Using Designed Experiments to Determine Optimal Levels of Unique Flavor Characteristics for Lemonade via Ortho-Nasal Aroma Evaluations

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Introduction

- Lemonade is a flavor with mainstream appeal and fits with several of the mega-trends occurring in the marketplace, including consumers desire for authenticity, customization and nostalgia.
- The quest for fresh and unique Lemonades is growing in Quick Service and Fast Casual Restaurants as well as in retail with the expansion of variants beyond traditional Strawberry, Raspberry and Pink Lemonades.
- The purpose of this study was to investigate the use of designed experiments and ortho-nasal evaluations to identify optimal Lemonade flavor combinations using traditional and unique flavors.

Products

- Traditional Lemonades
- Unique Lemon and Lime Flavors

Scientific Approach

Descriptive Profiling – Phase 1 (Flavor Evaluations)

- Quantitative Flavor Profiling (QFP) methodology
- 15 Givaudan expert panellists profiled Lemonades using a 100-pt line scale (0 = none to 100 = intense) and Givaudan's global Sense It™ language
- Principle Component Analysis (PCA) and Agglomerative Hierarchical Clustering (AHC) were employed to analyze the data (XLSTAT, version 2012.1.01).

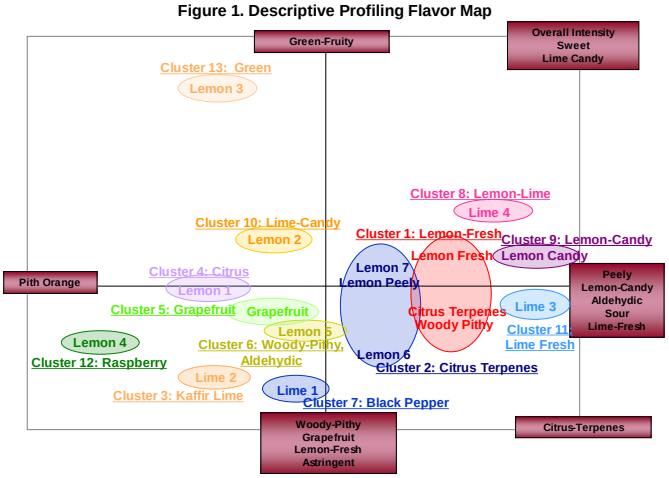
Phase 1a

- 17 traditional market Lemonades were evaluated
- The Lemonades grouped into six clusters that were categorized by the predominant Sense It™ characteristic; (1) Lemon Fresh, (2) Lemon Candy, (3) Lemon Peely, (4) Citrus Terpenes, (5) Woody Pithy and (6) Grapefruit.

Phase 1b

- From Phase 1a, Lemonade flavors were created to represent the key characteristics that identified the six Lemonade clusters. These six flavors and 11 unique Lemon and Lime flavors were evaluated in a Lemonade base.

Figure 1. Descriptive Profiling Flavor Map

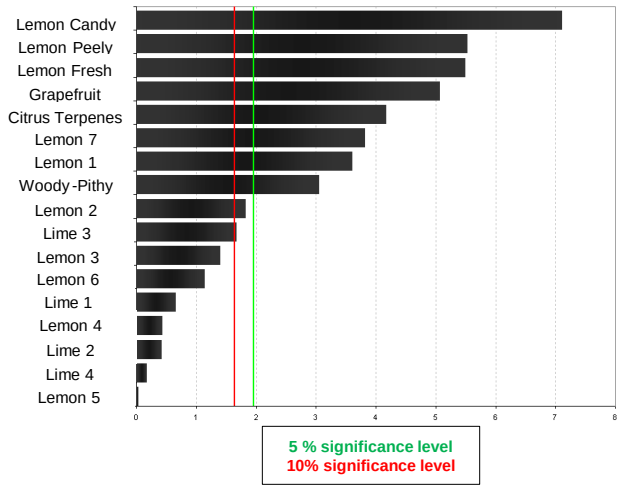


The Lemonades grouped into thirteen clusters, which helped to highlight the differentiation that exists between both traditional and unique Lemon and Lime flavors.

Plackett-Burman Consumer Test - Phase 2 (Aroma Evaluations)

- A Plackett-Burman design was used to screen through the 17 Lemonade flavors (6 market match flavors, 11 unique Lemon and Lime flavors) to determine which would have an impact on Lemonade flavor liking
- 127 consumers in two markets (Cincinnati, OH and Gaithersburg, MD)
- Acceptance Testing for Overall Liking (9-point scale) only
- Evaluated 27 aromas using Givaudan's MiniVAS™ technology. 25 aromas were formulated using the Plackett-Burman design, 1 sample was a warm-up sample to help consumers become familiar with the technology and 1 aroma was the center point replicated

Figure 2. Plackett-Burman Pareto Chart



The Pareto Chart shows the flavors that had a significant impact on liking at the 90% and 95% confidence level. Of the 17 Lemonade flavors, 9 flavors (both traditional and unique) were chosen to be included in the D-Optimal Consumer Test (shown below).

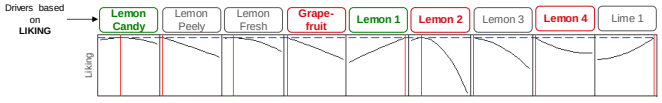
Flavor	Traditional or Atypical
Lemon Candy	Traditional
Lemon Peely	Traditional
Lemon Fresh	Traditional
Grapefruit	Traditional
Lemon 1	Atypical
Lemon 2	Atypical
Lemon 3	Atypical
Lemon 4	Atypical
Lime 1	Atypical

D-Optimal Consumer Test - Phase 3 (Aroma Evaluations)

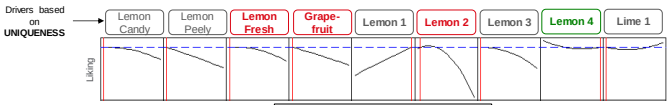
- D-Optimal Design was used to determine the effects (individual, curvature and interaction) of the 9 Lemonade flavors (identified in Phase 2) on liking and uniqueness
- 127 consumers in two markets (Cincinnati, OH and Gaithersburg, MD)
- Acceptance Testing for Overall Liking (9-point scale) and Uniqueness (5-point scale)
- Evaluated 58 aromas (using Givaudan's MiniVAS™ technology) to determine optimal flavor combinations which maximized liking and uniqueness. 55 aromas were formulated, 1 sample was the warm-up sample and 2 aromas were the center point replicated.

Figure 3: Optimal Profiles for Liking and Uniqueness

Optimal profile based on Liking



Optimal profile based Uniqueness



5 % significance level
10% significance level

At a 90% confidence level, the optimal Lemonade profile contained both traditional and unique flavors which helped to maximize both liking and uniqueness. Lemon Candy flavors are needed for a well-liked Lemonade whereas, Lemon Fresh flavors are needed for a new and unique Lemonade.

Conclusion

- The use of designed experiments successfully predicted optimal levels of 5 new and unique flavors that might be combined with traditional flavors to maximize liking while providing a new and unique experience for consumers.