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# METHODOLOGICAL ISSUES OF GOODS EVALUATION BASED ON EXPERT OPINIONS

In our investigation we examined the expert views on the importance of relevant characteristics influencing the quality of malting barley. We conducted our analysis based on correlations of rankings obtained from paired preferences concerning 14 quality characteristics evaluated by experts of breweries. From these we have found that expert views could be classified into two distinct groups that differed from one another in weighting 5 quality parameters. The differences and similarities in the judgements becoming explicit through the method of paired preferences have made it easier to interpret the complex notion of brewing quality.

A special subject of interest of the SZIE (St. Istvan University) Marketing Institute is to research the marketing-related aspects of agricultural product quality. In this, of course, we need to rely on the opinions of the experts who produce and use these products. It is true though that these opinions are very often different and, what is more, in some cases they may even be conflicting.

This is certainly justifiable and understandable. Such complex and many-sided notions as product quality can be interpreted in a number of ways and from several aspects, in which not the same characteristics are dominant in every case. On the other hand, it must also be taken into consideration that experts' main task is not to potter about with theoretical interpretations but rather to find a suitable interpretation helping to tackle problems in their specific areas. Thus it is obvious that their problem-specific experience may considerably influence their views.

Different opinions, however, are part of the possibilities of interpretation of a given complex notion, so we have to consider them in our model as well. The first

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step towards this is to compare expert opinions. In what respect are they the same and how do they differ from one another? In professional discussions and consultations, experts very often come to an agreement about these questions very soon. But in general this is insufficient to make a model, since they contain so many implicit professional preconditions that cannot be taken into consideration to the full when making a – for obvious reasons restricted – model.

Because of the above, different methods have to be chosen to evaluate and compare expert opinions. These may include methods specially designed to measure and compare so-called complex systems and which can be used to characterize interpretations of product quality as well. From among these we have frequently used the so-called paired preference test. This method consists of reducing complicated multi-factor comparisons to paired comparisons of all possible combinations of the factors (or systems) to be evaluated. For an evaluation of the factors determining quality this means that, presupposing well-defined conditions, experts compare pairs of evaluation factors to decide which one, under given circumstances, is of determining significance. This method has proved to be suitable to interpret expert opinions, since in addition to making the importance of evaluation factors comparable by weighting and ranking, paired comparisons also supplied information on experts' preference sensitivity.

In this paper I present this sort of use of the above-mentioned method based on evaluations from experts familiar with production and sales possibilities of breweries and malt-houses, giving their opinion of the importance of characteristics determining malting barley quality. The final goal of my research is to model the brewing quality of barley in terms of marketing and product development and to map out expert views on malting barley quality. It must be noted, however, that we did not conduct this survey because we had been commissioned by a member of the brewing industry, but in order to inspire malting barley breeding and to be able to set the goals of quality development as thoroughly as possible.

## BREWING QUALITY OF BARLEY (OVERVIEW)

The brewing quality of barley reflects its suitability for beer production as well as its attainable values of enjoyment, warehousing, transportability etc. These factors are affected by a number of characteristics of barley. Research into brewing industry has already revealed the influence of a lot of barley characteristics on quality, ascertaining at the same time their optimal and acceptable levels in quality. These levels are by no means of absolute validity. The importance of characteristics is flexible as well since their role in quality depends on a number of factors; thus for example on other characteristics, on the type of beer to be produced, on production technology and last but not least on the quality characteristics of current barley crop, which can vary significantly year by year. (This latter aspect does not naturally influence the quality of barley but is decisive in how brewing industry *grades* a given constellation of characteristics.) Under such circumstances it is understandable that it is difficult to give a general algorithm to characterise brewing quality of barley and that the *generalisability* of each and every particular evaluation is rather uncertain due to the large number of interrelated conditions that determine the evaluations. Owing to the above, brewing experts may judge the importance of barley characteristics determining malting barley quality differently, depending on the circumstances; this by itself is not a problem but in order to set precise goals for quality improvement, similarities and differences in views should have to be known better.

With the help of a paired comparison of evaluation factors we assessed the importance attached to malting barley parameters, which are most often considered to form expert views. Basically, the investigation can add to the interpretation of malting barley quality in the following:

- based on expert opinions it clearly ranks and weights the assumed importance of characteristics. Analysing the correctness and limitations of such an importance scale, the views on quality can be specified much better than without a scale;
- it can be determined and accurately characterized how similarly brewing experts judge the importance of individual characteristics in "shaping" brewing quality;
- an analysis of the differences in ranking and the inconsistency of individual rankings can also contribute to a more detailed interpretation of brewing quality.

## SELECTING THE CHARACTERISTICS DETERMINING MALTING BARLEY QUALITY

As the importance of quality parameters can be judged differently, a positive statement made by professional bodies about brewing values of certain barley types can only be regarded as a preliminary opinion in the multi-stage (sequential) system of malting barley grading. Its stages, according to LARSEN (2001), are as follows:

- In the first stage, the production possibilities of a variety are assessed. Varieties need to reach the agronomic level of formerly produced malting barleys (crop volume, disease resistance, stress tolerance, etc.) in order to be considered in the next phase.
- The second stage is a real qualitative filter performed based on the properties of barley and of the malt produced from it. The number of the characteristics examined is between 6 and 14. The potential brewing values of barley varieties are forecast by the EBC (European Brewery Convention) using 14, by the German variety granting office (Bundessortenamt) using 11, by the Danish Carlsberg Research and the Czech Research Institute for Brewing and Malting using 8 barley and malt characteristics each (EBC 1994, BSA 1996, LARSEN 2001, PSOTA and KOSAR 2002). In Hungary there is no institutionalised system to investigate and evaluate malting properties. In-house pre-decanting is more or less the same as in international practice.
- In the third stage a brewing pilot test is performed using the brewing malts that have been approved in the previous stage. On the one hand it is checked whether the brewing characteristics assumed based on the malt characteristics are correct, and on the other the varieties recommended for an in-plant test are selected. This phase has only been institutionalised in France and Great Britain.
- The fourth stage is the in-plant test. At this point a variety can still turn out to be inappropriate for brewing use, because the compound of flavours, the foam and decanting properties as well as the stability of the produced beer only develop under operative conditions and cannot be determined exactly at an early stage.

The most important quality check is in the second stage where it basically turns out whether a variety can be included among malting barleys. Therefore, our paired preference test measuring the importance of quality characteristics focused on these measures of value.

## AN OVERVIEW OF THE MOST IMPORTANT CHARACTERISTICS DETERMINING BREWING QUALITY

In *Table 1.* we have compiled a list of the characteristics to be assessed based on the practices of the European Brewery Convention (EBC), the German Bundessortenamt, the Czech Research Institute for Brewing and Malting and of Hungarian breweries. In the first column of the table you find the characteristics we considered, in the second their role in determining quality, this latter adapted from NARZISS (1981) and KUNZE (1983). In the third column the method used for measuring characteristics was summarized based on a joint project of the Dréher Sörgyárak Rt (South African Breweries Ltd) and the Söripari Kutató (Brewing Research) as well as on the methodological guidelines of the German MEBAK and of the EBC (BÉNDEK 1986, MEBAK 1984, EBC 1994). In columns 4-5 the generally respected acceptance and optimum levels of characteristics are given based on EBC, BSA as well as PSOTA and KOSAR (2002).

*Table 1.* is a kind of checklist for the evaluation factors involved in the investigation. It partly sets the frame for our investigation and partly includes the most important parameters determining the interpretation of these factors.

To analyse complex phenomena we consider it particularly important to design summary tables similar to the above, because they state initial presuppositions in a well-arranged and, if needed, easily modifiable manner. This is important at the beginning and at the end of investigations alike, but also when evaluating results, setting the limits of the conclusions drawn and when planning further jobs. Two seemingly evident principles of editing make it suitable for the above. These are: *a linear structure and a dual interpretation of efficient factors*.

A *linear structure* simply means that efficient factors and related information are summarised in a linear order, since this structure suits the patterns of human thinking the best. This makes it considerably easier to overview and to check initial knowledge but also to modify, rearrange, extend or reduce the amount of knowledge.

In this context a *dual interpretation* of efficient factors means that, when analysing complex phenomena, two types of analysis factors are to be defined obligatorily. One of the definitions characterizes these factors from the point of view of the interrelation system to be investigated (i.e. theoretically), whereas the other one does so from the operative side of their definition (i.e. as they are perceived). To put it in other words: the first one gives an interpretation of efficient factors, whilst the second one (the method of perception) marks out the boundaries of the scope of interpretation. It is important to mention the two kinds of approach together, because if they are treated separately, it could lead to serious misunderstanding, which might hinder further analyses considerably.

*Table 1.* has been compiled taking the above principles into consideration — but we are still open for any suggestions for modification.

## A SHORT DESCRIPTION OF THE PAIRED PREFERENCE SURVEY

In our survey, 6 experts were involved who had gathered their relevant production experience in Hungary's breweries and malt houses and who were sent 2 questionnaires.

*Questionnaire 1.* was basically identical with *Table 1.* We asked them to give their opinion of the items in it and if needed, to modify, reduce or expand its contents.

In *questionnaire 2.* a paired comparison of the qualitative characteristics was done. Here experts were expected to give their opinion on all possible combinations of pairs of 14 factors evaluating quality that are most frequently considered in Hungarian surveys. They had to decide which one of the two contrasted characteristics they consider to be more important in determining quality (provided that all the other characteristics take equally excellent values).

Based on the responses, the factors were then ranked and weighted using Gilford's methods adapted from KINDLER and PAPP (1977). The experts' consistency of preference was characterised with the ratio of preference triads compared to the maximum possible number of triads. The number of maximum triads was calculated using KENDALL's formulas (cit. KINDLER and PAPP 1977).

Global agreement among respondents was measured using KENDALL's W rank concordance, while paired preference similarities of experts were measured with SPEARMAN's r rank correlation (cit. SVÁB 1981)

The interrelation between the evaluation factors/malting barley quality obtained in the total of responses was characterised with the mean rank of evaluation factors, the scattering of ranks and with the values of aggregate preferences measured on a Guilford scale – this latter was calculated based on KINDLER and PAPP (1977).

## FINDINGS

Ranking of characteristics affecting brewing quality using paired comparisons.

In *Table 2.,* we illustrated the ranks (order of importance) determined from the paired preference responses given by experts A, B, C, D, E, and F. The experts' value judgement on the importance of characteristics was in general rather consistent: with five of them it reached 75-96 per cent and only the consistency index of expert F indicated a preference sensitivity lower than 49%.

The rankings, however, seem rather different. The W-rank concordance index is only 34%, which is already significant, but shows a rather low level of agreement. Thus opinions on the importance of particular characteristics are rather split. The average scattering of ranks is ±3.2 ranks; with seven characteristics it reaches or even exceeds ±3.5 ranks; and is lower than ±2 with three characteristics only.

From the above it appears that the views of Hungarian brewing experts on the importance of the characteristics determining quality are not uniform. This, however, only means that characteristics are judged differently. To determine how many trends this implies, we should have to compare the rankings of each expert pair by pair.

*Table 3.* shows the similarities of pairs of expert opinions using the Spearman f. rank correlation. As can be seen from the table, experts can be classified into two groups based on the similarity in their rankings. This suggests two markedly

different value judgements. One of these is represented by experts AB. The correlation between their rankings is rather high ($r_{rank}$=0.60, significant). The second opinion group includes the rankings of experts C, D, E, F, which again are more similar to one another. A comparison of rankings A, B and C, D, E, F by themselves and to one another is seen in *Table 4*.

The w concordance of rankings A and B is 81%, which is indicated by the low scattering of the ranks reflecting the importance of characteristics as well (±1.8 rank). Due to the high degree of similarity, the two rankings can be merged and interpreted as a joint trend regarding importance.

The similarity of rankings CDEF is lower but still acceptable. W concordance is 61% and the scattering of ranks is ±2.5. The relatively higher disagreement is caused by three characteristics that were evaluated in a considerably different way by certain experts. Expert F deemed the *soluble N-content of beer wort* to be of extreme importance whereas expert E did the same for its *beta-glucan content* and the *viscosity of the beer wort* (cf. *Table 2*.). This tiny yet significant difference in CDEF opinions could be revealed thanks to the fact that they had been assigned to a separate opinion group.

The last columns of *Table 4* compare the rankings of the two expert groups. There is no interrelation between the rankings and their rank correlation co-efficient is $r_{rank}$=–0.17. This however does not mean that they judge each of the characteristics differently. This is seen in the last column of the table where the characteristics were classified into 3 groups according to the similarity of judgements. Thus they were assigned to:

- group I if they had been judged practically in the same way (with a rank difference of up to 1);
- group II if they had been judged similarly (with a rank difference of 1-3), and to
- group III if they had been judged contrarily (rank difference >7, i.e. they are on opposite ends of the rankings).

To get a better overview, we summarized these characteristics in *Table 5*. separately, too. As for the characteristics in groups I-II we accept that they were judged by the experts more or less identically and a significant difference in judgement exists only with those in group III.

## MAJOR FINDINGS IN CONNECTION WITH MALTING BARLEY EVALUATION

The survey reflects the expert opinions based on the production experience of representative Hungarian breweries, providing us with an easily understandable illustration of the importance of the characteristics influencing malting barley quality, as well as the accord and disaccord of opinions. We have found that the relevance of characteristics is basically judged in two ways. The two rankings could be traced back to an opposite judgement of the importance of *protein content of barley, total N-content of malt, apparent final attenuation, the Hartong number and of diastatic enzyme activity*.

As our primary task was to demonstrate views in an adequate and illustrative manner, to present the prevailing opinions for the sake of malting barley breeding and further modelling, we shall not deal with analysing the actual reasons for the different judgements. Yet we may venture to say that in preferring *enzyme characteristics* (apparent final attenuation, Hartong number and diastatic enzyme activity) aspects of extract yield were of determining character, while in the case of *protein characteristics* (protein content of barley and the total N-content of malt), the factors of production safety were held more important.

In addition to a distinction of two markedly different opinion groups, we have also called attention to the fact that expert E attached extreme importance to *beta glucan content* and *viscosity*, although most of the experts considered these less important. Being that both measures of value are of determining importance for the decanting speed of beer wort, the preference of these two characteristics might suggest an increase in the importance of equipment utilisation in brewing practice.

While analysing the rankings of quality factors, it also became apparent that the rankings and scales we obtained do not reflect the actual quality of malting barley but the views about it instead. Obviously, the two do not necessarily coincide since respondents determine preference based on problems of usage rather than on an abstract image of quality. This is to say that respondents deemed those characteristics relevant with which lack of quality causes the most problems and drawbacks for them. The difference between the two approaches is well demonstrated by the fact that the majority of the respondents (each one of respondents C, D, E, F, to be precise) evaluated the importance of *protein content*, thought to be one of the most important measures of value, rather low. It obviously does not mean that they would not consider it very important, but since very strict threshold values can be observed when receiving barley, the amount of protein content seems less relevant.

From the above it follows that we are not able to directly quantify a stable and universal index for malting barley quality from the obtained rankings and the interval scales, which have not been dealt with in depth in this paper. Moreover, the practical goal that was set, the effective quality improving strategy of breeding might as well be wrong if ranks and weights of the characteristics are interpreted mechanically when this strategy is being designed. From the responses, for example, it appears that their *level of classification* is undoubtedly a characteristic that is appreciated the least. The reason for this is that, on the one hand, a poor level of classification is a strong price-reducing factor in buying-up (thus the brewing industry compensates itself in advance); on the other, the adjustment of the desired level of classification is an integral part of the technology, a routine job, so to say. Thus from the viewpoint of the processors, a poor level of classification indeed hardly influences the brewing quality of barley. From all this, however, we cannot conclude that breeding could neglect the improvement of the level of classification.

Despite the above, our investigation helped us to project the quality image of brewing industry to breeding by shedding light on current trends of importance. At the same time, it also revealed that the qualification criteria largely depend on the circumstances and, for this reason, can change easily. Thus when formulating breeding strategy, it should be born in mind that instead of a forced improvement of characteristics ranked to be more important, it could be more effective to improve characteristics with minimum values irrespective of their place in the ranking. The elimination of minimum levels could be so important that, to achieve this, it could be worth making a compromise over quality with one or the other important characteristic (in case there is room for this, of course).

## GENERALISABLE CONCLUSIONS OF METHODOLOGY

In this paper we tried to demonstrate that an evaluation using the method of paired preference could usefully contribute to a more specific interpretation of less precisely defined notions like the ones in our example. This assumption strongly reminds us of KINDLER and PAPP'S (1977) experience according to which in an evaluation of complex systems the viewpoints that have not been defied precisely enough come to the surface and can be specified later on. However, our approach slightly differs from theirs because being aware of the vagueness of the initial picture, we endeavoured to separate the interpretations that cause this vagueness and become blurred. We might as well say that our survey is a kind of algorithmised form of the cognitive process with which, by revealing consistencies and inconsistencies, or the accords and disaccords (more generally speaking: the inconsistent nature of the interrelation system and the sufficiency of system factors), we make the observed system manageable for human thinking.

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## LITERATURE

BÉNDEK GY.: 1986: Söripari labormódszerek. Söripari Kutató, Budapest.

BSA 1996: Beschreibende Sortenliste 1996. Getreide, Mais, Ölfrüchte, Leguminosen, Hackfrüchte. Bundessortenamt, Landbuch-Verlag.

EBC 1994: Malting technology. European Brewery Convention Manual of good practice. Fachverlag Hans Carl, Nürnberg.

KINDLER J., PAPP O. 1977: Komplex rendszerek vizsgálata Műszaki Könyvkiadó, Budapest.

KUNZE V. 1983: A sörfőzés és a malátázás technológiája. Mezőgazdasági Kiadó, Budapest.

LARSEN, J. 2001: Evaluation of new European malting barley varieties. Proceedings of the 10th Australian Barley Technical Symposium, Rydges (Lakeside), Canberra ACT, Australia, 16–20 September 2001. (http://www.regional.org.au/au/abts/2001/t2/larsen.htm)

MEBAK 1984: Brautechnische Analysenmethoden, Band I und Band II. Methodensammlung der Mitteleuropäischen Brautechnischen Analysenkommission (MEBAK). Selbstverlag, Freising-Weihenstephan.

NARZISS, L. 1981: A sörgyártás. Mezőgazdasági Kiadó, Budapest.

PSOTA, V. – KOSAR, K. 2002: Malting quality index. Kvasný Prúmysl (Journal for brewing, malting & beverage industry) 48 p. 142–148.

SVÁB J. 1981: Biometriai módszerek a kutatásban. Mezőgazdasági Kiadó, Budapest.

*Table 1.*
*Major characteristing determining the brewing quality of malt*

| | *Charac-teristic* | *Its effect on quality* | *Determined using or on the basis of* | *Unit of measure* | *Level of acceptance* | *Opt level* |
|---|---|---|---|---|---|---|
| 1 | Calibration | It refers to the evenness of grain size. The germination of grains of the same size is more harmonized.<br>It also refers to the rate of saturated grains. The more saturated a grain, the better the starch/skin ratio and, consequently, the extract yield. | Sieves with 2.2, 2.5 and 2.8 mm holes | % | >70% | >85% |
| 2 | Protein% barley | The more protein there is in a barley grain, the lower its carbohydrate content and extract yield.<br>Protein molecules hinder rehydration and water distribution in the grain, which makes dissolution more difficult.<br>Too much protein may cause the beer to be turbid and it negatively affects the durability of the beer.<br>Too little protein may refer to poor enzyme activity and may worsen the tasting effect. | Determination of N with the Kjeldahl method | % | 9.5-11.7% | 10.2-11% |
| 3 | Germinatio n% | Only germinating barley may become malt. The starch content of non-germinating barley grains gets into the malt in an indissolluble form and causes problems of decanting. Due to non-germination, this is a characteristic that changes with time. Barley with shorter non-germination period is better. | Laboratory germination. The non-germination period can be characterized with the values measured 3 weeks after harvesting. | % | >90% | >97% |

*Table 1. (cont'd)*
*Major characteristing determining the brewing quality of malt*

| | *Charac-teristic* | *Its effect on quality* | *Determined using or on the basis of* | *Unit of measure* | *Level of acceptance* | *Opt level* |
|---|---|---|---|---|---|---|
| 3,1 | 48 hour rehydration | A characteristic that refers to the mealiness and solubility of the endosperm and to the structure of the integument. It influences the malting speed directly. | Determination of rehydration within 48 hours under standardized conditions. | % | > 44% | >47 |
| 4 | extract% | The amount of resolved carbohydrates in the wort. Beers need to contain extract quantity characterizing their type. | From the specific weight of laboratory wort produced under standardized conditions (congress wort) with a density bottle. | % | >81.5% | >83% |
| 5 | Total N | Actually this is a more precise indication of the protein quantity in the malt. | The Kjeldahl method from malt. | % | <1.9% | 1.6-1.7% |
| 6 | Total soluble N | The dissolved protein content of wort, an optimum characteristic. | The Kjeldahl method from beer wort. | mg/l | 550-1000 mg/l | 600-700 mg/ |
| 7 | Kolbach% | Together with the above dissolved protein content, this is a figure reflecting the solubility of the extract. This is an optimum characteristic. | Calculation: total soluble N divided by total N. | % | 40-53% | 42-48% |
| 8 | Viscosity | A colloidal state characterizing the degree to which the beer wort can be decanted. | A viscosity meter. | mPa/s | <1.67 mPa/s | <1.6 mPa/s |
| 9 | Beta glucan content | Insoluble polysaccharide. It deteriorates decantability. | | mg/l | <250 mg/l | <100 mg/l |

*Table 1. (cont'd)*
*Major characteristing determining the brewing quality of malt*

| | *Charac-teristic* | *Its effect on quality* | *Determined using or on the basis of* | *Unit of measure* | *Level of acceptance* | *Opt level* |
|---|---|---|---|---|---|---|
| 10 | Friability | A value characterizing the mealiness and the solubility of malt. A compensatory characteristic of glassiness (vitreousness). | A degree of sievability attainable through standardized friability of malt. | % | >79% | >86 |
| 11 | Apparent final attenuatio n | The quantity of maximally fermented extract. It is apparent, because the different specific weight of alcohol and water is not taken into account when this figure is being determined. | Calculated from the extract content of the beer wort before and after fermentation. | % | >79% | >86 |
| 12 | Diastatic enzyme activity | A characteristic of the enzyme activity resulting in the saccharification of starch. A joint effect of alpha and beta amylase. The stronger, the better. | Based on the decomposition of the extra starch added in a given quantity to malt. | WK | > 220 WK | >300 WK |
| 13 | Extract difference | The difference in extract yield between coarsely and finely ground malt. The lower it is, the more soluble the malt is. | Based on the difference in extract yield between coarsely and finely ground malt. | % | <3.3% | <2% |
| 14 | Hartong number, 45 °C | The extract yield of mashing at 45 degrees Celsius. It refers to the solubility and the enzyme activity of malt. | Extract yield of mashing at 45 °C in comparison to total yield. | % | 35-53% | 42-48% |
| 17 | Colour of the beer wort | It determines the type of the beer. Its value is also influenced by the dissolution of malt. Malts of good dissolution are brighter. | A comparison of the wort colour to a colour scale. | EBC | <5 | <4 |

*Table 1. (cont'd)*
*Major characteristing determining the brewing quality of malt*

| | *Charac-teristic* | *Its effect on quality* | *Determined using or on the basis of* | *Unit of measure* | *Level of acceptance* | *Opt level* |
|---|---|---|---|---|---|---|
| 18 | Saccharification time | The time under which the saccharification of starch occurs during mashing. | Iodine tests carried out at regular intervals after mashing has been started by determining the decay time of starch. | min | <20 min | <10 min |
| 20 | Totally glassy (vitreous) grains | The endosperm is totally glassy (steely). Such grains do not dissolve. | By cutting the grains, visually; or with a friabilimeter on whole, non-friable grains. | % | <4% | <2% |
| 21 | Partially glassy grains | The endosperm is only partially glassy. | By cutting the grains, visually; or with a friabilimeter, on the coarse non-friable endosperm in the screen. | % | <10% | <4% |

*Table 2.*
*Measures of quality of malting barley ranked by 6 experts based on paired preference tests*

| Order | Characteristic | Ranks from experts | | | | | | Average | | | z transformation of aggregated preferences | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | Rank | Scattering | Order | Pref no. | Pref% | z | Order |
| 1 | Germination% | 4.5 | 1 | 5 | 1 | 1.5 | 5 | 3.0 | 1.8 | 1 | 64 | 80% | 100 | 1 |
| 2 | Apparent final atten. | 12.5 | 7.5 | 3.5 | 2 | 4 | 1 | 5.1 | 3.9 | 2 | 51 | 64% | 75 | 2 |
| 3 | Extract dif | 4.5 | 7.5 | 3.5 | 4.5 | 6 | 9 | 5.8 | 1.9 | 3 | 47 | 60% | 69 | 4 |
| 4 | Extract% | 1 | 5 | 7.5 | 7 | 10 | 5 | 5.9 | 2.8 | 4 | 49 | 62% | 72 | 3 |
| 5 | Diastatic enzyme activity | 14 | 10 | 2 | 4.5 | 5 | 2.5 | 6.3 | 4.3 | 5 | 42 | 54% | 61 | 7 |
| 6 | Hartong number | 12.5 | 9 | 1 | 4.5 | 7.5 | 5 | 6.6 | 3.6 | 6 | 43 | 55% | 63 | 5,5 |
| 7,5 | Protein% barley | 2 | 2.5 | 13 | 10 | 7.5 | 7 | 7.0 | 3.9 | 7,5 | 41 | 52% | 59 | 8 |
| 7,5 | Friability | 4.5 | 4 | 6 | 8.5 | 10 | 9 | 7.0 | 2.3 | 7,5 | 43 | 55% | 63 | 5,5 |
| 9 | Beta glucan | 8 | 11 | 12 | 4.5 | 3 | 11.5 | 8.3 | 3.5 | 9 | 35 | 45% | 50 | 9 |
| 10 | Total soluble N% | 9.5 | 6 | 9 | 12.5 | 12 | 2.5 | 8.6 | 3.5 | 10 | 33 | 43% | 47 | 10,5 |
| 11 | Total N% | 4.5 | 2.5 | 10.5 | 12.5 | 10 | 14 | 9.0 | 4.1 | 11 | 33 | 43% | 47 | 10,5 |
| 12 | Kolbach% | 7 | 13 | 7.5 | 8.5 | 13 | 9 | 9.7 | 2.4 | 12 | 29 | 38% | 41 | 12 |
| 13 | Viscosity | 11 | 12 | 10.5 | 11 | 1.5 | 13 | 9.8 | 3.8 | 13 | 27 | 36% | 38 | 13 |
| 14 | Calibr% | 9.5 | 14 | 14 | 14 | 14 | 11.5 | 12.8 | 1.7 | 14 | 9 | 14% | 0 | 14 |

| | A | B | C | D | E | F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of triads | 19 | 5 | 12 | 21 | 28 | 57 | | | | | | | |
| Consistency | 83% | 96% | 89% | 81% | 75% | 49% | | | | | | | |

Max triads 112    v accord 0,11    k number of experts 6    $\chi^2$= 26,8

W concordance 0,34    u 3,74    no. of n charact. 14    *P= 2,5%

*Table 3.*
*Correlation between experts' rankings*

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | 1 | **0.60** | -0.33 | -0.13 | -0.20 | -0.27 |
| B | **0.60** | 1 | 0.11 | 0.16 | 0.12 | 0.23 |
| C | -0.33 | 0.11 | 1 | **0.70** | 0.28 | **0.60** |
| D | -0.13 | 0.16 | **0.70** | 1 | **0.65** | **0.50** |
| E | -0.20 | 0.12 | 0.28 | **0.65** | 1 | 0.10 |
| F | -0.27 | 0.23 | **0.60** | **0.50** | 0.10 | 1 |

*Table 4.*
*A comparison of rankings from experts A, B and C, D, E, F*

| Char. No. | Characteristic | AB rank | | CDEF rank | | AB | CDEF | Similarity group |
|---|---|---|---|---|---|---|---|---|
| | | average | scattering | average | scattering | rank | | |
| 2 | Protein% barley | 2.3 | 0.3 | 9.4 | 2.4 | 1 | 11 | III |
| 3 | Germination% | 2.8 | 1.8 | 3.1 | 1.9 | 2 | 2 | I |
| 4 | Extract% | 3.0 | 2.0 | 7.4 | 1.8 | 3 | 6 | II |
| 5 | Total N% | 3.5 | 1.0 | 11.8 | 1.6 | 4 | 13 | III |
| 10 | Friability | 4.3 | 0.3 | 8.4 | 1.5 | 5 | 8 | II |
| 13 | Extract dif | 6.0 | 1.5 | 5.8 | 2.1 | 6 | 5 | I |
| 6 | Total soluble N% | 7.8 | 1.8 | 9.0 | 4.0 | 7 | 9.5 | II |
| 9 | Beta glucan | 9.5 | 1.5 | 7.8 | 4.0 | 8 | 7 | I |
| 7 | Kolbach% | 10.0 | 3.0 | 9.5 | 2.1 | 9.5 | 12 | II |
| 11 | Apparent final attenuation | 10.0 | 2.5 | 2.6 | 1.2 | 9.5 | 1 | III |
| 14 | Hartong number | 10.8 | 1.8 | 4.5 | 2.3 | 11 | 4 | III |
| 8 | Viscosity | 11.5 | 0.5 | 9.0 | 4.4 | 12 | 9.5 | II |
| 1 | Calibr% | 11.8 | 2.3 | 13.4 | 1.1 | 13 | 14 | I |
| 12 | Diastatic enzyme activity | 12.0 | 2.0 | 3.5 | 1.3 | 14 | 3 | III |

| | | | |
|---|---|---|---|
| W (concord.) | 0.80636 | W | 0.614788732 |
| k (expert) | 2 | k | 4 |
| n (charact.) | 14 | n | 14 |
| $\chi^2$ | 20.9654 | $\chi^2$ | 31.96901408 |
| s (scattering of ranks) | 1.76017 | average s | 2.495978909 |
| rank corr AB/CDEF | -0.175 | | |

*Table 5.*
*Similarities in judgement of evaluation factors*

| Group code | Judgement of measures of value | Characteristic | **AB/CDEF** | AB | CDEF |
|---|---|---|---|---|---|
| | | | **Rank joint** | Rank | |
| I | Identical | Germination% | **1** | 2 | 2 |
| I | | Extract dif | **4** | 6 | 5 |
| I | | Beta glucan | **7** | 8 | 7 |
| I | | Calibr% | **14** | 13 | 14 |
| II | Similar | Extract% | **2** | 3 | 6 |
| II | | Friability | **6** | 5 | 8 |
| II | | Total soluble N% | **9** | 7 | 9.5 |
| II | | Kolbach% | **12** | 9,5 | 12 |
| II | | Viscosity | **12** | 12 | 9,5 |
| III | Contrary | Protein% barley | **5** | 1 | 11 |
| III | | Total N% | **10** | 4 | 13 |
| III | | Apparent final attenuation | **3** | 9,5 | 1 |
| III | | Hartong number | **7** | 11 | 4 |
| III | | Diastatic enzyme activity | **10** | 14 | 3 |