PROCESS OPTIMIZATION OF FOAM MAT DRIED MORINGA AND GINGER INSTANT POWDERED TEA.

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ABSTRACT
Tea is one of the most popular beverages in the world due to its taste, aroma and health effects, herbal tea is a term used for any non-caffeinated beverage made from the infusion or decoction of herbs, spices or other plant material in water. The study investigated the optimization of the foaming process in the formulation/development of moringa/ginger instant powdered tea. The investigation was conducted using an eight factor general factorial design with 42 randomized experimental runs. The numerical optimization yielded a desirability index of 0.968 with optimized levels of independent variables as moringa 53.578%, ginger 20.01%, soy protein isolate 20%w/w, methyl cellulose 3.999%w/w, whipping time 14.999 min, drying temperature 60.037°C, foam thickness 7.986mm, whipping speed 10000.007 rev/min, foam expansion 54.568% and foam stability 74.863%.

KEYWORDS
Moriga/Ginger extract, Tea, Soy protein, Methyl cellulose, Foam expansion, Foam stability

1.0 INTRODUCTION
Tea [*Camellia sinensis*(L.)O.Kuntze] is one of the most popular beverages worldwide due to its taste, aroma, and health effects (Khokhar and Magnusdottir, 2002).Tea has historically been promoted for having a variety of positive health benefits and recent human studies suggest that green tea may help reduce the risk of cardiovascular disease and some forms of cancer (Peters *et al*., 2001). Herbal tea is a term used for any non-caffeinated beverage made from the infusion or decoction of herbs, spices or other plant material in water. These drinks are distinguished from caffeinated beverages like coffee and the true tea (black, green, white, yellow, oolong, etc.) or from a decaffeinated tea, in which the caffeine has been removed. In addition to serving as a beverage many are also consumed due to a perceived medicinal benefit (Merriam W, 2003).

Moringa oleifera is known as one of the world most useful trees, because all the parts of the tree can be utilized for industrial purposes, food and medication (Khalafalla*et al.*, 2010). It has been reported that *Moringa* leaves contain four times the calcium of milk, three times the potassium of bananas, seven times the vitamin c of oranges, two times the protein of yogurt and four times the vitamin A of carrots (Jed and Fahey, 2005).

Ginger (*ZingiberOfficinale*Roscoe) is a herbaceous perennial specie that belongs to the order *Scitamineae*and family *Zingiberaceae*and also a tropical monocotyledon. It is the most established rhizome broadly domesticated as a spice. The long history of the cultivation of ginger plant started in China and afterwards spread to South East Asia, India, Caribbean and West Africa (McGee, 2004).

Foam–mat dehydration is one of the emerging drying techniques suitable for food preservation. It involves drying of liquid or semi liquid food concentrate in the form of stabilized foam, prepared by the addition of foam agents and/or stabilizer in small quantity, followed by whipping in a continuous mixer to stiff foam. The stable foam is dried in heated air at relatively low temperature under atmospheric pressure (Kadam*et al.*, 2010; Orishagbemi*et al.*, 2010).

Foam-mat dried products are comparatively stable against microbiological, chemical and biochemical deterioration and have high retention of color, flavor, vitamin and sensory characteristics (Kadam and Balasubramanian, 2011; Kadam*et al.*, 2012).

Since the success of foam-mat drying is dependent on the achievement of stable foam, the aim of this study is to optimize the foaming process involved in the formulation/development of moringa/ginger instant powdered tea.

2.0 MATERIALS AND METHODS

2.1 Source of Raw Material

Fresh*Moringaoleifera* leaves were harvested from moringa trees around River Basin environs Minna, Nigeria; while dried Ginger (*ZingiberOfficinale*Roscoe) was purchased from Kure market Minna, Nigeria. The fresh Moringa leaves were washed and shade dried until completely dried. The dried Moringa leaves and dried Ginger root were milled using electric blender and then sieved. The extraction process for Moringa and Ginger was done with slight modification, one hundred grams of both powdered Moringa and Ginger was soaked in 1000ml boiled distilled water; shaken and left for 24 hours. The solution was filtered using muslin cloth (Harbourne, 1998). Soy protein isolate was purchased from Health wellness shop in Minna, and used as foaming agent and food grade carboxymethyl cellulose (CMC) was used as foam stabilizer at different concentrations.

2.2 Experimental Techniques.

2.2.1 Experimental Design using General Factorial Design.

The design of the experiment was conducted using eight-factor general factorial design with forty two randomized experimental runs to determine the effect of independent variables on response variables. Response surface methodology was used to establish the effects using Design Expert – version 10.0.3 (Statease Inc., Minneapolis, USA). The independent variables and their coded levels are 40% ≤ moringa leaf extract (x_1)≤ 68%, 20% ≤ ginger root extract (x_2) ≤ 48%, 10%w/w ≤ soy protein isolate (x_3) ≤ 20%w/w, 2%w/w ≤ methyl cellulose (x_4) ≤ 4%w/w, 5 min ≤ whipping time (x_5) ≤ 15 min, 60°C ≤ drying temperature (x_6) ≤ 70°C, 2mm ≤ foam thickness (x_7) ≤ 8mm, and 10000 rev/min ≤ whipping speed (x_8) ≤ 13000 rev/min.

2.2.2 *Analysis of Data*

The response surface models were fitted to the data and the statistical significance of the model terms were examined through analysis of variance (ANOVA). The adequacy of the models were established, the lack-of fit test were conducted and the coefficients of determination were estimated.

2.2.3 *Process Optimization of Parameters*

Both numerical and graphical optimizations were carried out for the responses. The optimization criteria were maximization of foam expansion and foam stability and the optimum process conditions were established.

Table 1: Recorded response for foaming process of moringa/ginger powdered tea.

Sample code	Soy Protein Isolate (%w/w)	Methyl cellulose (%w/w)	Foam Expansion (%)	Foam Stability (%)
1	20	4	34.76	74.86
2	10	4	44.19	47.33
3	10	2	52.07	26.96
4	20	4	40.11	54.74
5	10	4	52.18	40.36
6	20	2	56.18	27.69
7	20	4	50	72.94
8	20	2	40.9	30.72
9	20	4	44.44	55.73
10	20	2	49.54	18.73
11	10	4	52.17	54.64
12	20	4	46.07	49.12
13	20	2	54.55	32.99
14	10	4	52.17	40.54

15	10	2	42.39	41.87
16	20	4	55.56	58.48
17	20	2	52.22	23.44
18	20	4	51.14	49.65
19	20	4	45.45	51.72
20	20	4	43.37	71.28
21	10	4	46.74	56.86
22	20	4	56.81	51.99
23	20	4	54.55	48.24
24	20	4	52.33	55.2
25	20	4	48.31	62.53
26	20	4	46.07	51.16
27	20	4	48.86	56.92
28	10	4	46.74	49.57
29	20	4	47.73	43.73
30	20	4	56.82	36.39
31	20	4	44.44	53.91
32	20	4	52.28	49.12
33	10	2	53.91	41.33
34	20	2	42.17	20.67
35	20	4	55.81	48
36	10	4	62.04	38.03
37	10	4	53.33	35.71
38	20	4	38.89	37.78
39	10	2	51.09	35.62
40	10	2	47.37	31.43
41	20	2	53.33	34.93
42	20	2	45.56	25.56

2.3 Foaming Process

2.3.1 Foam Expansion

Foam expansion was calculated to determine the amount of air incorporated into the solutionduring whipping. It was calculated using the following equation, as described by (Kato *et al.*, 1983):

$$\text{Foam expansion } (\%) = \left[\frac{V1 - V0}{V0}\right] \times 100 \qquad (1)$$

where v_0 is the initial volume of moringa/ginger solution (cm^3) and v_1 is the final volume of foamedmoringa/ginger (cm^3).

2.3.2 Foam Stability

The foam obtained was placed in a transparent graduated cylinder and kept at room temperature for 3 h. The volume of liquid, which was separated from the foam as a result of drainage, and the reduction in foam volume, were measured. Foam stability was calculated using the following relationship, as described by (Marinova*et al.*, 2009):

$$\text{Foam stability } (\%) = \frac{V1}{V0} \times 100 \qquad (2)$$

Where $v_1$is the volume of foam after 3 h (cm^3) and v_0 is the initial volume of foam (cm^3).

2.4 Foam mat Drying of Moringa/Ginger Foam

The Moringa/Ginger foam was spread on aluminum drying trays at foam thickness off 2 mm, 5 mm and 8 mm and dried in an air dryer. The foam was dried at temperature of 60 °C, 70 °C and 80 °C the foam were taken out of the dryer at regular interval and weighed using an electronic balance and quickly returned back into the air oven, drying was terminated when dried product attained constant weight.

3.0DISCUSSION OF RESULTS

3.1 Effect of Concentration of Soy Protein isolate on Foam Expansion

From the foam expansion ANOVA table (Table 2), linear model is significant with an F-value of 22.6, the lack of fit F-value of 1.08 is good because it is not significant relative to pure error and we want the model to fit. The predicted R^2 of 0.7337 is in reasonable agreement with the adjusted R^2 of 0.7867and adequacy precision of 14.7489 indicates an adequate signal which means the model can be used to navigate the design space, a ratio greater than 4 is desirable. The standard deviation, mean and coefficient of variation are 5.04, 42.38 and 11.88%. The significant model terms for foam expansion are soy protein isolate (x_3), drying temperature (x_6) and foam thickness (x_7) with ($p < 0.05$).

The fitted linear model equation for foam expansion is represented below

$$y_{FE} = +39.74 + 3.79x_1 + 2.94x_2 + 12.17x_3 + 0.7299x_5 - 2.25x_6 + 2.39x_7 - 0.3602x_8 R^2 = 0.8231 \qquad (3)$$

Table 2: ANOVA table for foam expansion linear model

Source	Sum of Squares	df	Mean Square	F-value	pvalue	
Model	4014.15	7	573.45	22.6	<0.0001	significant
x_1	2.48	1	2.48	0.0977	0.7565	
x_2	1.46	1	1.46	0.0576	0.8118	
x_3	184.81	1	184.81	7.28	0.0108	
x_4	0	0				
x_5	15.39	1	15.39	0.6065	0.4415	
x_6	150.97	1	150.97	5.95	0.0201	
x_7	215.46	1	215.46	8.49	0.0063	
x_8	4.92	1	4.92	0.1939	0.6625	
Residual	862.62	34	25.37			
Lack of Fit	743.44	29	25.64	1.08	0.5238	not significant
Pure Error	119.18	5	23.84			
Cor Total	4876.78	41				

The contour and 3-D plots of foam expansion are presented in Figure 1.

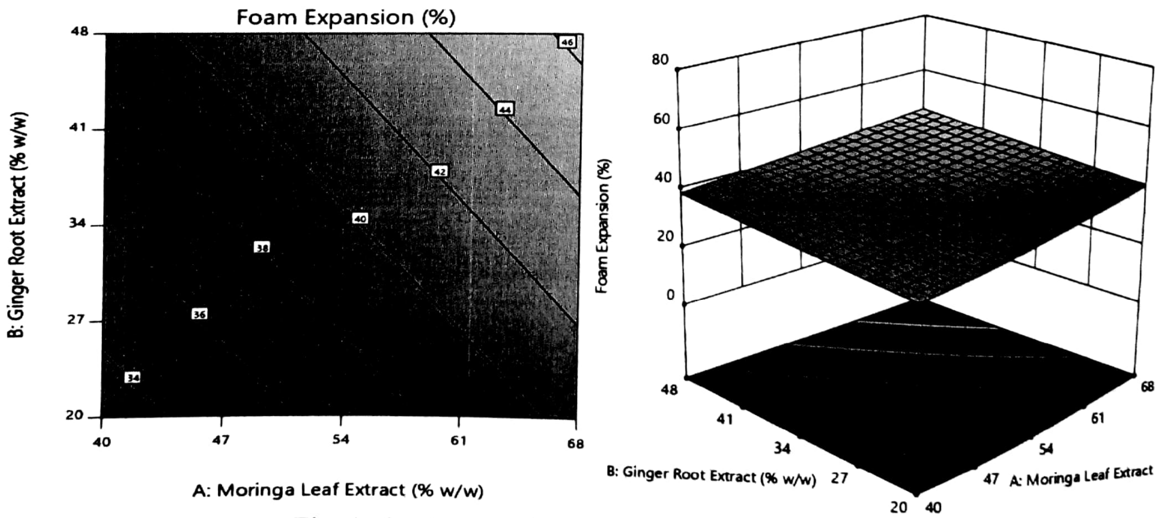

Fig. 1: Contour and 3-D plots of foam expansion

3.2 Effect of Methyl cellulose on Foam Stability

There was no significant effect of methyl cellulose on foam stability as seen from the ANOVA table this might be because the range chosen was narrow in the experimentation. From the foam stability ANOVA table (Table 3), the foam stability linear model had a significant F-value of 12.66.The lack of fit F-value of 1.03 is good because it is not significant relative to the pure error and we want the model to fit. The predicted R^2 of 0.5678 is in reasonable agreement with the adjusted R^2 of 0.6656and adequacy precision of 12.3603 indicates an adequate signal which means the model can be used to navigate the design space, a ratio greater than 4 is desirable. The standard deviation, mean and coefficient of variation are 7.9, 44.96 and 17.57%. The significant model terms for foam stability are moringa (x_1), ginger (x_2), soy protein isolate (x_3) and whipping time (x_5)with ($p < 0.05$).

The fitted linear model equation for foam stability is represented below

$$y_{FS} = -29.11 - 165.52x_1 - 166.39x_2 - 57.43x_3 - 5.99x_5 + 1.49x_6 - 1.64x_7 + 0.7481x_8 R^2 = 0.7227 \quad (4)$$

Table 3: ANOVA table for foam stability (linear) model

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	5531	7	790.14	12.66	<0.0001significant
x_1	4731.2	1	4731.2	75.79	< 0.0001
x_2	4665.39	1	4665.39	74.74	< 0.0001
x_3	4117.9	1	4117.9	65.97	< 0.0001
x_4	0	0			
x_5	1035.89	1	1035.89	16.6	0.0003
x_6	66.15	1	66.15	1.06	0.3105
x_7	101.65	1	101.65	1.63	0.2106
x_8	21.21	1	21.21	0.3398	0.5638
Residual	2122.33	34	62.42		
Lack of Fit	1818.78	29	62.72	1.03	0.5465 not significant
Pure Error	303.55	5	60.71		
Cor Total	7653.33	41			

The contour and 3-D plots of the foam stability are presented in Figure 2.

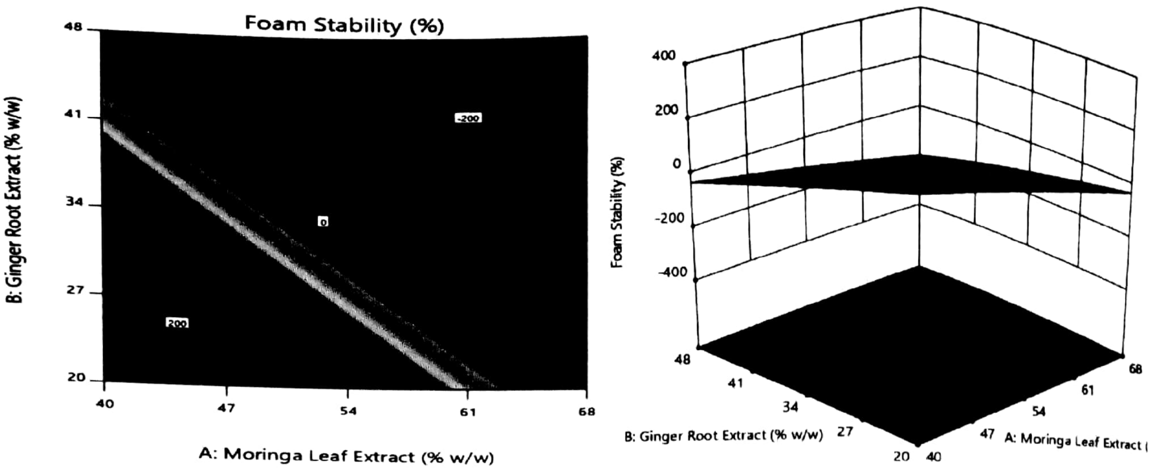

Fig. 2: Contour and 3-D plots of the foam stability

3.3 Optimization of the Process Parameters

Optimization was conducted in order to achieve the maximum foam expansion and maximum foam stability. The numerical optimization yielded a desirability index of 0.968 with optimized levels of independent variables as moringa 53.578%, ginger 20.01%, soy protein isolate 20%w/w, methyl cellulose 3.999%w/w, whipping time 14.999 min, drying temperature 60.037°C, foam thickness 7.986mm, whipping speed 10000.007 rev/min, foam expansion 54.568% and foam stability 74.863%.

The optimized foam expansion and foam stability 3-D plots are presented in Figure 3.

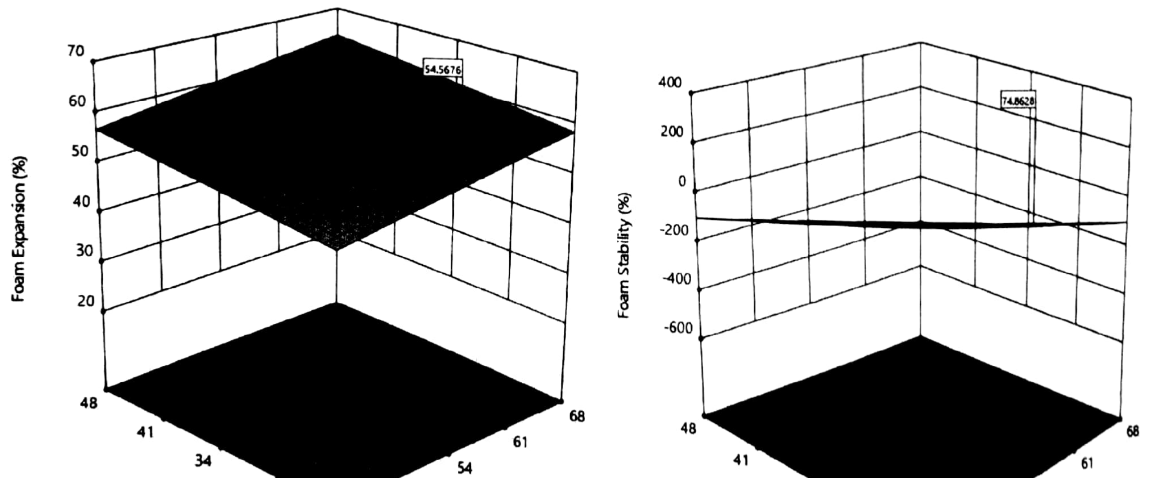

Fig. 3: Optimized foam expansion and foam stability 3-D plots

The desirability and overlay plots are represented in figure 4.

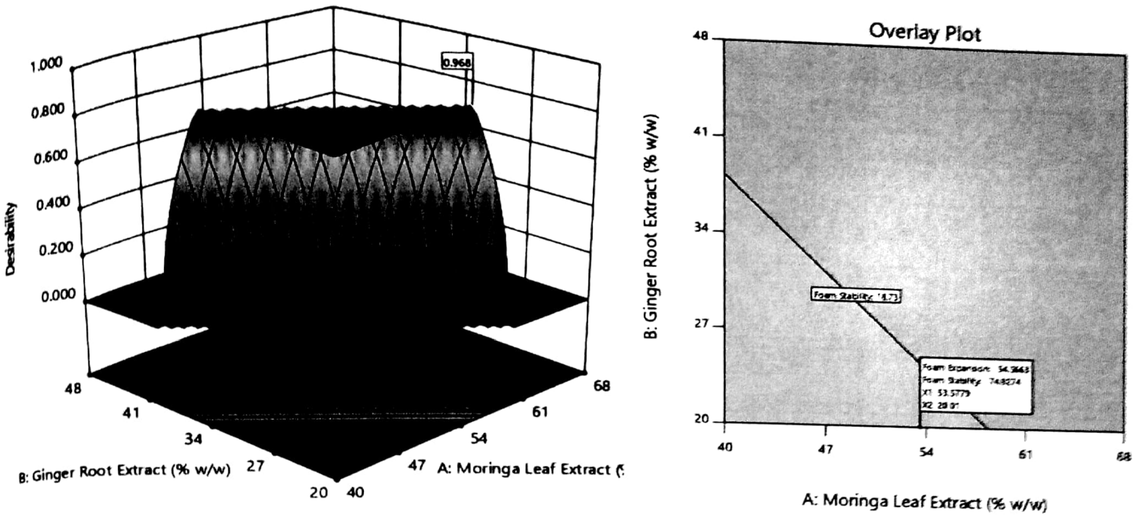

Fig. 4: Desirability and overlay plots

4.0 CONCLUSION

The study has shown that moringa/ginger extract may be foamed using soy protein isolate as a foaming agent and methyl cellulose as foam stabilizer. It was also found that increasing the soy protein isolate from 10% to 20% significantly increased the foam expansion of the moringa/ginger extract., However methyl cellulose has no effect on foam stability this might be because the ranges chosen for the experimentation is narrow. The numerical optimization yielded a desirability index of 0.968 with optimized levels of independent variables as moringa 53.578%, ginger 20.01%, soy protein isolate 20%w/w, methyl cellulose 3.999%w/w, whipping time 14.999 min, drying temperature 60.037°C, foam thickness 7.986mm, whipping speed 10000.007 rev/min, foam expansion 54.568% and foam stability 74.863%.

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