USING CHOICE EXERCISES AND MIXTURE DESIGNS TO OPTIMIZE NUTRACEUTICAL-RICH JUICE BASED ON HEALTH-ORIENTED AND SENSORY ATTRIBUTES

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Introduction

Expanding interest in the nutraceutical market inspires sensory- and nutraceutical-oriented optimization methods. Using screening choice designs and mixture experiments has the potential to optimize research resources and to design products that are valued for their sensory and health-oriented attributes.

Objectives

Choice Design

- Utilize a choice design to select the preferred three-component juice blend
- Identify preference, demographic, lifestyle, or attitudinal factors that influence juice blend choice

Mixture Optimization

- Determine the optimum proportions of black cherry, Concord grape, and pomegranate juice in a juice blend
- Describe how nutraceutical status and sensory attributes influence consumer overall liking and purchase intent of nutraceutical-rich juice blends

Materials and Methods

Methods: Choice Design

- Using research that ranked polyphenol-rich beverages according to an antioxidant capacity composite (Seeram *et al.* 2008), a choice survey was designed to select the best three-component blend of polyphenol-rich juices (pomegranate, Concord grape, blueberry, black cherry, açaí, and cranberry).

Participants (n=1291) were introduced to the online choice survey with the following information:

For the survey below, imagine you are shopping at the grocery store for a fruit juice blend. In each question, choose your most preferred blend. Consider how you think the juice would taste and the following information about antioxidants.

Pomegranate juice is highest in antioxidants.
Concord grape juice is second highest in antioxidants.
Blueberry juice is third highest in antioxidants.
Black cherry, açaí, and cranberry tie for the fourth highest in antioxidants.

- Two three-component juice blends were presented to consumers in each choice question, which created 190 possible choice questions.
- 190 possible choice questions were divided into five blocks so that each panelist only completed 38 choice questions.

Methods: Mixture Optimization

- The juice blend determined by the choice survey (black cherry, Concord grape, and pomegranate) was further optimized based on consumer consideration of sensory attributes and nutraceutical status using a mixture design (Table 1) and desirability function.
- Consumers (n=100) evaluated seven treatments (created from the Simplex Centroid mixture design) for overall liking, just-about-right (JAR) attributes, purchase intent, familiarity, and demographics. Overall liking based on the nine-point verbal hedonic score was measured for each juice before (pre-information) and after (post-information) consumers were given information about the antioxidant status of each sample.
- JAR attributes were converted to continuous variables (Worch et al., 2010). For conversion to the *too much* dummy, observations scored at 5 and 4 are converted to 2 and 1 respectively, and all other observations are converted to 0s. The 2s and 1s on the *too little* side of the JAR attribute are converted to -1 and -2 respectively in the *too little* dummy. A pair of dummies was developed for each JAR attribute, and partial least squares regression with overall liking as the response was performed.

TABLE 1: JUICE TREATMENTS FOR SIMPLEX CENTROID MIXTURE DESIGN

Black Cherry	Concord Grape	Pomegranate
100%	0	0
0	100%	0
0	0	100%
50%	50%	0
50%	0	50%
0	50%	50%
33.3%	33.3%	33.3%

Results

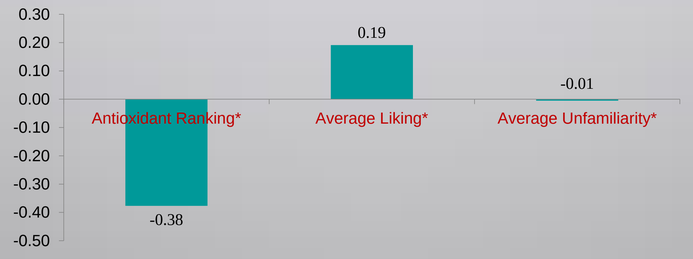
Results: Choice Design

The *black cherry, Concord grape, and pomegranate* juice blend had the highest marginal utility as determined by the choice survey.

TABLE 2: MARGINAL UTILITY OF JUICE BLENDS

Utility	Juice Blend
0.51	Black cherry, Concord grape, and Pomegranate
0.49	Concord grape, Cranberry, and Pomegranate
0.35	Blueberry, Concord grape, and Pomegranate

FIG. 1 PARTIAL LEAST SQUARES REGRESSION ON MARGINAL UTILITY[a,b,c]



[a]Partial least squares regression unweighted beta coefficients with marginal utility as response and average antioxidant ranking, estimated average liking, and estimated average unfamiliarity as predictors
[b]*Indicates significance at p-value <0.01
[c]Equations (Eq):
Eq 1. Overall liking (x) + Overall liking (y) + Overall liking (z)/3)= Estimated Average Liking
Eq 2. Frequency Never Consumed (x) + Frequency Never Consumed (y) +Frequency Never Consumed (z)/3) =Estimated Average Unfamiliarity, where Frequency Never Consumed= Frequency of sampled population who has never consumed a particular component.
Eq. 3. (Antioxidant ranking (x) + Antioxidant ranking (y) + Antioxidant ranking (z)/3)=Average Antioxidant Ranking

The level of antioxidants and overall liking were more predictive than unfamiliarity in determining each juice blend's marginal utility (i.e., the satisfaction consumers derive from consuming one more unit of the product).

Results: Mixture Optimization

Consumers shifted liking scores based on antioxidant information. The post-information solution contained more pomegranate juice (highest in antioxidants) and less black cherry juice (lowest in antioxidants) than the pre-information solution.

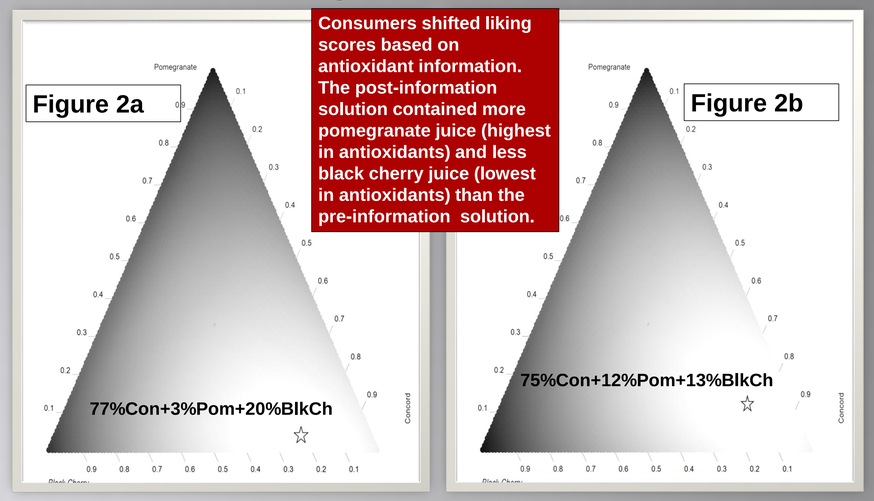


FIG.2a and b. PRE-INFORMATION AND POST-INFORMATION DESIRABILITY PLOTS[a,b,c]
[a]White (higher desirability) to black (lower desirability) shading indicates desirability
[b]Star indicates optimized solution
[c] Con=Concord, Pom=Pomegranite, BlkCh=BlackCherry

TABLE 3. PARTIAL LEAST SQUARES REGRESSION (PLSR) COEFFICIENTS FOR CONVERTED JUST-ABOUT-RIGHT VARIABLES[a]
[a]Shading indicates significance of the variable in the PLSR model at α<0.05

	100%Black Cherry (BlkCh)	100%Concord (Con)	100%Pomegranate (Pom)	33%BlkCh+33%Con+33%Pom
Intercept	7.09	8.15	7.64	7.91
Too Sweet	-0.39	-0.34	-0.01	-0.19
Not Sweet Enough	0.73	0.09	0.64	0.55
Too Sour	-0.6	-0.44	-0.67	-0.51
Not Sour Enough	0.44	0.12	0.06	0.13
Too Much Pom Flavor	-0.39	-0.09	-0.37	-0.39
Not Enough Pom Flavor	0.42	0.16	0.03	0.09
Too Much Concord Flavor	-0.19	-0.3	-0.06	-0.13
Not Enough Concord Flavor	0.53	0.09	0.23	0.33
Too Much BlkCh Flavor	-0.38	-0.07	-0.07	-0.04
Not Enough BlkCh Flavor	0.28	0.3	0.18	0.12
Too Astringent	-0.2	-0.56	-0.38	-0.63
Not Astringent Enough	0.32	0.08	0.06	-0.09
Too Bitter	-0.62	-0.29	-0.7	-0.66
Not Bitter Enough	0.33	0.13	0	0.02

To demonstrate the effect of blending on developing juice blends with optimal attributes, results are shown for the single component juices (BlkCh, Con, Pom) and the ternary blend (33%BlkCh+33%Con+33%Pom). For most variable sets, either the *too much* or the *too little* side of the JAR attribute was significant and had a higher coefficient than the other, which suggested a direction to improve the product (Table 3).

Coefficients indicated the effect of the attribute on mean overall liking. For example, 100% Pom juice had 6 attributes that were not JAR. The 0.01 coefficient for *too sweet* indicated that this side of the attribute had little effect on overall liking; however, the 0.64 coefficient for *not sweet enough* indicated that overall liking increased at a rate of 0.64 per unit of sweetness over the region of 1 to 3 (too little region). The intercept for 100%Pom was 7.64, which would be the potential maximum overall liking score if all of the variables were JAR.

Conclusions

Choice Design

- The *black cherry, Concord grape, and pomegranate blend* was identified as the best potential juice blend by the choice experiment.
- Overall liking and antioxidant ranking for each blending component were strongly associated with the juice blends chosen, which indicates consumers consider nutraceutical and sensory properties of a product.

Mixture Optimization

- Similar to previous research on nutraceutical products, consumer acceptance is driven primarily by sensory qualities, although nutraceutical status can provide consumers additional utility.
- According to JAR analysis, the blended juice was better-balanced than 100%Pom or 100%BlkCh juices. The blended juice also had more antioxidants than 100% Con, which supports the development of optimization procedures based on sensory and nutraceutical characteristics.

Literature Cited

SEERAM, N.P., AVIRAM, M., ZHANG, Y., HENNING, S.M., FENG, L., DREHER, M. and HEBER, D. 2008. Comparison of antioxidant potency of commonly consumed polyphenol-rich beverages in the united states. J. Agric. Food Chem. *56*, 1415-1422, DOI: 10.1021/jf073035s.
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