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Vodka: *distinct tastes of a tasteless drink*

Abstract

Vodka is one of the most popular drinks in the world. However, there has been very little scientific research done on it in comparison to other alcoholic beverages such as whiskey, beer, and wine. This is largely attributed to vodka's simple composition, and it's classification as a distilled beverage "without distinctive character, aroma, taste, or color." Regardless of this classification, the majority of consumers have a strong taste preference when choosing between clear vodkas of the same proof. Surprisingly, new research has shown that molecular structure could be a possible source for these preferences; thus making way for new prospects in the science of vodka.

What exactly is vodka?

A beverage used in countless mixed drinks and known to be a staple in countries such as Poland and Russia, vodka is one of the most popular drinks in the world. The word "vodka" is a deviation from the Russian word for water, *voda*, and literally translates to 'little water.' [1] Its versatility can be attributed to its lack of complexity by nature, as it is simply ethanol diluted by water. The standard typically found in commercial markets for vodkas is 80 proof, which is equivalent to a 60-40 percent mixture of water and ethanol. [2] According to the US Code of Regulations, Title 27, Volume 1, vodka is a spirit that is treated and distilled to be "without

distinctive character, aroma, taste or color," [3] a summation that fails to accurately depict the nuances associated with this popular drink.

Manufacturing Vodka

Vodka is typically made from a form of grain, but can also be made from potatoes, molasses, or anything that has a starch base. Starting with the starch base, vodka's manufacturing process can be broken down into six major steps detailed in the following figure.

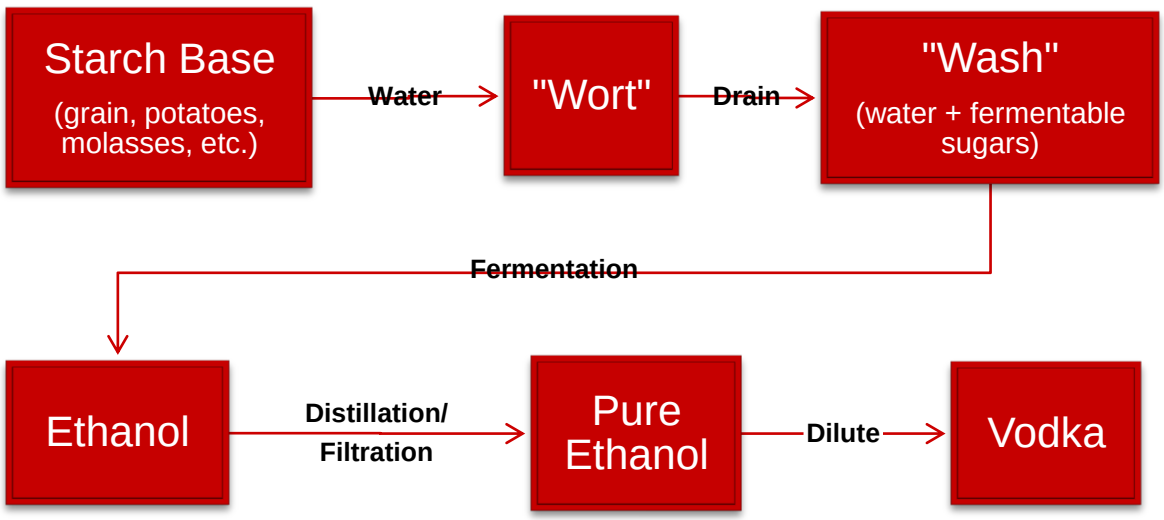

Figure 1. Steps in the vodka manufacturing process.

The starch must be broken down into fermentable sugars, which is done differently depending on the starting material. With most grains, water is added and the mixture is heated until a substance called 'wort' is formed. This substance is then drained leaving only the water and fermentable sugars called the 'wash.' The sugars in the wash are then converted to ethanol

via fermentation, which is a chemical reaction that naturally takes place when a glucose based organism is in an environment which lacks oxygen. [4]

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

Glucose → Ethanol + Carbon Dioxide

Figure 2. Fermentation Reaction.

Once fermentation is complete, the wash undergoes distillation, and in some scenarios, filtration. Distillation is a process that purifies a substance by utilizing the different boiling points of components within a single mixture. Any impurities with boiling points lower than that of ethanol can be boiled off. This is done through multiple cycles of evaporation and condensation that allow for the different impurities to escape from the collected wash. Filtration also serves to further purify any substance by adsorbing impurities into activated carbon or charcoal. By passing the ethanol product through a system where it comes in contact with activated carbon, the impurities adsorbed by the carbon and left behind. When the ethanol has reached its desired purity (typically based on quality level), it is then mixed with water until it reaches the appropriate proof.

Distinctive Character

Despite the federal government choosing to identify vodka as a spirit without any distinctive character, the majority of consumers tend to have a strict preference for which brand of vodka they drink. Most attribute their preferences to quality. Cheaper brands are known to undergo less distillation, leaving the final product with far more impurities than one might find in

a top shelf brand which ultimately affects the taste negatively. An example of this is the quality in taste between Prestige, a well-known "bottom-shelf" brand, and Ketel One, a common "top-shelf" brand. Ketel One undergoes a more scrupulous distillation regimen, leaving far less impurities and a purer taste. This is the expected outcome for any distilled beverage, not just vodka.

However, when considering vodka, there is a clear taste preference even amidst high end brands that have negligible impurities and are of the same proof. Market research has shown that when adults of all ages were asked to choose between common top-shelf vodkas that are all 80 proof (Grey Goose, Absolut, Smirnoff, Ketel One and Stolichnaya), each had a favorite brand. Results were measured against specific demographics and no clear correlation was present. Some of this data may be attributed to the reputation and marketing of the brand. However, the results did not show any brand to be more preferred over another. Instead, the data was spread evenly between each brand in the study. [5] This serves as an indication that preferences were in fact due to taste preference and not cultural or environmental influence.

Figure 3: A small snapshot of the numerous top-shelf brands of vodka available on the market today.

So, why do they taste different?

We know that impurities result in poorer tasting vodka, but when choosing between brands of equal quality and equal proof, the taste of impurities is not a factor in choosing one's favorite vodka. This has led researchers at the University of Cincinnati and Moscow State University to question the basis for taste distinction. The research teams characterized possible differences in the molecular basis of top-shelf vodkas in hopes of finding an answer. Theoretically, a solution of ethanol and water made in a laboratory setting should be remarkably close to any commercially branded vodka of the same proof. A variety of tests performed on five different brands of vodka and a laboratory solution proved quite the contrary. The tests measured both composition and hydrogen-bonding strength of the different vodkas, indicating differences in the structures between each sample. [6]

Structure Differences

Hydrogen bonding can be described as the attraction between hydrogen and another nearby atom within the mixture. In vodka, hydrogen bonding takes places between a hydrogen atom found on one water molecule and an oxygen atom found on another water molecule. These strong attractions act as bonds and result in structures within the mixture. The research done on vodka found that this hydrogen-bonding differs between commercial and non-commercial solutions and between commercialized brands. When hydrogen bonding takes place in vodka, it happens between multiple water molecules and results in the formation of a lattice called a clathrate. Because hydrogen bonding happens between numerous molecules at once, the clathrates comprised of water molecules take on a cage-like structure around ethanol molecules. Clathrate structures can also be formed between multiple ethanol molecules. Because of this, in

brands of vodka with higher alcohol content, such as 80-proof vodka, both water clathrates and ethanol clathrates are formed. [6]

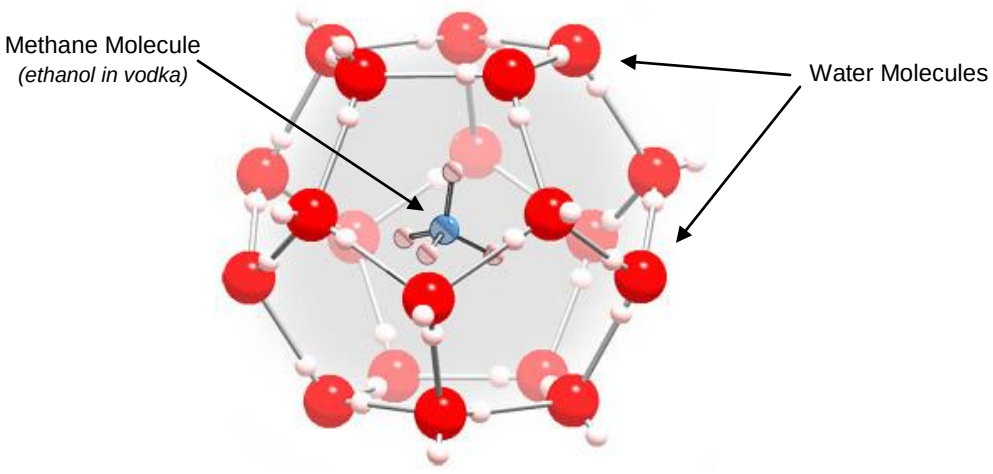

Figure 4: Hydrogen bonding occurring between water molecules resulting in a clathrate structure to form around a methane molecule. [7] In vodka, the methane molecule would be replaced with an ethanol molecule.

The research teams found that different brands of vodka and water-ethanol solutions created in the laboratory were found to have a unique collection of clathrates: some with more water clathrates, some with more ethanol clathrates, and some with close to equal parts. The two major categories were noted to either have low structurability or high structurability. In low structurability vodka, there is a greater amount of water clathrates present whereas in high structurability vodka, there is significant presence of both water and ethanol clathrates. As a result of water clathrates caging in ethanol molecules, the lower structurability vodkas tend to have a more watery taste than the high structurability vodkas. The clathrates within high structurability vodkas also tend to be transient, allowing ethanol molecules more movement throughout the solution. [6]

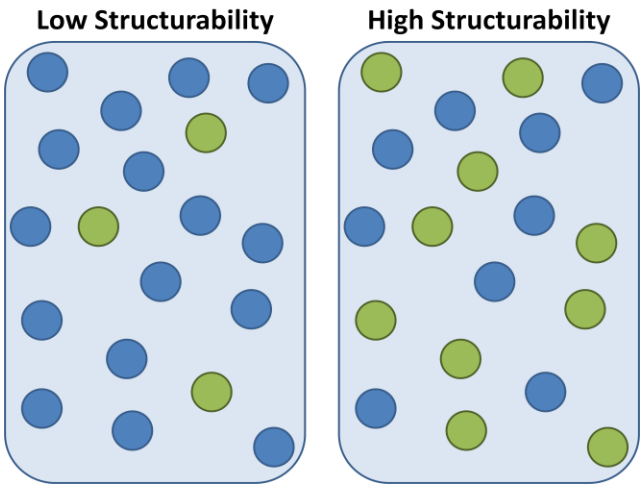

Figure 5. Low structurability vodkas have more water clathrates than high structurability vodkas which have roughly equal amounts of water and ethanol clathrates.

Structure Preference

Top-shelf brands of vodka have both low and high structurability, which suggests that one is not intrinsically better than the other. However, the difference in structure is believed to lead to a taste distinction amongst consumers. Vodka may be defined as a clear spirit that is "without distinctive character, aroma, taste or color," on paper, but the hidden complexity of each vodka brand on the molecular level leave its drinkers with unique consumption experiences.

Why the difference in structure?

It is still unclear what causes the differing clathrate collections in vodkas. There is a possibility that while the trace amounts of impurities in top-shelf vodkas cannot themselves be tasted, they may influence the formation of clathrate structures within the vodka. So although the amount of impurity between brands is the same, the identity of an impurity may have a unique effect on the vodka it resides in. This could be the reason that particular brands are more prone to a certain collection of clathrates. Impurities (or impurity combinations) from

equipment, packaging or any other component in the production process are specific to each company. One can imagine that vodka manufactured in a desert factory to have different impurities than one in a mountain environment. Researchers are currently attempting to assess this hypothesis. [6]

The Future of Vodka

If the current research continues to move forward, new ventures in vodka creation are likely to arise. Chemical engineers could begin to modify and manipulate specific impurities to garner more enjoyable structure collections. Vodka will be able to join the ranks of other alcoholic beverages with entire websites, books, and events devoted to its robust characteristics as a new category for alcohol. Vodka enthusiasts everywhere are likely to emerge. Perhaps a common question could be in regards to one's preference on structurability as opposed to red or white wine? The future is unclear, but with the new scientific backing on vodka's slight nuances, the directions of vodka research are just beginning.

Works Cited

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