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Application Of Preference Mapping In Food Science: A Case Study On Crispy Pili Nuts[1]

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ABSTRACT

The sensory profile and consumer acceptability of nine crispy pili nut samples were respectively determined using a trained sensory panel and a total of 95 respondents recruited from the students and employees of the University of the Philippines, Diliman, Quezon City. Instrumental analysis for color and hardness was also performed on the samples. Preference maps were built to provide a clear picture of product profiles and to interpret the preference patterns of the product. Preference mapping procedures including multidimensional preference (MDPREF) and preference mapping (PREFMAP) analyses were employed to understand and identify the important sensory and physical characteristics that drive the consumer acceptability of crispy pili nuts. Results could be useful to the Philippine pili nut industry in improving and standardizing the quality of crispy pili nuts to be competitive in the international market.

1. INTRODUCTION

Pili nut, an endemic food to the Philippines, is a promising export commodity. One of the primary processed *pili* products being exported is crispy *pili* nuts. Despite the fact that this traditional Filipino confection has captured the palate of Filipinos and foreigners, its foreign market has not been fully tapped due to inferior quality of nuts (Coronel 1996) and non-consistent product quality.

Quality should therefore be improved to fully exploit the international market for crispy pili nuts. Researches on production, utilization and packaging must be strengthened. Attention must be given to the improvement of quality and even standardization of crispy *pili* nuts to be globally competitive and stay in the foreign market. This can be started by identifying the factors and indicators of quality for the product.

Consumer perception is essential to the definition of food quality and can be measured through acceptance or preference test. Consumer acceptance will determine the degree of likes and dislikes of the product. Sensory and physical attributes that contribute to the overall likings of the product can be identified through preference mapping. Preference mapping can define also the consumer preference pattern for the food product.

Preference mapping is a group of multivariate statistical tools that display products, consumers and attributes in a single plot. This multivariate method can elicit product differences, differences in preference for the products and even individual subject preference. Preference mapping is widely utilized in market research. Oftentimes, preference mapping is

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employed to uncover competitive advantages in market research data. In this study, however, the method was applied in food science, particularly to crispy pili nuts.

For this purpose, the consumer acceptability, sensory properties and instrumental color and hardness of crispy pili nut samples were first determined to educe product profiles. Preference mapping was then applied on these data to elucidate the preference patterns for crispy pili nuts, and to identify food properties (sensory and physical) that drive the consumer acceptance of crispy pili nuts.

2. MATERIALS AND METHODS

Samples

Nine samples (determined by source of pili nut), representative of the presently available crispy pili nuts in the market were used in this study. Samples were purchased directly from manufacturers, shipped to Pilot Food Plant (PFP) of the College of Home Economics (CHE), University of the Philippines Diliman (UPD), Quezon City, and stored in a cool, dry place (to prolong shelf life) until testing. The descriptions of the samples utilized in this study are summarized in Table 1.

Table 1. Crispy *Pili* Nut Samples

Product Code	*Brand*	*Manufacturer*	*Origin*
A1	Albay Central	New Albay Central Pili Nut Candy	Legazpi City, Albay
CS1	Anciano's	E. P. Anciano's Pili Delicacies Store	Naga City, Camarines Sur
CS2	Arthur's	Arthur's Sweet Shop	Pili, Camarines Sur
A2	Bonto's	A & F Bonto Pilinut Candies	Tabaco City, Albay
CS3	Buena's	Emily Buena's Store	Iriga City, Camarines Sur
CM	Growers	Marketreach Distribution, Inc.	Quezon City, Metro Manila
MM2	Jovy's	Joe & Susan Food Products	Kaloocan City, Metro Manila
MM3	Poppoy's	L. Dometita & Sons Food Industries	Quezon City, Metro Manila
S	Tia Berning's	Tia Berning Pili & Handicraft	Sorsogon City, Sorsogon

Sensory Evaluation

Standard sensory evaluation procedures were followed in conducting consumer and descriptive sensory tests. A three-digit random number code was generated using a calculator

and assigned to each of the nine crispy pili nut samples. Controlled preparation requirements for samples were observed. Equal amount of samples (8 grams) was apportioned to each 1-oz plastic container with lid. The order of sample presentations was randomized across panelists. The samples were evaluated one at a time in separate sensory booths in odor-free and noise-free rooms. Evaluators were provided with purified water for rinsing their mouths between samples.

Consumer Testing. Ninety-five panelists were recruited from the University of the Philippines Diliman (UPD), Quezon City to judge the acceptability of the samples using a 9-point hedonic scale. The consumer test was conducted simultaneously in two locations: (1) International Center (IC), and (2) PFP-CHE.

Descriptive Sensory Testing. Descriptive sensory analysis is a technique used to elicit qualitative and quantitative sensory characteristics of a food product from a panel of judges. For this purpose, a twelve-member panel was selected and trained for descriptive sensory analysis of crispy pili nuts using a hybrid of Spectrum® and Quantitative Descriptive Analysis ® methods. The panel was composed of students and employees from Department of Food Science and Nutrition, CHE, UPD. Panelists evaluated the samples on all attributes in the developed lexicon for crispy pili nuts using a 15-cm line scale.

Instrumental Analysis

Triplicate measurements of color and hardness were carried out for each of the nine crispy pili nut samples. Using a HunterLab® spectrocolorimeter, the following color dimensions were determined: L (lightness/darkness), A (redness) and B (yellowness), chroma and hue angle. The hardness of the samples was assessed using a Humboldt® penetrometer with needle-like probe attachment. Measurements were reported as the depth of penetration through the sample (tenths of millimeters in 15 seconds).

Statistical Analyses

The mean and standard error of the mean (SEM) were obtained for all product attributes. Analysis of variance (ANOVA) was employed to determine differences among samples at 95% confidence level: single-factor ANOVA for instrumental data, and two-way ANOVA for sensory evaluation data. Duncan's multiple range test (DMRT) was performed to find out significantly different (α=0.05) samples (in instrumental and sensory data) and significant effects of panelists or replicates (in sensory data).

Preference mapping were then applied on the individual ratings of consumers on acceptance and on the means of the product properties (sensory and instrumental) to elicit the preference patterns for crispy pili nuts and identify the drivers of consumer acceptance. Multidimensional preference (MDPREF) analysis generated the dimensions of the product map, computed the product coordinates and regressed either the product attributes (external analysis) or individual acceptance scores (internal analysis) to the map dimensions. Preference mapping (PREFMAP) analysis aids in the interpretation of the preference map by regressing either the individual acceptance scores (external analysis) or product attributes (internal analysis) to the map dimensions. The multidimensional space depicting both products and vectors (attributes and individual preferences) were drawn using % PLOTIT macro.

All statistical analyses were executed in SAS software, version 8.1 (SAS Institute, Inc. 1999) using PROC GLM (for means, SEM, ANOVA and DMRT) and PROC PRINQUAL (for MDPREF), PROC TRANSREG (for PREFMAP) and % PLOTIT macro (for graphs).

3. RESULTS AND DISCUSSION

Sensory Evaluation

Consumer Testing. Analysis of variance and Duncan's multiple range test revealed that crispy pili nut samples are significantly different in acceptability (overall, appearance, flavor and texture) at $p<0.0001$. The acceptability ratings of the samples ranged from 3.77 (slightly dislike) to 6.81 (moderately like), as shown in Table 2. Among the samples, Tia Berning's (S) and Growers (CM) were the most acceptable (slightly like to moderately like) while Poppoy's (MM3) was the least acceptable (slightly dislike).

Table 2. Mean Acceptance Scores Of Crispy Pili Nuts

Sample	*Acceptability Scores*[1,2]			
	Overall	*Appearance*	*Flavor*	*Texture*
A1	4.66^{e}	5.18^{d}	4.34^{e}	5.04^{d}
CS1	5.27^{cd}	5.08^{d}	5.29^{d}	5.49^{cd}
CS2	5.07^{de}	4.54^{e}	5.18^{d}	5.07^{d}
A2	5.48^{bcd}	5.51^{cd}	5.42^{d}	5.54^{bcd}
CS3	5.76^{bc}	5.36^{cd}	5.95^{c}	5.64^{bc}
CM	6.63^{a}	6.17^{b}	6.48^{ab}	6.51^{a}
MM2	5.93^{b}	5.74^{bc}	6.01^{bc}	6.01^{b}
MM3	3.89^{f}	4.17^{e}	3.77^{f}	4.49^{e}
S	6.79^{a}	6.81^{a}	6.55^{a}	6.73^{a}

[1]Ratings on a 9-point Hedonic scale (1-dislike extremely to 9-like extremely).
[2]Means (n=95) in each rows with the same letter are not significantly different ($p>0.05$) using ANOVA and DMRT.

Descriptive Sensory Testing. The trained panel came up with the following terms to describe the nature of sensory attributes perceived in crispy *pili* nuts: brown, glossiness, evenness of coating, sweetness, saltiness, bitterness, caramelized aroma, heated oil aroma, burnt aroma, woody aroma, *pili* nut aroma, *pili* nut aromatics, walnut aromatics, heated oil aromatics, astringency, oily/greasy, roughness, hardness, crispiness, fracturability and toothpack. ANOVA and DMRT of trained panel ratings (not shown) revealed that significant differences ($p<0.0001$) exist among the samples in all sensory attributes identified and evaluated, except for heated oil aroma, *pili* nut aroma and astringency.

Instrumental Analyses

Crispy pili nut samples were generally hard; in fact, an extra weight of 15g was added to test rod to obtain penetrometer readings. This was expected because the products are made from pili nuts glazed with caramelized sugar. The sugar was heated to caramelization stage which eventually formed a hard coat around the pili nuts. As shown in the depth of penetration

values, two samples were found to be extremes. MM3 registered 1.39 tenth-millimeters (hardest) whereas, A has a depth of penetration of 18.17 tenth-millimeters (least hard). Majority are moderately hard, with penetrometer readings between 6.91 to 12.50 tenth-mms. The 95% confidence interval (CI) for the color coordinates of crispy pili nut samples were: L=(37.67, 40.78), A=(14.47, 15.55), and B=(25.64, 29.43). These values imply that the samples were somewhat dark in intensity with less of red and more of yellow color qualities. Results are in accordance with the trained panel characterization of the sample where they described crispy pili nuts as having moderate brown color. Instrumental analyses of the samples manifested significant differences in hardness and in all color parameters (lightness, redness, yellowness, chroma and hue).

Preference Mapping

Internal Preference Analysis. Figures 1a and 1b depict the internal analysis of overall acceptability. In internal preference mapping, the product map was generated from the first three principal components which accounted for a total of 81.38% variation in overall acceptability (figure 1a). The preference dimensions 1, 2 and 3 described 39.36%, 24.56% and 17.37% of the overall acceptability variation, respectively. Internal preference mapping of crispy pili nuts segregated the products, in increasing order of acceptability, into four distinct groups: (1) MM3, (2) A1, (3) CS2, CS1 and A2, (4) CS3, CM and MM2 and (5) S. The order of preference is from left to right toward the fourth and fifth groups. The respondents were segmented into two large groups with regard to overall preference. In figure 1b, the projections of sensory and instrumental data onto the preference map further illuminated the patterns of preference. Even coating and more intense (chroma), light yellow color appeal to those respondents who prefer the most acceptable sample (S). CS3, CM and MM2 are well-liked because of its strong nut-related flavors (pilinut and walnut aromatics) and softness (ins_hard) aside from possessing the typical properties of S. Quite a large percentage of the respondents have preference vectors pointing toward portion of the map without products. Vectors are directed to walnut and pilinut aromatics and ins_hardness, suggesting a market for softer crispy pili nuts with distinct pili nut flavor. The internal map also reveals the drivers of overall acceptance for crispy pili nuts. The most important sensory and instrumental variables that determine overall acceptance were evenness of coat, roughness, surface oiliness, bitterness, burnt aroma and caramelized aroma. The acceptable products tend to have even coat and greater caramelized aroma. The less acceptable products are bitter, oilier, rougher and more burnt.

External Preference Analysis. In external preference mapping the product map, shown in figure 2, was created from the first and second principal components which described 53.72% and 36.96%, respectively, amounting to 90.68% of the variation in overall acceptability. Four distinct product groups were formed in decreasing order of preference by external preference mapping: (1) S, (2) MM2, CM, CS3, A1, A2 and CS1, (3) CS2, and (4) MM3. Six products (MM2, CM, CS3, A1, A2 and CS1) forms a cluster near the origin, indicates that they share similar profiles on the basis of the 21 sensory attributes and six instrumental measurements. The remaining three products (S, MM3 and CS2) are located on the different parts of the product space. The fact they apart from the other samples implies that they are perceived differently from each other and from the other samples. MM3, located on the edge of the upper right quadrant is highly associated with crispiness, roughness, hardness, bitter taste, glossiness, surface oiliness, and woody, burnt and heated oil aromas. S, situated at the center of the top left section of the sensorial space, appears to be associated

with instrumental color parameters (L, A, B, chroma and hue angle) and one descriptive sensory attribute (evenness of coat). Meanwhile, CS2, positioned on the lower right quadrant, appears to be associated with brown color, sweetness, toothpack, and nutty and caramelized aromas.

The preference map also disclosed two large segments of respondents with regard to overall preference. A large plurality of the respondents prefers crispy pili nuts which are characterized by softer (in terms of instrumental hardness) texture and more pilinut and walnut aromatics (not represented in the study). This segment of consumers disliked those products with bitter taste, strong woody aroma, hard, rough and crispy textures, particularly MM3 (Poppoy). Another large plurality of the respondents prefers evenly coated crispy pili products with high values on instrumental color parameters (L, A, B, chroma and hue angle), particularly S. This consumer segment strongly detests those products having higher intensities of sugar-related characteristics such as sweetness, caramelized aroma, brown color and toothpack as well as nutty and heated oil aromas, specifically CS2 (Arthur's).

Figure 2 further reveals the characteristics related to overall acceptance. Positively associated characteristics to overall acceptance of crispy pili nuts are evenness of coat, walnut aromatics, pili nut aromatics and softness (instrumental hardness). Glossiness, roughness, hardness, crispiness, bitterness, woody, burnt, heated oil aromas are considered negative characteristics.

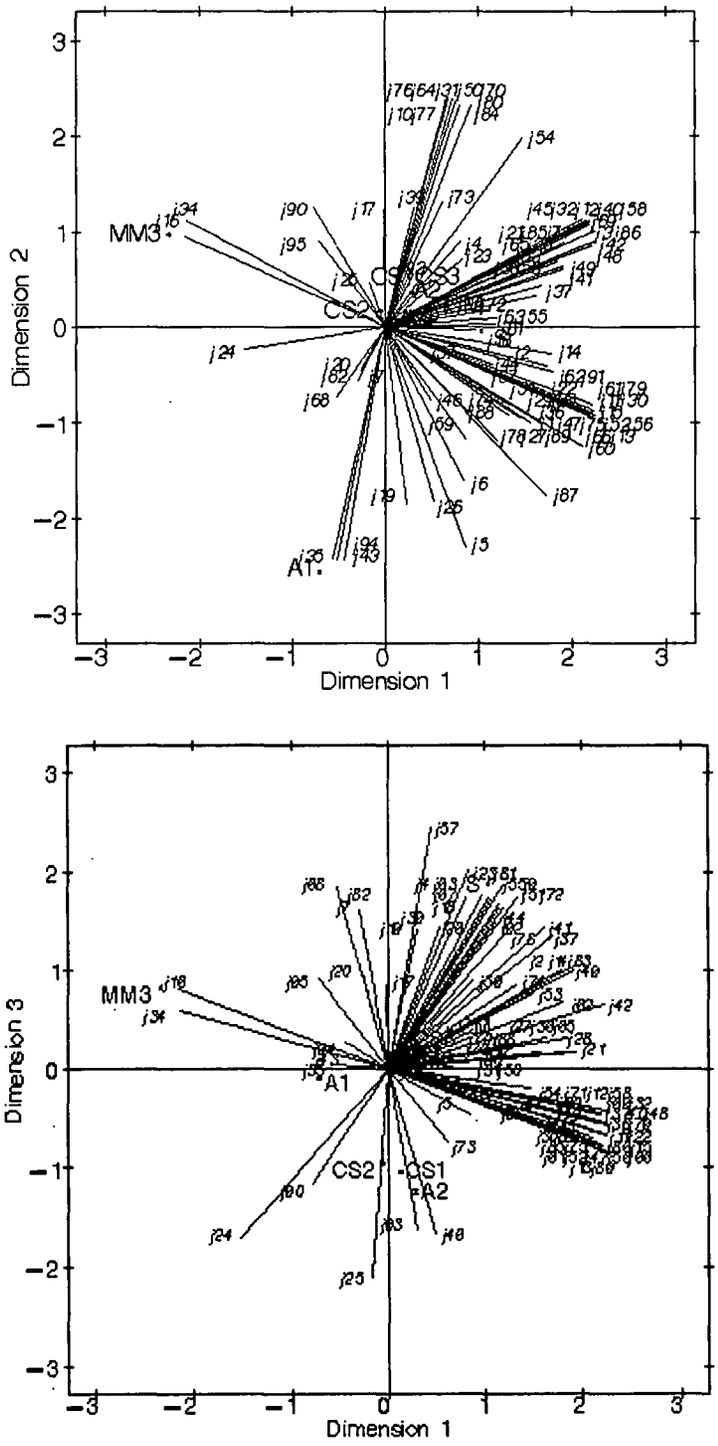

Figure 1a. Internal Preference Map Of Crispy Pili Nut Samples Using Multidimensional Preference (MDPREF) Analysis. Overall acceptability data variation described was (a) 39.36% and 24.56% for dimensions 1 and 2, respectively; (b) 39.36% and 17.37% for dimensions 1 and 3, respectively.

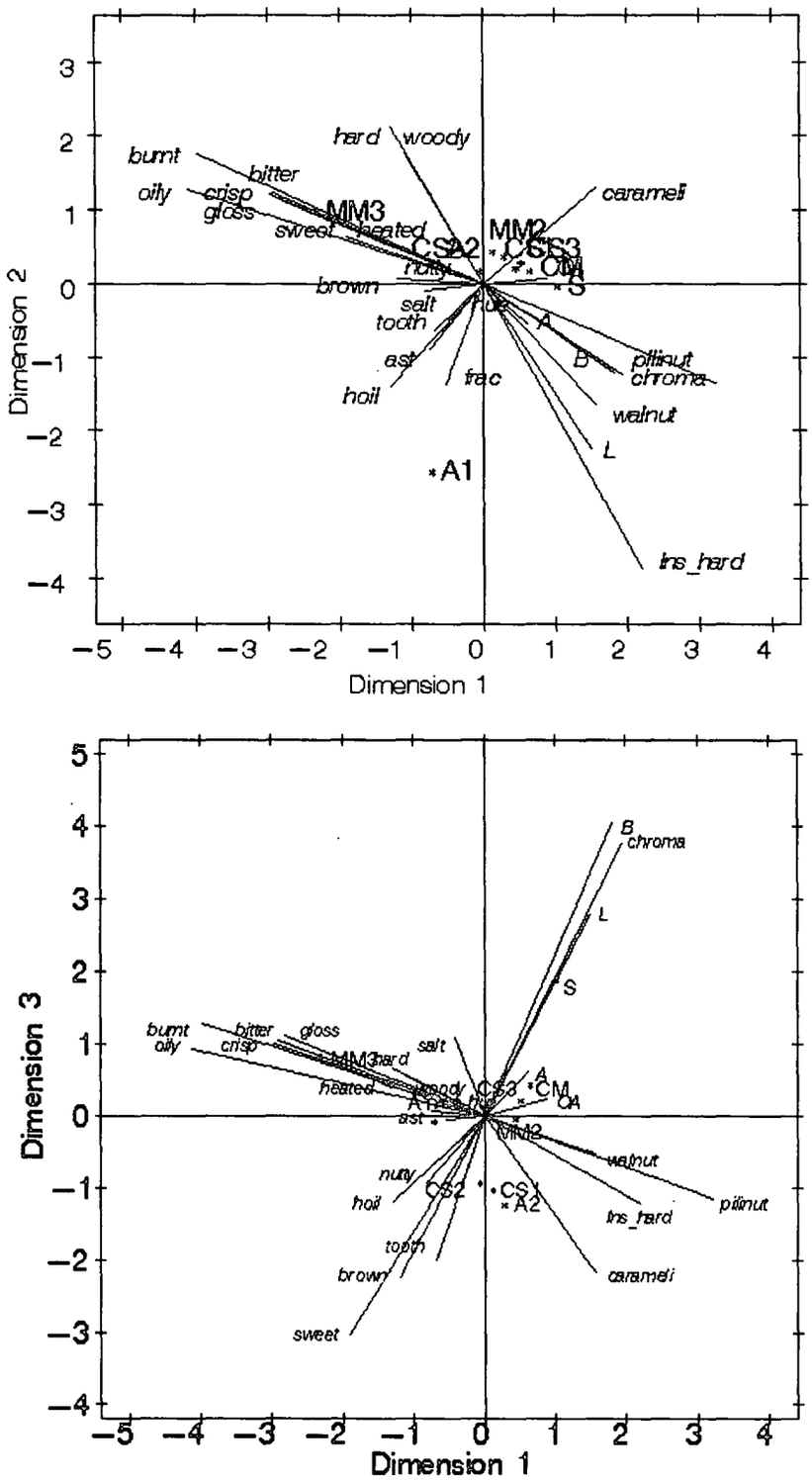

Figure 1b. Interpretation Of Crispy Pili Nuts Preference Dimensions Using Sensory And Instrumental Analyses, Excluding Evenness And Roughness

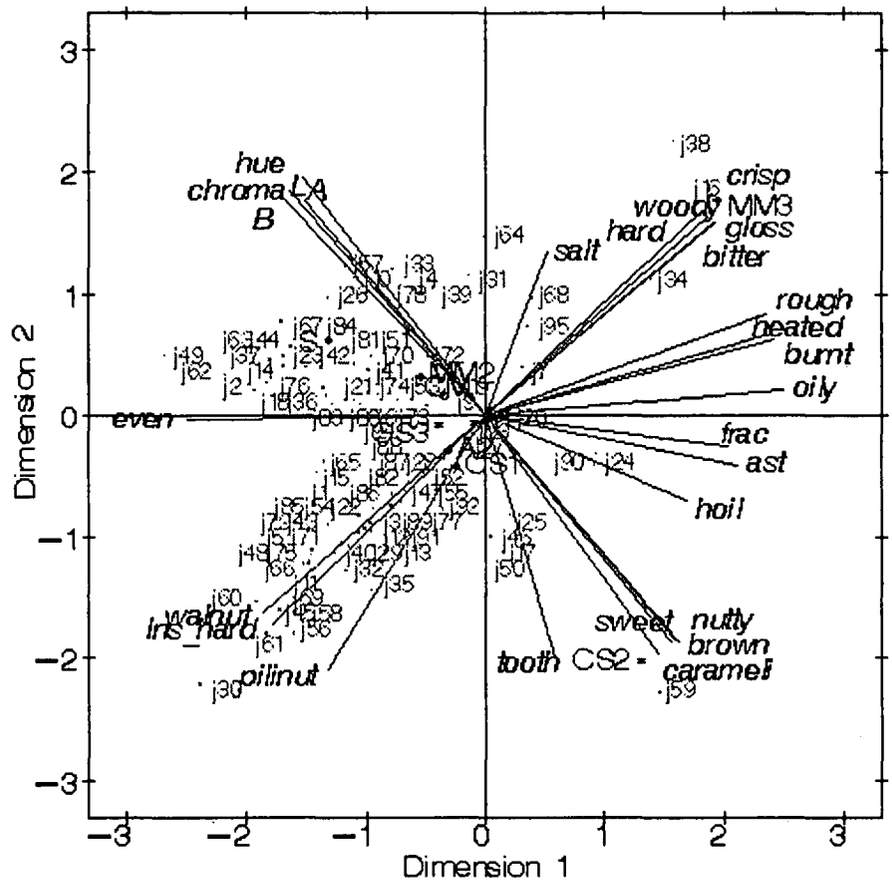

Figure 2. External Preference Map Of Crispy Pili Nuts Obtained From Descriptive Sensory And Instrumental Data Using Multidimensional Preference (MDPREF) And Preference Mapping (PREFMAP) Analyses. Overall acceptability data variation described was 53.72% for dimension 1 and 36.96% for dimension 2.

CONCLUSION

This study revealed that crispy pili nut samples exhibit diverse consumer acceptability (slightly dislike to moderately like). Descriptive sensory and instrumental analyses (color and hardness) yielded distinct profiles for each sample which provided the basis for the differing preferences. The preference maps reflected four (external analysis) to five (internal analysis) product types of crispy pili nuts as well as two large segments of consumers. It is also of worthwhile to note that there is a market potential for samples not represented in this study. The results suggest that preference mapping could be useful in food science to differentiate products, uncover product preference patterns, investigate individual differences in consumer preferences, manifest markets to take advantage, and relate food properties to acceptability to identify drivers of preferences.

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