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EFFECT OF ALKALINE CONDITIONS AND SOAKING TIME ON QUALITY OF CANNED FABA BEANS (*VICIA FABA* L.)

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ABSTRACT

Response surface methodology was utilized to analyze the effect of pH and soaking time on solid and carbohydrates content of drained liquor, percent splitting, drained weight, water absorption, texture, flavor and overall liking of canned Faba Beans (Vicia faba L.) A central composite design consisting of 2 variables (pH and soaking time), at 3 and 5 levels patterns, with 10 different treatments run in triplicate, were used to develop models for the above quality attributes. Soaking of dry beans was carried out for 2, 3, 4, 5 and 6 hours at pH values of 8.27, 10 and 11.73. All treatments were thermally processed for 25 minutes at 121°C thus reducing its processing time by 74% compared to that of the control. A product similar to the control in texture, flavor, overall liking and drained weight was attained at pH ≥ 11.6 and soaking time ≥ 5.2 hours. However, the product had lower degree of splitting (70.4% vs. 98% for the control), more solid in the drained liquor (13.1%vs. 7.79% for the control) and more carbohydrates in drained liquor (35.7mg/ml vs. 32.12 for the control). Water absorption of faba beans was not affected by pH and increased linearly with time of soaking.

Keywords: *canned faba beans, alkaline pH, soaking time, processing, control, Fo and quality attributes.*

RÉSUMÉ

La méthodologie de "response surface"a été utilisée pour analyser l'effet du pH et du temps de trempage sur les solides, les hydrates de carbone contenus dans le liqueur, le pourcentage de fissures, le gain en poids, l'absorption en eau, la texture, la saveur et l'impression générale des fèves en boites de conserves (Vicia faba L. Un dessin composé central consistant de 2 variables (pH et temps de trempage), ayant 3 et 5 niveaux, avec 10 traitements différents effectués en triple réplication, ont été employés pour développer des modèles pour les qualités des attributs précités. Le trempage des grains secs a été emporté pour 2, 3, 4, 5 et 6 heures à des valeurs de pH de 8.27, 10 et 11.73.tous les traitements furent exécutés thermiquement pendant 25 minutes à 121°C, réduisant ainsi son processus de 74% en comparaison avec le temps de celui du contrôle. Un produit similaire au contrôle du point de vue texture, saveur, impression générale et gain en poids fut atteint à pH ≥ 11.6 et pendant un temps de trempage ≥ 5.2 heures. D'autre part, le produit atteint un degré inférieur de fissures (70.4% contre 98% pour le contrôle), plus de solides contenus dans le liqueur (13.1%contre 7.79% pour le contrôle) et plus d'hydrates de carbone dans le liqueur (35.7 mg/ml contre 32.12 mg/ml pour le contrôle. L'absorption en eau des grains de faba n'a pas été affectée par le pH et croît linéairement avec le temps de trempage.

***Mots clés** : fèves en boîtes de conserves, pH alcalin, temps de trempage, procession, contrôle, Fo et qualités attribuées.*

INTRODUCTION

Faba Beans are among the oldest legume crops in the world. As a crop, its main advantage lies in the fact that it is a cheap source of good quality protein for human diet. The past decade has seen a renewed interest in the crop on a worldwide basis. Rising protein feed costs; issues of national food security, the need for agricultural diversification and rapidly increasing populations have all contributed to this revival.

Bigelow and Fitzgerald (1927) reported that canners sometimes find that the heat process required to sterilize canned beans is insufficient to make them tender. The major constraint for such legume consumption has been a storage-induce textural defect commonly referred to as Hard-to-Cook (HTC)

phenomenon. Studies have shown that storage conditions and the HTC defect are complex. As a result, HTC seeds required prolonged soaking to absorb adequate amounts of water and extended cooking for the cotyledons to separate and achieve proper tenderness. Because seed hardening leads to increased consumption of energy and decreased palatability and nutritional values of legume food, the economic loss due to the HTC phenomenon is enormous.

Bean utilization and product quality are influenced by numerous factors, including dry beans physicochemical characteristics, specific bean product type and processing variables such as pH and processing times. The importance of soaking lies in allowing the beans to attain an adequate moisture level that would assist the propagation of heat by increasing the solubility of pectin and protein bodies.

Scant information exist on the effect of storage on tissue pH that is the key factor governing the behavior of the cellular constituents of the seed like starch granules and protein bodies thus determining the water uptake (Saio *et al.,* 1980; Liu *et al.,* 1992). Studies have emphasized the role of alkaline soaking solution (Saifi, 2001) and water absorption was found to be linearly related to initial pH of soaking solution.

Therefore the objective of this work was to manipulate the pH of the soaking medium and soaking time to shorten soaking and cooking times for processing of canned faba beans specifically "foul muddammas".

MATERIALS AND METHODS

Whole dry faba beans (*Vicia faba* L.) imported from Canada were obtained from Dove Processing SAL (Nahr el mot, Beirut, LEBANON). NaH_2PO_4, Na_2HPO_4, Na_3PO_4 and NaCl salts were mostly obtained from the Holy Spirit University and the American University of Beirut.

1. Experimental Design

Two variables namely: pH and soaking time (h) were studied on three and five levels yielding ten different treatments (Gacula and Singh, 1984). Following the central composite design ten different treatments were performed in Dove Processing S.A.L.

Table 1: Variables and the Standardized levels.

Time in hour (X1)	2	3	4	5	6
Standardized levels	-1	-0.5	0	0.5	1
pH (X2)	-	8.27	10	11.73	-
Standardized levels	-	-0.866	0	0.866	-

2. Preparation of Soaking Solutions

0.025M phosphate buffers of pH 8.27, 10 and 11.73 were prepared using Na_2HPO_4, NaH_2PO_4 and Na_3PO_4 and adjusted to the same ionic strength by addition of NaCl.

For pH= 8.27
$[NaH_2PO_4] = 2.10^{-3}$ moles
Mass = 2.10-3 x 120 = 0.24 g/l H_2O
$[Na_2HPO_4]$ = 0.023 moles
Mass = 0.023 moles x 142 = 3.266 g/l H_2O

For pH= 10
$[Na_2HPO_4]$ =0.0249 moles
Mass = 0.0249 x 142 = 3.5358 g/l H_2O
$[Na_3PO_4]$ =0.012 moles
Mass = 0.012 x 164 = 0.012 g/l H_2O

For pH= 11.73
$[Na_2HPO_4]$ = 0.01988 moles
Mass = 0.01988 x 142 = 2.823 g/l H_2O
$[Na_3PO_4] = 5.12 \times 10^{-3}$ moles
Mass = 5.12×10^{-3} x 164 = 0.84 g/l H_2O

Mass of NaCl for each buffer = _ final x Molecular Weight
For buffer pH= 8.27
M = 0.01936 x 5805 = 1.13256g
For buffer pH=10
M = 0.01496 x 58.5 = 0.87516g
For buffer pH=11.73
M = 0.09036 x 58.5 = 5.28606g

3. Processing of Faba Beans

The procedure consisted in the preparation of 4 cans of foul muddamas from each of the ten treatments mentioned in the experimental design. Experiments were run in triplicate.

Dry beans were soaked for different hours in different pH media. Soaked beans were weighed at the end of soaking time in order to determine the amount of water absorbed by each treatment. After soaking, the beans were blanched at 94-98°C for 8 minutes. After blanching, a brine solution (composed of 63g of fine salt, 7.8g of citric acid and 1.46g of Na2-EDTA in 4000ml water) was added to the beans in cans with the filling weight according to each design. Cans were immediately closed and transferred to a retort set at 121°C (250°F) and fitted with a temperature and pressure controller. The heat penetration data were converted to F0 values using the precision thermometer and F0-value computer (CTF 9004, ELLAB A/S, Denmark). The F0 value is equivalent to the number of minutes require to destroy the spores of *Clostridium botulinum* at 121.1°C (250°F) when Z-value is 10°C (18°F). F0 value is equal to 10 when the cold- point temperature of canned product is held at 121.1°C for 10 minutes and this value is adequate for commercial sterility of low acid foods (Toledo, 1980). In our experiment F0 was equal to 25. After heating, the cans were cooled inside the retort for 8 minutes and then cooled out for 10 minutes and stored for three weeks to insure equilibration prior to testing.

4. Determination of Drained Weight

Drained weight was measured by determining the mass of beans after allowing draining for three minutes on number eight sieves. Determinations were carried out in triplicates and their average expressed as grams of drained beans per gram of soaked beans.

5. Determination of Percent Solid in the Liquor

Triplicate samples of 25 ml of the liquor, obtained after draining can contents were transferred into aluminum moisture dishes, and heated until total evaporation of water. The dishes were then placed in an airtight dessicator and weighed. The difference in weight was recorded and the value multiplied by four to determine percent solid in drained liquor (AACC, 1995).

6. Determination of Percent Splitting

Percent splits were calculated by taking duplicate random samples of 25 beans and examining for cracks or splits. Splits should be longer than 1/5 of the circumference of the bean. The number of split beans found in duplicate samples was multiplied by two to obtain % splits and determinations were carried out in triplicate (Junek *et al.*, 1980; Van Buren *et al.*, 1986).

7. Determination of Percent Carbohydrates

The filtrate obtained after draining can contents was mixed and 2ml diluted to 100 ml with water. Of this solution, another 6 ml were further diluted in 100ml and 25 ml of the resulting solution were also diluted in 50ml. Triplicate samples of 2 ml from the resulting solution were used for total carbohydrate determination using the phenol-sulfuric acid method described by Dubois *et al.*, (1956). According to this method, 2ml solution was placed in a colorimetric tube and 0.05ml of 80% phenol (20g H_2O, 80g phenol) were added. 5ml of concentrated H_2SO_4 were added rapidly and the tube allowed to stand for 10 minutes. The tube was shaken vigorously, placed in a water bath at 25-30°C for 20 minutes and its absorbance read at 490nm. Carbohydrate contents were determined by reference to a standard curve prepared using known increments of glucose.

8. Sensory Evaluation

The panel consisted of 45 subjects. Each panelist received 4 samples of the treated cans and was asked to taste each sample and compare to the reference (Al Wadi Al Akhdar). Their appearance, color, flavor, texture and overall liking in comparison with the control judged samples. The assessors repeated their test 3 times in order to reduce inherent noise in the data.

9. Statistical Analysis

For each response or quality attribute of canned faba beans, analysis of variance (ANNOVA) was conducted to determine differences among the 10 treatments combinations. When the response showed significant differences, data were analyzed by multiple regression using the three triplicate values by MSTAT (1989) to estimate the variables effect on the response. The variable effects were estimated by fitting the design to the second-order regression equation:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_{11}X_{12} + b_{22}X_{22} + b_{12}X_1X_2$$

Where X1= soaking time (h), X2= pH. Including quadratic and interaction effect. Coefficients of determination (R^2) were computed as well. For each response, contour plots (generated by Statgraphics STSC, 1991) were produced from the equations.

RESULTS AND DISCUSSION

The ranges of quality attributes studied namely: solid in liquor, carbohydrates in liquor, drained weight, percent split, water absorption, texture, flavor and overall liking of the different treatments are shown along with the corresponding regression equations in Table 2.

Analysis of variance detected significant differences ($p < 0.001$) among treatments surveyed in present work and accordingly regression equations were computed for responses and presented as well. The coefficients of determination (R^2) indicated that the regression equations accounted for 32.8% - 93.6% of the variance in the responses. Contour plots of different responses were generated by varying the levels of pH and soaking time as shown previously in the design.

Table 2: Ranges [a] of mean of solid in liquor, carbohydrates in liquor, drained weight, percent split, water absorption, texture, flavor and overall liking of canned faba beans and regression analysis of responses.

	Solid in liquor (%)	Carbohydrates in liquor (mg/ml)	Drained weight (g)	Percent split	Water absorption (g H_2O/100g solids)	Texture [b]	Flavor [b]	Liking [b]
Control	7.79	32.12	284.47	98	-	5	5	5
SEM [c]	0.79	0.48	1.08	0.2	-	-	-	-
Ranges of means of treatments	4.99-13.55	19.1-37.8	263.3-286.4	58-94	52.0-86.9	1-9	1-9	1-9
Regression Analysis [d]								
b_0	5.917***	29.249***	271.822***	78.481***	72.498***	4.241***	4.669***	4.457***
b_1	1.390*	0.689	5.156**	4.926	16.276***	0.896***	0.557**	0.546*
b_2	1.096*	3.109*	5.750***	0.577	-0.51	0.192	-0.009	-0.028
b_{11}	1.983	-1.683	2.033	-30.889***	-3.956	-0.511	-0.578	-0.611
b_{22}	0	0	0	0	0	0	0	0
b_{12}	3.333**	-7.095*	0.66	16.326*	-2.041	0.509	0.31	0.316
R^{2} [e]	0.527	0.328	0.546	0.752	0.936	0.623	0.603	0.515
Equation Significance	***	*	***	***	***	***	***	***

[a] Range over 10 design points

[b] Rated on a hedonic scale from 1 to 9 (sensory)

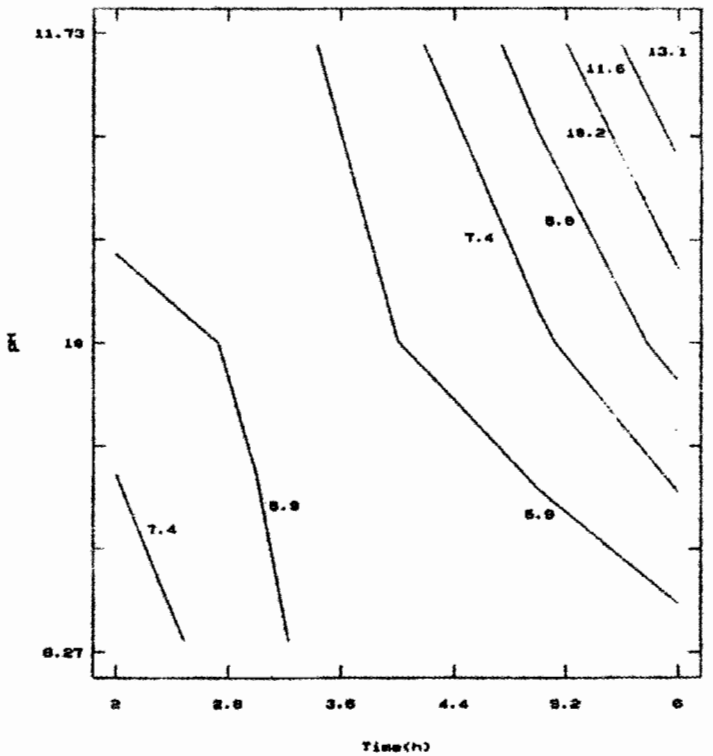
[c] Standard Error of the Mean

[d] $Y = b_0 + b_1 X_1 + b_2 X_2 + b_{11} X_1^2 + b_{22} X_2^2 + b_{12} X_1 X_2$. Where X_1= soaking time (h), X_2= pH

*, **, *** Significant at $p<0.05$, $p<0.01$, $p<0.001$, respectively

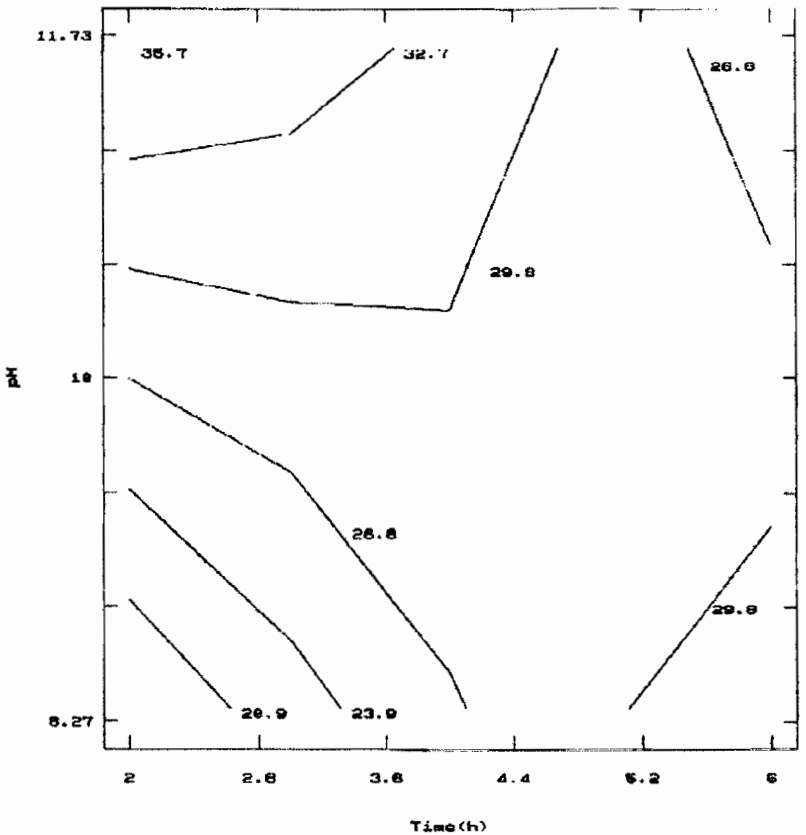
[e] Coefficient of determination

3.1. Percent solid in liquor



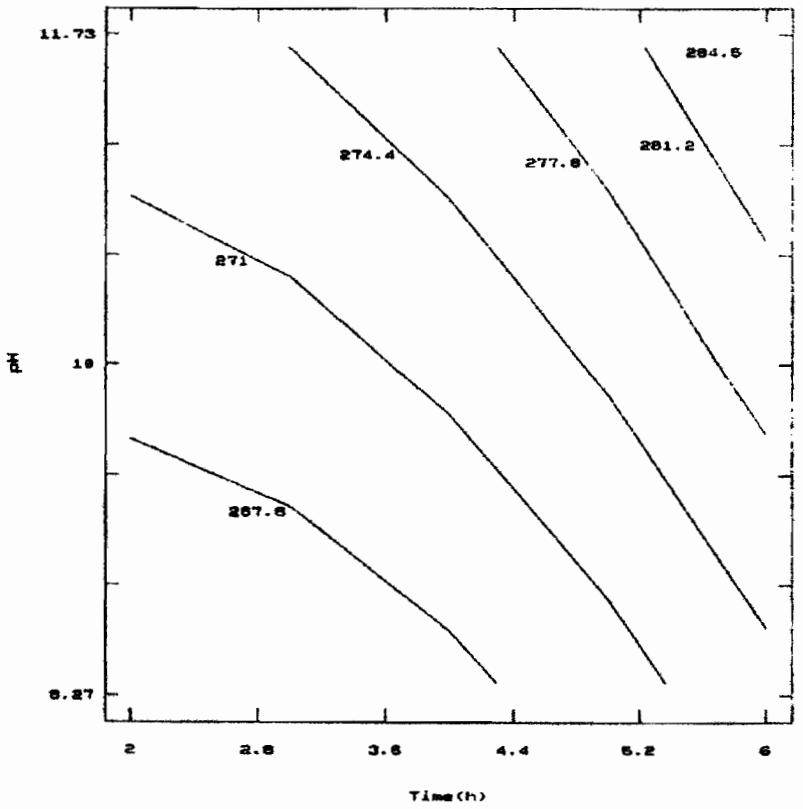
Regression analysis showed that the equation was highly significant ($p < 0.001$). Percent solid in the drained solution was affected by both pH and soaking time ($p < 0.05$). Moreover, significant interactions of independent variables ($p < 0.01$) were noted on this response. The response showed a minimum value of 5.9% at 8.3 <pH< 10.5 and soaking times between 2 and 3.2 hours or at 8.5 <pH< 11.6 and soaking times between 3.5 and 6 hours. Percent solids were at maximum of 13.1% at 11 <pH< 11.6 and soaking times between 5.6 and 6 hours. The variable is expected to meet the control (7.79%) at 9.4 <pH< 11.6 and soaking times between 4.4 and 6 hours.

3.2. Carbohydrates in liquor



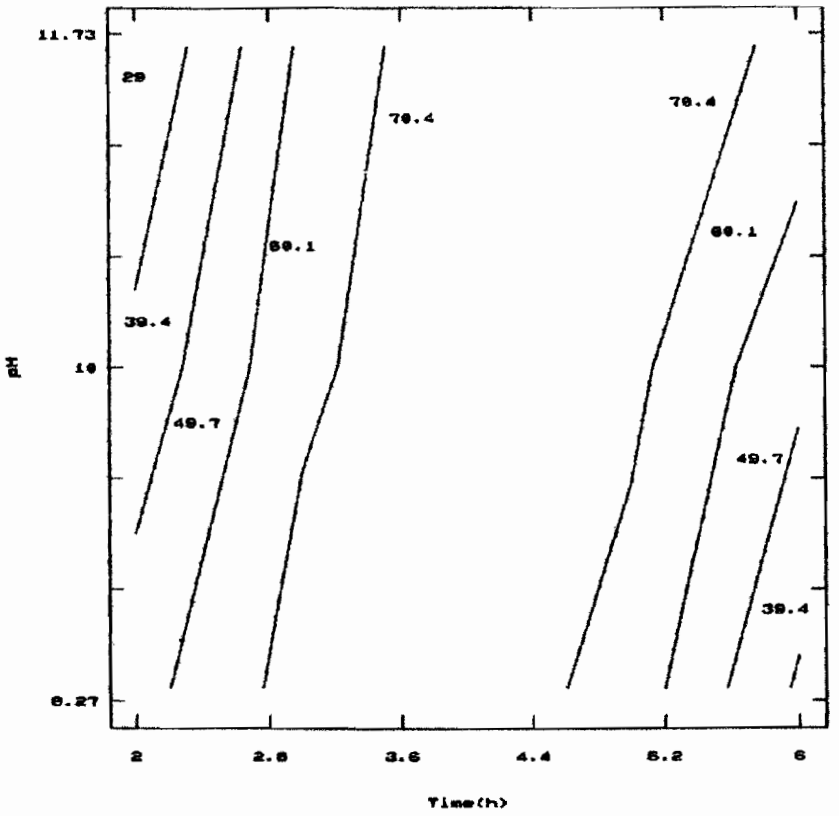
The amount of carbohydrates in drained liquor was affected by pH ($p < 0.05$) rather than soaking time. Moreover, significant interactions of independent variables ($p < 0.05$) were noted on the amount of carbohydrates in the samples' liquors. The response showed a minimum value of 20.9 mg/ml at $8.3 < pH < 8.87$ and soaking times between 2 and 2.6 hours. Its value increased reaching a maximum of 35.7 mg/ml at pH of 11.63 and soaking time of 2 hours. The amount of carbohydrates in liquor is expected to meet the control (32.12mg/ml) at $11 < pH < 11.63$ and soaking times between 2 and 3.6 hours.

3.3. Drained weight



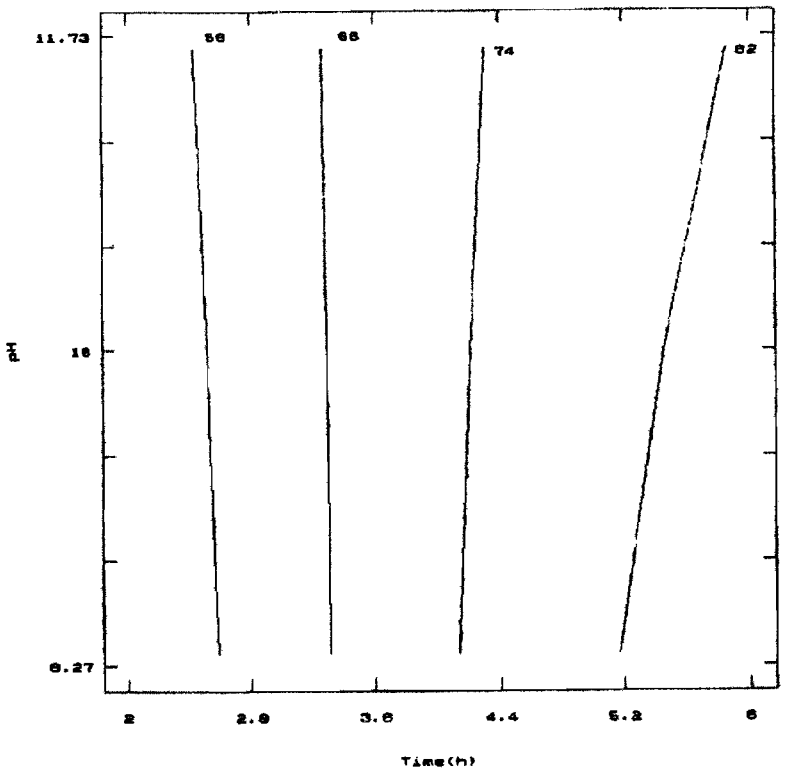
Regression analysis showed that the equation was highly significant ($p < 0.001$). Drained weight was more affected by pH ($p < 0.001$) than by soaking time ($p < 0.01$). The response showed a minimum value of 267.6g at $8.3 < pH < 9.6$ and soaking times between 2 and 4.2 hours. Drained weight was at a maximum of 284.5g at a pH of 11.63 and soaking time of 6 hours. In this region, drained weight is similar to that of the control at 284.47g.

3.4. Percent split



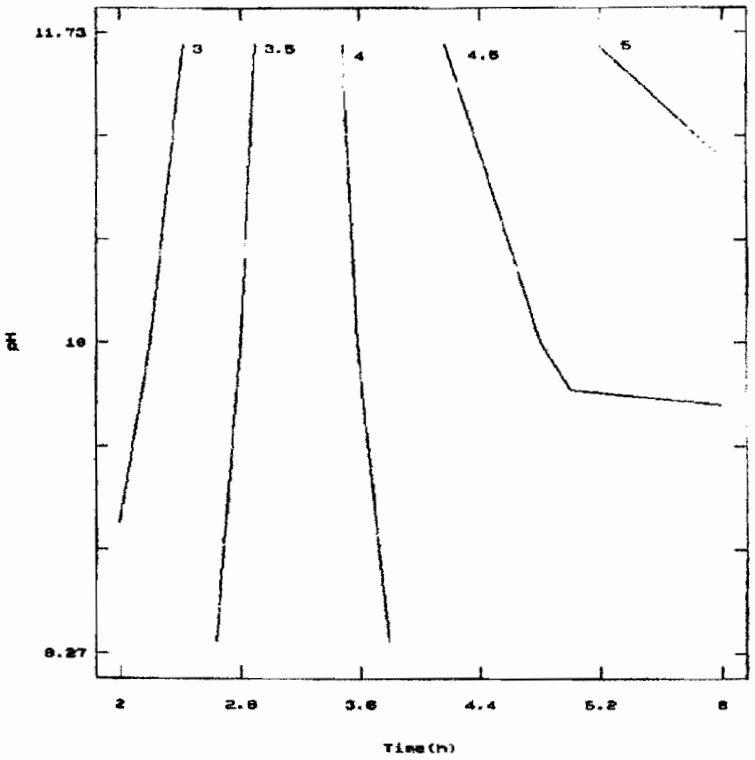
Regression analysis showed that the equation was highly significant ($p < 0.001$). Significant ($p < 0.001$) quadratic effect of soaking time was noted on this response. The response showed a minimum value of 29% at pH of 11.6 and soaking time of 2 hours. At $8.3 < pH < 11.6$ and increasing soaking times between 2.7 and 3.4 hours or between 4.6 and 5.8 hours a maximum of 70.4% was attained. At this level the variable failed to meet the control (98%).

3.5. Water absorption



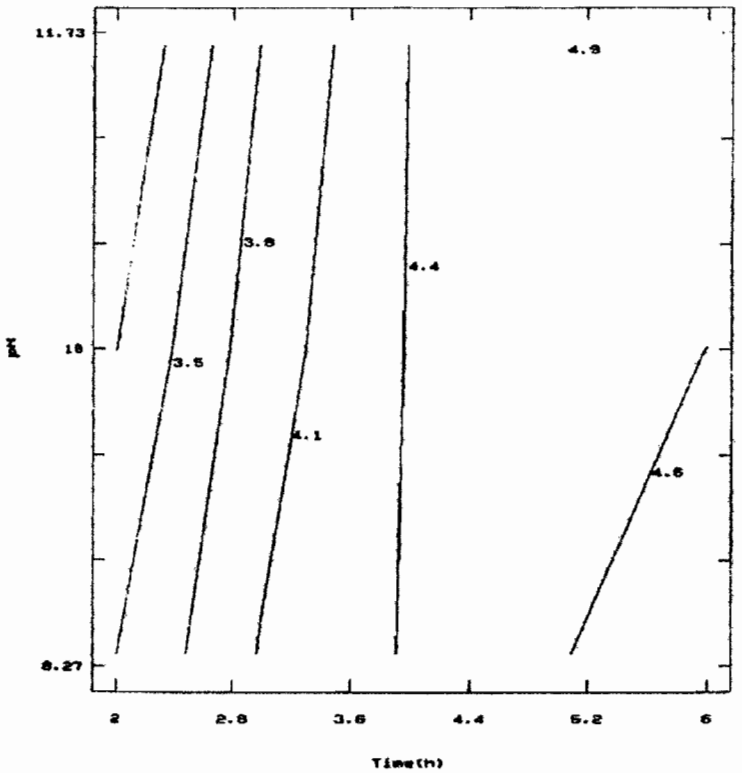
Regression analysis showed that the equation was highly significant ($p < 0.001$). Water absorption of soaked beans was significantly ($p < 0.001$) affected by soaking time. The response s showed a minimum value of 58g /100g solids at 8.3 <pH< 11.7 and soaking times between 2.4 and 2.6 hours. The variables increase in the region of 8.3 <pH< 11.7 with increasing soaking time reaching a maximum of 82g/100g solids between 5.2 and 5.8 hours.

3.6. Texture



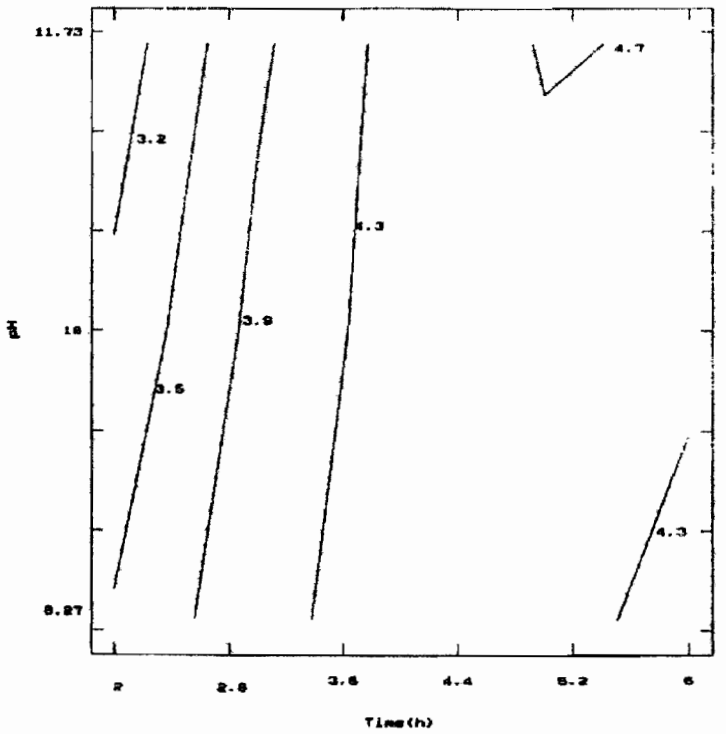
Regression analysis showed that the equation was highly significant ($p<0.001$). Moreover, texture was significantly ($p<0.001$) affected by soaking time. The response showed a minimum value of 3 at $9<pH<11.6$ and soaking times between 2 and 2.4 hours. The variable meet the control (5) at $11<pH<11.6$ and soaking times between 5.2 and 6 hours.

3.7. Flavor



Regression analysis showed that the equation was highly significant ($p<0.001$). Flavor was affected by soaking time ($p<0.01$) rather than pH. The response showed a minimum value of 3.5 at $8.3<pH<11.6$ and soaking times between 2 and 2.6 hours. The variable reached its maximum of 4.9 at pH of 11.6 and soaking time of 5.2 hours. At this level the control is very close with a value of 5.

3.8. Overall liking



Regression analysis showed that the equation was highly significant ($p<0.001$). Overall liking was affected by soaking time ($p <0.05$) rather than pH. The response showed a minimum value of 3.2 at $10.58 <pH< 11.6$ and soaking times between 2 and 2.3 hours. The variables showed a maximum of 4.7 at $11.3 <pH< 11.6$ and soaking times between 5 and 5.3 hours. At this level, the variable is expected to meet the control at pH of 11.6 and soaking time >5 hours.

CONCLUSION

As a result for the contour plots of the different quality attributes: percent solid in liquor, carbohydrates in liquor, drained weight, percent split, water absorption, texture, flavor and overall liking.

The models developed detected regions comparable with the control for a number of quality attributes. When a comparable region was not identified, the plots provided predictions to develop this goal at combinations of pH and soaking times.

Sensory evaluation revealed that quality of texture; flavor and overall liking have met the control. Moreover, the comparable region shown in the response was very close for the above-mentioned attributes and was defined at pH ≥ 11.6 and soaking time ≥ 5.2 hours.

Contour plot for the percent solids in liquor showed of value of 13.1%, which is higher than the control of 7.79%. This region was defined at 11 < pH < 11.6 and soaking times between 5.6 and 6 hours.

Contour plot for carbohydrates showed maximum value of 35.7mg/ ml, which is slightly higher than the control of 32.12mg/ml. This was attained at pH of 11.63 and soaking time of 2 hours.

Contour plot of drained weight showed maximum value of 284.5 g, which is similar to that of the control of 284.47g at pH of 11.63 and soaking time of 6 hours.

Contour plot of percent split showed maximum value pf 70.4% which was markedly lower than that of the control at 98%.

Our results have proven that it is possible to obtain a product that compares well to the control while applying high alkaline conditions of soaking media when pH ≥11.6 and soaking time ≥ 5.2 hours. Not to mention that all applied treatments were thermally processed for a F0 value of 25, which is much lower, as compared to that applied on the control at F0 of 95.

It is recommended that other varieties be tested according to the optimized procedure developed in the present work. Also, the economic implications of the newly developed process ought to be investigated/ evaluated.