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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Use of Mixture Design for the Sensory Evaluation of Carrot and Orange Juice

Irum Raza[1], Naseem Bibi[2], Muhammad Ahsan Khan[2] Muhammad Zubair Anwar[1] and Sumaira Bukhari[3]
[1]Social Science Research Institute, NARC, Islamabad, Pakistan
[2]Food Science and Product Development Institute (FSPDI), NARC, Islamabad, Pakistan
[3]The Islamia University Bahawalpur, Bahawalpur, Pakistan

Abstract: The present study was intended to use mixture design for the quality evaluation of mixed fruit juice. Juice was prepared with carrot and orange. The sensory evaluation for taste, texture, aroma, color and overall acceptability of carrot and orange mixed juice was subjected to a panel of six judges from FSPDI and SSRI. The results based on sensory evaluation showed that the overall acceptance level for treatment four specifically the blend with 75% carrot and 25% orange was highest (7). Mixture regression technique was used to select the best or the highly acceptable blend of carrot and orange juice. The results of mixture regression analysis showed no variation in the opinions of judges as regards to taste, texture, color, aroma and overall acceptability of the blends of juices because the p-values for all of the interaction components were greater than 0.05.

Key words: Mixture design, Mixture regression, Carrot and orange juice, Sensory evaluation

INTRODUCTION

The term mixture experiment refers to blending of ingredients together to form a product (Bondari, 2002). Piepel and Cornell (1994) have discussed about the planning of mixture experiments and mixture design. A number of studies show the application of mixture design for the quality evaluation of different products such as cakes, biscuits, mixed fruit juices and beverages. For Instance Deka *et al.* (2001) applied mixture methodology for quality evaluation of mixed fruit juice/pulp ready to serve beverages. Chauhan *et al.* (2012) developed a mixed fruit juice by blending coconut water with lemon juice, to obtain a refreshing beverage. The optimum condition for the coconut water beverage was obtained at 13.5°Brix blended with 2% lemon juice. Mixture experiments make use of mixture design and mixture regression by taking response variable as the function of the proportion of ingredients in mixture (Cornell, 2002; SAS, 2002-2003). The synergistic effects of the blending components and a highly acceptable product can be known easily using mixture regression Montgomery and Voth (1994). Fruits are very popular due to high consumption as well nutritional importance, delicate flavor. They contain water, carbohydrates, protein, minerals such as Ca, Mg, K, Zn. Fe and vitamin A, B1, B2, C, D and E (Okwu and Emenike, 2006) fruit Juices are rich sources of vitamins, minerals, fiber and salts. Orange juice is also famous because of its high vitamin C content and its flavor (Ashurt, 1991). Carrots roots are used as fresh and processed form in canned foods as well as in juices. Carrots are rich sources of β-carotene vitamins B1 and C and dietary fiber (Mayne *et al.*, 1992) now a days blending of juice is considered best in order to improve the nutritional quality of juices depending upon the kind and quality of mixture fruits (De Carvalho *et al.*, 2007).

Mixed fruit juices are rich source of vitamins and minerals. Substantial attention is being paid to the blended juices as their market potential is increasing Lakshmi Jayachandran (2013). Mixed fruit juice containing carrot and orange are a rich source of vitamin C. It also helps a human body maintain the immune system and look younger (Young and Raw, 2013). Keeping in view the importance of carrot and orange juice a study was planned in collaboration with Food Sciences and Product development Institute (FSPDI). The objectives of the study were to first prepare the mixed fruit juice containing carrot and orange and then sensory evaluation of juice using mixture regression technique.

MATERIALS AND METHODS

Materials: Fresh carrots and oranges were provided by PATCO NARC.

Carrot and orange juice preparation: Eight kg carrots and 10 dozens oranges were washed properly and then juice was extracted using juice extractors. After the juice extraction three blends such as 50% carrot *50% orange, 75% carrot *25% orange and 25% carrot *75% orange were made and filled in the sterilized bottles. These bottles were kept in the refrigerator.

Corresponding Author: Irum Raza, Social Science Research Institute, NARC, Islamabad, Pakistan

Sensory evaluation: The sensory evaluation for color, taste, flavor, texture and over all acceptability of carrot and orange juice was subjected to a panel of judges from FSPDI and SSRI NARC. A nine point hedonic scale test (1 = extremely dislike, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = extremely like) was used for the judgment of juice as described by Lawless and Heymann (1998).

Statistical analysis: Data generated from the evaluation Proformas were statistically analyzed using mixture regression analysis technique in MINITAB software. The ingredients or the components were set in the independent variables tab and taste, texture, color, aroma and over all acceptability were selected as response variables.

The regression equations for mixture was written as:

Taste = Carrot+orange+carrot*orange
Texture = Carrot+orange+carrot*orange
Color = Carrot+orange+carrot*orange
Aroma = Carrot+orange+carrot*orange
OA = Carrot+orange+carrot*orange

OA: Overall acceptability

RESULTS AND DISCUSSION

Juice prepared from carrot and orange in different combinations were subjected to sensory evaluation for color, taste, texture, aroma and overall acceptability. The results of the sensory scores are compiled in (Table 1). The taste of juice prepared with the blend of 50% orange and 50% carrot (T3) got highest mean score (6.5). 100% orange juice scored lowest mean score (5.67). In case of texture of juice T4 that is the blend with 75% carrot and 25% orange scored the highest mean score (6.83) and lowest score was obtained by pure orange juice (5.83). For the parameter aroma the highest mean was obtained by T4 that is the blend of 75% carrot and 25% orange. The color of pure orange juice T2 got highest mean score (7.67) and lowest mean was obtained by T1 that means pure carrot juice. Lastly the overall acceptance level for T4 specifically the blend with 75% carrot and 25% orange was highest (7). Literature show different studies about the sensory characteristics and consumer acceptance of fruit juices such as Wunwisa Krasaekoopt and Kamolnate Kitsawad (2010), worked on the sensory characteristics of fruit juice containing probioitcs beads in Thailand. Most consumers bought fruit juice due to its taste (9.6) and nutritional value (8.9). However, the addition of probiotic beads influenced the sensory quality of the product. The majority of consumers accepted orange and grape juices containing probiotic beads (82.3 and 84.3%, respectively), giving scores of texture and overall preferences as 6.6 and 6.7 for orange juice; and 6.8 and 6.9 for grape juice. Application of probiotic beads also increased turbidity of grape juice.

Mixture regression analysis: Estimated regression coefficients for juice taste are summarized in Table 2. The parameter estimate of carrot (6.09) is more than parameter estimate of orange (5.69) (Table 2), which implies that the taste of pure carrot juice is more acceptable by the panel of judges than pure orange juice. The mixture of carrot and orange juice has t-value 2.64 and p-value 0.118 which means that there is no difference in the taste preferences of the juice when these components are blended together. The value of R^2 (68.12%) indicates that 68.12% of the variation in the response variable taste is present due the independent variables. The regression equation for juice taste is given below. Positive relationship is found between dependent variable taste and independent variables carrot and orange. It means that if carrot juice is increased by one unit the taste of juice will be improved by 6.09 units. Similarly one unit increase in the orange juice causes 5.69 units of improvement in the taste of juice. The relation between taste and the interaction coefficient signifies that with one unit increase in the mixture of carrot and orange juice will result 1.89 units of progress in the taste of the mixed juice. The regression coefficients for the juice texture are given in Table 3. The coefficient of carrot is 6.59 which is greater than the coefficient of orange 5.8 which implies that the texture of carrot juice alone is more acceptable than pure orange juice. The blend or the interaction of carrot*orange has t-value 0.36 with the associated p-value 0.75 which is a sign of non significance. In other words we can say that the preferences of judges about the texture of juice are about the same. The value of R^2 is 12.6% which means that only 12.6% of the variation is explained by the independent variables that is there is only 12.6% of difference in the opinion of the judges about the texture of juice. The regression equation below describes positive relationship between texture and the components carrot and orange. This is apparent from the equation and the coefficients that improvement in the texture of juice is due to the pure carrot and orange juice because their coefficients are higher than the interaction of carrot*orange. Table 4 demonstrate the regression coefficients for juice aroma. Again the coefficient for carrot 6.7 is more than the coefficient of orange 6.3 which indicates that acceptance of carrot juice alone is more likely than orange juice. The interaction coefficient is -1.22 which symbolizes that carrot and orange when blended together are antagonistic towards one another. That is these components do not act significantly for improving the aroma of the juice. Also the t-value 0.36 with p-value 0.75 clearly signifies non significance and

Table 1: Sensory characteristics (Range 1-9) of juice prepared from different blends of carrot and orange

Treatments	Carrot	Orange	Taste	Texture	Aroma	Color	Overall acceptability
T1	1	0	6.17	6.5	6.6	6.33	6.33
T2	0	1	5.67	5.83	6.5	7.67	6.17
T3	0.5	0.5	6.5	6	6.3	7.33	6.67
T4	0.75	0.25	6.17	6.83	6.67	7.5	7
T5	0.25	0.75	6.17	6.33	6	6.5	6.08

T1: 100% carrot; T2: 100% orange; T3: 50% carrot and 50% orange; T4: 75% carrot and 25% orange; T5: 25% carrot and 75% orange

Table 2: Estimated Regression Coefficients for juice taste/flavor (component proportions)

Term	Coef	T	P
Carrot	6.099	*	*
Orange	5.699	*	*
Carrot*orange	1.897	2.64	0.118

Taste: 6.099 (carrot) + (5.699) orange + 1.89 (carrot*orange)
R^2: 68.12%

Table 3: Estimated Regression Coefficients for juice texture (component proportions)

Term	Coef	T	P
Carrot	6.5946	*	*
Orange	5.8586	*	*
Carrot*orange	0.5714	0.36	0.754

Texture: 6.59 (carrot) + (5.85) orange + 0.57(carrot*orange)
R^2: 12.67%

Table 4: Estimated Regression Coefficients for juice aroma (component proportions)

Term	Coef	T	P
Carrot	6.783	*	*
Orange	6.379	*	*
Carrot*orange	-1.223	-1.09	0.390

Aroma: 6.78 (carrot) + 6.3 (orange) - 1.22 (carrot*orange)
R^2: 14.20%

Table 5: Estimated Regression Coefficients for juice color (component proportions)

Term	Coef	T	P
Carrot	6.6357	*	*
Orange	7.3077	*	*
Carrot*orange	0.7543	0.23	0.839

Color: (6.63) carrot + 7.3 (orange) + 0.75 (carrot*orange)
R^2: 21.10%

Table 6: Estimated Regression Coefficients for juice overall acceptability (component proportions)

Term	Coef	T	P
Carrot	6.495	*	*
Orange	5.999	*	*
Carrot*orange	1.623	1.01	0.419

Overall acceptability: 6.5 (carrot) + 5.9 (orange) + 1.62 (carrot * orange)
R^2: 2.58%

no difference in the opinions of judges regarding the mixed juice. The value of R^2 is 14.20 which connotes that 14.20% of difference is observed in the opinions of judges about the aroma of the mixed juice. The regression equation below indicates positive relation between aroma and carrot alone but negative relationship is observed between aroma and the interaction of carrot*orange. It shows that if the mixture of carrot and orange is increased by one unit, it will decrease the aroma of juice. The results of mixture regression and its estimates for juice color are described in (Table 5). The color of pure orange juice was more acceptable than the carrot one because the coefficient of orange 7.3 is more than the coefficient of carrot 6.6. T-value for the interaction of carrot*orange is 0.23 with the p-value 0.89 which shows these components do not act complimentary with each other and at the same time cannot be used together in improving the color of the mixed juice. The value of R^2 is 21.1 and it suggests that the model does not fit well to data and only 21% of variation is found in the preferences of judges about the color of the mixed juice. Positive correlation is found between color and carrot, orange and carrot*orange. The results of mixture regression and its estimates for juice color are described in Table 5. The color of pure orange juice was more acceptable than the carrot one because the coefficient of orange 7.3 is more than the coefficient of carrot 6.6. T value for the interaction of carrot*orange is 0.23 with the p-value 0.89 which shows these components do not act complimentary with each other and at the same time cannot be used together in improving the color of the mixed juice. The value of R^2 is 21.1 and it suggests that the model does not fit well to data and only 21% of variation is found in the preferences of judges about the color of the mixed juice. Positive correlation is found between color and carrot, orange and carrot*orange. The results for overall acceptability of juice are illustrated in Table 6. The parameter estimate of carrot 6.4 is more than orange 5.9 which is a sign of likeliness of carrot juice alone. T-value for the interaction of carrot and orange is 1.01 and p-value is 0.419 which indicates that these components together are not compatible for improving the overall acceptance of mixed juice. The value of R^2 is 2.58 and it specifies that only 2.58% of variation is found in the opinions of judges as regards the overall acceptance of mixed juice. Positive correlation between overall acceptability and the two independent variables symbolize that one unit increase in the carrot juice causes 6.5 units increase in the overall acceptability of juice. In the same way one unit increase in orange juice alone will lead to 5.9 units of increase in the overall acceptability. Overall acceptability of the mixed juice is

Table 7: F-values from analysis of variance

Source	DF	Taste	Texture	Color	Aroma	Overall acceptability
Regression	2	5.27^{ns}	1.29^{ns}	0.27^{ns}	1.33^{ns}	1.05^{ns}
Linear	1	3.55^{ns}	2.45^{ns}	0.48^{ns}	1.48^{ns}	1.09^{ns}
Quadratic	1	6.99^{ns}	0.13^{ns}	0.05^{ns}	1.18^{ns}	1.02^{ns}
Carrot*orange	1	6.99^{ns}	0.13^{ns}	0.05^{ns}	1.18^{ns}	1.02^{ns}
Residual error	2	-	-	-	-	-
Total	4	-	-	-	-	-

Ns: Non significant

increased by only 1.62 units due to one unit increase in the interaction of carrot and orange. Regression in the analysis of variance (Table 7) tests whether the terms in the model ie the two components alone and their combinations have any effect on the response variables namely taste, texture, color, aroma and overall acceptability. The regression model is not significant which means that all of the terms in the regression equation do not make a significant impact on the response variables. Regression is broken into different orders of terms in the model, linear and quadratic. The p values for all effects are greater than 0.05. There are non significant linear and quadratic effects for components.

Findings of the present study can be compared with other studies in which researchers have made use of mixture design for the quality evaluation of mixed fruit juice and beverages. Apinya Chareonkul (2008), evaluated the influence of levels of xylitol and the proportions of roselle and carrot juices on physical and sensory properties of low carlorie carrot juices. The results from mixture design containing roselle-carrot (87.07: 12.93) juice and 13.41% xylitol resulted in an optimal product having an overall acceptability score of 7.42, while the product with roselle-carrot (70 : 30) juice with 12% xylitol was rated only 4.17 of the same attribute. Deka *et al.* (2001) and Fernando *et al.* (2004) made a study in which fruit juices/pulp of lime, aonla, grape, pineapple and mango were blended in different proportions and nectar was developed based on papaya pulp and passion fruit juice to formulate the best recipe. (Kumar *et al.*, 2010) have also reported the formulation and optimization of dehydrated fruit punch five categories of fruit punches with different percentages. A highly acceptable dehydrated fruit punch was developed with selected fruits, namely lemon, orange and mango, usinga a mixture design and optimization technique. The results provide information on the sensory quality of best fruit punch formulations liked by the consumer panel based on lemon, orange and mango. HUOR *et al.* (2006) carried out a study to formulate and test the acceptability of a fruit punch containing watermelon juice. Optimum proportions of juices were determined, using mixture response surface methodology, laboratory sensory evaluation and small scale consumer tests. In a different study Lakshmi and Jayachandran (2013) worked on the optimization and formulation of mixed fruit beverage composed of litchi juice, coconut water and lemon juice based on sensory analysis. Formulations were developed and optimized using Mixture Design. The ingredient compositions having 71.6% Litchi juice, 27.2% coconut water and 1.2% lemon juice was selected as optimum and used for further studies.

Conclusion and recommendations: The results based on the sensory evaluation showed that juice prepared with 50% carrot and 50% orange (T3) was more acceptable than other blends with respect to taste. The likeliness of texture of juice was observed with T4 that is a blend with 75% carrot and 25% orange. In the same manner the aroma, color and overall acceptability were satisfactory with T4, T2 (100% orange) and T4, respectively.

The results of mixture regression depicted no statistical difference in the preferences or fondness of the panel of judges towards taste, texture, color, aroma and overall acceptability as the p- values for all the mixtures such as 50% carrot * 50% orange, 75% carrot * 25% orange and 25% carrot *75% orange were all greater than 0.05. Therefore it was difficult to choose the best blend of juice derived from mixture regression.

The study results suggest that at least three components or ingredients should be used for the formulation of juice because with three components more blends will be generated which will definitely lead to meaningful results and the improved or the best recipe. Moreover this statistical technique should be applied for the evaluation and optimization of other products developed by PATCO NARC.

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