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RESEARCH ARTICLE

INFLUENCE OF TYPES OF SOYMILK FORMULATIONS ON SENSORY CHARACTERISTICS: A STUDY IN NORTHERN REGION OF GHANA

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ABSTRACT

Five soymilk products formulated differently were compared in terms of appearance, color, taste, smell, and texture. They were also compared in terms of their overall sensory characteristics. Fourteen semi-trained Ghanaian students majoring in Nutrition and Food Scienceevaluated each of the 5 different formulations of soymilk in a randomized order. For each sensory characteristics, the rating options were "Excellent", "Good", "Fair", and "Poor" coded respectively as 10, 7, 5, and 3. A Friedman test was carried out to compare *appearance*, *color*, *taste*, *smell*, *texture*, and *overall score* for the five soymilk formulations; and pairwise comparisons to determine the source of significant differences in mean ranks for color, taste, smell, texture, and the overall score were performed using the Wilcoxon Sign Rank test. The results showed that Soymilk with pineapple flavor (100g in 1000mL formulation) was the most preferred in terms of color, smell, and texture and that Soymilk with banana flavor (100g in 1000mL formulation) was the most preferred in terms of taste.The magnitude of the differences observed ranged from medium to large for most of the differences observed. The results of this study will provide decision-makers in Ghana with the right knowledge in their effort to improve nutrition.

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INTRODUCTION

Sensory perception is an important factor to understand and effectively appeal to consumers (Haase, Wiedmann & Labenz, 2018). Haase, et al. went on to define sensory perception as the consumer's evaluation of an object (e.g., product or brand) that determines the degree of appeal of the object to the human senses (i.e., visual, acoustic, haptic, olfactory, and gustatory). The sensory perception involves detecting the stimuli, characterizing, and recognizing it. This process happens to be done through the organs usually the senses like sound, vision, taste, and smell. It is known that when a new product is launched in the market, food companies spend time, energy, and money to test and analyze consumers' perceptions of that product. And thus, use of human subjects in sensory evaluation tests is done in research and development departments to generate and evaluate products (Capule & Barcelon, 2016). In fact, one of the most used sensory techniques in the evaluation of new or existing products is difference testing (Meilgaard, Civille, & Carr,2007).

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Additionally, difference testing is used to determine if foods differ in certain aspects such as smell, taste, appearance, color, and texture. Historically, difference tests have been conducted to determine whether a sensory difference exists among samples (Amerine, Pangborn, & Roessler, 1965). Capule and Barcelon, in their study, looked at the effect of five different colored ready-to-drink soymilk on sensory parameters like sweetness, aftertaste, naturalness, artificiality, liking and consumption. They found that color does influence perception and manner of consumption. Ennis, Rousseau, and Ennis (2014) reviewed recent developments in sensory difference testing that have allowed a shift away from the binary perspective of "significantly different or not" to the more nuanced perspective of measuring sensory effect size. They concluded that products are necessarily different when they are reformulated, but the difference may be so small as to be irrelevant to consumers. This conclusion is similar toIshii,O'Mahony, and Rousseau (2014) who concluded that the question of what size of sensory difference is meaningful to consumers is a crucial one that can only be investigated experimentally. Soymilk is a beverage made from soybeans. It is defined as an aqueous extract of whole soybeans (dehulled or non-dehulled), closely resembling dairy milk in physical appearance and composition (Patil and Jha, 2008). Soymilk is abundant in protein and fatty acids with multiple beneficial attributes.

Tunde-Akintunde and Souley (2009) reported in their study that they noticed that the sensory properties of soymilk increased with decrease in nutritional quality indicating that methods, which increase sensory properties of soymilk by reducing its beany flavor have lower nutritional qualities. Our sense of sight is the first interaction with food because it allows people to see the color, size, shape and other imperfections a food may have. In fact, color is a major visual factor in the decision process of food consumption (deHamer, 2012, as cited by Capule & Barcelon). According to Brown (2010), vision is the first step in the process of sensory evaluation to gather perception about any food products without tasting the food itself. Previous studies have already been conducted to determine if there is a correlation between color, flavor, and taste perception (King and Duineveld, 1998; Chan and Kane, 1997; Oram, 1995; Philipsen et al., 1995). In a separate study, Piqueras-Fiszman (2012) and Guéguen (2003), correlated color of the serving plate and color of the drinking glass to determine the taste perception of a food and thirst-quenching quality of a beverage. These two studies proved that even the color of the serving plate and drinking glass had a significant influence on the sensory perception of a beverage and food. It has been reported that soybean varieties greatly affect the protein content and color of soymilk, and the sensory attributes of perceived color and flavor are the most important characteristics in soymilk because they are readily assessed by consumers (Odu, Egbo, & Okonkwo, 2012).

Rationale for this study: In their study, Capule and Barcelon (2016) found out that color does influence perception and manner of consumption. While this is an especially important finding, especially since beverage companies rely on color for their advertising campaigns, other aspects in addition to color such as smell, taste, appearance, and texture, are usually used for difference testing. In 2017, a SoyaKit project was launched in Northern Ghana with Mennomite Economic Development Association (MEDA). In the town of Wa, eleven trainers were trained in the use of the SoyaKit, to make about 7 liters of soymilk per hour (Malnutrition Matters, 2017). According to the initiators of this project, the production and sale of affordable soymilk will improve nutrition, enable sustainable operations, and create employment in these locations. Thus, food companies producing soymilk in Northern Ghana conduct research to improve sensory qualities and acceptability of soymilk. To the knowledge of the researchers, there is no study that aims to examine the effects of appearance, color, taste, smell, and texture on different soymilk flavors and formulations in the context of Ghana. This study was undertaken to fill that gap in answering the question "What is the influence of appearance, color, taste, smell and texture on soymilk flavors?" Most research on soymilk recognition has been on color. Additionally, there are limited literature on identifying soymilk based on taste, smell, and texture. This study uses data collected from 14participants on appearance, color, taste, smell, and texture that serves as sensory triggers that appeals to consumers and subconsciously leads to self-generation of (desirable) rather than those verbally provided by the advertisers (Messina, 2010).

METHODS

Design/Setting: This study was carried out using a repeated measure design. A total of 14 semi-trained Ghanian students majoring in Nutrition and Food Science in Ghana evaluated each of the 5 different formulations of soymilk in a randomized order.Informed consent of the participants was obtained before they took part in the study.The formulations were the following: Soymilk with banana flavor (100g in 1000mL formulation) [Formulation A], Soymilk with pineapple flavor (100g in 1000mL formulation) [Formulation B], Soymilk only (100g in 1000mL formulation) [Formulation C], Soymilk only (50g in 1000mL formulation) [Formulation D], and Soymilk only (200g in 1000mL formulation) [Formulation E]. A 4-point rating scale was used to determine how much each sample was perceived based on appearance, color, taste, smell, and texture. For each of characteristic being evaluated, the participants were instructed to choose one of the following options: "Excellent", "Good", "Fair", and "Poor". This rating scale was chosen for its simplicity. For each of the 5 different formulations, each participant was assigned for the evaluation in a random order.

Data Analysis: The data was analyzed in many stages. First, the ratings were recoded as follows: "Excellent" = 10, "Good" = 7, "Fair" = 5, and "Poor" = 3, and an overall score for the formulation being evaluated was computed for each participant by adding the scores for appearance, color, taste, smell, and texture. Second, descriptive statistics of the ratings and overall scores were obtained. Third, the reliability of the scale made of appearance, color, taste, smell, and texture was assessed to justify the creation of the overall score. Fourth, the Friedman test was used to analyze significant differences among the five different soymilk samples based on the appearance, color, taste, smell, and texture. The Friedman test has the following assumptions: (1) one group is measured on three or more different occasions; (2) group is a random sample from the population; and (3) the dependent variable should be measured at the ordinal or continuous level (Laerd Statistics, 2013). Following the Friedman test, the Wilcoxon test which is a post hoc test was used to determine the source of significant differences in mean ranks revealed by the Friedman test. Finally, as per the recommendations of Ennis et al. (2014) and Ishii et al. (2007), the effect sizes were of main interest in this study. Since effect sizes cannot be calculated directly for a Friedman test, an alternative called Kendall's W, which is a coefficient of concordance, was used. In fact, the Kendall's W is a test which looks at agreement between subjects and gives a value which ranges between 0 and 1. In this context, a Kendall's W (Kendall, 1948) of 1 indicates that all subjects ranked the five soymilk formulations in the same way and therefore they were in complete agreement. The Kendall's W coefficient of concordance can be seen as an index of interrater reliability and uses the Cohen's interpretation guidelines of 0.1 to 0.3 (small effect), 0.3 to 0.5 (moderate effect) and greater than 0.5 (large effect) in the same way as the Cohen's d effect size.

RESULTS

Descriptive analyses: The construct "overall score" was created by adding the participants' ratings on appearance, color, taste, smell, and texture. The results of the reliability analyses indicated that the "overall score" has an acceptable internal consistency for formulations A, B, C, and E; however, the internal consistency value for formulation D indicate low reliability (see Table 1).

Table 1. Reliability Results of Overall Score

Formulation	Cronbach's Alpha
A	.747
B	.780
C	.901
D	.332
E	.833

Tables 2 through 7 below show the descriptive statistics for appearance, color, taste, smell, texture, and the overall score for each of the five soymilk formulations. Formulation B has the highest average rating score on appearance, color, smell, texture, and overall score, followed by formulation A, formulation E, formulation C, and formulation D, respectively. Formulation A has the highest average rating score on taste, followed by formulation B, formulation E, formulation C, and formulation D, respectively.

Table 2. Descriptive Statistics for Appearance

Formulation	Mean	Median	SD
A	7.57	7.00	2.311
B	8.29	10.00	2.164
C	6.79	7.00	1.968
D	6.07	6.00	1.685
E	7.29	7.00	1.978

Table 3. Descriptive Statistics for Color

Formulation	Mean	Median	SD
A	7.57	7.00	2.311
B	8.29	10.00	2.164
C	7.07	6.00	2.369
D	5.93	5.00	1.685
E	7.43	7.00	2.409

Table 4. Descriptive Statistics for Taste

Formulation	Mean	Median	SD
A	8.21	8.5	1.968
B	7.50	7.00	2.245
C	5.71	5.00	2.268
D	5.50	5.00	2.103
E	6.57	6.00	2.563

Table 5. Descriptive Statistics for Smell

Formulation	Mean	Median	SD
A	7.14	7.00	2.070
B	7.86	7.00	2.070
C	6.00	5.00	2.00
D	5.00	5.00	0.784
E	6.71	7.00	1.858

Table 6. Descriptive Statistics for Texture

Formulation	Mean	Median	SD
A	7.29	7.00	1.978
B	7.64	7.00	1.985
C	6.14	5.00	1.834
D	5.64	5.00	1.646
E	6.57	7.00	1.910

Friedman tests of difference: A Friedman test was carried out to compare *appearance*, *color*, *taste*, *smell*, *texture*, and *overall score* for the five soymilk formulations.

Table 7. Descriptive Statistics for Overall Score

Formulation	Mean	Median	SD
A	37.79	39.00	7.516
B	39.57	41.5	7.861
C	31.74	29.5	8.88
D	28.14	29.00	4.28
E	34.64	37.00	8.54

There was found to be a significant difference between the five soymilk formulations in terms of color (p = .0372), taste (p = .0182), smell (p<.001), texture (p = .0108), and overall score(p = .0043), but not in terms of appearance (p = .0531) (see Table 7). To estimate the effect sizes, the Kendall's W coefficient of concordance was computed for each significant result (See table 7). The results indicated small effect size for the differences in the five soymilk formulations for color, taste, texture, and the overall score, and a medium effect size for smell.

Table 7. Friedman Rank Sum Test Results

	Friedman chi-squared	df	p-value	Effect size (Kendall's W)
Appearance	9.34	4	.0531	.167
Color	10.199	4	.0372	.182
Taste	11.892	4	.0182	.212
Smell	19.295	4	<.001	.345
Texture	13.1	4	.0108	.234
Overall Score	15.194	4	.0043	.271

Pairwise comparisons: The Wilcoxon test was carried out to determine the source of significant differences in mean ranks for color, taste, smell, texture, and the overall score revealed by the Friedman test (see table 8). The results revealed that there were significant differences between colors for formulations B and D, between tastes for formulations A and D, B and C, and B and D, between smells for formulations A and D, B and C, B and D, and D and E, between textures for formulations A and D, B and C, and B and D, between overall score for formulations A and D, B and C, and between B and D.

Table 8. Wilcoxon Sign Rank Test Results

	p-value	Effect size (Kendall's W)
Color B – Color D	.0083	.457
Taste A – Taste C	.0063	.457
Taste A – Taste D	.0037	.327
Taste B – Taste C	.0401	.321
Taste B – Taste D	.0272	.257
Smell A – Smell D	.0016	.457
Smell B – Smell C	.0224	.526
Smell B – Smell D	<.001	.714
Smell D – Smell E	.0026	.643
Texture A – Texture D	.0214	.457
Texture B – Texture C	.0345	.257
Texture B – Texture D	.0076	.457
Overall A – Overall D	.0017	.510
Overall B – Overall C	.0321	.214
Overall B – Overall D	<.001	.735

DISCUSSION

This study aimed to examine the effects of appearance, color, taste, smell, and texture on five different soymilk formulations. It was revealed from the results that these five soymilk formulations differed in their rankings based on color, taste, smell, and texture, but not in appearance.

However, when these rankings were averaged to create an overall ranking score, it was found that the five soymilk formulations differed. The difference observed based on colorwas between the formulations Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation) and the pineapple flavor was the preferred between the two.In fact, the addition of pineapple flavor to soymilk might be the cause of color difference between the two formulations and this could influence the perception and manner of consumption. This result confirmed what Capule and Barcelon (2016), found that color does influence perception and manner of consumption.Terhaag et al (2013) found in their study that the most desirable characteristics of soymilk were darker color, higher viscosity, higher protein content and higher vanilla flavor. This suggests again that color plays a key role in determining the preference of soymilk types by consumers.An important finding is that adding a banana flavor to soymilk does not significantly change the color from soymilk only in formulations of 100g in 1000mL and 200g in 1000mL.

The difference observed based on taste was between 1) Soymilk with banana flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), 2) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), and 3) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (100g in 1000mL formulation). These results imply that soymilks with no flavor taste the same on average, regardless of the concentration of soybean in the formulation and both the banana flavor and the pineapple flavor were preferred in terms of taste. This confirms again the claim that flavor is important in driving consumption (Murphy et al., 2008) as characteristics of odor play a crucial role in the consumer preference and acceptance (Zhu & Xiao, 2015). The difference observed based on smell was between 1) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), and 2) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (100g in 1000mL formulation). The smell of soymilk with banana flavor was undistinguishable from the smell of soymilk with no flavor. The smell of soymilk with pineapple flavor was preferred from the smell of the soymilk only of 50g in 1000mL formulation and 100g in 1000mL formulation; however, when the smell from the formulation of soymilk only was increased to 200g in 1000mL was undistinguishable from the smell of the pineapple flavor. Afroz et al (2016) found comparable results in their study as they found out that there was statistical difference within smell and taste score of different concentrations of soymilk. Their study indicated that smell and taste score decreased with increased concentration of soybean. The difference observed based on texture was between 1) Soymilk with banana flavor (100g in 1000mL formulation) and Soymilk only (100g in 1000mL formulation), 2) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), and 3) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (100g in 1000mL formulation). These results imply that the texture of soymilks with no flavor was the same on average, regardless of the concentration of soybean in the formulation and both the banana flavor and the pineapple flavor were preferred in terms of texture as they were denser.

Preparation of soymilk with different fruit flavors could be the probable cause of the differences in texture. Using the overall rating score, a difference was observed between 1) Soymilk with banana flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), 2) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (50g in 1000mL formulation), and 3) Soymilk with pineapple flavor (100g in 1000mL formulation) and Soymilk only (100g in 1000mL formulation).This revealed that the addition of different flavors to soymilk increasesits acceptability, and therefore,makes panelists recognize significantdifferences between formulations. This result confirmed whatNti and Larweh (2003) found in their study conducted on a consumer acceptance test in Ghana to determine the most desirable flavors for soymilk. They reported that the addition of any flavor (vanilla, banana, coffee, or chocolate) improved the overall acceptability of the soymilks. This study aimed to examine the effects of appearance, color, taste, smell, and texture on five different soymilk formulations.

Conclusion

This study aimed to examine the effects of appearance, color, taste, smell, and texture on five different soymilk formulations. While examined individually, the results showed that Soymilk with pineapple flavor (100g in 1000mL formulation) was the most preferred in terms of color, smell, and texture and that Soymilk with banana flavor (100g in 1000mL formulation) was the most preferred in terms of taste. The overall rating score proved to be a reliable way to simultaneously examine the effects of appearance, color, taste, smell, and texture on five different soymilk formulations as the results were in adequacy with the individual tests performed. Overall, 1) Soymilk with banana flavor (100g in 1000mL formulation) was most preferred over Soymilk only (50g in 1000mL formulation); 2) Soymilk with pineapple flavor (100g in 1000mL formulation) was most preferred over Soymilk only (100g in 1000mL formulation); and 3) Soymilk with pineapple flavor (100g in 1000mL formulation) was most preferred over Soymilk only (50g in 1000mL formulation).

Strengths, Limitations, and Ideas for Future Research: The strength of this study lies in the estimation of the magnitude of the differences observed in the five formulations in terms of color, taste, smell, and texture, as well as the differences observed in the five formulations based on the overall score. The magnitude of the differences observed ranged from medium to strong, except for the differences between formulations B and D based on taste and the differences between formulations B and C based on texture, and the differences between formulations B and C based on the overall score whose magnitudes were small. The results of this study will provide decision-makers in Northern Ghana with the right knowledge in their effort to improve nutrition, enable sustainable operations, andcreate employment in Northern Ghana. A limitation of this study is the number of participants. Only 14 participants could take part in the study due to the restrictions on the training kits for participants in the study. Another limitation is the lack of variability in the formulations evaluated in this study. In fact, the 5 formulations included three formulations made of Soymilk only. Like this study, many other studies have shown that consumer judgements of overall liking could be influenced by their ratings of the liking

of flavor, texture, aroma, or appearance. A future study could aim to develop a single measure of overall liking of soymilk formulations that incorporates the relative importance of liking ratings from appearance, color, taste, smell, and texture. This can be done by applying a Many-Facet Rasch model to produce interval-scaled estimates of overall liking.

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