Formulation and Optimization of Herb-Flavored Sweetpotato-Chocolate Spread

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ABSTRACT

The study aimed to formulate and optimize the production process of herb-flavored sweetpotato-chocolate spread. Determination of the right proportions of sweetpotato, cocoa tablet and basil in the production of chocolate spread is necessary in order to produce a finished product which is a highly acceptable and nutritious spread. Plackett-Burman (PB) variable screening design and Response Surface Methodology (RSM) were used as experimental designs. A 3^3 factorial experiment arranged in Central Composite Design (CCD) with sweetpotato (125, 150 and 175g), cocoa tablet (20, 25 and 30g) and basil (5, 10 and 15g) were used as independent variables.

Results using the Plackett-Burman variable screening showed that cocoa tablet and basil significantly influenced the acceptability of aroma, flavor, aftertaste and general acceptability, while buffalo's milk, sweetpotato color and cocoa tablet significantly affected the color of the product. Response surface analysis revealed that basil significantly affected the pH, consistency, flavor, taste, aftertaste and general acceptability of herb flavored sweetpotato-chocolate spread. Sweetpotato influenced the cost per 100g of the finished product. Sweetpotato, cocoa tablet and basil did not significantly affect the TSS, spreadability, color and aroma of the product. Superimposed plots of the different variables indicate that the combination of 150g sweetpotato, 29g cocoa tablet and basil was the optimum formulation with a production cost of Php8.00/100g product. The optimum formulation was preferred by 58% of the consumers over the 42% preference on similar commercial chocolate spread. It was found negative of Salmonella and E.coli and had lower microbial count after six weeks of monitoring. The optimized product contained low fat content, low carbohydrates and sugar content but high in dietary fiber. It also contained calcium and potassium.

Keywords: *Sweetpotato-chocolate spread, Formulation, Optimization, Response surface methodology*

INTRODUCTION

A wide variety of chocolate-related products is available in the market today, and one of them is chocolate spread. It is a type of paste with a consistency similar to peanut butter, made with or flavored with chocolate. The paste usually contains cocoa, oil, milk and additional flavorants. At times, it also includes nuts or honey.

Chocolate spreads available in the local market are usually added with almond, hazelnut and peanut. The high cost of the product is due to the price of almond and hazelnut, which are relatively expensive considering that these products are imported. If these can be substituted with locally available materials, then the production cost will decrease and will result to a relatively cheaper cost of the product.

Sweetpotato is a potential material for the production of spread being starchy in nature, which can act as emulsifier. Lauzon, et al.[5] developed a chocolate like product from sweetpotato, as well as sweetpotato marmalade and jam.

Consumers today are concerned more of their health and wellness. This explains why the food industry is becoming increasingly interested in aromatic herbs and spices, which are used not only for flavoring but also for other purposes, including medicinal and anti inflammatory properties or their antioxidant activities. Diets rich in selected natural antioxidants such as polyphenols, flavonoids, vitamin C and vitamin E are believed to reduce the risk of incidence of cardiovascular, other chronic diseases and certain types of cancer. This has led to the revival of interest in plant-based foods (Choi, et al.[2]; Mata, et al.[7].

Determining the right proportions of sweet-potato, cocoa tablet and basil, an herb, in the production of chocolate spread is deemed necessary in order to produce a highly acceptable and nutritious spread. Hence, this study was conducted.

OBJECTIVES OF THE STUDY

1. Screen different variables that may affect the product using the Plackett-Burman design;
2. Determine the influence of variables on the sensory qualities of herb-flavored sweetpotato-chocolate spread;
3. Evaluate the effect of variables on the physico-chemical properties of the product;
4. Determine and compare the cost of production of the developed herb-flavored sweetpotato-chocolate spread;
5. Determine the optimum formulation and processing condition for the production of herb-flavored sweetpotato-chocolate spread;
6. Verify the sensory acceptability of the optimum formulation;
7. Assess consumer reaction towards the formulated product; and
8. Evaluate the microbial and nutritional quality of the optimized product.

MATERIALS AND METHODS

Procurement of Materials

Fresh buffalo's milk was purchased from Philippine Carabao Center (PCC) – Visayas Region. Sweetpotatoes colored purple and orange (genotype JK09-25-5) were procured from Philippine Root Crops Research and Training Center (PRCRTC), while other ingredients were purchased at Baybay City public market.

Preliminary Experiment

The preliminary studies employed Plackett-Burman design with eight runs and seven factors. The experimental runs were carried out in order to find out possible combinations of factors and levels which have significant effect on the processing of herb-flavored sweetpotato-chocolate spread. The factors were as follows: (1) buffalo milk levels (125-250g); (2) coconut milk levels (125-250g); (3) cocoa tablet levels (5-20g); (4) sweetpotato color (purple and orange); (5) basil levels (10-30g); and (6) cooking method (water bath and pan cooking). The seventh variable was a dummy. The response variables considered were the color, aroma, consistency, aftertaste, and general acceptability.

Experimental Design

In order to determine the optimum processing conditions and formulation, a 3^3 fractional experiment was employed following the Central Composite Design (CCD). The factors and levels were chosen based on the results of Plackett-Burman screening experiment. A total of fifteen experimental combinations were performed for physico-chemical analyses and sensory evaluation.

Table 1. Distribution of treatments following the Central Composite Design

Trt	Sweet potato (g)	Cocoa tablet (g)	Basil (g)
1	125	20	5
2	125	20	15
3	125	30	15
4	125	30	5
5	175	20	5
6	175	20	15
7	175	30	15
8	175	30	5
9	150	20	10
10	150	25	15
11	150	30	10
12	150	25	5
13	175	25	10
14	125	25	10
15	150	25	10

Product Manufacture

The fundamental steps involved in the manufacture of herb flavored sweetpotato–chocolate spread includes the following: weighing of ingredients, mixing, adding sweet potato and basil, homogenizing, filtering, adding refined sugar and cocoa tablet, cooking, stirring, packing, and storing. Prior to processing, utensils and glass jars were sterilized by immersing them in boiling water for thirty minutes. The processing area was also sanitized to prevent any form of contaminants from adhering into the product.

Physico-chemical Evaluation of Herb-flavored Sweetpotato-Chocolate Spread

Physico-chemical tests such as pH, total soluble solids (TSS) and spreadability were carried out on all the experimental treatments. Measurement of pH spread revealed that basil and the interaction of the finished product was done by immersing the electrode of the laboratory pH meter into the sample. Refractometer was used to determine the total soluble solids (TSS) of samples.

Spreadability was determined by applying the spread on the surface of sliced bread. The weight of bread before and after spreading the herb-flavored sweetpotato-chocolate spread was taken (Samsudin, n.d.[6].

Sensory Evaluation

Sixty panelists familiar with the sensory evaluation techniques evaluated the sensory attributes of the product following the Incomplete Block Design (Cochran and Cox[3]). Each panelist was presented with seven samples from different treatments. The sensory attributes which were evaluated were the color, aroma, consistency, flavor, taste, aftertaste and general acceptability. The pane-lists were asked to rate each samples using the 9-point Hedonic scale.

Attaining the Optimum Experimental Combination

Data gathered from the sensory evaluation were subjected to appropriate statistical analysis to determine treatment effects. The accuracy of the information gathered during sensory testing depended entirely on the appropriateness of the statistical methods to which these data were subjected (Mabesa[6]).

Sensory and production cost data for all experimental treatments were analyzed employing the response surface regression with the use statistical analytical software (SAS). Using the Statistica version 6, a graphical presentation of the response surface plots were generated for all analyses of each run condition. Contour plots were superimposed to identify the optimum formulation and processing conditions.

Verification

Two treatments were selected: one treatment which fall within the optimum region and one which fall outside the optimum region. Evaluation was conducted employing 28 panelists.

Microbial Analyses

Microbial population was determined once every two weeks for a period of six weeks using Plate Count Agar (PCA) (Lañada[4]). Testing for the presence of pathogens (*Salmonella spp.* and *E. coli*) was also conducted on the optimum formulation.

Chemical Analyses

Moisture content, ash, total fat, protein, sodium, potassium, calcium, total dietary fiber, food energy value, carbohydrates and total sugar of the acceptable treatment were analyzed.

Statistical Analyses and Modelling

Sensory and physico-chemical evaluation data were analyzed using SAS v6.12 and Statistica v.6 to determine the effects of independent variables and to generate surface and contour plots. Predicted values were determined using the prediction profiling tab of Statistica v.6 and model equation.

Consumer Acceptance Test

One hundred (100) consumer panels composed of 50 children and 50 college students and staff of Visayas State University evaluated the acceptability of the herb flavored sweetpotato-chocolate spread. Respondents were asked to choose between the two samples presented and state the reason for their choice, as adapted by Andrino[1].

Cost Analysis

Production cost per treatment was calculated based on the current market price of raw materials, ingredients, equipment and utilities consumed in the processing of sweetpotato-chocolate spread, as well as the labor cost.

RESULTS AND DISCUSSION

Plackett-Burman Variable Screening

Variables which caused significant effect on the quality of herb-flavored sweetpotato-chocolate spread were considered in the succeeding experiment. These variables were sweetpotato, cocoa tablet, and basil.

Physico-chemical Evaluation

Results in regression analysis (Table 2) of physico-chemical analyses conducted on fifteen treatments of herb-flavored sweetpotato-chocolate between cocoa tablet and sweetpotato significantly affected the pH, while total soluble solids and spreadability were not significantly affected.

Table 2. Summary of effect estimates on the physicochemical analysis of herb-flavored sweetpotato-chocolate spread

Parameter	Effect Estimates		
	pH	TSS^{ns}	Spread^{ns}
SP	0.00540^{ns}	-0.141211	0.07916
CT	0.00711^{ns}	-0.299630	1.26482
BI	0.12778*	0.092315	-0.63241
SP*SP	0.00007^{ns}	0.000877	0.00020
CT*SP	-0.00100**	-0.001167	-0.00600
T*CT	0.00378^{ns}	0.009259	-0.00829
BI*SP	0.00020^{ns}	0.000167	0.00267
BI*CT	-0.00267*	-0.005833	0.00633
BI*BI	-0.00489*	0.001259	0.00504

ns - not significant *- significant (p>0.05) **- significant (p>0.001)
Legend: Spread - spreadability SP - sweetpotato
CT - cocoa tablet BI- basil

Sensory Evaluation

The herb-flavored sweetpotato-chocolate spread samples were subjected to sensory evaluation in order to come up with an optimum formulation. Table 3 shows the effect estimates on the sensory attributes using different parameters.

Table 3. Summary of the effect estimates on the different sensory attributes of herb flavored sweetpotato-chocolate spread

Parameter	Effect Estimates			
	color^{ns}	Aroma^{ns}	Consistency	Flavor
SP	0.0072	0.0488	0.0976^{ns}	0.1151^{ns}
CT	-0.2814	0.2502	0.0607^{ns}	-0.5114^{ns}
BI	-0.1781	-0.3378	0.3754^{ns}	-0.9096**
SP*SP	-0.0001	-0.0002	-0.0003^{ns}	-0.0004^{ns}
CT*SP	0.0010	-0.0000	0.0005^{ns}	0.0003^{ns}
CT*CT	0.0027	-0.0053	-0.0036^{ns}	0.0079^{ns}
BI*SP	-0.0001	0.0000	-0.0009^{ns}	0.0002^{ns}
BI*CT	0.0023	0.0009	0.00464^{ns}	0.0061^{ns}
BI*BI	0.0063	0.0118	0.01857**	0.0314**

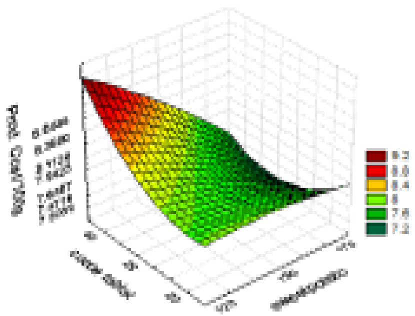
Parameter	Effect Estimates		
	Taste	Aftertaste	Gen.Acc.
SP	0.1130^{ns}	0.0716^{ns}	0.1358^{ns}
CT	-0.5022^{ns}	-0.4835^{ns}	-0.4089^{ns}
BI	-0.7560*	-0.6029**	-0.74198**
SP*SP	-0.0004^{ns}	-0.0003^{ns}	-0.0005^{ns}
CT*SP	-0.0001^{ns}	0.0006^{ns}	0.0003^{ns}
CT*CT	0.0094^{ns}	0.00698^{ns}	0.0064 ^{ns}
BI*SP	0.0003^{ns}	-0.00029^{ns}	0.0001^{ns}
BI*CT	0.0029^{ns}	0.00250^{ns}	0.0043^{ns}
BI*BI	0.0273**	0.02627**	0.0271**

ns – not significant *- significant(p>0.05) **- significant (p>0.001)
Legends are same as Table 2

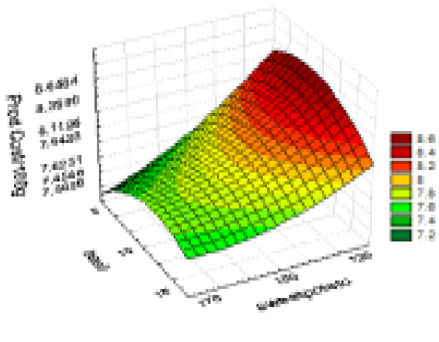
Data show that color and aroma were not significantly affected by the variables, while consistency, flavor, taste, aftertaste and general acceptability were significantly affected particularly by the levels of basil added into the formulation. The results implied that as the level of basil was increased, a corresponding decrease in the acceptability of consistency, flavor, taste, aftertaste and general acceptability were noted. On the other hand, levels of sweetpotato and cocoa tablet did not significantly affect the acceptability of the different attributes being evaluated.

Production Cost

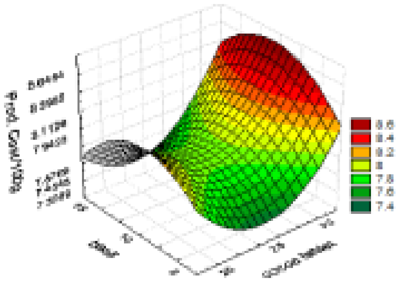
Production cost analysis provides an assessment on the estimated expenses of the product. The response surface plots (Figure 1) of the different variables depict the roles of these variables in the total cost of production. At constant amount of basil (6 g), increasing the amount of cocoa tablet and decreasing the amount of sweetpotato led to an increase in production cost (Figure 1a). Maintaining the amount of cocoa tablet at 29 g, production cost decreased with an increase in the amount of sweetpotato across any level of basil (Figure 1b). On the other hand, Figure 1c shows that at constant 150 g sweetpotato, production cost increased at an increased level of cocoa tablet across any level of basil.



(a)



(b)



(c)

Figure 1. Response surface plots for production cost per 100g of herb-flavored sweetpotato-chocolate spread at constant: (a) basil; (b) cocoa tablet; and (c) sweetpotato levels

Optimum Formulation

Factors considered in the selection and identification of the optimum formulation were the cost of production, which was limited to eight pesos per 100 grams, and the sensory attributes being evaluated such as color, aroma, consistency, flavor, taste, aftertaste and general acceptability. To further limit the optimum region, a cut-off score of 6.75 was set as the minimum. Figure 2 shows the superimposed contour plots of the herb-flavored sweetpotato-chocolate spread. At constant basil (Figure 2a) graph shows the acceptable region (the shaded portion) which corresponded to 29 g of cocoa tablet at any level of sweetpotato was acceptable.

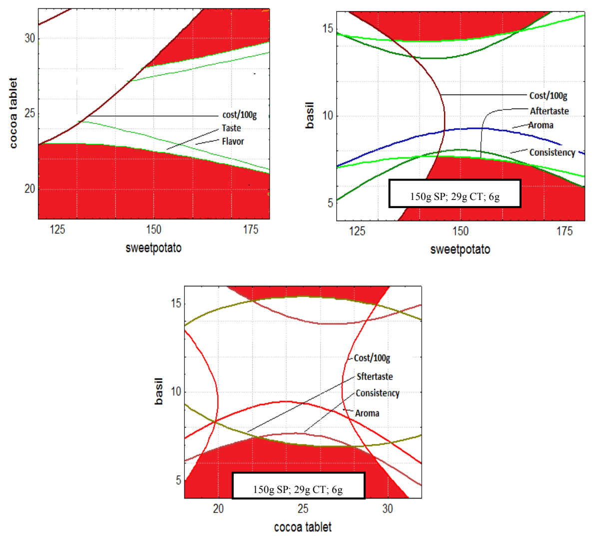


Figure 2. Acceptable regions (shaded) for herb-flavored sweetpotato-chocolate spread obtained by superimposing contour plots of production cost per 100 g and sensory acceptability $\geq$ 6.75 with constant (a) 6 g basil, (b) 29g cocoa tablet and (c) 150 g sweetpotato.

At constant cocoa tablet level (29 g), shaded region was found to be 6g of basil and the optimum region for sweet potato is 140g or higher (Figure 2b). At constant sweet potato (Figure 2c), the shaded region revealed that any level of cocoa tablet was acceptable but basil level was only up to 6 g. Considering all these results on superimposing the production cost and all the acceptability scores led to the identification of the optimum formulation to be 150 g sweetpotato, 29g cocoa tablet and 6 g basil.

Verification Experiment

The T-test results from verification test for comparing treatment inside and outside the optimum region is shown in Table 4.

Table 4. T-test results from verification test for comparing treatment inside and outside of the optimum region

Parameter	Mean Optimum	Mean Outside Optimum Region	Prob>|T|
Color	7.36	7.11	0.58083^{ns}
Aroma	7.32	6.89	0.31464^{ns}
Consistency	7.04	6.96	0.88081^{ns}
Flavor	7.43	6.82	0.112333
Taste	7.71	6.54	0.00192**
Aftertaste	7.57	6.71	0.02914*
Gen. Acceptability	8.07	7.11	0.00005**

^{ns} not significant   * significant (p≥0.05)   ** significant (p≥0.001)
N = 28 panelists

The data show that the optimum formulation is significantly better than the treatment outside the optimum region particularly in terms of taste, aftertaste and general acceptability, although color, aroma, consistency and flavor were not significantly different from each other. The data shows that the optimum formulation had higher acceptability ratings than its counterpart. Therefore, the verification experiment proved that optimum formulation is better than the treatment outside the optimum region.

Consumer Preference

The graphical representation of the breakdown of responses (Figure 3) shows the variation of choices among respondents with adults preferring the herb-flavored sweetpotato-chocolate spread over the commercial brand. In the case of children, variation of choices was not so apparent as children prefer the commercial brand more than the optimum formulation by a small margin.

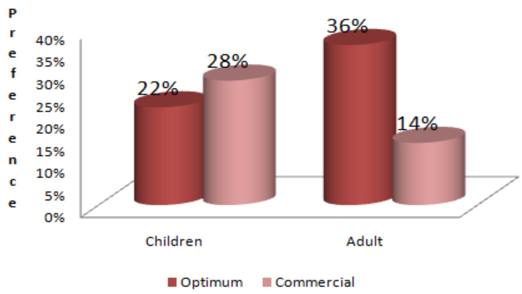


Figure 3. Graphical presentation of the percentage distribution of respondents over their choice between the optimum formulation of herb-flavored sweetpotato-chocolate spread and commercial chocolate spread

Microbial Quality of the Optimum Formulation

Results in microbial analysis revealed that the herb-flavored sweetpotato-chocolate spread has low microbial count (expressed as colony forming units) after six weeks of storage at room temperature. The result indicates that the microbial load of the product is low (Figure 4) and is within the set guideline level of $\leq10^4$ and $\leq10^6$ by NSW Food Authority for determining the microbiological quality of ready-to-eat food under Category A (foods in which all components are fully cooked for immediate sale or consumption).

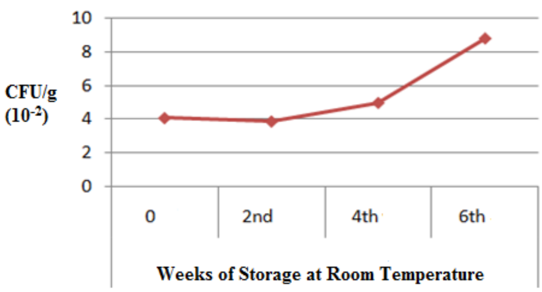


Figure 4. Microbial population of herb-flavored sweetpotato-chocolate spread for six weeks of storage at room temperature

The result indicated that the optimum formulation was acceptable and safe for human consumption. Low microbial count signified that it has good micro-biological quality.

There were no pathogens (Table 5) detected in the different culture media used all throughout the duration of monitoring. This implies that the optimum formulation is free from pathogenic micro-organisms and is therefore safe for human consumption.

Table 5. Pathogen testing for the presence of *Salmonella* and *E. coli* of the optimum formulation of herb-flavored sweetpotato-chocolate spread

Culture Media	Weeks of Storage			
	0	2	4	6
Brilliant Green Agar	-	-	-	-
Bismuth Sulfite Agar	-	-	-	-
Deoxycholate Agar	-	-	-	-
Eosin Methylene Blue Agar	-	-	-	-
MacKonkey Agar	-	-	-	-
Salmonella Shigella Agar	-	-	-	-
Xylose Lactose Agar	-	-	-	-

Nutritional Value of the Optimum Formulation

The nutrient analysis of the optimum formulation of herb-flavored sweetpotato-chocolate spread is presented in Table 6. Compared to commercially available spreads, the optimum formulation of herb-flavored sweetpotato-chocolate spread has higher total dietary fiber content, lower carbohydrates and sugar content. It also contains potassium and calcium which are not found in commercially available chocolate spreads. The higher fiber content of the product primarily comes from the sweetpotato being added in the formulation.

Table 6. Nutritional facts of herb-flavored sweet potato-chocolate spread with 150g sweetpotato, 29g cocoa tablet and 6 g basil.

Parameter	NC	DV**
Moisture	46.1%	N/A
Ash	0.856%	N/A
Total Fat	10.5%	65g
Protein	2.42%	50g
Total Dietary Fiber	4.11%	25g
*Total Carbohydrates	40.1%	300g
Total Sugar	30.5%	N/A
Food Energy Value	265kcal/100g	N/A
Sodium (as Na)	127mg/kg	2400mg
Potassium (as K)	2675mg/kg	3500mg
Calcium (as Ca)	559mg/kg	1000mg

**- Based on a 2,000 Calorie Intake; for Adults and Children 19 to 29 Years of Age (US Food and Drug Administration, 2007)
NC – Nutritional Content

Fiber, also known as roughage, is the key to gastric motility and regular bowel movements. Unlike fat, protein, and other carbohydrates, fiber passes through the gastrointestinal tract relatively intact. Dietary fiber can be described as a sponge and is categorized based on its ability to dissolve in water.

Soluble fiber, forms a gel-like material that soaks up cholesterol and stabilizes blood sugar levels. Insoluble fiber, acts as scrubber to cleanse the intestinal lining, add bulk to stools and promote regularity (Smith[10]).

The low level of sugar, fat and calories per serving is good especially for those people who are conscious about their caloric intake. The United States Department of Agriculture (USDA, 2007) recommends that adults receive only 20 to 30 percent of their daily caloric intake from fat. When the amount of fat intake is cut, it minimizes the amount of fat in the body. Fat has almost double the amount of calories than carbohydrates and proteins, so when fat intake is minimized, the amount of calories from fat is cut back.

CONCLUSIONS

Based on the results of the study, the following conclusions were drawn:

1. Variables that affect the quality of herb-flavored sweetpotato-chocolate spread include sweet potato, cocoa tablet, and basil.
2. Sweetpotato and basil significantly affect the pH level of the different formulations while TSS and spreadability were not significantly affected.
3. Levels of sweetpotato, cocoa tablet and basil do not significantly influence the color and aroma of the product. Consistency, flavor, taste, aftertaste and general acceptability are significantly affected by the levels of basil added.
4. Cocoa tablet and sweetpotato were the contributing factors that affected the production cost.
5. The optimum formulation of herb flavored sweetpotato-chocolate spread is 150 g of sweetpotato, 29 g of cocoa tablet and 6 g of basil.
6. Verification results show that the optimum formulation has higher acceptability scores than the formulation located outside the optimum region.
7. Consumers prefer the optimum formulation over the commercially available chocolate spread.
8. The optimum formulation is microbiologically safe, has higher total dietary fiber content, lower carbohydrates and sugar content, and contains calcium and potassium.

RECOMMENDATIONS

It is recommended to use semi-trained or trained panel for the sensory evaluation to minimize extreme effects on the predictive models of the regression analysis, thus preventing saddle effects on the predictive values for stationary points. The shelf life of the product at different storage temperatures may also be studied to determine how long it will last when already out in the market. Identification of the dominant microorganism that could cause spoilage of the product should also be conducted. A similar study may be conducted utilizing other available and underutilized herbs in the locality.

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