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Process and Formulation Optimization of Vacuum Fried Aninikad (*Plicate conch*)

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Key words: Central composite design, Optimization, Plicate conch, Response surface methodology, Sensory evaluation, Vacuum frying.

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Abstract

Fried snacks emerged as one of the enticing, delightful snacks of modern consumers. Vacuum frying emerged as a new frying technology that improves the quality and retains the nutrients of food products. The concept of applying this to marine produce, specifically the "aninikad" could be a unique product since mostly vacuum frying is applied to fruits and vegetables. This study aims to utilize, optimize and evaluate the sensory acceptability of the vacuum fried aninikad. Response Surface Methodology using Central Composite Design (CCD) of Experiment was employed in order to optimize the product. The three identified factors, namely pre-cooking time (5, 10, and 15 min.), soy sauce (5, 10, and 15 %) and sugar (20, 30 and 40%), were used in the experiment. Determination of the sensory acceptability was the parameter used for optimization. The optimum condition of the product that would give acceptability of ≥7.1 was 9.7 min. pre-cooking time, 9% soy sauce level and 30.2% sugar level. Hence, the results in this study prove that a healthy snack can be produced and will add value to aninikad.

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Introduction

Fried snacks emerged as one of the enticing, delightful snacks of modern consumers. Fried products are liked by all ages because of the unique flavour texture developed during cooking. Frying is an ancient practice of preserving the food wherein the foodstuff is being dried up because of the withdrawal of moisture, resulting in a counter flow of water vapour and oil at the surface of the product. However, health issues arise with the consumption of fried products because of the oil uptake leading to some serious ailments. With the advancement of technology and continuous research in order to sustain the needs of humanity, vacuum frying emerged as new technology. Vacuum frying is a reasonably new technology that uses lower pressure and temperature rather than atmospheric deep-fat frying to improve the quality attributes of food products (Diamante, *et al.*, 2015). This technology has been used for different foods, mostly fruits and vegetables.

The impact on the application of vacuum frying technology meets its promising role in satisfying consumer's needs. This study seeks to adopt the technology, and develop and apply the said technology to marine produce.

The concept of applying this to marine produce, specifically the "aninikad" could be a unique product since mostly vacuum frying is applied to fruits and vegetables. Reality hits this marine produce that it is being mostly rejected and labelled as an inferior seashell. By this, the idea of applying vacuum frying to "aninikad" could raise its market status and will add value, making it competitive with other marine produce.

Materials and methods

Preparation of the aninikad

The preparation of the aninikad was based on the results of the variable screening using Plackett-Burman Design. Pre-cooking of the aninikad at the specified time. Removal of its meat from the shell then follows. It was soaked overnight in the marinating solution. Then follows the freezing of the aninikad. After which, it was subjected to vacuum frying at 90psi for 30 minutes. Spin drying then follows to remove the excess oil.

Experimental design for optimization experiment

The optimization experiment included three variables that showed significant effects on the acceptability of the vacuum fried aninikad. To further determine the optimum conditions and formulation of the product, a 3x3 fractional factorial experiment was used following the Central Composite Design (CCD) with 15 treatments. All other variables were set at a constant level.

The identified experimental combinations were subjected to sensory analysis. Table 1 shows the experimental combination for the vacuum fried aninikad.

Statistica Version 8 software was used for graphical presentation of the response surface plots, determining the predicted response of each treatment, mode of descriptive scores and profiling of the product acceptability.

Results and discussion

Determination of the Optimum Condition for Vacuum fried aninikad

Vacuum fried aninikad was produced using the 15 treatments for experimental combinations. All other variables were set constant and subjected to sensory analysis. Fig. 1 shows the appearance of the 15 treatments.

The frequencies on descriptive scores of the different attributes of all treatments of Vacuum-fried aninikad product are summarized in Table 2.

The basis for the dominant perception of each sensory attribute was based on the sum of the top frequencies with a total of ≥60% of the descriptive score. The mean acceptability of each treatment were reflected in Table 3.

Table 1. Experimental Combination of the Vacuum-fried aninikad.

TREATMENT	PRE-COOKING TIME (min)	SOY SAUCE (%)	SUGAR (%)
1	15	5	20
2	15	15	20
3	15	15	40
4	15	5	40
5	15	5	20
6	5	15	20
7	5	15	40
8	5	5	40
9	10	5	30
10	10	10	40
11	10	15	30
12	10	10	20
13	15	10	30
14	5	10	30
15	10	10	30

Table 2. Summary of frequencies of the descriptive scores for the sensory attributes of the Vacuum-fried aninikad.

Rating	Color		Aroma		Crispiness		Flavor		Taste	
	Cnt	%	Cnt	%	Cnt	%	Cnt	%	Cnt	%
1	91	28.9	113	35.9	23	7.3	70	22.2	10	3.2
2	113	35.9	162	51.4	49	15.6	101	32.1	49	15.6
3	111	35.2	40	12.7	82	26	108	34.3	109	34.6
4					161	51.1	26	8.3	139	44.1
5							10	3.2	8	2.5

Quality Description: Color (1-light brown, 2-dark brown, 3-blackish brown), Aroma (1-very pronounced fishy/shell meat aroma, 2- slightly pronounced fishy/shell meat, 3- no distinct fishy/shell meat aroma), Crispiness (1- soggy, 2- slightly crispy, 3- moderately crispy, 4- very crispy), Flavor (1- more pronounced fishy/shell meat than soy sauce, 2-slightly pronounced fishy/shell meat, 3-well-blended fishy/shell meat to salty and sweet, 4- slightly pronounced soy sauce than fishy/shell meat, 5- more pronounced soy sauce than fishy/shell meat), Taste (1- Bland, 2- slightly salty, 3-slightly sweet, 4-well-blended salty and sweet, 5- very sweet).

Acceptability scoring

Color

Color is a critical parameter in frying food because it is usually the first quality evaluated by consumers when determining product acceptance (Dueik *et. al*., 2010). The appearance of the different formulations is shown in Fig. 1. It has been described by 35.9% of the panellists as dark brown and 35.2% as blackish brown (Table 2). This is influenced by the absorption of soy sauce during marinating. In a similar study of the use of soy sauce as marinating solution, Kim *et.al*, 2014 state that the presence of soy sauce contributed to a decrease in the lightness, as well as an increase in both the redness and yellowness of the chicken breast, due to staining. Hence, the same is true with the plicate conch's meat; it has a natural color appearance of brownish with shaded black, and an increase dark color was observed after marinating and cooking. Most of the treatments were perceived between dark brown and blackish brown; this means that any level of soy sauce and sugar affects the overall color description of the product.

Table 3. Sensory acceptability mean score for the different attributes of the Vacuum-fried aninikad.

Treatment	Color	Aroma	Crispiness	Flavor	Taste	Gen.Acc.
1	6.95	6.90	7.10	7.38	7.19	7.19
2	6.90	7.05	6.81	7.19	7.24	7.05
3	7.14	7.19	7.38	7.14	7.33	7.48
4	6.48	6.86	7.29	7.33	7.33	7.19
5	7.10	6.71	7.10	7.14	6.95	6.90
6	6.95	7.05	7.57	7.43	7.14	7.10
7	7.14	7.29	7.57	7.24	7.10	7.24
8	7.24	7.14	7.00	7.67	7.43	7.52
9	6.67	6.90	6.57	6.52	6.86	6.76
10	7.00	7.52	7.29	7.38	7.38	7.24
11	7.10	6.95	7.05	7.14	7.14	7.19
12	6.90	6.29	6.43	6.67	6.67	6.52
13	6.76	7.10	7.29	7.43	7.48	7.33
14	6.62	7.00	7.43	7.10	7.48	7.10
15	6.90	6.95	7.05	7.29	7.33	7.29
MEAN	6.92	6.99	7.13	7.20	7.20	7.14

*9-point Hedonic rating scale: score of 9 (like extremely) to 1 (dislike extremely).

Table 4. Summary of Analysis of Variance (ANOVA F-Ratios) result for the different sensory attributes of Vacuum-fried aninikad.

	Color	Aroma	Crispiness	Flavor	Taste	Gen.Acc
(1)Pre-cooking(L)	0.1213	0.2710	0.2264	0.5184	0.0034	0.2608
Pre-cooking(Q)	0.1295	1.1920	0.0180	0.0286	0.8203	0.6261
(2)Soy sauce(L)	0.7583	0.9669	1.7467	0.2916	1.8075	0.7986
Soy sauce(Q)	0.0452	0.0449	0.1617	0.8643	0.0003	0.6843
(3)Sugar (L)	0.0539	1.7699	7.5568	3.0276	2.1355	3.4267
Sugar (Q)	0.4279	1.9185	2.5871	5.8425	3.1047	3.8421
1L by 2L	0.0674	2.2124	0.4227	0.8820	2.4601	1.4719
1L by 3L	0.4213	0.9410	0.4227	0.0180	0.1538	0.0051
2L by 3L	2.4264	0.2049	0.1712	0.8820	0.0171	1.1460

The color acceptability of the different treatments ranges from 6.48 to 7.14 (Table 3), which falls within the range of "like slightly to like moderately" on the 9-point hedonic scale. The overall response mean found in Table 3 (6.92) is slightly lower than the predicted value of 7.05 (Table 6). Depicted in Tables 4 and 5 is the response surface regression analysis of the linear and cross-product effect of different variations in the formulation of color acceptability. However, both the linear, quadratic and cross-product interaction does not have a significant effect. Depicted in Figs 2, 3 and 4 are the contour plots that define the acceptability regions at different levels for color acceptability of Vacuum-fried aniniakd at constant Pre-Cooking time, Soy Sauce and Sugar levels. At a constant sugar level, the acceptability decreases when the levels of soy sauce increase. This is evident in the results of the sensory analysis wherein combinations of the highest level of soy sauce (15%) and lowest level of pre-cooking (5min) has a majority acceptability mean at 6 which falls under like slightly on 9 point hedonic scale. On the other hand, at constant pre-cooking, the acceptability increases as the level of sugar increases; only when combined with soy sauce amounting to

12% and an increase of sugar level greater than 32% the acceptability decrease. Soy sauce has a black color characteristic which then greatly affects the color of the product, also coupled with the chemical properties of sugar when heated, undergoes the process of non-enzymatic reaction-caramelization which leads to the development of brown color also contributes to its dark-colored appearance.

Table 5. Parameter estimates for the acceptability of all sensory attributes of Vacuum-fried aninikad.

Parameter	Color	Aroma	Crispiness	Flavor	Taste	Gen.Acc.
Intercept	6.28095	4.92857	5.61429	5.97143	5.75238	5.98095
Pre-cooking	0.08608	0.13204	0.02357	-0.07307	-0.15116	-0.13765
Pre-cooking^2	-0.00233	-0.00709	-0.00095	0.00106	0.00582	0.00466
Soy sauce	-0.06296	-0.03606	-0.08452	-0.19116	-0.03021	0.01664
Soy sauce^2	-0.00138	-0.00138	0.00286	0.00582	0.00011	-0.00487
Sugar	0.04873	0.13349	0.15143	0.19413	0.16746	0.14254
Sugar^2	-0.00106	-0.00225	-0.00286	-0.00378	-0.00283	-0.00288
Pre-cooking*Soy sauce	-0.00095	0.00548	0.00262	0.00333	0.00571	0.00405
Pre-cooking*Sugar	-0.00119	-0.00179	-0.00131	0.00024	-0.00071	-0.00012
Soy sauce*Sugar	0.00286	0.00083	0.00083	0.00167	-0.00024	0.00179

Table 6. Summary of the critical and predicted values of Sensory Acceptability of Vacuum-fried aninikad.

Response	Critical Values			Predicted Value at Stationary Point
	Pre-cooking(min)	Soy Sauce (%)	Sugar (%)	
Color	6.57950	12.67624	36.43695	7.052872[s]
Aroma	17.27480	29.86673	28.35737	7.4233
Crispiness	5.67835	8.33697	26.41452	7.328829
Flavor	21.48005	6.30240	27.72158	7.275026
Taste	5.78382	18.18247	28.08502	7.39213
General Acceptability	10.30523	11.11970	27.94590	7.355935

Aroma

Seafood have their characteristics fishy aroma which retains even after being subjected to processing. The aroma of the product was perceived by 87.3% of the panellist as "very pronounced to slightly pronounce fishy/shell meat aroma".

Fig. 1. Vacuum-fried samples from each treatments of the optimization experiment.

The results revealed that perhaps the addition of the fermented solution (soy sauce) covers the fishy aroma of the product. The overall response mean of aroma is 6.99 with mean values ranging from 6.29 to 7.29, which corresponds to "like slightly" to "like moderately" based on a 9-point Hedonic scale (Table 3). The predicted aroma acceptability mean value is 7.42 (Table 6), which is slightly higher compared to the overall response mean value. Based on the parameter estimates (Table 5) and analysis of variance (Table 4) showed that there is no significant effect of the independent variable on the aroma acceptability of the product. Contour and surface plots for aroma acceptability at constant Pre-cooking, Soy sauce and sugar levels are illustrated in Figs 5, 6 and 7, respectively. These plots generated reflect the acceptability regions at various levels. At constant Pre-cooking time, the acceptability increases with the increases in sugar and soy sauce levels. This is evident in Treatment 7 with the highest soy sauce (15%) and sugar level (40%) having an acceptability mean of 7.29 which falls to "like moderately" in 9 point

Hedonic scale. Furthermore, the acceptability declines as an increase in pre-cooking time are combined with sugar and soy sauce. Results implied that during pre-cooking of the plicate conch, some of the aromatic compounds evaporate as the heat penetrates unto the shell's meat.

Crispiness

Crispiness or its texture is an important attribute for the acceptability of fried food, and it is influenced by both raw material and process conditions (Pan, G., et. al., 2014). Increased crispiness positively affects the acceptability of the product (Malty, T., et. al., 2014).

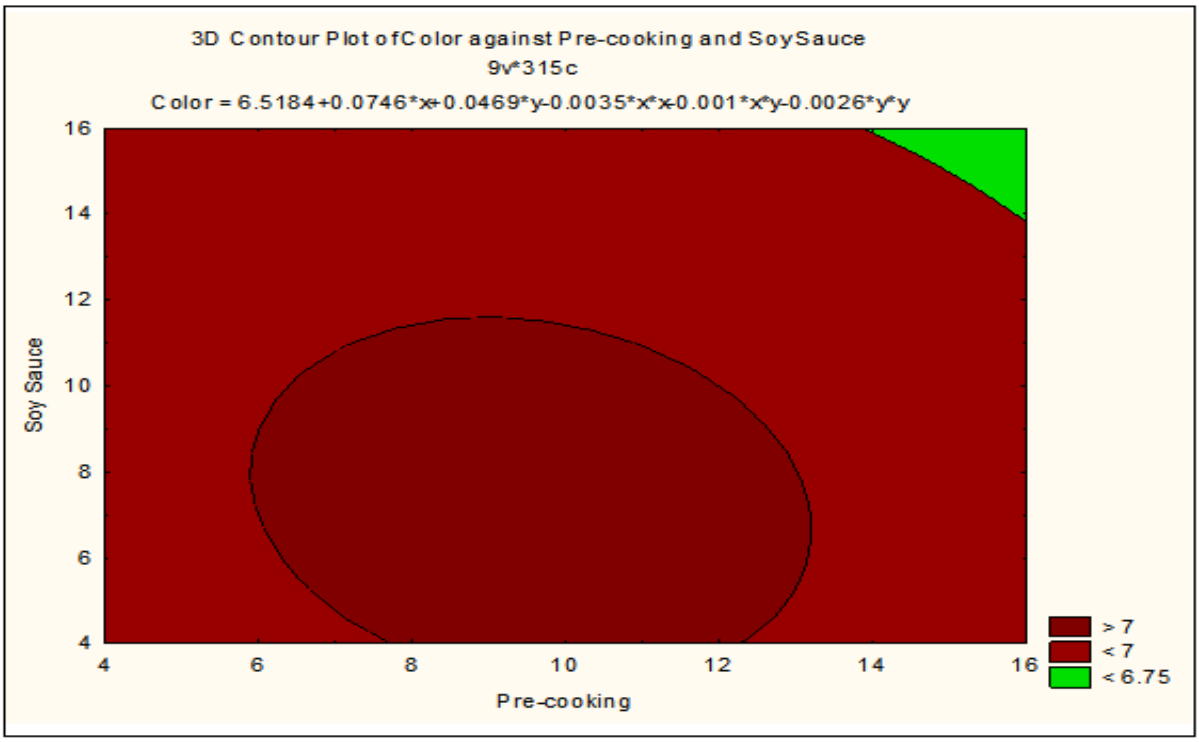

Fig. 2. Surface Plots for color acceptability of Vacuum-fried aninikad at constant Sugar Level.

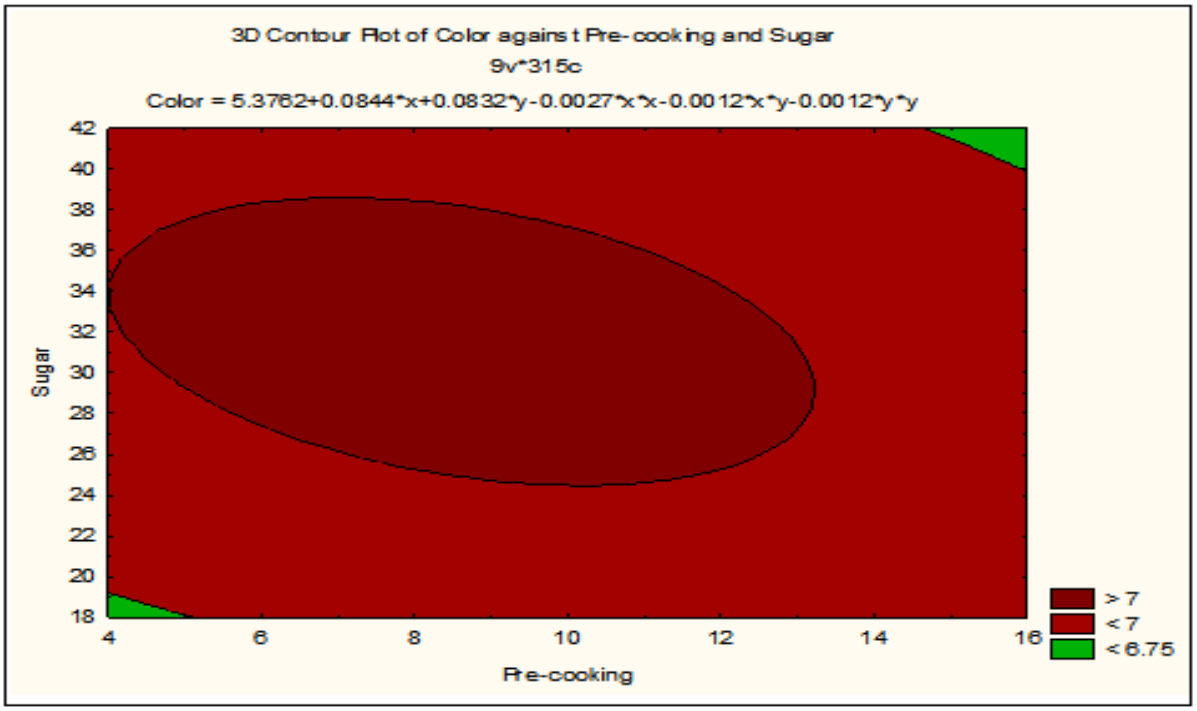

Fig. 3. Contour for color acceptability of Vacuum-fried aninikad at constant soy sauce level.

The properties of raw materials such as starch content, size of starch granules, cell wall polysaccharides, nonstarch polysaccharides, pectin substances and processing conditions determine the texture quality acceptability (Nourian, F. and Ramaswamy, HS., 2003). Vincent, Z.M., 1998 states that crispness is perceived in relation with a rapid drop of force during the mastication process attribute that is based on fracture propagation in brittle materials.

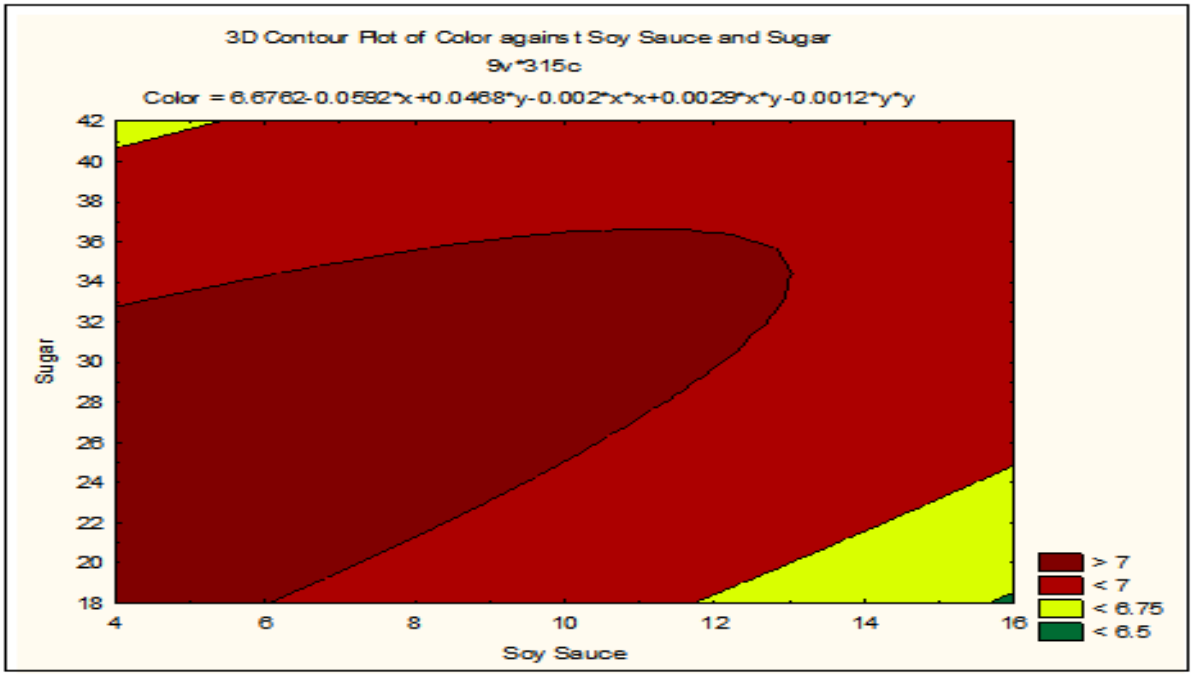

Fig. 4. Contour Plots for color acceptability of Vacuum-fried aninikad at constant pre-cooking.

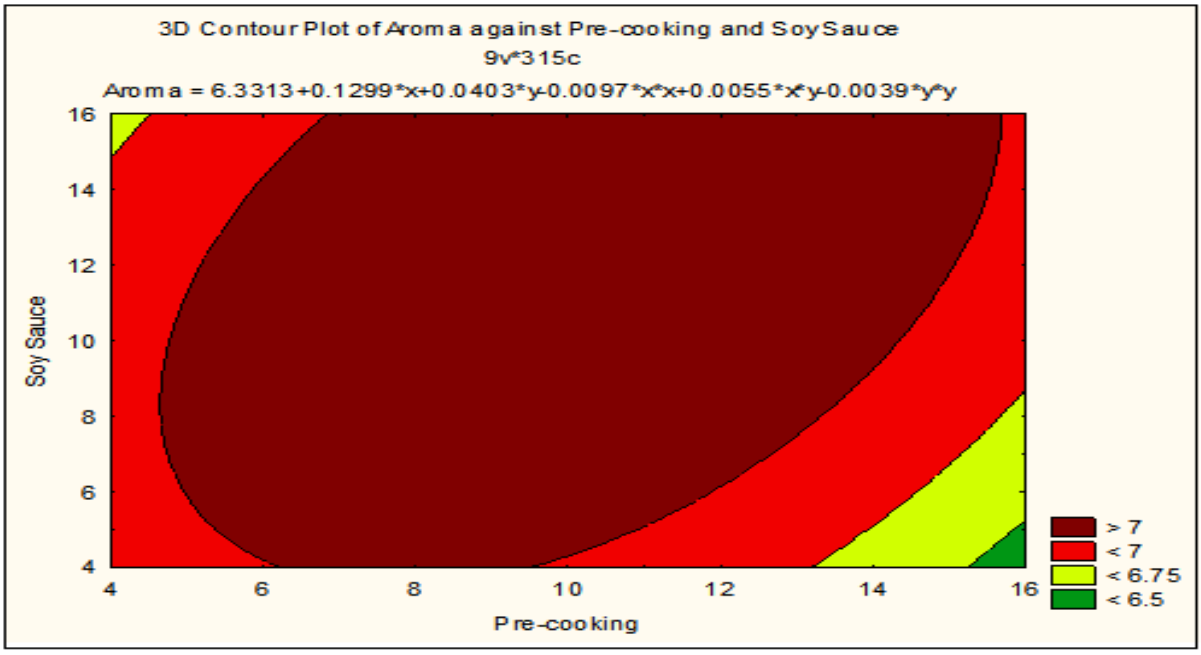

Fig. 5. Contour Plots for aroma acceptability of Vacuum-fried aninikad at constant sugar level.

In addition, crispness is perceived through a combination of tactile, kinaesthetic, visual and auditory sensations and represents the key texture attributes of dry snack products. (Heidenreich, et. al., 2014). About 77.1% (Table 2) of the panellist described the crispiness of the product from

"moderately" to "very crispy". The majority of the treatments with high levels of sugar and high pre-cooking time (Trt-1,2, 7, 8 and 9) has the highest frequency perceived as "very crispy" which falls in acceptability rating of > 7, corresponds to like moderately in 9 point Hedonic Scale. Table 6 it has an overall response at a stationary point of 7.32 which is slightly higher than the acceptability mean. There is a significant linear effect of sugar on the crispiness of the product, as shown in Table 4. However, as shown in Table 5, shows that there is no significant effect of the independent variables.

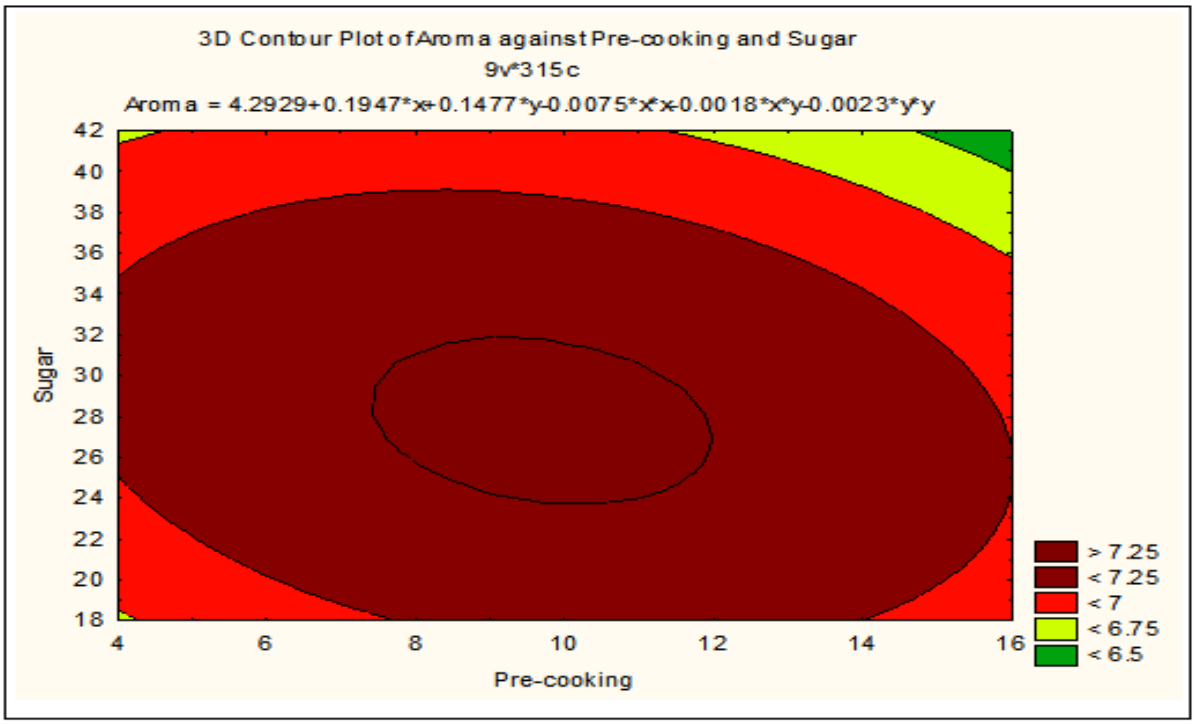

Fig. 6. Contour Plots for aroma acceptability of Vacuum-fried aninikad at constant soysauce level.

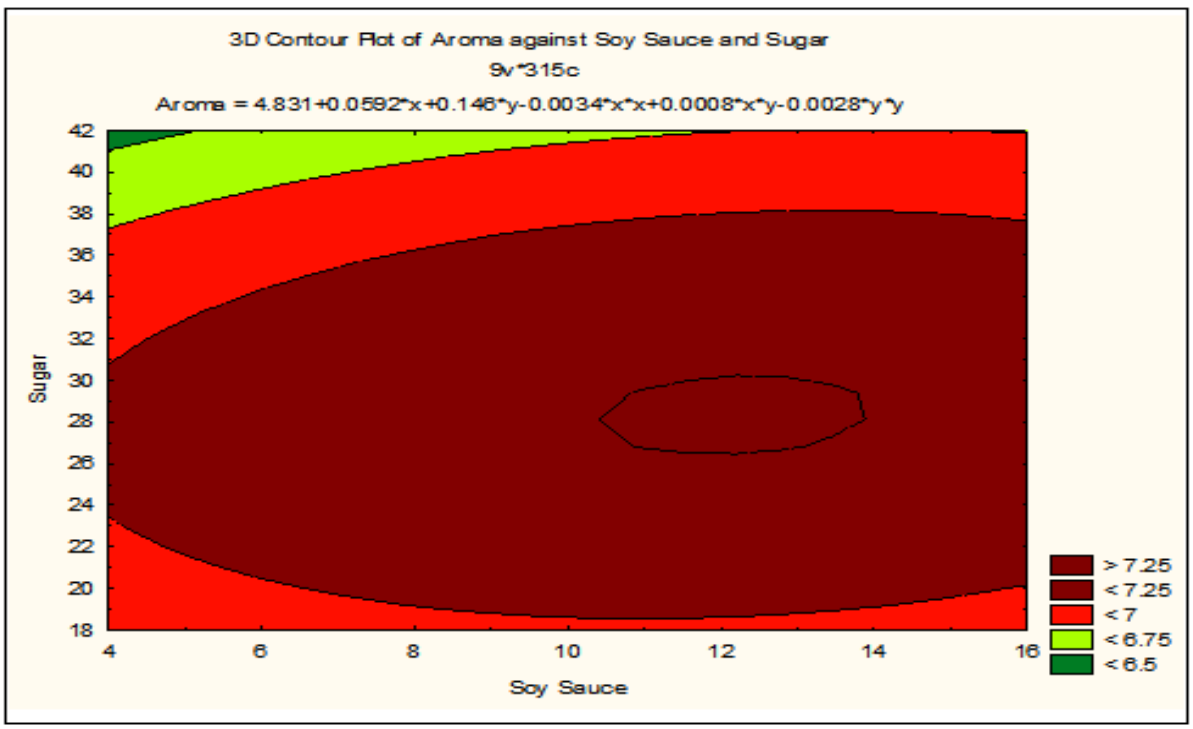

Fig. 1. Contour Plots for aroma acceptability of Vacuum-fried aninikad at constant pre-cooking time.

Depicted on Figs 8, 9 and 10 are the Contour and surface plots of the crispiness acceptability against constant pre-cooking time, soy sauce and sugar levels. It is shown that at an increased sugar level at levels 38% with an increasing pre-cooking less than 12 min. increases the crispiness acceptability. The same result correlates with the crispiness frequency perceived by panellists. This relates to the property of sugar, for example, in giving crispy crust to bread once heated. Moreover, the increase of soy sauce also increases the crispiness acceptability this is due mainly to the effect of soy sauce on muscle protein solubility during soaking. Aktas *et. al*, 2003 state that the solubility of muscle proteins is greatly associated with the tenderizing effect of marination, especially increased solubility of myofibrillar proteins and collagen, which is a major protein of meat, contributes to the tenderness.

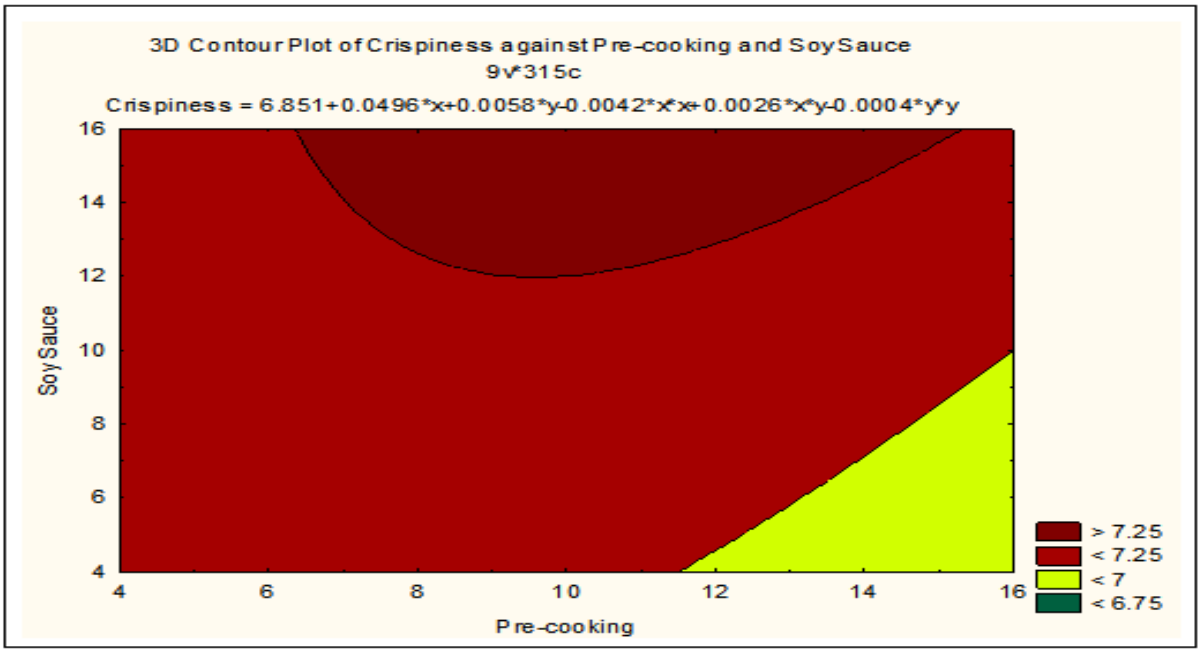

Fig. 8. Contour Plots for Crispiness acceptability of Vacuum-fried aninikad at constant sugar level.

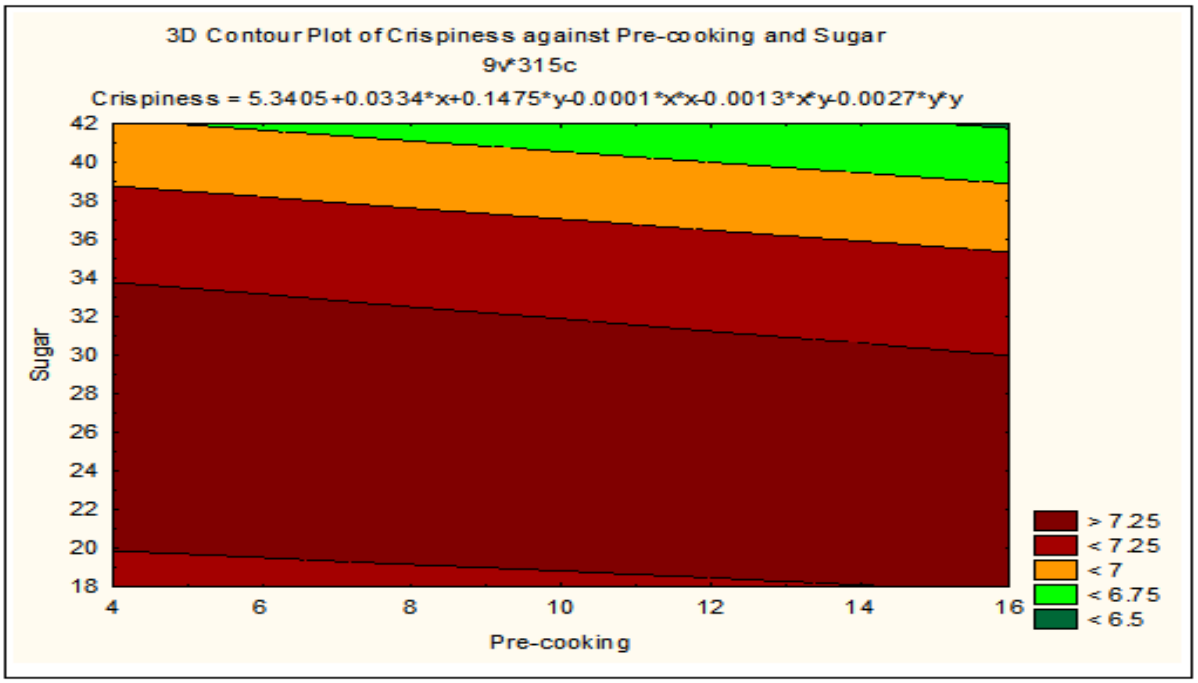

Fig. 9. Contour plots for Crispiness acceptability of Vacuum-fried aninikad at constant Soy Sauce level.

The softer the meat, the crispier the resulting product. Hence, the softening of the conch's meat proteins brought about by the action of soy sauce during marination also influences the crispiness of the product.

Flavor

The flavor is a combination of taste, aroma and mouthfeel. The flavor of the Vacuum-fried aninikad was perceived by 66.4% of the panellist with "slightly pronounced fishy/shell meat" to "well-blended fishy/shell meaty to salty and sweet". The majority of the treatments were perceived by the panellists as "well-blended fishy/shell meaty to salty and sweet" (T1, 2,3,6,9,11,13,14 and 15). In contrast, slightly pronounced fishy/shell meat was perceived at treatments 7, 8, 9, 10 and 12. The mean acceptability of the product ranged from 6.52 to 7.67 which falls on the "like slightly" to "like moderately" category in the 9-point hedonic scale. It has an overall response of 7.20 to "like moderately" on the same scale. The predicted mean value is 7.27 which is slightly higher compared with the overall response mean. However, both fall in the same category of the 9-point hedonic scale. The analysis of variance presented in table 4 shows a significant effect on sugar and its quadratic effect. Similarly, parameter estimates show a significant linear and quadratic effect of sugar on the dependent variables. This implies that sugar has a direct effect on flavor acceptability.

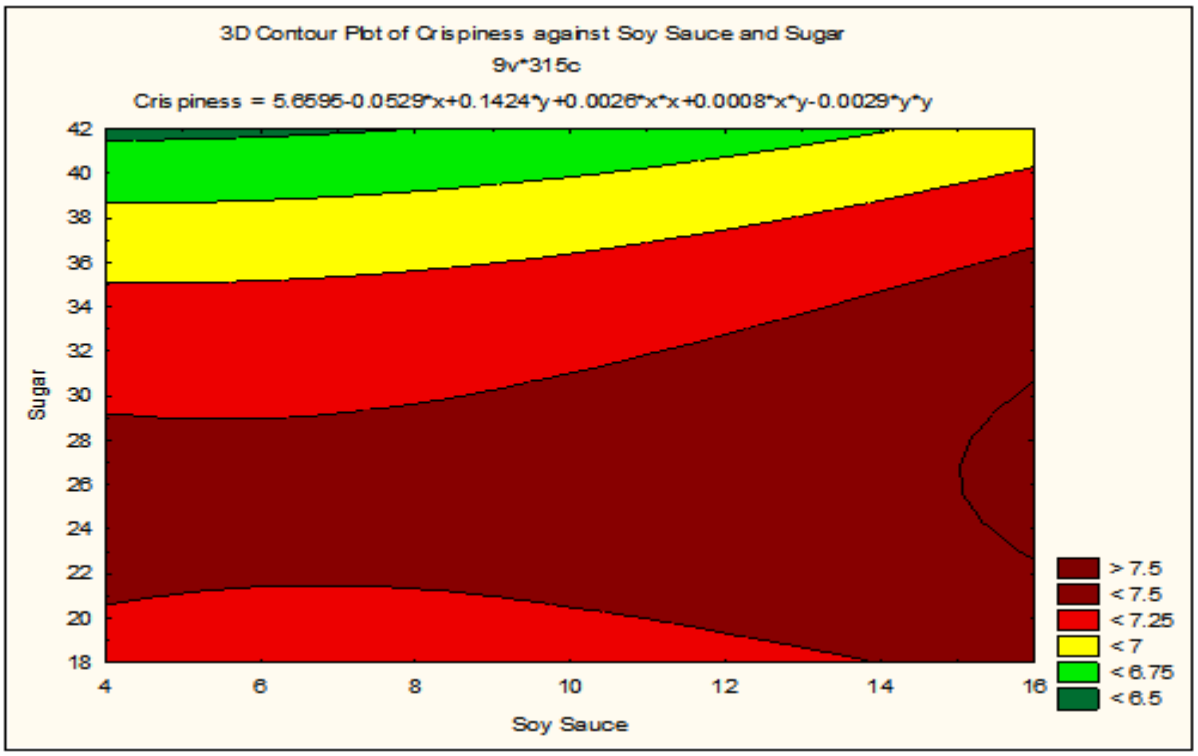

Fig. 10. Contour plots for Crispiness acceptability of Vacuum-fried aninikad at constant Pre-cooking time.

Depicted in Figs 11, 12 and 13 are the contour and surface plots of flavor acceptability at constant pre-cooking, sugar and soy sauce levels. Contour and surface plots reveal that high acceptability could be seen between 14-16% levels of soy sauce combined with 24-34% of sugar. Additionally, acceptability also increases on the other side if 16% of soy sauce is used at only 15 minutes of pre-cooking time. The flavor acceptability is influenced by the natural volatile organic flavour compounds consisting of alcohols, esters, phenols, acids and heterocyclics found in soy sauce (Feng, *et. al.,* 2013). Soaking the plicate conch's meat to soy sauce also improves the flavor of the meat. On the other side, an increase of the sugar level above 38% would decrease the acceptability of the product; this is basically because of the chemical characteristic of sugar, a burned flavor will be developed due to an excessive amount of sugar used.

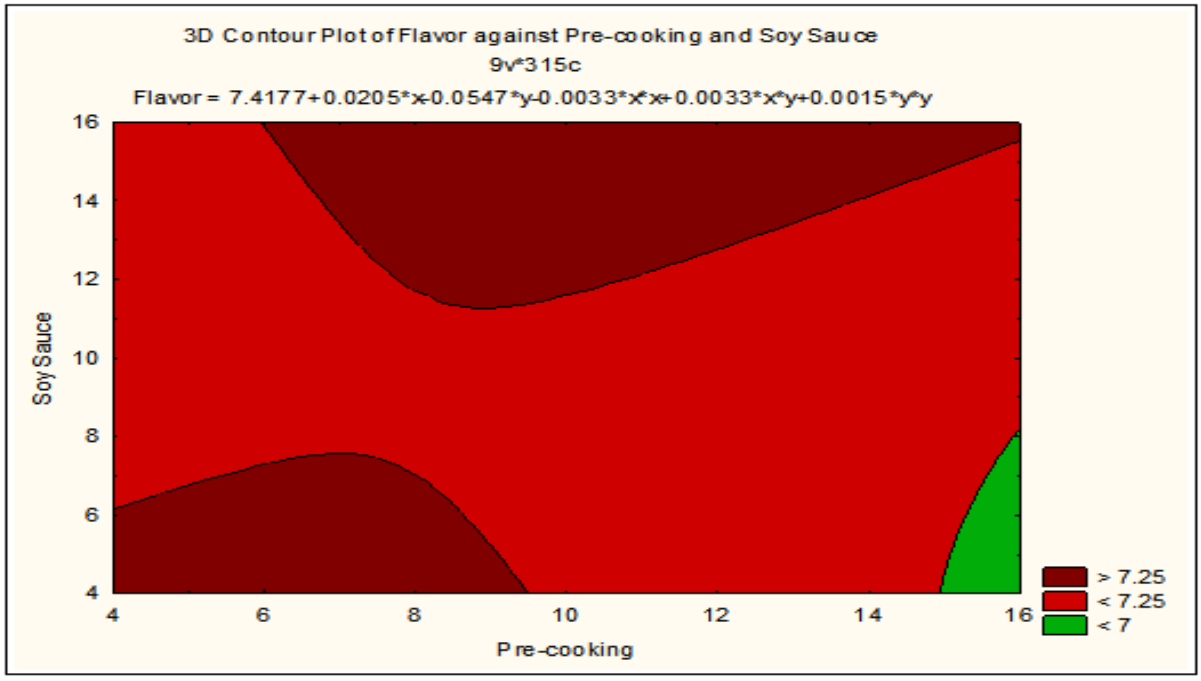

Fig. 11. Contour Plots for Flavor acceptability of Vacuum-fried aninikad at constant Sugar Level.

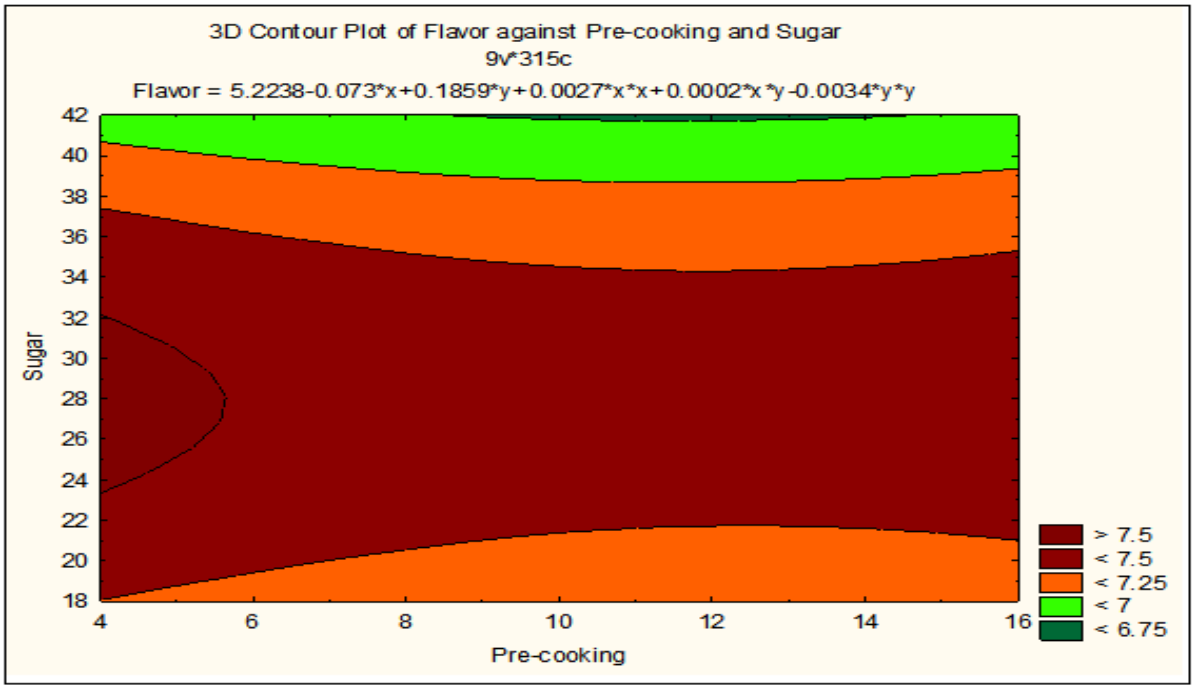

Fig. 12. Contour plots for Flavor acceptability of Vacuum-fried aninikad at constant Soy Sauce level.

Taste

Taste, or the perception of the gustatory input, is the most influential factor in selecting a particular food. "Slightly sweet" to "well-blended salty and sweet" is the description of the different formulations of the Vacuum-fried aninikad as perceived by 78.7% of the panellist. Almost all the treatments were perceived by the panellist as "well-blended salty and sweet" this is due to the counter-effect of sugar to soy sauce. Unrecorded, it was also observed that "umami" taste was perceived by some of the panelists' comments.

Kikunae Ikeda, a Japanese scientist, identified umami as the fifth basic taste. In addition, Ninomiya, 1998 reported that measured free glutamic acid is naturally present in different foods such as seafood.

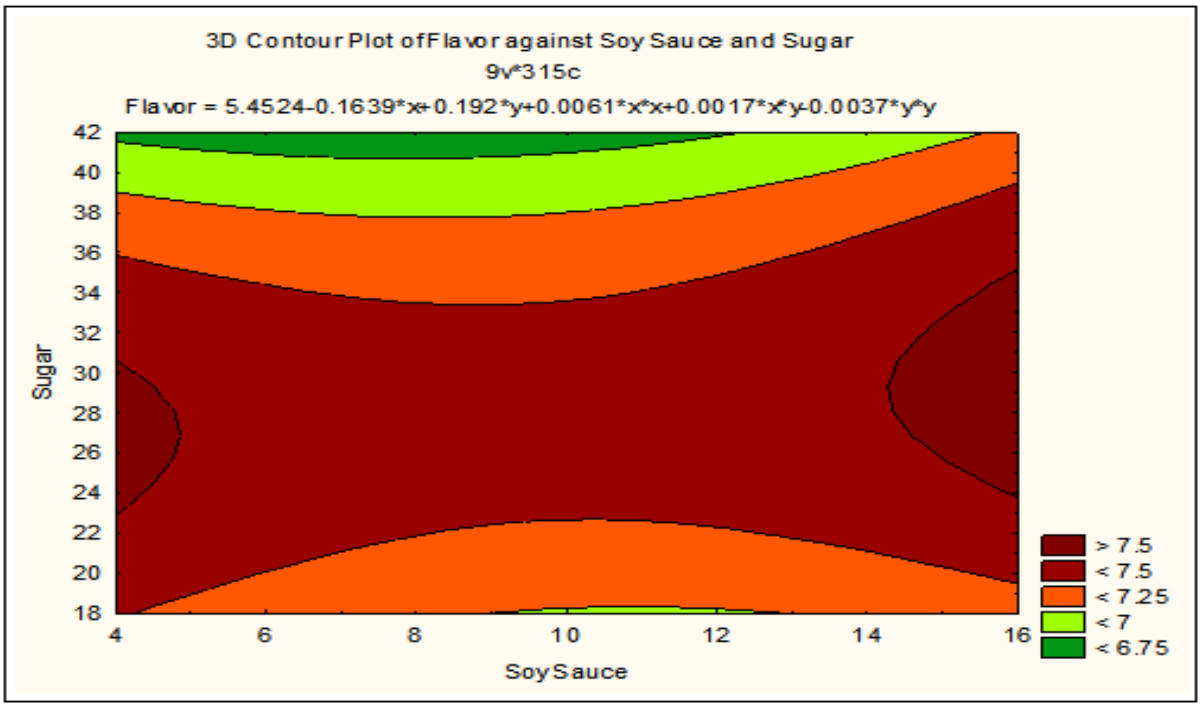

Fig. 13. Contour plots for Flavor Acceptability of Vacuum-fried aninikad at constant Pre-Cooking time.

The taste acceptability score of the Vacuum-fried aninikad ranges from 6.67 to 7.48 which falls on the "like slightly" to "like moderately" in the 9-point hedonic scale (Table 3). The highest taste acceptability was recorded in treatments 13, 14 and 15 which were composed both of 10% soy sauce and 30% sugar. The lowest acceptability level is recorded in treatment 12 which consists of 10% soy sauce and 20% sugar. The overall response mean (7.20) of the product was reflected to fall at "like moderately" on 9-point hedonic scale and this is slightly lower than the predicted mean value at 7.39213 (Table 6). Depicted in Tables 4 and 5 there is no significant effect of the independent variable on the taste acceptability.

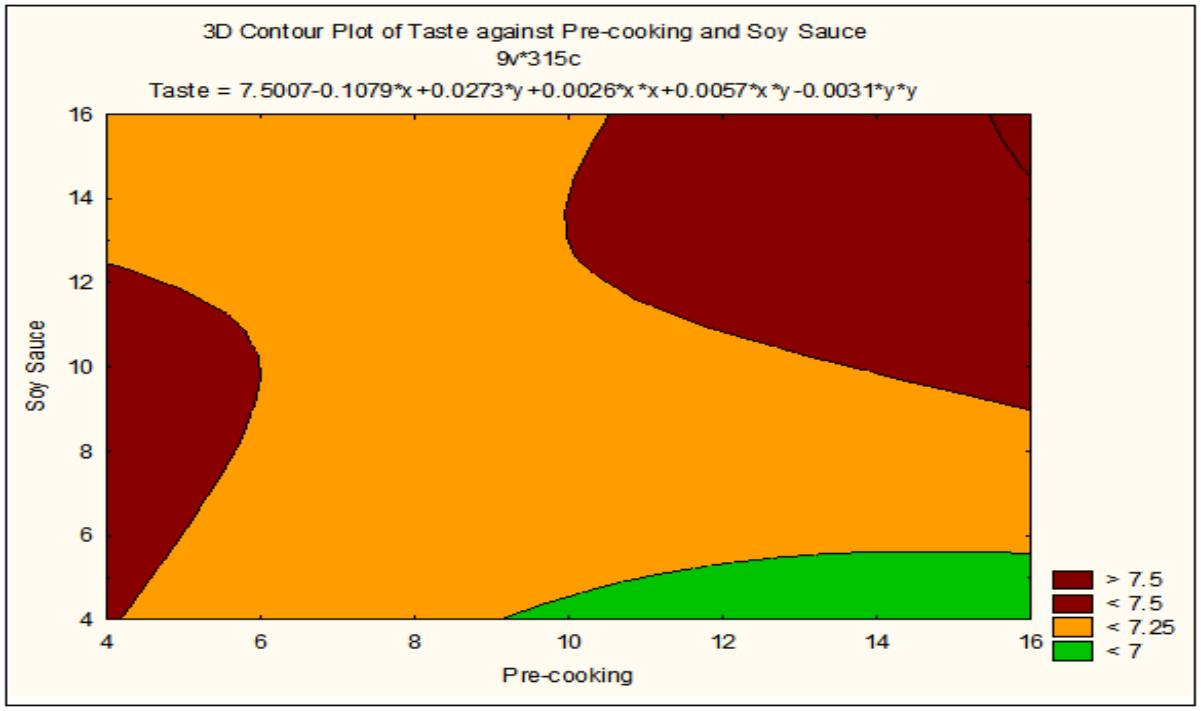

Fig. 14. Contour Plots for taste acceptability of Vacuum-fried aninikad at constant Sugar level.

Contour and surface plots for taste acceptability are illustrated in Figs 14, 15 and 16 at a constant pre-cooking time, soy sauce and sugar level, respectively.

At a constant sugar level, the acceptability increases in two ways. First, when the amount of soy sauce and pre-cooking time used is 4%-12%, <6 min, respectively and secondly, when 10-16% soy sauce level and >10 min pre-cooking time is used. Values not within the range results in decreasing acceptability of the taste. There is also an increasing effect. Conversely, there is a decreasing effect when sugar levels are held at >42% and pre-cooking time at .16 min. Furthermore, sugar and soy sauce greatly acts as a flavor enhancer to the product; depicted on the graph at a constant pre-cooking time, the acceptability increases at increasing sugar level only up to 36% and increasing soy sauce level >16%.

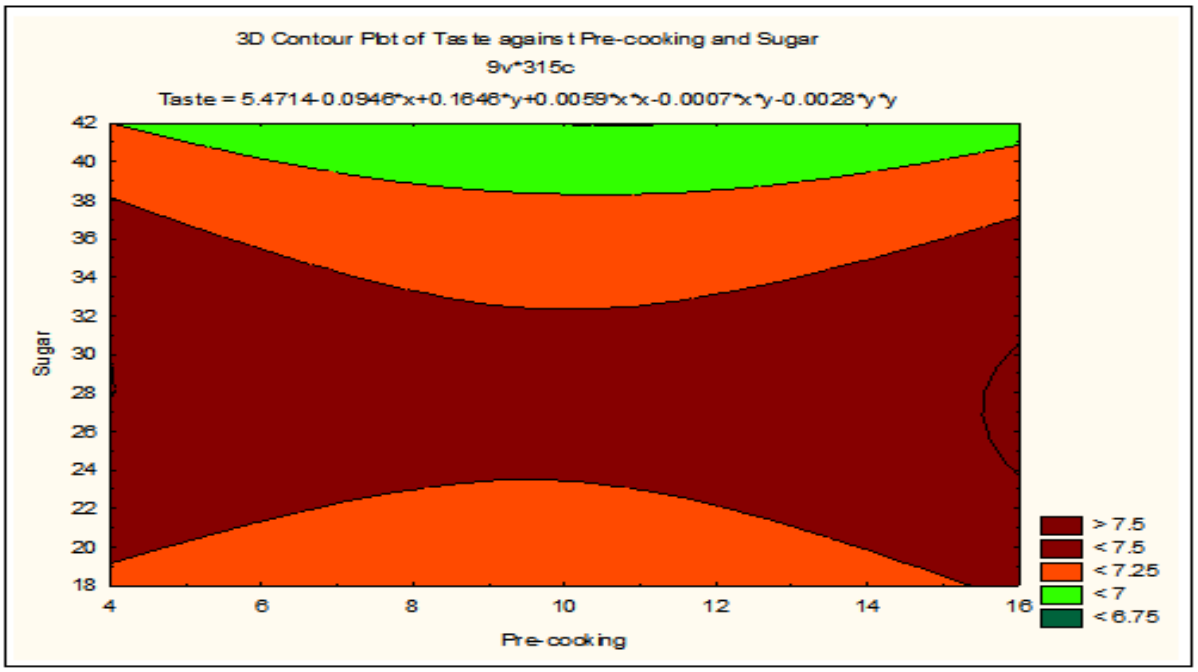

Fig. 15. Contour plots for taste acceptability of Vacuum-fried aninikad at constant Soy Sauce level.

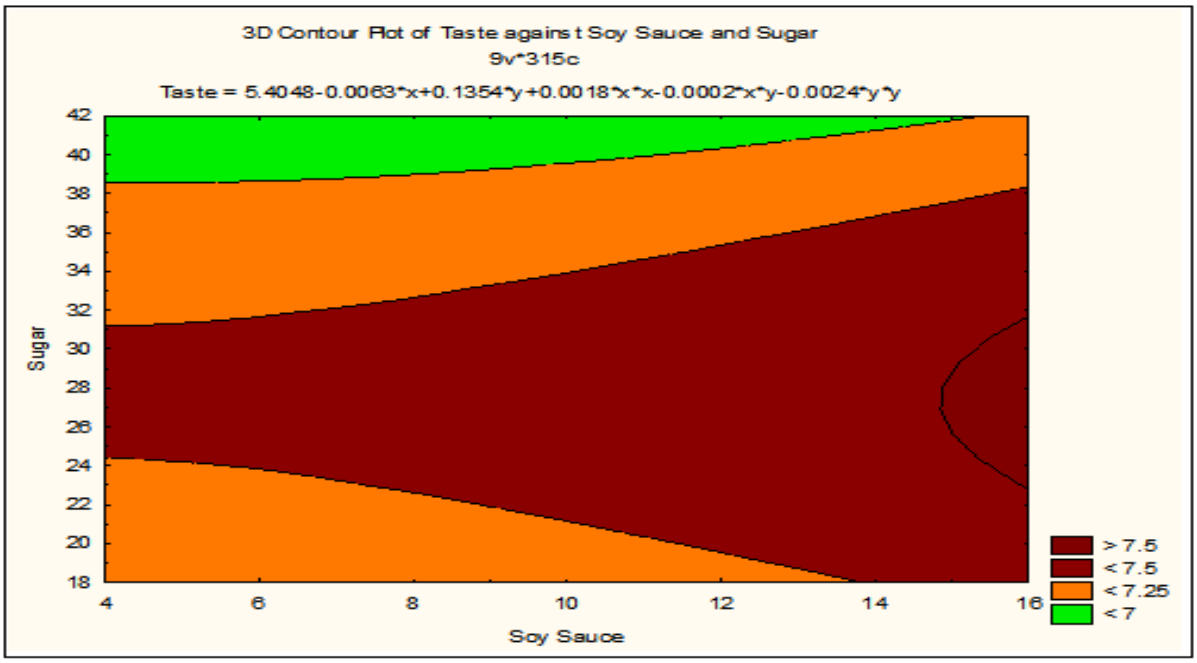

Fig. 16. Contour plots for taste acceptability of Vacuum-fried aninikad at constant Pre-cooking time.

This connotes that mixtures of soy sauce and sugar held at this level will increase the taste acceptability as sugar and soy sauce enhances the natural flavor of the plicate conch's meat.

General acceptability

Vacuum-fried aninikad has general acceptability mean values ranging from 6.52 to 7.52 with an overall mean of 7.14 (Table3). These values correspond between the categories of "like slightly" to "like very much" based on 9-point hedonic scale. The predicted value 7.3555 (Table 6) is slightly higher than the overall response mean. The highest acceptability at 7.52 was found in treatment 8 with 5 min pre-cooking, 5% soy sauce, and 40% sugar and the lowest acceptability was found in treatment 12 with 10 min pre=cooking time, 10% soy sauce and 20% sugar level.

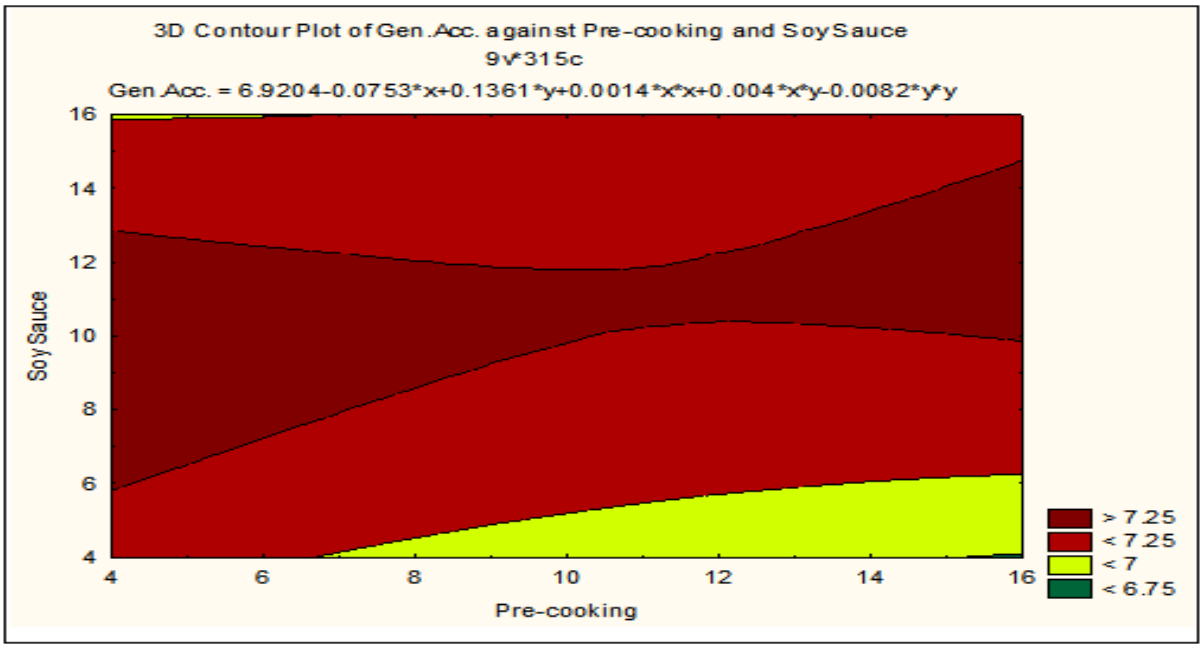

Fig. 17. Contour plots for general acceptability of Vacuum-fried aninikad at constant Sugar level.

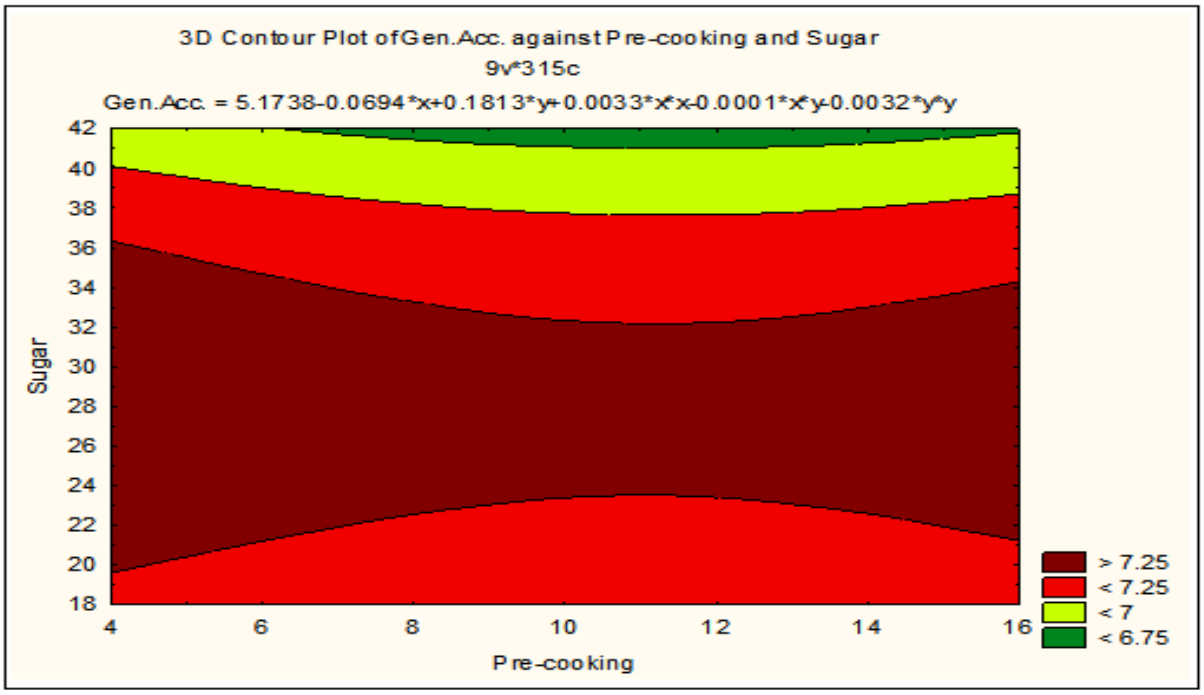

Fig. 18. Contour plots for general acceptability of vacuum-fried aninikad at constant Soy Sauce level.

Results from response surface regression show that the general acceptability of the product is not significantly affected by the independent variables and their interactions. Depicted in Figs 17, 18, and 19 are the contour plot for the general acceptability of the Vacuum-fried aninikad at a constant pre-cooking time, soy sauce and sugar levels, respectively.Graphically reveals that held at constant sugar level, acceptability increases at increasing soy sauce level at 6-14% with increasing pre-cooking time.

On the other hand, acceptability decreases when pre-cooking time is held only at <6 min with a sugar level of 42%; inversely, an increase of acceptability is found at a sugar level of 20-36% with increasing pre-cooking time.

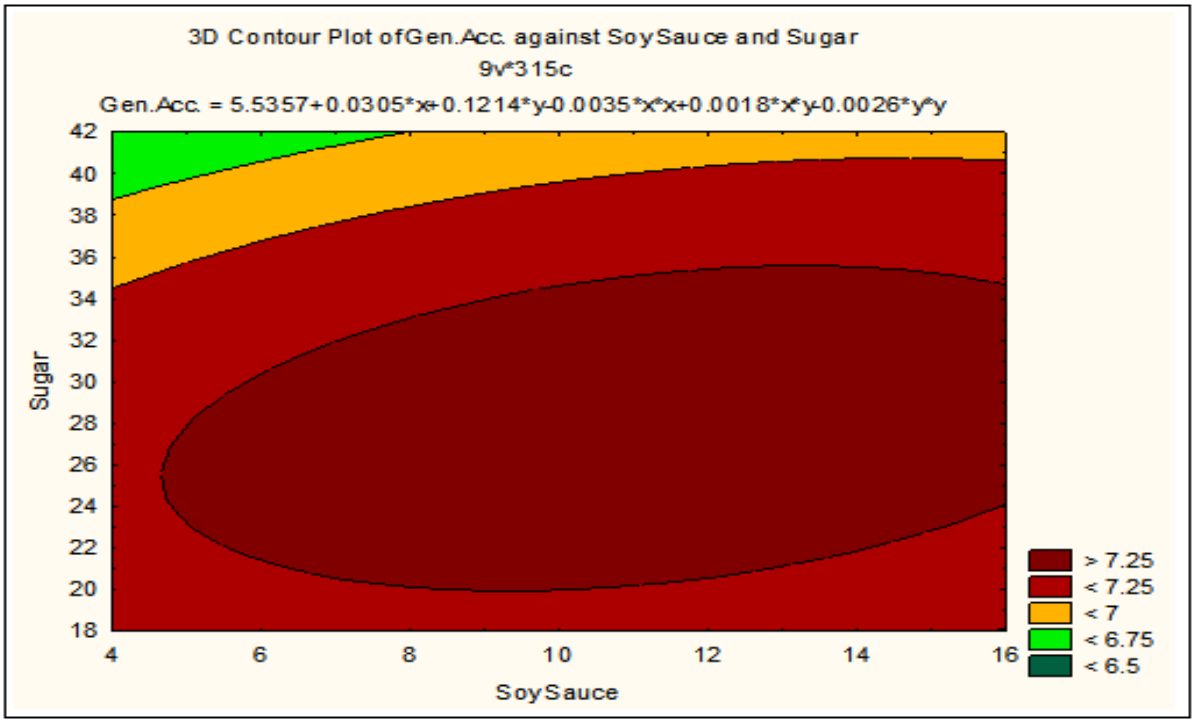

Fig. 19. Contour plots for general acceptability of Vacuum-fried at constant Pre-cooking time.

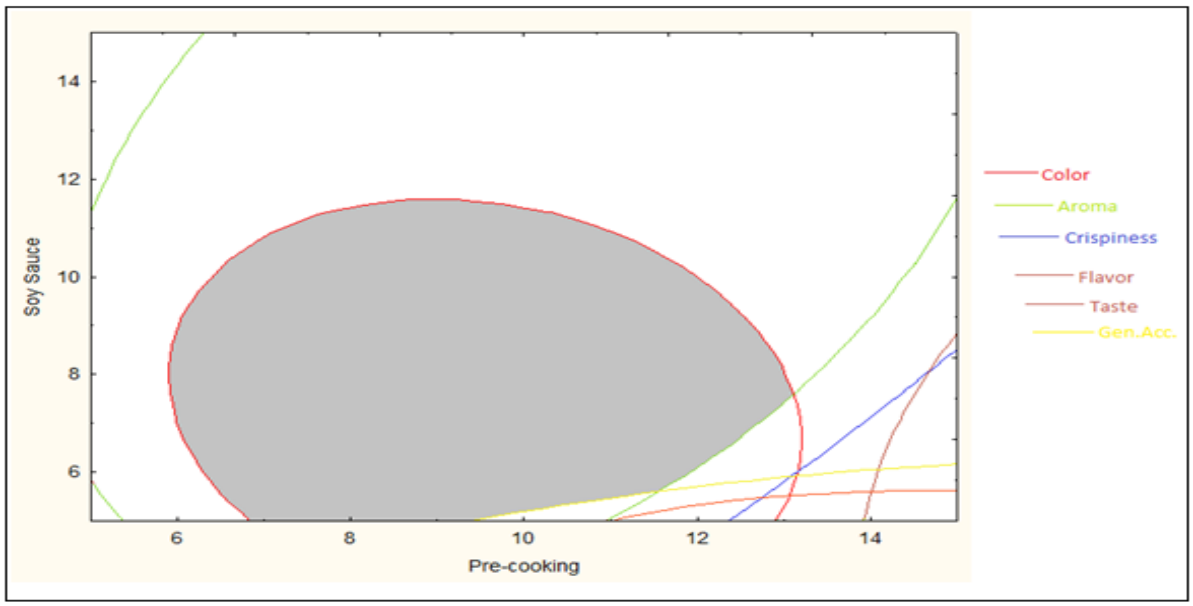

Fig. 2. Optimum Region A for Vacuum-fried aninikad obtained by superimposing the contour plots of sensory attributes at constant sugar level with acceptability of >7.1 using the 9-point Hedonic scale.

At the constant pre-cooking time, acceptability increases at an increasing sugar level range from 20-34% with increasing soy sauce level. However, sugar values of > 38% and 8% soy sauce level decrease the acceptability of the product. The pre-cooking affects the acceptability of the product as it will also contribute to the plicate conch's meat condition and tenderness prior to vacuum-frying. Furthermore, the two condiments used also affect chemically and physically the overall acceptability of the vacuum-fried.

Optimized region of the experiment

Superimposing the contour plots of the acceptability scores of all sensory attributes being evaluated from Vacuum-fried aninikad with the same factor held constant, the location of the optimum region would be identified. The contour plots were obtained by using the mean values of the different attributes carried on.

This would provide an idea of the level of sugar and soy sauce and pre-cooking time that would indeed result in a good quality product with high acceptability. The shaded region presented in Figs 20, 21 and 22 indicates the values corresponding to scores of ≥7.1 which falls to "like moderately" on the 9-piont Hedonic scale. Any point of combination within the shaded region represents optimized combinations of the processing variables.

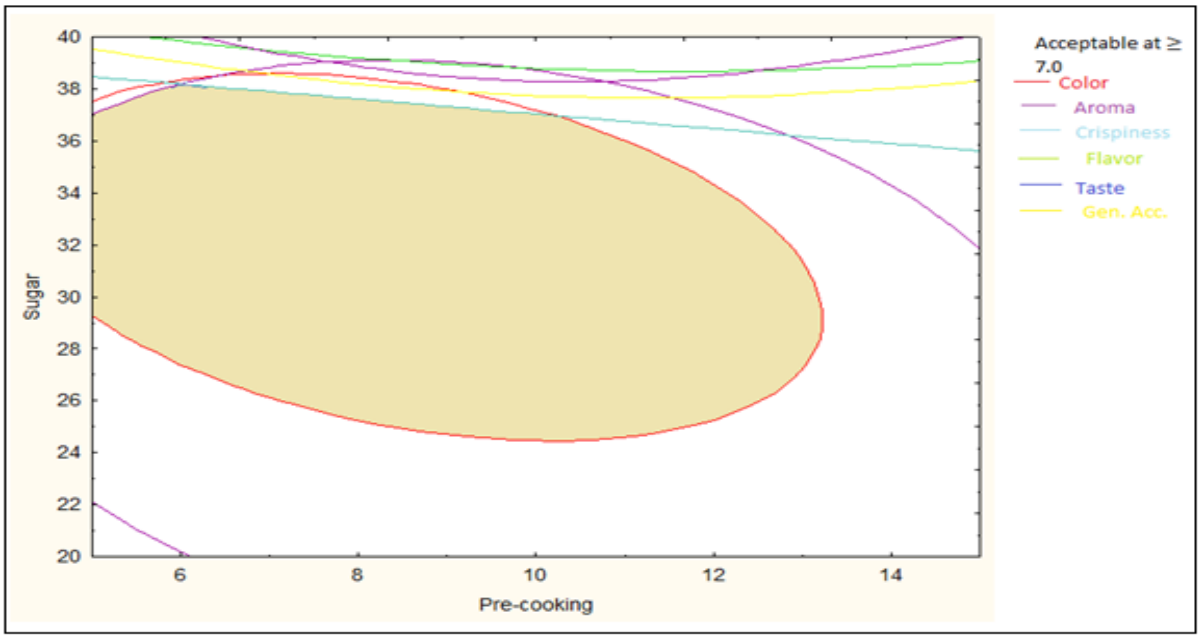

Fig. 21. Optimum Region B for Vacuum-fried aninikad obtained by superimposing the contour plots of sensory attributes at constant soy sauce level with acceptability of >7.1 using the 9-point Hedonic scale.

The optimum combinations based on the experimental design (CCD) used would be found at the middle levels of each factor. The result of the optimum region shall determine if the predicted optimum combination (middle levels of the variables) is within the optimum region. Presented in Figs 20, 21, and 22 are the superimposed plots of Vacuum-fried aninikad at a constant level of Pre-cooking time (15min.), soy sauce level (15%) and sugar level (40%). The optimum region at constant sugar level has been revealed to be located at an approximately maximum level of 11% combined with pre-cooking held at above 7 min.. Meanwhile, when held at a constant level of soy sauce, the optimum region of sugar level range from 25-38% with the pre-cooking time that ranges from 5-15 min.

The optimum region of the product that would give acceptability of ≥7.1 at a constant pre-cooking time of 15 min. is revealed graphically in Fig. 22, wherein the optimum region is found to be at an area of 21.8% to 36% sugar level and 7 to 13% soy sauce level.

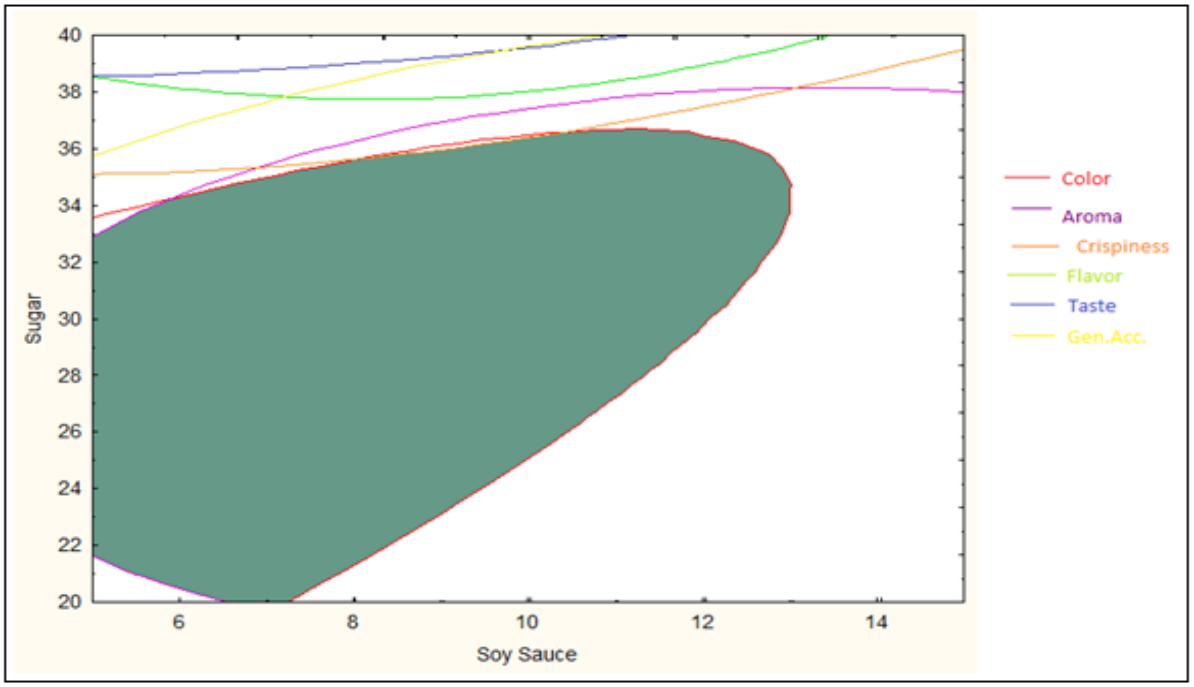

Fig. 22. Optimum region C for Vacuum-fried aninikad obtained by superimposing the contour plots of sensory attributes at constant pre-cooking time with acceptability of >7.1.

Any point within these regions would generate an acceptability response of greater than 7.1 for all the sensory parameters evaluated including color, aroma, crispiness, flavor, taste and general acceptability. To select the overall optimum combinations of the three variables (pre-cooking, soy sauce and sugar), the mean levels of these variables in each region will be selected as the optimum region for these variables. Considering the three optimum regions determined and chosen, results have able to determine that the optimum formulation of the product could be at 9.7 min pre-cooking time, 9% soy sauce level and 30.2% sugar level.

Conclusion

Generally, this study was conducted to add value to aninikad and evaluate its sensory acceptability. Response Surface Methodology using Central Composite Design (CCD) of the experiment was employed in order to achieve this. The three identified factors, namely the three identified factors, namely pre-cooking time (5, 10, and 15 min.), soy sauce (5, 10, and 15 %) and sugar (20, 30 and 40%), were used in the experiment. Determination of the sensory acceptability was the parameter used for optimization. The optimum condition of the product that would give acceptability of ≥7.1 was 9.7 min. pre-cooking time, 9% soy sauce level and 30.2% sugar level. Hence, the results in this study prove that a healthy snack can be produced from inferior marine resources and will add value to aninikad. It is recommended to conduct a proximate analysis of the product to determine the nutrients retained in the product, microbial analysis and shelf-life study. It is also recommended to conduct product packaging studies.

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