0.14
2002	80.76[e]		82.57[d]	
2003	80.40[d]		85.04[e]	

a, b, c, d, e – homogenous groups (α=0.05); A. B – grain samples from different areas of the Lower Silesia; NIR/LSD – least significant difference (p=0.05)

TABLE 3. Effect of a cultivar factor and grains thickness on theoretical and practical extractivity of 10 cultivars of brewing barley from the growing season of 2005.

Differentiating factor		Theoretical extractivity (% d.m.)	Practical extractivity (% d.m.)
Barley cultivar	Class	80.94[f]	81.53[d]
	Blask	80.50[d]	80.57[a]
	Riviera	81.41[g]	80.66[a]
	Lailla	80.70[e]	80.62[a]
	Hanka	80.24[c]	80.56[a]
	Sebastian	80.14[c]	79.69[b]
	Bolina	79.82[b]	80.10[c]
	Philadelphia	79.65[a]	80.82[a]
	Tolar	79.69[a]	79.67[b]
	Stratus	79.82[b]	80.17[c]
	NIR	*0.11*	*0.31*
Grains thickness	2.5-2.8 mm	79.68[a]	80.18[a]
	>2.8 mm	80.56[b]	80.75[b]
	NIR	*0.06*	*0.17*

a, b, c, d, e, f, g – homogenous groups (α=0.05); NIR / LSD – least significant difference (p=0.05)

ferentiating effect on the theoretical and practical extractivity of Rudzik, Brenda and Scarlett cultivars. Those results are consistent with findings of other authors that the course of a growing season modifies the growth and development of plants [Pecio, 2002; Błażewicz *et al*., 2003]. Variability of extractivity in particular years could be due to diversified water utilization [Bertholdsson, 1999], affecting the yielding and protein content of grain [Eagles *et al*., 1995] as well as efficacy of agricultural practices [Pecio, 2002]. In the group of cultivars examined the practical and theoretical extractivities were alike despite variable conditions occurring during the four subsequent growing seasons.

Table 3 collates results of analyses referring to the theoretical and practical extractivity of grain originating from one growing season (2005), from the same cultivar experiment. A comparison of those values for 10 cultivars of brewing barley, cultivated under the same agricultural, soil and climatic conditions, points to small cultivar-specific differences between them. Results of the one-year cultivar experiment were characterised by low variability and low number, which impaired calculation of correlation coefficients. A comparative analysis of the theoretical and practical extractivity for individual cultivars demonstrated that they were very similar (for most of the cultivars, the difference reached <1%). It substantiates the practical application of Bishop's formula for predicting the malting usability of barley grain.

Data presented in Table 3 indicate also that sorting barely grains for their thickness into fractions of 2.5-2.8 mm and >2.8 mm differentiates the grain and malts obtained from it in terms of extractivity. A change in thickness of barley grains is, obviously, linked with starch accumulation in the grain. It affects the weight of thousand grains and, indirectly, the content of protein, which is considered in the Bishop's formula.

It seems that the calculation of malt extractivity acc. to Bishop's formula, with the initial evaluation of malting usability of barley grain, may be accepted by farmers and malt producers, treating the extractivity of malts as the basic measure of the work efficiency of a malt-house and brewery. According to the authors, dependencies between the theoretical and practical extractivity of malts, determined in this study under laboratory conditions, did not become out of date and provide the possibility of initial predicting the malting usability of grain of old and new cultivars of brewing barley based on the Bishop's formula.

CONCLUSIONS

1. The application of Bishop's formula in the evaluation of the malting usability of brewing barley grain, especially in multi-year analyses, enables predicting the extractivity of Pilzen type malts with high accuracy.
2. Differentiated cultivar-specific traits, changeable weather conditions during growing seasons as well as grains fractionation in terms of their thickness neither impair nor significantly change the effects of predicting the malting usability of brewing barleys with the formula of Bishop.

REFERNCES

1. Analytica – EBC, Verlag Hans Carl Getraenke-Fachverlag, 1998, Nuernberg.
2. Bathgate G.N., Quality requirements for malting. Aspects Appl. Biol., 1987, 15, 18-32.
3. Bertholdsson N.O., Characterization of malting barley cultivars with more or less stable protein content under varying environmental conditions. Eur. J. Agron., 1999, 10, 1-8.
4. Błażewicz J., Liszewski M., Index Q and Bishop's method efficacy in barley brewing quality determination. Pam. Puł., 2004, 135, 7-17 (in Polish; English abstract).
5. Błażewicz J., Liszewski M., Part II. The influence of nitrogen fertilization on brewing value of barley grain of Rudzik and Brenda cultivars. Zesz. Nauk. AR Wroc., Technol. Żyw., 2001, 14, 407, 101-107 (in Polish; English abstract).
6. Błażewicz J., Liszewski M., Pląskowska E., The brewing value of barley grain of Rudzik and Brenda cultivars from the growing

season in the year 2000. Żywność. Nauka. Technologia. Jakość, 2003, 34, 99-109 (in Polish; English abstract).
7. Dylkowski W. (ed.), Kontrola chemiczno-techniczna produkcji słodu i piwa. 1959, WPLiS, Warszawa, pp. 102-115 (in Polish).
8. Eagles H.A., Bedggood A.G., Panozzo J.F., Martin P.J., Cultivar and environmental effects on malting quality in barley. Aust. J. Agricult. Res., 1995, 46, 831-844.
9. Garstang J.R., Giltrap N.J., The effect of applied and soil mineral nitrogen on yield and quality of malting barley varieties. Asp. App. Biol., 1990, 25, 315-327.
10. Klockiewicz-Kamińska E., The procedure of malting quality evaluation in barley used in polish cultivar testing. Pam. Puł., 1998, 112, 93-103 (in Polish; English abstract).
11. Kunze W., Technology Brewing and Malting. 1999, VLB, Berlin, pp. 155-160.
12. Molina-Cano J.L., The EBC Barley and Malt Committee Index for the evaluation of malting quality in barley and use in breeding. Plant Breeding, 1987, 98, 249-256.
13. Pecio A., Environmental and agrotechnical limitations of the grain yield and quality of malting barley. Fragm. Agron., 2002, 76, 1-113 (in Polish; English abstract).

PRZYDATNOŚĆ WZORU BISHOPA W OCENIE JAKOŚCI SŁODOWNICZEJ ZIARNA JĘCZMIENIA

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Celem pracy było określenie wpływu cech odmianowych, sezonów wegetacyjnych oraz grubości ziarniaków jęczmienia browarnego na ekstraktywność ziarna obliczoną wzorem Bishopa i ekstraktywność słodów typu pilzneńskiego, określoną metodą laboratoryjną. Materiałem badawczym było: ziarno jęczmienia browarnego odmian Rudzik, Brenda i Scarlet, z sezonów wegetacyjnych 2000-2003, pochodzące z rejonu Dolnego Śląska, pobrane z dostaw surowca przygotowanego do przerobu w słodowni, a także ziarno 10 odmian jęczmienia browarnego (Class, Blask, Riviera, Lailla, Hanka, Sebastian, Bolina, Philadelphia, Tolar, Stratus), z sezonu wegetacyjnego 2005, pochodzące z Rolniczego Zakładu Doświadczalnego w Pawłowicach, prowadzącego badania w ramach porejestrowego doświadczalnictwa odmianowego (PDO). Ziarno poddano frakcjonowaniu, określono zawartość białka metodą Kjeldahla oraz masę tysiąca ziaren. Z ziarna jęczmienia wszystkich odmian badanych odmian wyprodukowano w warunkach laboratoryjnych 6-dniowe słody typu pilzneńskiego. Słody poddano zacieraniu. W uzyskanych brzeczkach oznaczono zawartość ekstraktu metodą piknometryczną, a na jej podstawie obliczono ekstraktywność słodu, którą porównano z ekstraktywnością ziarna, obliczoną wzorem Bishopa. Wyniki poddano analizie statystycznej. Stwierdzono, że zastosowanie formuły Bishopa w ocenie przydatności słodowniczej ziarna jęczmienia browarnego, szczególnie w badaniach wieloletnich, pozwala z dużą dokładnością przewidywać ekstraktywność słodów typu pilzneńskiego (tab. 1, rys. 1). Zróżnicowane cechy odmianowe, zmienne warunki pogodowe w trakcie sezonów wegetacyjnych oraz frakcjonowanie ziarna pod względem grubości nie utrudniają, ani nie zmieniają zasadniczo efektów prognozowania przydatności słodowniczej ziarna jęczmienia przy użyciu wzoru Bishopa (tab. 2 i 3).