# DISTILLED SPIRITS

## *Tradition and innovation*

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# Chapter 33

## The renaissance of American Bourbons: developments and technical challenges of the production of premium Bourbon distillates by batch distillation

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### Introduction

Generally, whisky is made from grain, distilled to less than 95% alcohol and aged in oak barrels for 3 years. Examples of American whiskies range from Canadians like Canadian Mist to Bourbons like Old Forester and Jack Daniels Tennessee Whiskey. American Bourbon has become the new American spirit and its heritage starts in the 1800s. The Bourbon making tradition at Brown-Forman started in 1870 when George Garvin Brown founded the company. The company still remains under the same family ownership. During this early time, whisky and Bourbon making was established and rooted in Kentucky as fine art and became a very vigorous industry. River ports like Louisville became key hubs of shipping whisky bulk in barrels down south to major cities like New Orleans.

Some key market facts related to the late rebirth of the American Bourbons.

- Approximately $1.5 billion in retail sales
- Bourbon rebirth began in 1992
- 70+ Super/Ultra-premium brands introduced.
- 230,000 cases in sales in 2000.
- Significant shift to Super/Ultra-premium brands.
- Bourbon category 1996-2000 Gross Revenue growth: +0.1%
- Super/Ultra-premium 1996-2000 Gross Revenue growth: +20.1%
- Super/Ultra-premium volume doubled since 1996.

Let us focus on one of the brightest success stories and the oldest registered distillery in the US, Labrot and Graham (L&G), where Woodford Reserve is produced.

The standard of identity of American Bourbon is more restrictive than the one for general whisky, which was outlined previously. Bourbon should be:

- At least 51% corn grain recipe
- Distilled at maximum 160 proof (80% abv)
- Entry proof no more than 125 (62.5 % abv)
- Matured in newly charred American white oak barrels
- Produced and matured in the USA

### Bourbon manufacturing process

Water is a key and vital element in creating the final Bourbon of premium quality. The Kentucky limestone water has been credited since early times as being the cornerstone of the production of fine Bourbons and great thoroughbred racehorses in Kentucky.

The grain recipe is a mix of corn, rye, and malted barley in varying proportions with corn at least 51%.

Milling is conducted to a defined particle size. Mashing and Bourbon beer preparation is done in the same old fashioned process described in the old recipes and the fermentation is carried through in old-fashioned Cypress fermenters under controlled conditions.

Distillation is carried through by continuous column distillation (Coffey stills) for most of the Bourbon produced in the USA. However, L&G is the only distillery in the US where Bourbon is produced by triple copper pot distillation, as it was produces by our forefathers in the early 1800s.

This process utilizes copper pots that were manufactured in Scotland and is the only process employed worldwide on a large commercial scale to produce Super Premium Bourbon such as Woodford Reserve.

This unique Bourbon process presented us some challenges that where the result of the inherent properties of the Bourbon mash beer and the traditional copper pot still distillation.

We are going to review these unique differences in mash beer composition, distillation process and distillation equipment that makes American Bourbon and specifically Woodford Reserve a truly unique product rooted in the American Bourbon tradition.

Comparing Bourbon beer with Scotch wash in Figure 1, reveals the unique properties and therefore challenges of Bourbon distillation.

Starting from the bottom of figure 1, Scotch wash and Bourbon beer appear very similar from alcohol to ethyl acetate content.

However, starting with the fusel oils we see differences, with beer containing higher amounts. Even more dramatic are the differences when we compare % solids, % protein and total lipids. Bourbon beer contains much higher amounts of solids and lipids compared to Scotch wash and therefore presents a much greater challenge in its distillation by copper pot stills.

A quick comparison (Table 1) of the typical grain recipe for Scotch malt and Bourbon beer shows the great difference in the amount of total lipids in an average beer charge of 2500 gals. While in a traditional wash charge we find almost negligible lipids, in the case of Bourbon beer it is common that over 200 lbs of lipids

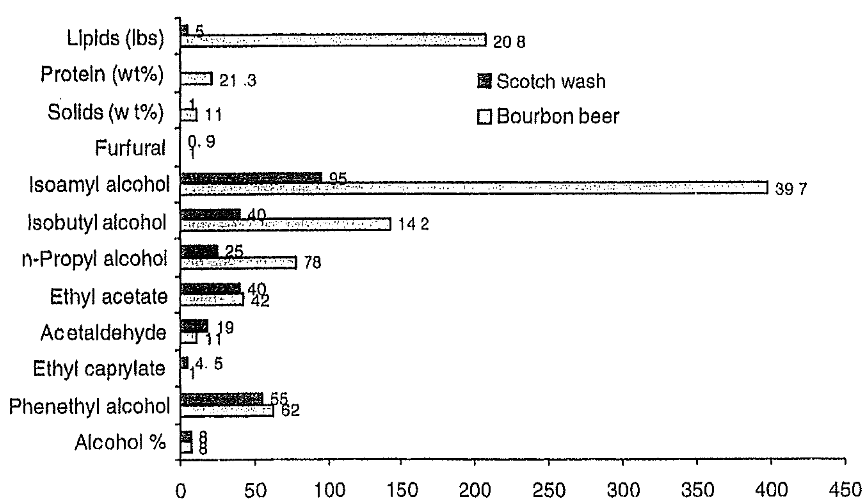


**Figure 1.** Analytical chemistry comparison between Bourbon beer and Scotch wash (except where shown, units are ppm).

may be present during beer distillation. This necessitates very careful management of the subsequent three distillation steps and the resultant heads and tails in order to prevent unnecessary development of flavors related to lipid oxidation.

**Table 1. Lipids In Bourbon Beer**

| | *Scotch malt wash* | *Bourbon beer* |
|---|---|---|
| Charge volume (gal) | 2500 | 2500 |
| Grain weight (lbs) | 4100 | 5000 |
| Grain usage (wt%) | | |
| Corn | 0 | 78 |
| Rye | 0 | 10 |
| Malt barley | 100 | 12 |
| Lipid content (wt%) | | |
| Corn | 4.8 | 4.8 |
| Rye | 1.8 | 1.8 |
| Malt barley | 2.1 | 2.1 |
| Lipids (lbs) | Negligible | 208 |

Let us look at the key differences between the two distillation processes in use for the production of American Bourbon.

Copper pot still
- Batch
- Three plates (Triple)
- Copper
- Heat transfer: metal-liquid/solid
- Steam from water
- Solid / liquid ratio increases with time
- Distilled to 160 proof (80%)

Coffey column still
- Continuous
- Multiple plates
- Stainless steel
- Steam contact (bubbles throughout
- Solid / liquid ratio decreases with time
- Distilled to 140 proof (70%)

In more detail, the traditional Scotch distillation is a double distillation of the wash. Foreshots and feints management is employed during the second spirit distillation (Figure 2).

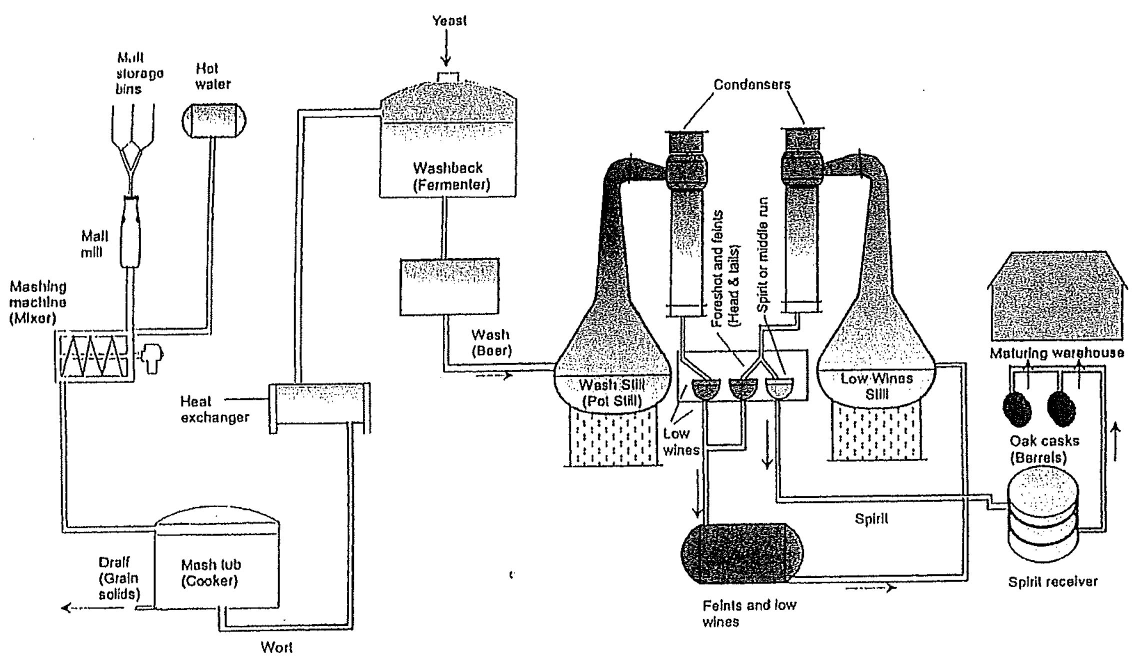


**Figure 2.** Traditional Scotch whisky distillation process

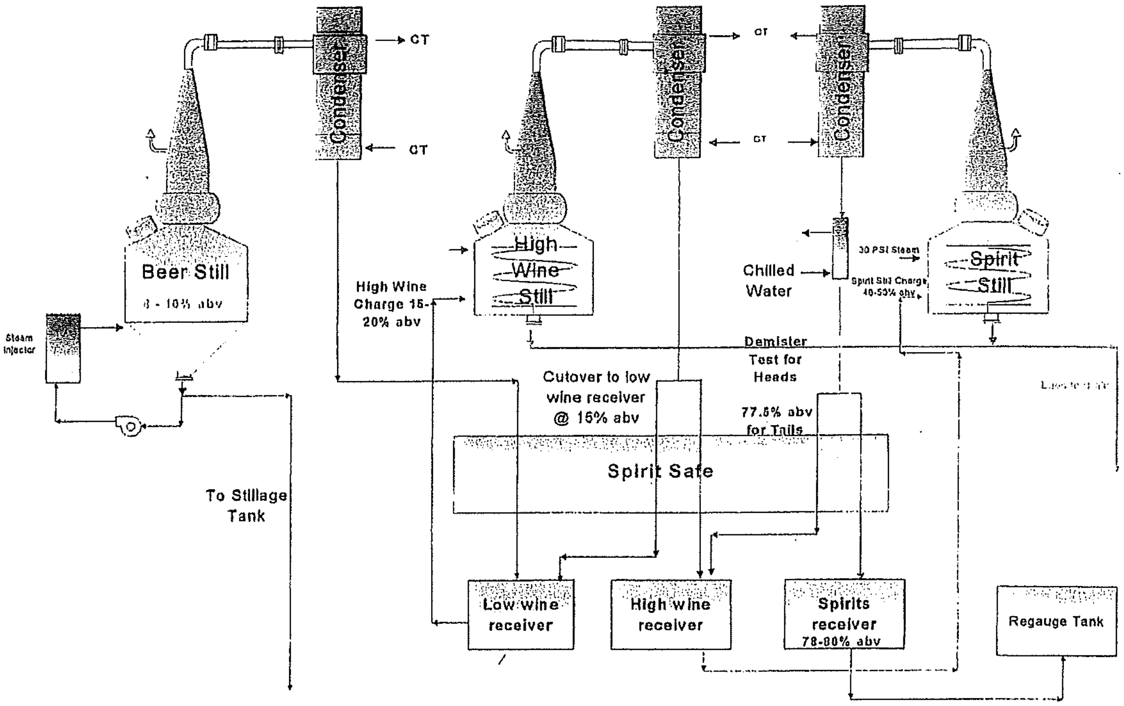


**Figure 3.** Labrot & Graham triple pot still distillation for Bourbon

However, in the case of L&G we have a triple distillation with heads and tails management during the second (high wines) and third (spirit) distillations (Figure 3).

Let us look at another key processing difference between column and pot stills that may affect even more the final product quality if not carefully managed. Looking at the time and temperature profile comparison for the product (Figure 4), we see that, during column distillation, the product temperature rises quickly and in about 20 minutes spirits and tails are separated with minimum heat exposure. However, in the case of the pot beer distillation, the product sees a slow and gradual temp rise and a constant distillation at around 200°F for about 6 hours.

This extended heat exposure requires challenging separation and management of heads and tails downstream in order to produce superior quality.

## Product quality evaluation and research methodology

Let us review some of the key analytical and sensory methods we have employed during the scale up of the Triple Copper Pot still process. Chemical analysis included gas and liquid chromatography while in sensory analysis we will discuss discrimination, descriptive and consumer analysis.

### Gas chromatography

- GC/FID with glass packed column
- GC/FID with capillary column
- Multidimensional GC with multiple detectors
  - Mass spec
  - FID
  - PID
  - Sniffing port

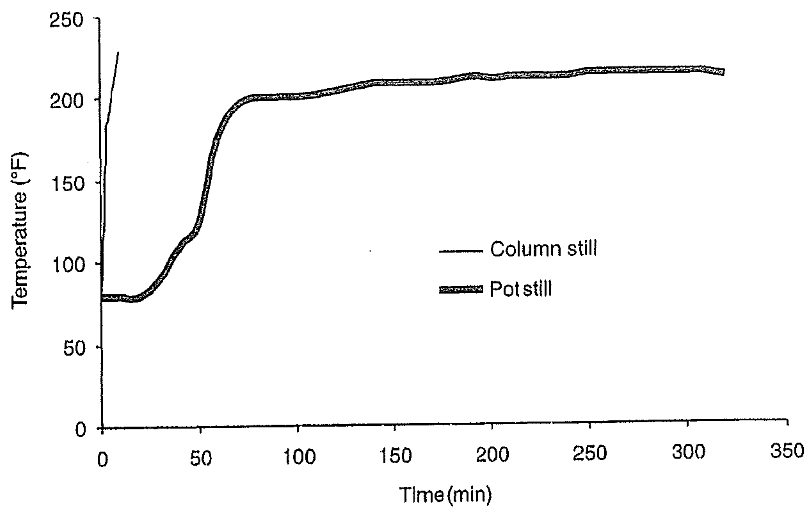


**Figure 4.** Beer distillation time-yemperature profile column vs. pot stills

### Liquid chromatography

- Ion exchange column & refractive index detector for whiskey sugars
- C18 column & photo-diode array detector for whiskey phenolics

### Sensory analysis

Sensory analysis was crucial in establishing correlations between the analytical and the sensory descriptors of the panelists and more importantly the terms that the consumer uses to describe and appreciate the products.

Three different general techniques were used:

#### *Discrimination testing*

- 30-member triangle tests
- 30-member Degree of Difference test
- Multidimensional Scaling

#### *Descriptive testing*

- Quantitative Descriptive Analysis: employee panel
- Trained panel providing descriptors and intensities of aromas and flavors in American Whiskies

#### *Consumer testing*

- Local consumer database of 4,000 consumers
- Segmentation by brand consumption
- Central location testing

## Chemical composition comparison

Now that we have covered the evaluation methodologies let us turn our focus to the distilled whiskies as they were tracked from the state of new spirit to the later stages of more mature products.

Figure 5 shows a typical time profile of some critical compounds as they distill off the beer pot still. Isoamylacetate, ethylcaproate and ethylcaprylate come off the beer earlier relative with ethyllacetate and phenethylacetate.

Comparison of the volatile profiles of new whiskeys from column and pot still distillations in figure 6 reveals some interesting differences.

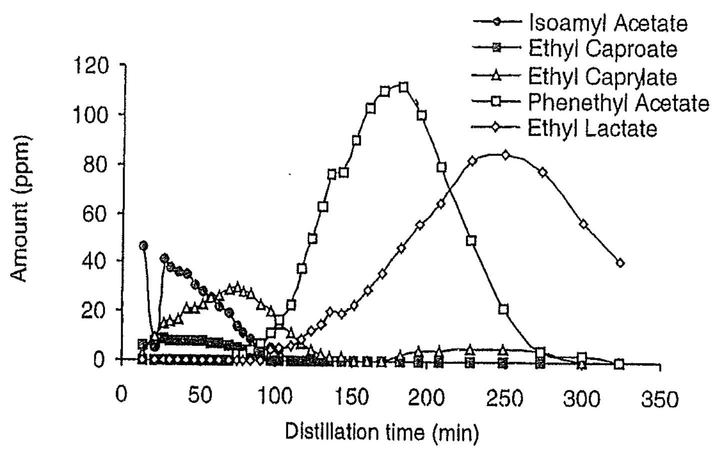


**Figure 5.** Volatile compounds time profile from Bourbon beer copper pot still distillation

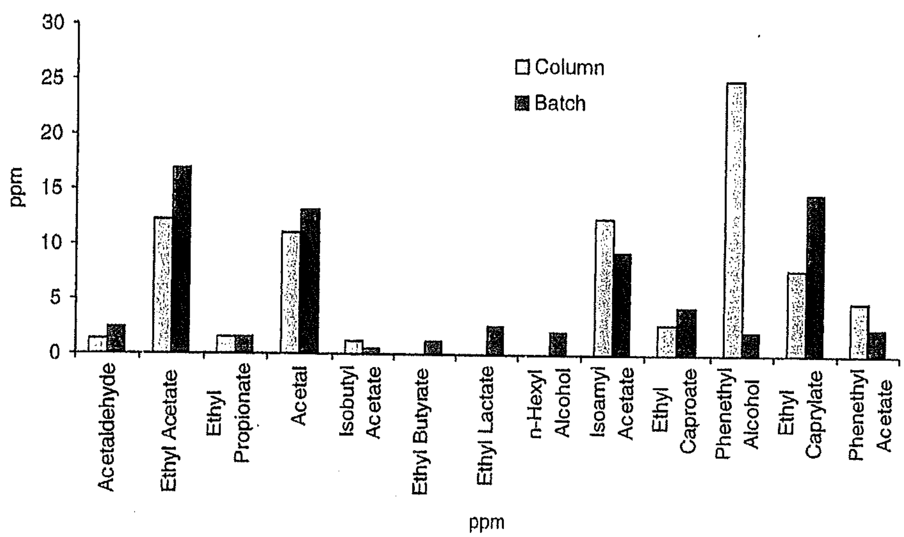


**Figure 6.** Comparison of volatile profiles of new whiskeys from column and pot still (batch) distillations

Although column and pot still new whiskies are generally the same for the first compounds on the left (acetaldehyde, ethyl acetate, acetal etc.) there are marked differences in the middle of the bar chart (ethyl butyrate, ethyl lactate, n-hexyl alcohol), and a big difference in the content of phenethyl alcohol. Column distilled new whisky contains much higher amounts of phenethyl alcohol.

The same comparison of the fusel oils reveals general similarity between the two processes with total fusel oils for both column and pot still produced new Bourbon whisky ranging between 3000 and 3500 ppm.

A different way that demonstrates the difference in the analytical fingerprint between the column and pot still new whiskies is shown in the Figure 7 spider graph.

The scale has been standardized at 100% for the column Bourbon analytical quantities. The pot still new whisky analytical chemistry is compared to this relative scale.

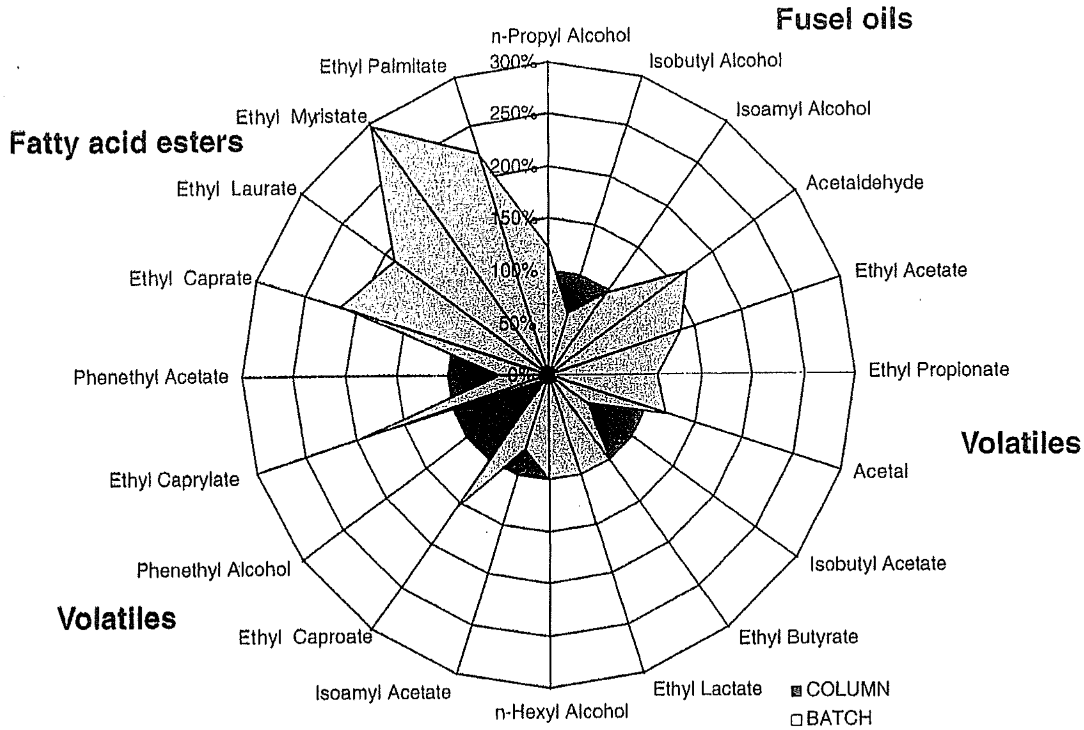


**Figure 7.** Comparison of analytical data for Bourbon new whiskeys produced by column and pot still distillation.

The key differences are in the fatty acid esters and in some volatiles like phenethyl alcohol, phenethyl acetate, isobutyl acetate, and isobutyl alcohol. Additionally, we found that the presence of some key low threshold compounds in the new pot still spirit can have a profound impact on the flavor and aroma profile of the new whisky.

In general, early new spirits from the pot still were characterized by the presence of furfural, benzaldehyde, 2-nonenal, higher amounts of 2-amylfuran and the absence of phenethyl alcohol.

## Maturation tracking

Let us turn our focus on our maturation tracking as these new whiskeys mature in newly charred American oak barrels. This is one of the most crucial stages of the development of the product since it is during this stage that more than 60 to 70% of Bourbon identity is developed.

Figure 8 shows the results of multi-dimensional scaling and sorting of a host of new whisky samples from the two processes of pot still and column distillation (designated as PB for Pot Bourbon and CB for Column Bourbon).

Principal component analysis of all the sensory differences shows clearly that the two processes produced products that grouped apart from each other in these two dimensions.

However, as we advanced our expertise with the new copper pot stills we were able through some careful management of the distillation process, to produce experimental samples with the pot stills that were easily grouped closer to the column Bourbon group (Figure 9).

As we tracked these fine new spirits through maturation, we discovered they merged closer to each other as the effect of the wood had a major impact.

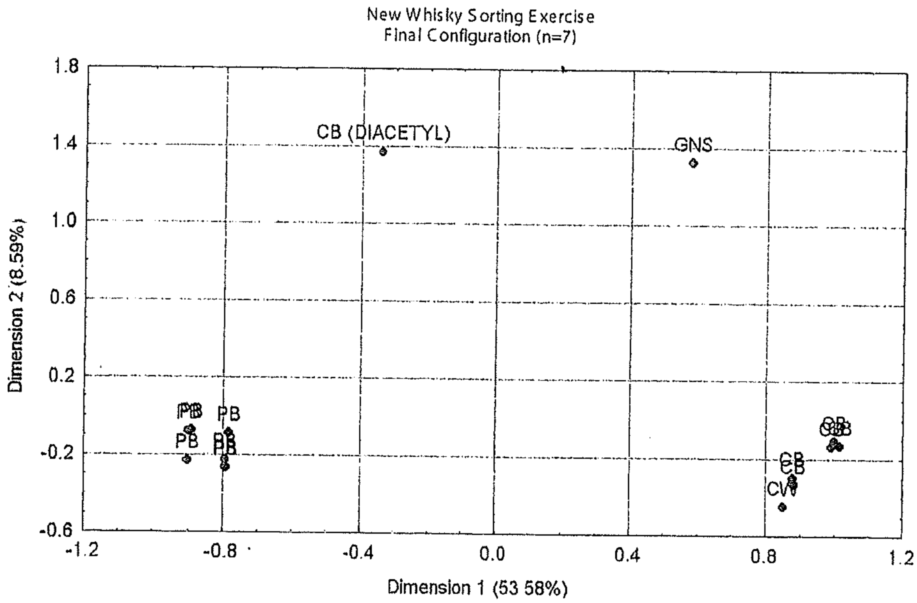


Figure 8. Sensory multidimensional scaling and sorting of Bourbon new whisky

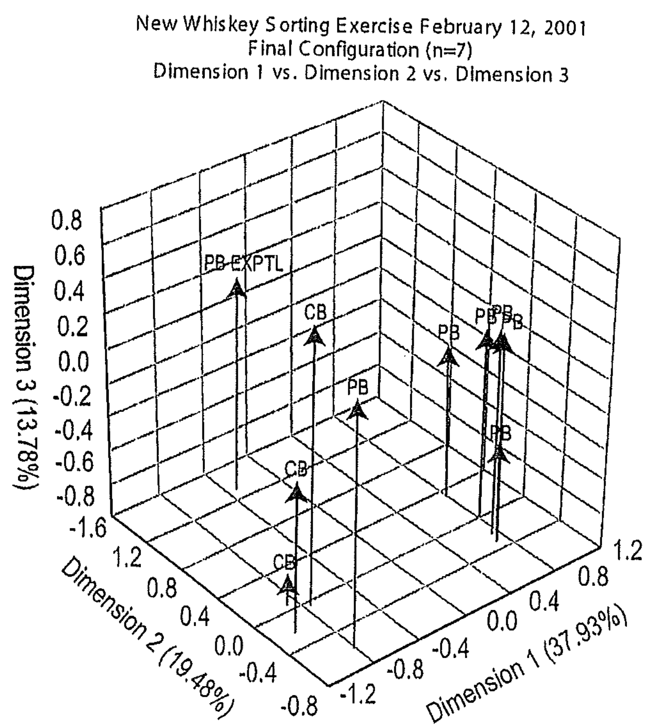


Figure 9. Sensory multidimensional scaling and sorting of Bourbon new whisky

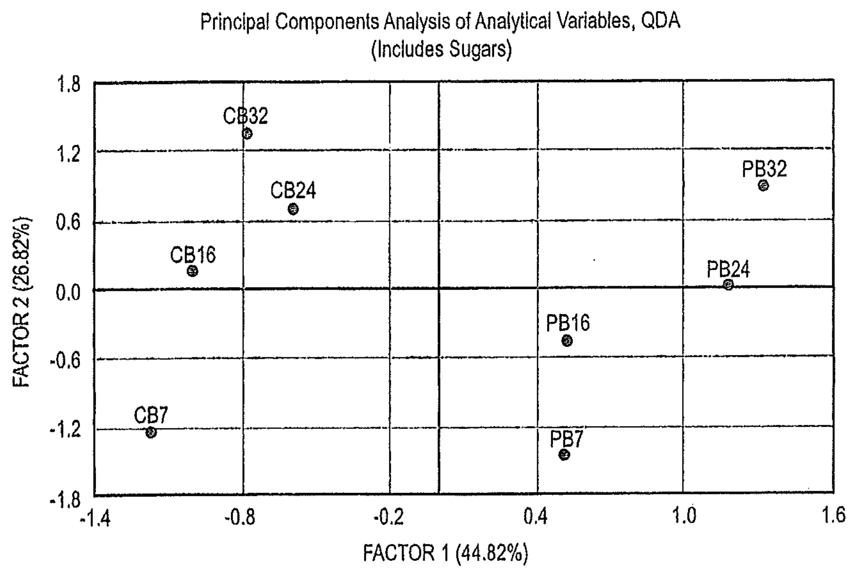


Figure 10. Analytical data principal component analysis of Bourbon new whiskies

Figure 10 shows principle component analysis of the analytical variables for the two new spirits as they mature with time designated by the number of months. Again PB is for Pot Bourbon and CB for Column Bourbon.

The progression of these two spirits is shown to be almost parallel based on the measured analytical chemistry. In the same way, we can see how the tracked aroma components changed as a function of maturation time in Figure 11. As you move to the left lower hand corner of this figure the effect of wood increases in the form of higher intensities of vanilla, caramel, and diminishing grainy and fusel oil aromas.

The progression of the Pot Bourbon can be seen nicely converging with the Column Bourbon samples through month number 32. A similar plot of the tracked flavor parameters shows exactly the same effect in Figure 12. Here movement to the right lower hand corner represents an increasing effect of wood during maturation. All the pleasant flavors that åre associated with fruity, sweetness, vanilla and caramel descriptors develop during this stage.

The same movement represents diminishing grainy, sourness and alcohol burn. Again the converging of the Pot Bourbons and Column Bourbons can be seen as maturation continues.

Now I would like to review in brief some additional programs that are in development at Brown-Forman and at our own Blue Grass Cooperage. These programs have shown great promise and give us more tools in our efforts to develop more exciting Super Premium Bourbons to compete in this new high growth market:

New studies into the origin of American oak and how it affects the products.

New barrel toasting technology that gives new dimensions to maturation.

New comprehensive moisture management system, which spans from the log yard to the barrel raising factory.

New research into the effect of wood seasoning is starting to give new insights into this undervalued and often neglected process during production of barrels for spirit maturation.

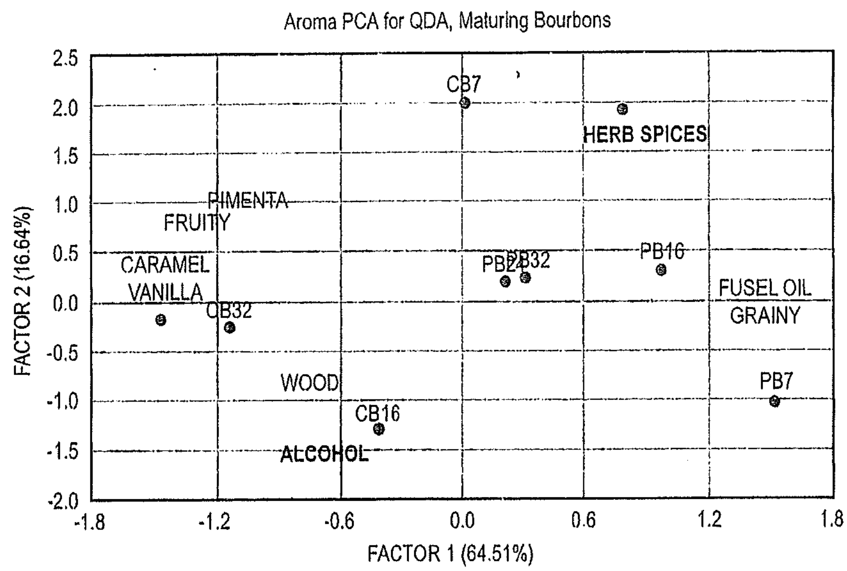


Figure 11. Aroma component principal component analysis of Bourbon new whiskies

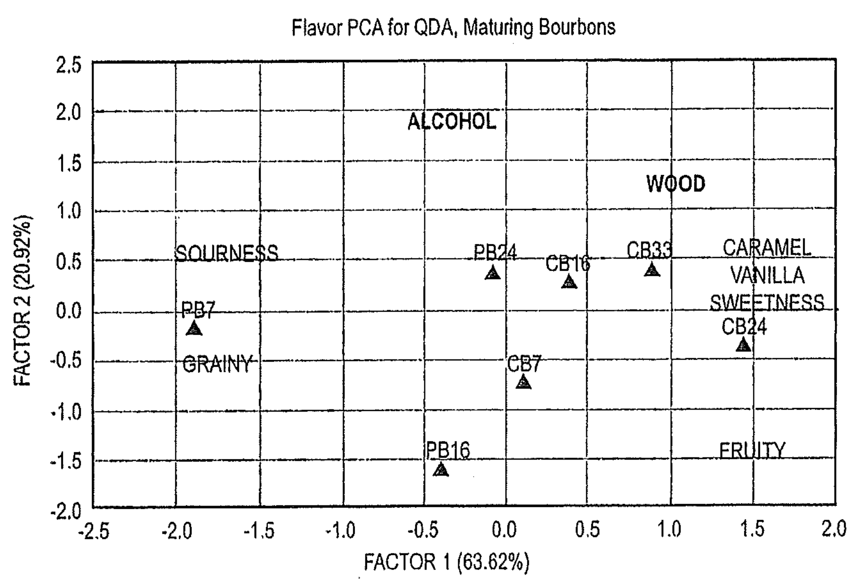


Figure 12. Flavor component principal component analysis of Bourbon new whiskies

New automated and computerized stave jointing equipment ushers in a new era for Blue Grass Cooperage as it moves from the traditional manual jointing to this accurate high-speed process.

New integrated data acquisition system which integrates all functionss from the log buying operation and origin of wood through barrel making, to maturation and warehouse temperature and location.

This new system now gives the capability to predict colour, overall quality and even yield loss of the whiskey on an individual barrel basis.

## In summary we have found that:

- Creating a super premium Bourbon via pot still distillation has proven challenging but not impossible;
- Wood/barrel and maturation effects were key factors and they are responsible for more than 60% of the flavor identity of the product;
- New research into oak regions in the USA, wood seasoning and toasting technology has given Brown-Forman new avenues to create exciting Super Premium Products in this fast growing category;
- New sensory and analytical techniques have been critical in quantifying product differences between column and pot still whisky; and
- These same techniques were invaluable in designing and producing Woodford Reserve.

Even more valuable, is the confirmation that despite all our insights it is still up to "Mother Nature and Father Time" to help with the refinement of these fine products.

As we continue to understand the complex chemical reactions that take place during maturation, we are committed to produce and bottle this fine Bourbon from Woodford County, Kentucky. A fine heritage which started with a group of dedicated individuals in 1812 still continues full circle today at Labrot & Graham.