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AGRICULTURAL ENGINEERING

Optimization of Level of Ingredients for Production of Banana-Papaya Mixed Fruit Bar Using Response Surface Methodology

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ABSTRACT

Fruit bar is the product prepared by blending pulp from sound ripe fruit, nutritive sweeteners and other ingredients appropriate to the product and dehydrated to form sheet which can be cut to desired shape and size. The research was carried out to optimize levels of different ingredients for production of banana-papaya mixed fruit bar and its quality evaluation. Central composite design (CCD) was used to conduct experiments and optimization was carried out using response surface methodology (RSM). The effect of banana-papaya pulp ratio (0:100, 25:75, 50:50, 75:25 and 100:0), citric acid (0.3-1.0%), corn starch (1.0-5.0%) and pectin (0.2-0.6%) was evaluated with respect to overall acceptability scores, hardness, stickiness and ascorbic acid in dried mixed fruit bar. The best recipe was 25:75 of banana- papaya pulp ratio, 0.48% citric acid, 4% corn starch and 0.5% pectin. This resulted in acceptable product with overall acceptability score 7.31, hardness 304.06 N, stickiness 1.57382 N.mm and ascorbic acid 34.10 mg/100g.

Highlights

- This paper covers an exhaustive research work on development of banana-papaya mixed fruit bar using Response Surface Methodology and effects of different ingredients on quality of mixed fruit bar.

Keywords: Banana, papaya, drying, mixed fruit bar, ascorbic acid, texture profile analysis

India is the second largest producer of fruits only after China, with an annual production of 86.60 million tons from cultivated area of 6.11 million hectares (National Horticulture Board 2015). Banana production is the second largest only after citrus, contributing to about 16% of the world's total fruit production. India contributes to 27% of world's banana production. The major banana producing states of India are Maharashtra, Kerala, Tamilnadu, Gujarat, Bihar, West Bengal, Assam, Andhra Pradesh and Karnataka (Mohapatra *et al.*, 2010). India is blessed with a variety of agro-climatic conditions and therefore, our country produces a wide range of tropical, subtropical, temperate and arid zone fruits. Limited availability and high perishability are two major bottlenecks that demand its immediate post-harvest utilization. (Panja *et al.*, 2016). For utilization of produce in the glut season, it is necessary to save it from spoilage. Hence, the development of the low cost processing technology of papaya and banana is highly required. Thus, the preparations of papaya as well as banana pulp with simple technology and its utilization in the form of pulp and fruit bar have a great scope. (Vagadia *et al.*, 2016).

Fruit bar is a confectionery product prepared by drying fruit pulp after mixing with appropriate quantities of sugar, pectin, acid and colour (Narayana *et al.*, 2007). Fruit bars are novel products, nutritious, tasty and chewy and relished by all categories of people, particularly very popular among children. Fruit bar serves as an instant source of energy and provides needed vitamins and minerals. It is very appealing, can be attractively packaged and consumed readily. The product is hygienic and has a good shelf-life. Fruit bars can find a good market in the urban as well as rural area for its taste, aroma and convenience.

Banana is highly rated for its easy digestibility and therapeutic values. It provides more than a quarter of the food calories, vitamins, calcium and potassium (Singhal 2003). Banana is a low in fat content and is rich in potassium, magnesium and phosphorous. It is also a good source of iron, calcium, vitamin A and vitamin C (Marriott and Lancaster 1983). Papaya is another popular tropical fruit. India is the fourth largest producer of papaya in the world with an annual production of 4.93 million tons from an area of 1.15 lakh hectares (National Horticulture Board 2015). Papaya fruits are called protective food because they contribute vitamins, minerals, bulk cellulose and protopectin. Papayas are rich in carotene, vitamin C, flavonoids, folic acid, pantothenic acid, potassium, magnesium, and fiber. Papaya also contains an enzyme called *papain* that may help lower inflammation.

Banana and papaya are relatively cheaper fruits and available round the year in India, yet during glut season, a considerable portion of the produce (25-30%) is lost due to lack of storage and preservation facility. To utilize the surplus production and avoid post-harvest losses, both fruits may be suitably processed into products which will be good source of vitamins (vitamin C, β-carotene), carbohydrate, minerals, with long shelf-life.

The processes are available for making bars from mango, banana, guava, papaya and pineapple. However, not much published information is available for making mixed fruit bar from banana and papaya. Banana being good source of carbohydrates, dietary fibers and minerals and papaya having higher percentage of β-carotene, both fruits if used in combination can give superior quality products. The study was undertaken with the aim of optimization of levels of ingredients for production of banana-papaya mixed fruit bar.

MATERIALS AND METHODS

Materials

Mature and ripe banana (cv. Grand Naine) and papaya fruits (cv. Taiwan) were procured from the university farm, Anand Agricultural University, Anand, Gujarat. Crystalline cane sugar, Pectin (High methoxyl type), corn starch and citric acid (Make: SDFCL, Mumbai) were procured from the local market of Anand.

Process technology

Fruit bar was prepared from different combinations of banana and papaya pulps with addition of sugar, corn starch, pectin and citric acid as per experimental design (Table 1).

Table 1: Actual and coded values of different parameters for experimentation

Expt. No.	Banana: Papaya Pulp ratio, (%)	Citric acid, (%)	Corn starch, (%)	Pectin, (%)
1	75:25 (+1)	0.82 (+1)	4 (+1)	0.5 (+1)
2	50:50 (0)	1.0 (+2)	3 (0)	0.4 (0)
3	75:25 (+1)	0.82 (+1)	4 (+1)	0.3 (-1)
4	50:50 (0)	0.65 (0)	3 (0)	0.6 (+2)
5	25:75 (-1)	0.82 (+1)	4 (+1)	0.5 (+1)
6	25:75 (-1)	0.48 (-1)	4 (+1)	0.3 (-1)
7	25:75 (-1)	0.48 (-1)	2 (-1)	0.3 (-1)
8	25:75 (-1)	0.48 (-1)	4 (+1)	0.5 (+1)
9	50:50 (0)	0.65 (0)	1 (-2)	0.4 (0)
10	50:50 (0)	0.3 (-2)	3 (0)	0.4 (0)
11	50:50 (0)	0.65 (0)	5 (+2)	0.4 (0)
12	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
13	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
14	100:0 (+2)	0.65 (0)	3 (0)	0.4 (0)
15	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
16	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
17	50:50 (0)	0.65 (0)	3 (0)	0.2 (-2)
18	25:75 (-1)	0.82 (+1)	4 (+1)	0.3 (-1)
19	75:25 (+1)	0.82 (+1)	2 (-1)	0.3 (-1)
20	25:75 (-1)	0.48 (-1)	2 (-1)	0.5 (+1)
21	75:25 (+1)	0.48 (-1)	2 (-1)	0.5 (+1)
22	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
23	75:25 (+1)	0.48 (-1)	4 (+1)	0.3 (-1)
24	25:75 (-1)	0.82 (+1)	2 (-1)	0.3 (-1)
25	75:25 (+1)	0.48 (-1)	2 (-1)	0.3 (-1)
26	0:100 (-2)	0.65 (0)	3 (0)	0.4 (0)
27	50:50 (0)	0.65 (0)	3 (0)	0.4 (0)
28	25:75 (-1)	0.82 (+1)	2 (-1)	0.5 (+1)
29	75:25 (+1)	0.82 (+1)	2 (-1)	0.5 (+1)
30	75:25 (+1)	0.48 (-1)	4 (+1)	0.5 (+1)

Figures in bracket ( ) show coded level.

Sugar level was kept constant throughout all the experiments i.e. 15 % of the pulp (Ekanayake and Bandara 2002). The mixture was heated at 80°C for

10 min to have 30°B (Mir and Nath, 2000), sulphited with 100 ppm of SO_2 by addition of potassium meta bisulphate and spread on SS trays (l=26.4×10^{-2} m, w = 15.8 × 10^{-2} m *and* h = 3.4 × 10^{-2} m dimensions) smeared with glycerin. The initial thickness of the bar was kept as 10 mm (Mir and Nath 2000) and was dried in a tray dryer (Make: Narang Scientific Works Pvt. Ltd., New Delhi) set at 1.16 m/s air velocity and at 65°C temperatures till about 15 % moisture content was obtained. After drying, the fruit bar was cooled and cut into rectangular shapes using a SS knife. Fruit bars were evaluated for sensory quality on the basis of colour, texture, taste, flavor and overall acceptability, ascorbic acid content and texture profile analysis.

Experimental design and statistical analysis

The optimization of different ingredients for development of mixed fruit bar was done using response surface methodology (RSM). To evaluate the effects of different ingredients such as banana-papaya pulp ratio, citric acid, corn starch and pectin were decided using a Central Composite Design. The treatments consisted of four variables, each have five levels which were decided using the code values of - 2, - 1, 0, + 1, + 2 (Das 2005) as shown in Table 1. The analysis of variance (ANOVA) was done and the effect and regression coefficients of individual linear, quadratic and interaction terms were determined. The significances of all terms in the polynomial were judged statistically by computing the F-value and compared with standard significance level of 0.1%, 1% and 5%.

Physico-chemical analysis of fresh pulps and dried fruit bar

Moisture content was estimated using gravimetric method (AOAC, 1990). The pH value of the sample was determined using a digital pH meter (Elico LI 610 – pH meter). Acidity was calculated by titrating against 0.1 N NaOH (Ranganna 1986). Ash content was determined according to the procedure described by Ranganna (1986). Fat of sample is soluble in hexane which is extracted from oven dried sample using a soxhlet extraction apparatus as per Ranganna (1986). Protein content of the sample was determined using Micro-Kjeldahl method as per AOAC (1990). The total soluble solids of the sample was determined using two different digital refractometers (Atago, Japan) having a range of 0 – 53 °Brix and 45 – 93 °Brix; respectively. Ascorbic acid was estimated by titrating against 2,6- dichlorophenolindophenol dye. Reducing sugar and total sugar contents of the prepared beverage were determined by Lane and Eynon method as described by Ranganna (1986).

For the sensory evaluation of mixed fruit bar, the samples were evaluated using a 9 point hedonic rating test. The score-card suggested by Ranganna (1986) was used for judging the product. Microbial analysis (standard plate count, yeast and mould count and coliform count) was carried out as per the standard procedure (Ranganna, 1986). Three samples of each experimental mixed fruit bar were subjected to uniaxial compression to 40% of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine for texture profiling.

RESULTS AND DISCUSSION

Bio-chemical characteristics of banana and papaya pulps

The bio-chemical characteristics of banana and papaya pulps are presented in Table 2.

Table 2: Bio-chemical characteristics of banana and papaya fruit pulps

Parameters Variety	Banana pulp Grand Naine (*Musa acuminata*)	Papaya pulp Taiwan (*Vasconcellea pubescenes*)
Moisture, % wb	75.16±0.48	88.96±0.63
Protein, %	1.70±0.03	1.25±0.02
Fat, %	0.3±0.05	0.5±0.06
Carbohydrates, % by difference	21.81±0.23	9.29±0.37
Ash, %	1.03±0.13	0.99±0.08
Total Soluble Solids (º Brix)	20.8±1.5	10.2±1.3
Acidity, %	0.176±0.057	0.208±0.032
pH	5.2±0.4	4.8±0.3
Reducing sugars,%	6.08±0.16	1.96±0.13
Total sugars, %	11.98±0.38	5.20±0.23
Non-reducing sugars, %	5.9±0.22	3.24±0.10
Ascorbic acid, mg/100g	17.04±5.68	204.48±5.68

Effects of level of ingredients on quality of mixed fruit bar

Overall acceptability

The sensory scores in terms of overall acceptability (OAA) of banana-papaya mixed fruit bar were ranged from 4.75 to 7.43. It was observed that banana-papaya pulp ratio and citric acid were more sensitive for OAA compared to other independent variables. It was found that OAA scores increased with decrease in banana-papaya pulp ratio. It might be because the increase in papaya pulp gives better sensory attributes to dried fruit bar than the bar prepared from banana pulp. It was also found that OAA scores increased with decrease in citric acid. This might be due to the better sugar-acid blend of the product. Prasad (2009) reported that the addition of citric acid to a level of 0.45 % in banana pulp improved the colour and OAA scores. This may be due to increased libration of SO_2 from KMS at lower pH and subsequent inhibition of browning.

It was observed that banana-papaya pulp ratio had highly significant ($p < 0.01$) effect on OAA, while citric acid had significantly effect at $p < 0.05$ and there was no significant effect of corn starch and pectin. No significant effect was found for all interactions on OAA. The quadratic terms PR^2 had highly significant ($p<0.01$) effect and CS^2 had significant ($p<0.05$) effect and no significant effect were found for CA^2 and P^2. The regression equation describing the effects of process variables on OAA scores of mixed fruit bar in terms of actual levels of variables is given as:

$$OAA = 3.78 + 0.051\ PR + 3.835\ CA - 0.0005\ PR^2 - 0.062\ CS^2$$

Hardness

The values for hardness of banana-papaya mixed fruit bar obtained in present investigation ranged from 73.807 to 328.956 N. The banana-papaya pulp ratio and pectin content were more sensitive compared to other independent variables and affected hardness of the fruit bar. It was observed that as the banana-papaya pulp ratio was decreased and pectin content was increased, the hardness of the bar increased. This might be because of the possibility of more gelling effect of pectin. If the pectin content is higher, a firm and tough product is formed (Srivastava and Kumar 2006) and thus results in more hardness in dried bar. Organoleptically it was found that addition of pectin improved the texture of the product. The high pectin content provides for more cross-linking of the polymer, and thereby increases the rigidity of the gel. The hardness of the jelly increased significantly with increase in quantities of pectin (Lee *et al.*, 2010).

From ANOVA (Table 3), it can be observed that banana-papaya pulp ratio had highly significant ($p < 0.01$) effect and there was no significant effect of citric acid, corn starch and pectin as well as for all interactions on hardness. The quadratic term PR^2, CA^2, CS^2 and P^2 highly significant ($p<0.01$) effect on hardness of mixed fruit bar. The effects of the process variables on texture analysis in terms of actual levels of variables are given in terms of regression equation:

$$Hardness = 1165.051 - 8.288\ PR + 0.039PR^2 + 590.497\ CA^2 + 18.473\ CS^2 + 1852.318\ P^2$$

Stickiness

The values for stickiness of banana-papaya mixed fruit bar obtained in present investigation ranged from 0.6123 to 3.6513 N.mm. The banana-papaya pulp ratio and citric acid were more sensitive compared to other independent variables and affected stickiness of the fruit bar. Corn starch and pectin content did not affect stickiness of fruit bar. It was also observed that the stickiness of fruit bar increased with decrease in banana-papaya pulp ratio and increase in citric acid content (Fig. 1). Similar results were found by Prasad (2009) that higher addition of citric acid in banana pulp resulted into a product of excessive stickiness. This is may be due to the possible spontaneous exudation of fluid from a gel (syneresis) caused by excess of acid (Srivastava and Kumar 2006).

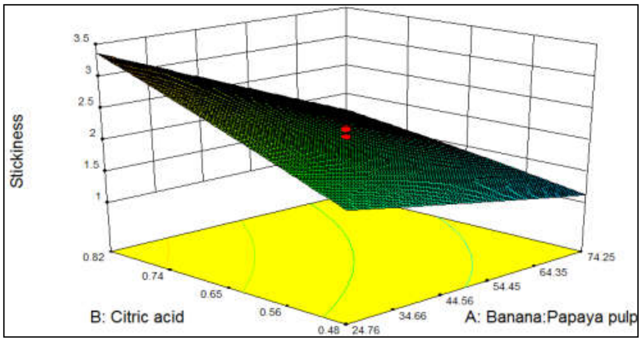

Fig. 1: Interaction effects of banana-papaya pulp ratio and citric acid on stickiness of mixed fruit bar

From ANOVA (Table 3), it can be observed that banana- papaya pulp ratio and citric acid had highly significant ($p < 0.01$) effect, interaction of PR and CA had significant ($p < 0.05$) effect on stickiness. The quadratic term CS^2 was affected significant at $p < 0.1$ on stickiness of mixed fruit bar where as no significant effect found for PR^2, CA^2 and P^2. The effects of the process variables on texture analysis in terms of actual levels of variables are given in terms of regression equation:

$$\text{Stickiness} = -3.687 + 0.003\ PR + 7.794\ CA - 0.051\ PR\ CA - 0.132\ CS^2$$

Ascorbic acid

Ascorbic acid data was estimated for banana-papaya mixed fruit bar at various combinations as per experimental design. The values for ascorbic acid of mixed fruit bar obtained in present investigation ranged from 7.32 to 49.98 mg/ 100g bar. The banana-papaya pulp ratio was more sensitive compared to other independent variables and affected ascorbic acid content of fruit bar. It was observed that as the banana-papaya pulp ratio was decreased, the ascorbic acid in the bar increased. This is may be due to the increased amount of papaya pulp which contained more amount of ascorbic acid than the banana pulp. Thus the dried bar prepared from papaya pulp having the highest ascorbic acid content than the fruit bar prepared from banana pulp. ANOVA (Table 3) indicated that banana-papaya pulp ratio had highly significant ($p < 0.01$). There was no significant effect of citric acid, corn starch and pectin on ascorbic acid content of fruit bar. Non significant effect was also observed for all the interactions. The quadratic term PR^2 had highly significant effect at $p < 0.01$ on ascorbic acid of fruit bar where as no significant effect found for CS^2, CA^2 and P^2. The regression equations describing

Table 3: ANOVA for various responses of Banana Papaya Mixed Fruit Bar

		OAA			Hardness			Stickiness			Ascorbic acid		
Source	**df**	**Sum of Squares**	**Mean Square**	**p-value Prob> F**	**Sum of Squares**	**Mean Square**	**p-value Prob> F**	**Sum of Squares**	**Mean Square**	**p-value Prob> F**	**Sum of Squares**	**Mean Square**	**p-value Prob> F**
Model	14	9.952	0.71	< 0.0001	235094.38	16792.45	< 0.0001	17.394	1.242	< 0.0001	2515.4	179.671	< 0.0001
A- PR, %	1	6.161	6.161	< 0.0001	201793.45	201793.45	< 0.0001	8.46	8.46	< 0.0001	2404.31	2404.316	< 0.0001
B- CA, %	1	0.311	0.311	0.005	530.5	530.5	0.484	6.471	6.471	< 0.0001	0.104	0.104	0.8
C- CS, %	1	0.003	0.003	0.741	174.49	174.49	0.686	0.058	0.058	0.52	1.29	1.293	0.377
D- P, %	1	0.042	0.042	0.256	4.37	4.37	0.948	0.012	0.012	0.764	0.729	0.729	0.505
PR CA	1	0.079	0.079	0.126	278.21	278.21	0.61	0.77	0.77	0.03	2.403	2.403	0.234
PR CS	1	0.018	0.0187	0.443	73.4	73.4	0.793	0.404	0.404	0.102	0.901	0.901	0.459
PR P	1	0.0005	0.0005	0.897	43.68	43.68	0.839	0.127	0.127	0.344	0.322	0.322	0.656
CA CS	1	0.066	0.066	0.158	180.27	180.27	0.681	0.183	0.183	0.259	0.044	0.044	0.867
CA P	1	0.0002	0.0002	0.931	746.33	746.33	0.408	0.28	0.28	0.169	1.68	1.68	0.316
CS P	1	0.002	0.002	0.771	772.32	772.32	0.4	0.004	0.004	0.859	0.827	0.827	0.478
PR2	1	3.254	3.254	< 0.0001	16235.24	16235.24	0.001	0.002	0.002	0.888	76.568	76.568	< 0.0001
CA2	1	0.09	0.09	0.104	8856.8	8856.8	0.01	0.015	0.015	0.737	4.694	4.694	0.103
CS2	1	0.106	0.106	0.08	9342.19	9342.19	0.008	0.477	0.477	0.078	4.507	4.507	0.11
P2	1	0.028	0.028	0.347	9392.96	9392.96	0.008	0.134	0.134	0.332	2.025	2.025	0.273
Residual	15	0.454	0.03		15449.19	1029.94		2.011	0.134		23.491	1.566	
Lack of Fit	10	0.407	0.04	0.059	12483.03	1248.3	0.213	1.72	0.172	0.121	18.544	1.854	0.253
Pure Error	5	0.047	0.009		2966.16	593.23		0.291	0.058		4.946	0.989	
Total	**29**	**10.406**			**250543.58**			**19.405**			**2538.892**		
R-Squared		0.95			0.93			0.89			0.99		
Adj R-Squared		0.91			0.88			0.79			0.98		
C.V. %		2.56			18.45			19.7			5.47		
Std. Dev.		0.17			32.09			0.36			1.25		

the effects of process variables on OAA scores of mixed fruit bar in terms of actual levels of variables are given as:

$$\text{Ascorbic acid} = 35.482 - 0.728\ PR + 0.0027\ PR^2$$

Furthermore, the co-efficient of determination (R^2) that reflects the proportionate variability in data, explained or accounted for by the model. The R^2 values for overall acceptability (OAA) scores, hardness, stickiness and ascorbic acid were 0.95, 0.93, 0.89 and 0.99, respectively, showing good fit of models to the data. The lack of fit test was found to be non significant for each responses model which indicated that the developed models were adequate for predicting the responses.

CONCLUSION

It can be concluded from present investigation that overall acceptability of mixed fruit bar increased as the banana-papaya pulp ratio and citric acid were decreased. Banana-papaya pulp ratio highly affected the final ascorbic acid content of the fruit bar and ascorbic acid content of dried fruit bar increased as the banana-papaya pulp ratio was decreased. The best solution was found with the desirability value of 0.86 having OAA 7.31, hardness 304.06 N, stickiness 1.57382 N.mm and ascorbic acid 34.10 mg at 25:75 of banana- papaya pulp ratio, 0.48% citric acid, 4% corn starch and 0.5% pectin.

REFERENCES

AOAC, 1990 - *Official methods of analysis* 13th ed. Association of Official Analytical Chemist Benjamin Franklin Station, Washington D.C., USA.

Das, H. 2005. *Food processing operations analysis.* Asian Books Private Limited.

Ekanayake, S. and Bandara, L. 2002. Development of banana fruit leather. *Ann Sri Lanka Dept Agri.* **4**: 353-358.

Lee, E.H., Yeom, H.J., Ha, M.S. and Bae, D.H. 2010. Development of banana peel jelly and its antioxidant and textural properties. *Food Science and Biotechnology,* **19**(2): 449-55.

Marriott, J. and Lancaster, P.A. 1983. *Bananas and plantains.* Handbook of tropical foods, USDA.

Mir, M.A.and Nath, N. 2000. Protein fortification of mango bar using soy protein concentrate and coconut powder. *Journal of Food Science and Technology,* **37**(5): 525-528.

Mohapatra, D., Mishra, S. and Sutar, N. 2010. Banana and its by-product utilization: an overview. *Journal of Scientific and Industrial Research*, **69**(5): 323-329.

Narayana, C.K., Mustaffa, M.M. and Sathiamoorthy, S. 2007. Standardization of process for preparation of banana fruit bar. *Indian Journal of Horticulture*, **64**(3): 349-350.

National Horticulture Board. 2015. Annual Report for year 2014-15.

Panja, P., Marak, D.S. and Thakur, P.K. 2016. Effect of packaging on quality of enriched fruit bars from aonla (*Emblica officinalis* G.) during storage. *International Journal of Agriculture, Environment and Biotechnology.* **9**(3): 411.

Prasad, K. 2009. Protein fortification of mango and banana bar using roasted Bengal gram flour and skim milk powder. *Agricultural Engineering International: CIGR Journal*. **11**: 1-6.

Ranganna, S. 1986. *Handbook of analysis and quality control for fruit and vegetable products.* Tata McGraw-Hill Education.

Singhal, V. 2003. *Banana in Indian Agriculture.* Indian Economic Data Research Centre, New Delhi.

Srivastava, R.P. and Kumar, S. 2015. *Fruit and vegetable preservation: principles and practices.* CBS Publishers & Distributors Pvt. Limited.

Vagadia, P., Senapati, A., Tank, R., Mayani, J. and Koyani, B. 2016. Evaluation of Physico-chemical and organoleptic quality of Papaya Cv. Taiwan and Banana Cv. Grand naine based mixed fruit bar during storage. *International Journal of Agriculture, Environment & Biotechnology*, **9**(4): 541.