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THE USE OF WHEAT BY SCOTTISH GRAIN DISTILLERS

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THE USE OF WHEAT BY SCOTTISH GRAIN WHISKY DISTILLERS

INTRODUCTION

Two types of distilleries exist in Scotland. Malt distillers produce malt whisky from barley malt which forms both the source of enzymes and the substrate for fermentation. This barley malt is produced from barley suitable for malt manufacture. Grain distillers, by contrast, mix barley malt with a substrate of ground cooked cereal. The cereal can in principle be either maize, wheat or barley since the cereals are primarily being used as a source of starch for the fermentation process. Although mainly used in grain whisky production, the grain spirit can be further distilled for use in the manufacture of gin or vodka.

Traditionally, imported maize has satisfied the grain distillers' requirement for a consistent and easily processed supply of starch at a competitive price. North American maize can be imported at the world price under a special Inward Processing Relief (IPR) scheme that allows import levies to be abated by the 'export coefficient' that is agreed annually by the industry and the Commission. Since 1981, when grain in 'free-circulation' within the Community became eligible for export refunds, distillers have utilised home-grown grains. For the purposes of export refund calculations grain whisky was initially defined as whisky produced from 85% maize and 15% barley or malted barley. This definition was relaxed in July 1983 to include whisky made from any cereal and malt. Table 1 shows the changes that have occurred since 1980/81 in the use of grain reported by all the Scottish distillers to the Department of Agriculture and Fisheries for Scotland (DAFS).

Table 1 Use of Grain by Scottish Grain Distillers[1]

	Maize		Barley		Wheat		Total
	'000t	(%)	'000t	(%)	'000t	(%)	'000t
1980/81	457	(69)	203	(31)	0		660
1981/82	370	(75)	122	(25)	0		492
1982/83	332	(65)	182	(35)	0		514
1983/84	296	(55)	231	(42)	18	(3)	545
1984/85 (Estimate)[2]	125	(27)	145	(30)	200	(43)	470
1985/86 (Forecast)[2]	95	(19)	125	(25)	280	(56)	500

[1]Some distillers will purchase barley for malt production
[2]NOSCA

Maize purchases by distillers have fallen from around 70% of total grain purchases in 1980/81 to an estimated 29% of the total in 1984/85. Grain distillers initially replaced maize with barley when barley refunds first became available in 1981. Barley purchases increased rapidly over the period 1981/82-1983/84 to represent 42% of total grain purchases by Scottish distillers. The increase in barley purchases over this period from just 122,000 tonnes in 1981/82 to 231,000 tonnes two years later represented a major substitution of barley for maize.

After satisfactory trials with wheat as a cereal substrate in 1983/84, wheat has displaced both barley and maize in 1984/85 to such an extent that it now provides around 40% (200,000 tonnes) of the grain requirements of the Scottish distilling industry. It is used entirely by the grain distillers as a source of starch.

In selecting between maize, wheat and barley as cereal substrates the grain distillers are influenced by market prices for the grains, the export refunds available and the cost and efficiency of converting the different cereals into grain spirit. These various influences on the choice of cereal are now considered in some detail.

EXPORT REFUNDS AVAILABLE TO WHISKY DISTILLERS

Under the terms of the Common Agricultural Policy, refunds are payable on cereals used in the production of both Scotch Whisky and Irish Whisky. These arrangements were introduced on July 1st 1981 and published in Council Regulations Nos 1187/81 and 118/81 and Commission Regulation No 1842/81. The purpose of these refunds is to enable exporters of whisky to compete on world markets at prices which reflect the world price of cereals at the time of distillation. These refunds are paid to distillers at the time of distillation rather than at the time of export. This recognises that the export of whisky will often take place a number of years after distillation and that the prices of cereals at the time that the whisky is exported will bear little or no relationship to the prices of the cereals used in the production of that whisky. Furthermore, as whisky is frequently a blend of numerous similar products, it would be difficult to specify precisely the cereals used in the production of a specific batch.

The refund is payable to distillers on all purchased cereals of sound and fair merchantable quality and in 'free-circulation' within the Community. The basic rate of refund is fixed monthly. Prior to payment to distillers, the refunds are adjusted by an export coefficient which reflects the proportion of total whisky sales which was exported in the previous calendar year. These coefficients are set annually for the industry as a whole and result in the industry receiving refunds only on the proportion of material it expects to export.

Up to the 1st February 1985 the refund rate offered to distillers represented the difference between world grain prices and EEC threshold prices, regardless of the state of internal EEC markets. As a result, they often overcompensated EEC exporters using EEC grain, purchased at prices well below the threshold price. As from the 1st February 1985, the basic rate of refund now reflects the difference between the actual market price of grain within the Community and the price for similar material on world markets. The adjustments made on 1st February 1985 produced large reductions in wheat and barley refunds since prices for these cereals within the Community normally lie well below the threshold price. Maize, however, remains in deficit within the Community and prices tend therefore to be just below the threshold price. As a consequence, maize refunds were little affected by the change in the method of calculation.

The adjustment to the new method of calculation was spread over the three months December 1984 to February 1985. The resulting changes in the refund rates are reported in Table 2.

Table 2 Export Refunds on Cereals Used by Distillers (£/tonne)

	Barley	Maize	Wheat
August 1984	37.78	19.82	45.73
September	40.39	24.60	38.64
October	38.61	25.23	35.04
November	38.61	25.23	34.92
December	38.85	39.64	24.52
January 1985	35.23	40.34	16.36
February	36.92	37.78	15.47
March	36.92	37.78	15.47
April	34.97	40.40	22.89
May	42.44	48.47	32.17
June	44.25	49.54	34.83
July	43.86	54.27	45.75

Prior to the recalculation of refunds at the end of 1984, wheat and barley refunds were consistently greater than the maize refund. The wheat refund was regularly the most attractive of the three, principally because of its much higher threshold price.

Following the recalculations of refund rates and the gradual introduction of the resulting new rates, over the period December-February 1984/85, the wheat refund moved to a position well below both the maize and the barley refund. At times (January-March 1985) the wheat refund was just 40% of the maize refund. Since then the wheat refund has moved much closer to both the barley and the maize refunds. Barley refunds, over the period August-February 1984/85, moved in a similar direction but not to the same degree.

With maize prices within the EEC consistently well above wheat and barley prices, the maize refund will remain larger than wheat or barley refunds. Any weakening of the world wheat price relative to maize and barley will certainly increase the wheat refund but is most unlikely to equate it with that for maize.

THE CALCULATION OF EXPORT REFUNDS

Export refunds available for cereals exported in the form of processed products are based upon the 'basic' import levy charged to the grain. Basic import levies for individual grains are set each month and reflect the difference between the current threshold price and the average world price of the grain over the first 25 days of the 2nd preceeding month. This arrangement was introduced in June 1985 to allow easier anticipation of refund changes. Previously levies were based upon the average world price over the first 25 days of the 1st preceding month.

Export refunds equal import levies adjusted for 'Community preference'.

Community preference takes into account:-

1. The difference between internal EEC market prices and the threshold price used to calculate the import levy.

2. The difference in transport costs between import and export quotations.

3. The quality premiums paid within the Community for grain used by processors.

The first factor is calculated monthly by comparing, in the case of wheat, the average Rouen market price with the intervention price and the intervention price with the threshold price. The second and third factors (transport and quality differentials) are agreed figures that are reviewed whenever it is considered appropriate.

Before export refunds are paid to distillers they are reduced by the export coefficient which reflects the proportion of production the industry expects to export. Export coefficients are agreed each year and apply from the 1st of August for malt whisky and grain whisky. In recent seasons a decline in export activity has steadily reduced the coefficient from over 60% to 51.1% for grain whisky in 1985/86 and to 56.7% for malt whisky.

The 1985 July wheat export refund of £45.75 (Table 2) and the net refund actually paid (£23.93) were calculated in the following manner:-

Basic July Import Levy	£66.29
Less	
Community Preference	£20.54
= July Export Refund	£45.75
x 1984/85 Export Coefficient (Grain Whisky)	0.523
= Net Refund Received by Distillers	£23.93 (per tonne of wheat purchased)

While this method of calculating export refunds is now firmly established, small modifications may be introduced, if appropriate, by the Commission in the new 1985/86 marketing year. This system of calculating refunds enables claimants to predict refund rates quite precisely two months in advance. Distillers can therefore to some extent plan their grain purchases to take advantage of this knowledge.

GRAIN SPIRIT YIELDS FROM ALTERNATIVE CEREALS

The yield of spirit than can be obtained from a cereal grain is primarily determined by its starch content. Spirit yield can however be enhanced by the non-starch nitrogenous materials, such as proteins, found in cereals. During the fermentation process these materials will break down and contribute towards alcohol production. This process implies that any measurements of starch content under simulated distillery conditions, as carried out by Pentlands Scotch Whisky Research Ltd, will indicate a higher spirit yield than that indicated by a straight chemical analysis for starch. While the precise magnitude of the differences that result from the two methods is unclear it is not expected to be more than 1-2 percentage points.

Little variation appears to exist in the efficiency of the fermentation of starch from different cereal grains or in the subsequent distillation. The starch content of cereals is however only rarely measured. The Feedstuffs Evaluation Unit of the Rowett Research Institute has measured by chemical analysis the starch content of different cereals as part of an evaluation of the feed values of a wide variety of materials (Table 3).

Table 3 Starch Content of Cereal Grains

Cereal Grain	Mean Starch Content ±SD (%)	Range of Values Recorded	Range Within ± 1 Standard Deviation of the Mean (66% of Samples)
Barley (1974)(1)	55.6 ±2.59	51.6-60.9	53.01-58.19
Wheat (1977)(2)	66.0 ±3.95	61.5-76.8	62.06-69.97
Maize (1983)(3)			
US - No. 3 Yellow Corn	68.4 ±1.09	67.2-70.1	
French - South West	70.0	1 sample only	
- North of Loire	67.8	1 sample only	

Source: Feedstuffs Evaluation Unit, Rowett Research Institute.

(1)First Report 1975
(2)Second Report 1978
(3)Fourth Report 1984

For all three grains, 16 samples taken either from the respective GB harvest (barley 1974; wheat, 1977) or from what was generally available on the market (maize, 1983) were analysed using chemical methods. These results can only be considered to give an indication of the starch content found in the wheat, barley and maize purchased by grain distillers since no account was taken of the minimum quality standard now typically set by grain distillers. Furthermore, with grain samples taken from quite separate harvests, the results are not strictly comparable. However, in the absence of more comprehensive data these figures are used as the basis for comparisons between the three grains.

According to the Gay Lussac Equation 1,000 kg of pure starch will yield 721 litres of alcohol. This assumes a fermentation efficiency of 100% with no secondary metabolites and no yeast growth occuring. The chemical method used at the Rowett to derive starch content does not take into consideration other fermentable material in the cereal grain. Given this limitation and using a plant efficiency of 88% the commercial spirit yield for each cereal analysed at the Rowett can be calculated (Table 4). If other fermentable materials are taken into account many distillers will achieve a fermentation efficiency of 90%. This higher figure would not, however, change the **relative** costs of using either wheat, barley and maize.

If French maize from the South West is taken as the standard maize now used by distillers, the ratios of the mean spirit yield from maize as compared with that from wheat and barley samples is as follows:-

Maize:	Wheat:	Barley
100	91.0	76.7

Table 4 Estimated Spirit Yields of Cereal Grains (litres/tonne grain)

Cereal Grain	Mean Spirit Yield	Range Within ± 1 Standard Deviation of the Mean (66.6% of Samples)
Barley at 15% Moisture	300	286 - 314
Wheat at 15% Moisture	356	335 - 377
Maize at 12% Moisture		
US - No 3 Yellow Corn	382	376 - 388
French - South West	391	

Of the four grains considered in Table 4, barley has the lowest yield at 300 litres of alcohol per tonne of grain. Barley is not preferred by process managers because of its much higher fibre content and the problems this causes within distilleries. By-product yields from barley and consequently by-product recovery costs are greater than with wheat or maize whilst the value of the by-product is somewhat lower.

The spirit yield obtained from barley has been lifted by around 10% to over 330 litres per tonne of grain by some distillers when high quality grain has been used. The procurement of consistently high quality samples of barley has however proved difficult. As large bold grains are required with a high bushel weight to ensure a high starch content, some distillers have purchased intervention stocks of barley at well above the free-market price in order to ensure a consistently high quality supply of the grain.

The wheat sampled by the Rowett Research Institute had an average starch content of 66.0% (Table 3) and is estimated to yield 356 litres of alcohol per tonne of cereal. It should be noted, however, that this mean yield had an associated coefficient of variation (6%)* rather higher than that for the barley (4.7%) and US maize (1.6%). This comparison is tenuous however, given the different years involved. Despite its possibly more variable quality, wheat is well liked by grain distillers because it causes few of the problems that are associated with barley. Wheat with very high bushel weights of around 80 kg/hl (64 lbs/bushel) has been reported by several distillers to give a spirit yield very similar to that of maize. The bushel weight of wheat harvested in 1984 was exceptionally high and much of the wheat purchased by distillers in the first half of the season would have approached 80 kg/hl. As the season progressed the variation in the quality of the wheat available increased and it is likely that the spirit yield from wheats obtained in the second half of the season was lower. The exceptional qualities harvested in 1984 cannot be expected to be regularly repeated and it is therefore likely that grain distillers will normally be using wheat with a spirit yield inferior to that of maize.

Maize is the grain favoured by grain distillers because it is relatively easy to process and its use is well accepted by both producers and consumers alike. Whilst Scottish distillers have traditionally purchased US No.4 Yellow Corn, French maize is becoming increasingly competitive and will probably account for over half of Scottish grain distillers' maize purchases in 1984/86. Maize from the South of the Loire is favoured because of its superior quality. Unfortunately the Rowett Research Institute only analysed one maize sample from S.W. France but the very slender evidence may suggest a superior starch content to US No.3 Yellow Corn.

CEREAL VALUES FOR GRAIN SPIRIT PRODUCTION

The alcohol yields from the different cereals (Table 4) can be used to derive a grain cost per litre of alcohol produced. Such a calculation indicates the relative value of each cereal but without taking account of any differences between cereals in processing cost, by-product values or by-product recovery costs. Information on the costs of spirit and by-product production is not freely available but it seems likely that the processing costs of all cereals are very similar. In contrast, by-product recovery costs and market values vary greatly between plants and each distillery would need to calculate the specific consequences for by-product production of a change in the cereal substrate used.

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*66% of observations fall in the range 6% either side of the mean value.

The calculation of grain cost per litre of alcohol indicates shifts in the relative attractiveness of each cereal source even if precise information on the absolute value of the cereals cannot be given. In practice other non-price factors such as difficulties in obtaining consistent cereal quality and supplies, and organoleptic and marketing considerations as regards the alcohol produced will have a constraining influence on the choice of cereal. For example, a number of distillers have invested in plant designed specifically to process maize and maize by-products. These distillers are reluctant to switch to wheat since this would mean plant closure and loss of by-product markets. Furthermore, some whisky buyers are reluctant to accept grain spirit produced entirely from wheat. In order to guarantee an acceptable spirit quality, many distillers are limiting wheat to 75% of the mash with maize making up the remainder.

Table 5 and Figure 1 show the movement, since January 1984, in the cost of the cereal grains used in the production of one litre of alcohol from each cereal grain. This is simply the price of the cereal less the export refund (adjusted by the appropriate coefficient) divided by the spirit yield per tonne of grain. In deriving the Table 5 costs the following assumptions were made:-

(a) Grain distillers purchase cereal grains at the average spot price reported by the HGCA[1] - See Table 5.

(b) The spirit yield per tonne of grain purchased is equal to the average yield reported in Table 4.

(c) Grain distillers claim and receive the relevant export refund appropriate at the time - adjusted by the relevant export coefficient (Table 3).

Table 5 Cereal Cost per Litre of Alcohol Produced (p/litre, 1984/85)

Date	Barley	Maize	Wheat
Jan 1984	33.58	32.76	26.66
Feb	34.14	33.20	27.11
March	32.43	31.75	25.78
April	31.14	31.67	26.75
May	30.96	32.13	29.04
June	30.99	33.35	28.72
July	25.07	33.99	28.79
Aug	27.09	35.22	23.06
Sept	25.82	35.60	22.92
Oct	26.77	30.66	24.15
Nov	28.10	32.19	25.08
Dec	29.06	31.54	26.96
Jan 1985	30.19	31.45	29.72
Feb	30.56	32.30	30.31
March	30.61	32.81	30.51
April	31.54	33.49	30.64
May	30.40	31.90	29.69
June	28.98	31.75	29.15
July	26.30	29.58	27.47

(1) Home Grown Cereal Authority Weekly Bulletin.
Wheat and Barley prices reported weekly in Table 6 - Scottish average.
Maize prices reported weekly in Table 17 - Belfast (ciffo).

Figure 1 Grain Cost per Litre of Alcohol

Yield Ratio = Maize 100
Wheat 91.0
Barley 76.7

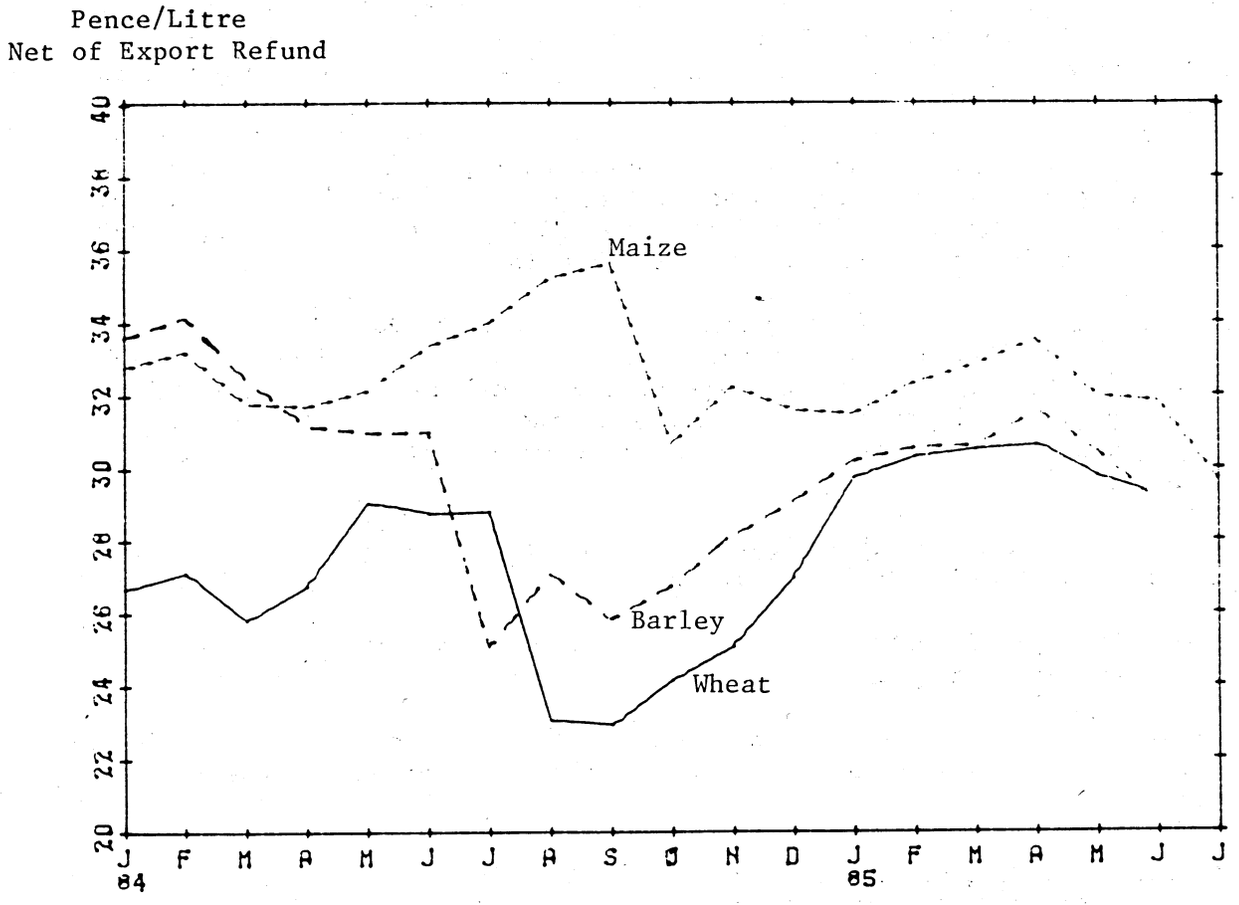


Figure 1 shows that since wheat became eligible for export refunds the cost of using wheat (per litre of alcohol produced) has been consistently below maize costs and generally below barley costs. Barley costs fell below wheat costs in July 1984 when winter barley became available well before wheat at low harvest prices. At that time of year many distillers close for their summer break and would not respond to short term price changes.

Maize costs reached a peak of 35.6 p/litre in September 1984 (Table 5) before falling back to average 32.7 p/litre through the rest of the 1984/85 season. This strong rise to the September peak was brought on by the combined effect of a strong end-of-season French maize price (£152/tonne) and a sharp fall in refund rates following the strong rise in the strength of the dollar and the dollar price of maize on world markets. A recovery in refund rates and a weaker French maize price, following the harvest, reduced maize costs quickly to around the 32 p/litre level.

In sharp contrast, wheat reached its lowest price level in September 1984 at 22.92 p/litre - almost 13 p/litre cheaper than maize. This low cost resulted principally from low wheat prices within the EEC following a record wheat harvest. Wheat refunds meanwhile had held up well following a sharp fall in world wheat prices. The recalculation of export refunds has significantly narrowed the gap between maize and wheat costs. Despite this,

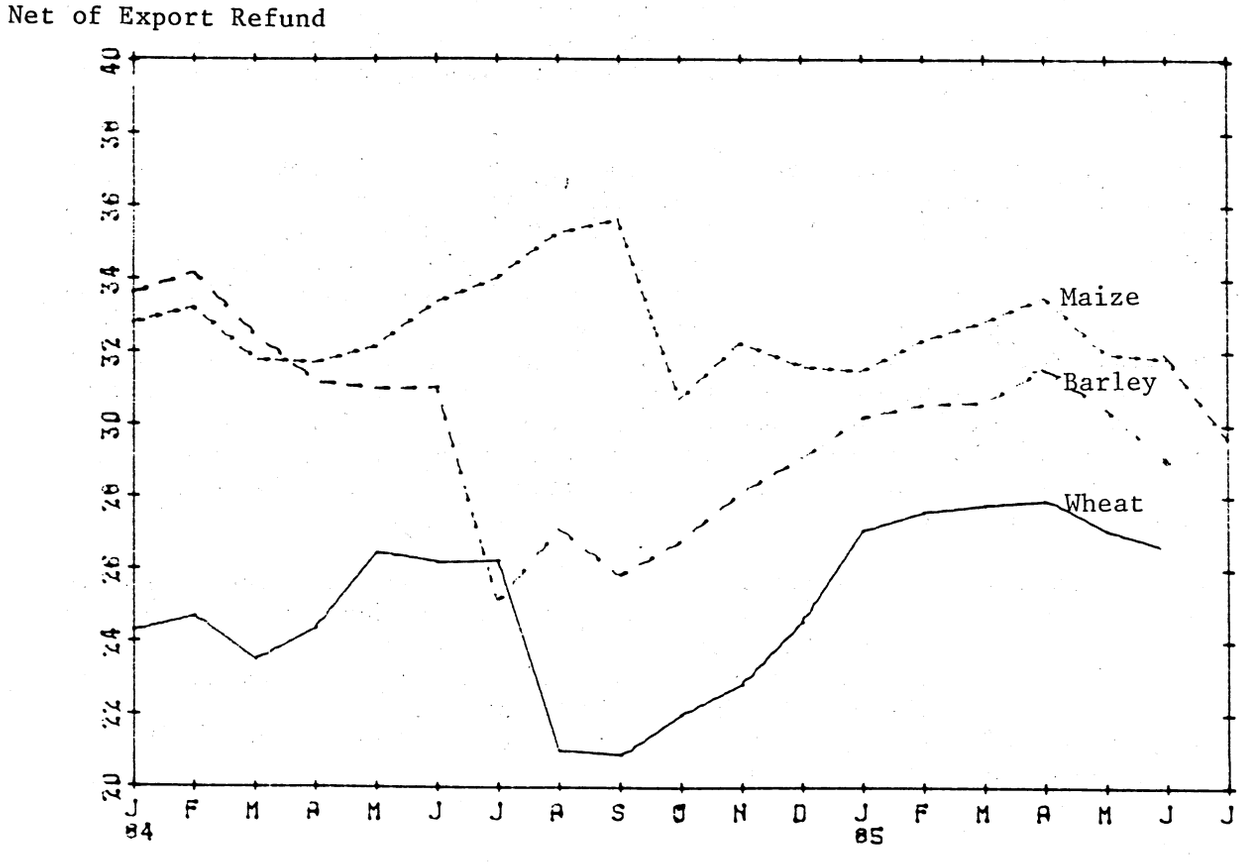
the cost of using wheat has remained at least 2 p/litre below maize costs since March 1985. This margin between wheat and maize is encouraging distillers to substitute wheat for maize whenever possible.

In Figure 1, wheat and barley are assumed to have spirit yields of 91.0% and 76.7% of maize respectively (Table 3 and 4). With this assumption wheat and barley costs appear to have become very competitive with each other since Janury 1985 - the period following the re-calculation of refund rates. However, given the difficulties experienced by many process managers in handling barley and the increased cost of by-product recovery, this convergence of wheat and barley costs will not have done much to encourage the use of barley as a substitute for wheat or maize.

In Figure 2, wheat is assumed to have a spirit yield equal to that of maize. This approximates to the 1984/85 situation when exceptional growing conditions lifted both wheat bushel weights and spirit yields. In this situation, wheat has remained the most competitively priced source of alcohol despite the recalculation of refunds. The extent to which distillers will switch from maize to wheat, given a price incentive, will in practice be constrained by the various manufacturing and marketing considerations discussed on page 7.

Figure 2 Grain Cost per Litre of Alcohol

Yield Ratio = Maize 100
Wheat 100
Barley 76.7



GRAIN QUALITY FOR DISTILLATION

When purchasing wheat or barley, distillers need to be aware of any price/quality relationships in order to buy in such a way as to minimise the costs of spirit production. The key indicators of quality for distillation are fermentable yield and starch content, both of which are highly correlated. The only quality criterion commonly used by traders is bushel weight. The bushel weight and starch content of barley do seem to be related.In 1980 when a large quantity of low bushel weight barley was harvested in the North East of Scotland, the Rowett Research Institute evaluated the starch content and feed value of various barley samples from the area (Table 6).

Table 6 Starch Content of Low Bushel Weight Barley[1]

Bushel Weight			Starch Content
	kg/hl	(lbs/bushel)	g/kg DM
'High'	62.1	47.9	528
'Medium'	56.7	45.4	500
'Low'	49.9	39.3	470

[1]Feedingstuffs Evaluation Unit Fourth Report 1984. Rowett Research Institute 1984, p. 42.

The results show the starch content dropping from 52.8% with 'high' bushel weight grain to just 47% with 'low' bushel weight grain which suggests a relationship between starch content and bushel weight and supports the present practice adopted by grain distillers of specifying a minimum bushel weight for barley.

By contrast, recent work by the Flour Milling and Baking Research Association(1) concluded that no justification can be found for using specific weight (bushel weight) as a quality characteristic in wheat. Correlations between specific weight and flour yield potential of wheat samples harvested during 1979-1982 were generally poor and influenced by endosperm texture, variety, growing site and year. Specific weight measurements were strongly influenced by both grain moisture content and its moisture history. The relationships established in this investigation were not considered useful as predictive aids to the flour miller. An extensive review of earlier work in this area indicated a lack of any general agreement between researchers as to the value of specific weight as an indicator of flour yield.

Clearly, further work is needed to identify a bushel weight/spirit yield or starch content relationship in wheat and to produce a within-year relationship that could be useful to distillers. At present, therefore,distillers do not seem well equipped to specify bushel weight requirements because the spirit yield gains from increased bushel weights are not known precisely. In view of the Rowett evidence with low bushel weight barleys their avoidance of low bushel weight wheats seems a sensible measure.

(1)Specific weight and wheat quality. Simon C W Hook, Flour Milling and Baking Research Association, April 1984.

An alternative approach would be to measure the chemical components of grain using infra-red analysis. This procedure is regularly used by maltsters to measure the nitrogen content of barley and there is no reason why it could not be applied to starch content in wheat. Before advocating such a move, however, it would be useful to have more information on the variation in starch content present in any one year and the extent to which starch content could be predicted by some simple measure such as bushel weight or 1000 grain weight.

THE FUTURE USE OF WHEAT BY GRAIN DISTILLERS

The uptake of wheat by Scottish grain distillers will depend upon the continuing availability of wheat in Scotland at prices (net of refund) that are competitive with barley and maize. Given the current method of calculating refund rates, which relate internal EEC grain prices to world prices, any change in internal EEC prices will produce an equal change in refund rates and will not alter the relative position of wheat, maize or barley. A Scottish wheat harvest with poor bushel weights would, however, encourage distillers specifying a minimum bushel weight of 72 kg/hl to purchase the majority of their supplies from better quality areas in England and France. A price premium of, say, £4/tonne for high quality wheat with a spirit yield similar to that of maize (approximately 400 litres/tonne) would increase production costs by 1 p/litre of alcohol produced. Given the relative attractiveness of using wheat, such a penalty is unlikely to deter grain distillers from maximising their wheat usage. Only changes in the method of calculating refunds or changes in world prices are therefore likely to affect the competitive position of wheat in relation to barley and maize.

No further change is expected in the method of calculating refunds. On world markets, price relativities and refund rates could be expected to remain stable if no change occurred in the current market situation. With the prospect, however, of further increases in the world production of wheat and coarse grains, increasing stock levels and a reduced level of world trade in grain, price differentials between the major grains are likely to narrow. This movement will tend to favour wheat which normally trades at a premium over maize and barley. This will in turn tend to increase the wheat refund relative to refunds for both maize and barley.The overall effect of a narrowing of price differentials on world markets would therefore be to increase the competitive position of wheat relative to barley and maize and ensure its continued use by distillers.

Table 1 illustrated the use of grain by Scottish distillers of all types, reported to DAFS since 1980/81. The estimates made for 1984/85 are based upon returns made to DAFS up to May 1985. They indicate that total purchases of grain by distillers will fall from 545,000 tonnes in 1983/84 to around 470,000 tonnes in 1984/85. Of this 125,000 tonnes will be maize - (compared to 296,000 tonnes the previous season) and 143,000 tonnes will be barley - (compared with 231,000 tonnes in 1983/84). The remaining 200,000 tonnes is wheat and reflects the rapid switch by grain distillers from maize and barley, to wheat.

In 1985/86 some recovery in distilling activity is expected with total grain usage by the Scottish distillers climbing back to a forecast 500,000 tonnes. Of this, at least 25% (125,000 t) will be barley purchased for the production of malt. The remaining 375,000 tonnes can be expected to be split between wheat and maize in the ratio 3:1. With maize continuing to represent up to 25% of the grist, wheat usage will continue to expand to an estimated level of around 280,000 tonnes in 1985/86.

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(1)Specific weight and wheat quality. Simon C W Hook, Flour Milling and Baking Research Association, April 1984.

SUMMARY

1. Since July 1983 when, for the purposes of export refund calculation, grain whisky was re-defined to include spirits produced from any cereal, Scottish distillers have been evaluating wheat as a source of starch for distillation. In principle either maize, wheat or barley can be used as a source of starch for the fermentation process. The choice is influenced by grain prices, the export refunds available and the cost and efficiency of converting the different cereals into grain spirit.

2. Using measurements of cereal starch content, made at the Rowett Research Institute, the yields of spirit obtained from maize, wheat and barley were calculated to the related in the following ratio:

Maize 100: Wheat 91.0: Barley 76.7

Using these levels of efficiency it is calculated that the cost of using wheat has been up to 13 p/litre of alcohol produced below the cost of using maize. In the first half of 1985 wheat costs have rarely been less than 2 p/litre below maize costs. These margins have encouraged grain distillers to substantially increase their use of wheat. Whilst the cost of using barley (per litre of alcohol produced) has become similar to wheat in recent months, other problems associated with barley have discouraged distillers from using barley for whisky production.

3. Wheat with a high bushel weight approaching 80 kg/hl is believed to give a spirit yield similar to maize. Many distillers were able to obtain wheats with high spirit yields from the 1984 harvest by specifying bushel weights of at least 72 kg/hl. More detailed investigation is needed in this area together with an evaluation of the potential for quality determination by infra-red analysis.

4. Wheat is expected to remain the most competitively-priced source of cereal starch for Scottish grain distillers. Consumer requirements and past investments in maize-specific plant will dictate that at least 25% of grain distillers' purchases are as maize. The remainder (apart from barley purchased for the production of malt) will be wheat. A recovery in distilling activity in Scotland in 1985/86 should lift total wheat usage by Scottish grain distillers to 280,000 tonnes.