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Development of Method to Produce Snacks Supplemented with Brewer's Spent Cassava

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Abstract. Brewer's spent cassava (BSC) generated from beer production using high quality cassava flour is a rich source of fiber and other nutrients. Extruded snack products are predominantly made from cereal flour or starches and tend to be low in protein and fiber with little nutritional value. A new type of snack foods, which are supplemented by BSC, would provide the consumers with more fibre, low energy, more digestible and at an affordable price. The aim of this study is to incorporate BSC into extruded snack at a reasonable level and to determine the technical parameters to ensure the quality of snacks. BSC flour was added at different ratio of the base ingredients weight. The extrusion process was carried out using a twin-screw extruder. A commercial snack made by extrusion process from corn and rice flour with defined physicochemical properties was used as desirable target for optimization. Effect of levels of BSC and other processing parameters were studied on the qualities of the snacks. At certain levels of supplemented CSB no significant change of the snack quality were found. This result suggested the potential of incorporating BSC into food to make a new brand of snacks.

Keywords: extruded snacks, brewer's spent cassava

1. Introduction

In the manufacture of beer, various residues and by-products are generated. The most common ones are spent grains, spent hops and surplus yeast, which are generated from the main raw materials [1]. The use of high quality cassava flour will generate by-products called brewers' spent cassava (BSC) which could be useful for food and industrial purposes and when converted to flour, can be a rich source of fiber and other nutrients as well as a functional marketable material. Various researches have been carried out on the use of brewers spent grains, by-products from the use of barley and other grains for food and feed purposes [2], [3]. However, there is no information on the utilization of brewers spent cassava flour (BSCF). Brewer's spent cassava (BSC) is a rich source of dietary fibre and protein. In general, BSC is considered as a lignocellulosic material rich in protein and fibre, which accounts for around 20 and 70% of its composition, respectively (SAB Miller plc laboratory report), In the extruded snack production the presence of components other than starch as BSC has a lubricating effect on the melt. This interferes with the air cell formation and limits the starch gelatinisation required for expansion of the snacks, as a result the snacks will be less expanded and hard in texture [4]-[6]. Raw ingredients such as rice, wheat, corn, produce extruded snacks with different physico-chemical characteristics. This is related to the variations in the chemical composition of the grain. For example, wheat has a higher protein and lower starch content compared to rice and corn, therefore extruded wheat products are harder and less expanded [7]. It may be possible to improve the physico-chemical properties and the BSC content of the snacks by manipulating the base ingredients. Hence, the objective of this study is to evaluate some quality parameters of snacks produced from blends of brewers spent cassava flour.

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2. Materials and Methods

2.1. Materials

Fresh BSC was produced and provided by SABMiller. One part was dewatered until W=80%, dried until W=10% and milled into fine particles. The remaining BSC was stored in the freezer at -18^{o}C. Rice and corn flour was used as basic ingredients for snack production

2.2. Production of extruded snacks

The extruded products were prepared from blends of dried cassava spent beer and rice and corn flour at differing proportions. Base ingredients (rice and corn flour) with defined recipe were weighed in advance. BSC flour was added at 4, 6, and 8% of the base ingredients weight. The samples were mixed with a calculated amount of water so that each formulation has a specified level of water. The extrusion process was carried out using a twin-screw extruder. The effect of barrel temperature, feed moisture content, screw speed on functional properties was studied for optimal values.

2.3. Experimental design

Optimisation procedures were applied to determine the optimum level of the four independent variables based on desirability concept. A commercial snack made by extrusion process from corn and rice flour with defined physicochemical properties was used as desirable target for optimization. The snacks produced according to the optimised conditions were mixed with five different formulas of spices. These samples were tested for sensorial preferences to select the suitable spices formula.

Response surface methodology (RSM) was applied to determine the best combination of extrusion process variables for the production of snack with a twin-screw extruder. In this study, a four-factor experimental set-up was used with brewers spent cassava levels-BSC (X1), barrel temperature-Temp (X2) (Barrel temperature of zone 3), water levels-W (X3) and main screw speed-MSS (X4) as the independent factors at three levels each where X1 ranged from 4 to 8%, X2: 120-150^{o}C, X3: 1-3%, X4: 20-30Hz. The data obtained was analysed by response surface methodology (RSM) using Box–Behnken design (Table 1) to optimize process variables, including bulk density (BD), lateral expansion (LE), water absorption index (WAI), water solubility index (WSI). Twenty-nine combinations including five replicates of the centre point was performed in random order according to the Box–Behnken design. A second-order polynomial model for the dependent variables as shown in equation (1) was established to fit the experimental data. An analysis of variance (ANOVA) test was carried out using Design-Expert Version 7 (Stat-Ease) to determine level of significance at 5% level.

$$Y = \beta_o + \sum_{i=1}^{4}\beta_i X_i + \sum_{i=1}^{4}\beta_{ii} X_i^2 + \sum\sum_{i<j=1}^{4}\beta_{ij} X_i X_j + \varepsilon \quad (1)$$

where Y is the response; β_o is a constant; while β_i, β_{ii} and β_{ij} are linear, quadratic and interaction coefficients, respectively; and ™ is the error.

2.4. Physico-chemical analytical methods

Determination of fried snack expansion ratio and bulk density of snack was conducted as previously described [8] using Texture analyser TA.XT Plus**.** Other physico-chemical properties of extruded snacks were described as follows:

Lateral expansion (LE): The ratio of diameter of extrudate and the diameter of die was used to express the expansion of extrudate [9]. Lateral expansion (LE, %) was then calculated using the mean of the measured diameters: LE = (diameter of product - diameter of die hole) / (diameter of die hole)* 100

Bulk density (BD): The samples obtained for measurement of extrudate expansion were also used to determine the bulk density [9].

Water absorption index (WAI) and water solubility index (WSI): The WAI and WSI were measured using a technique developed for cereals [10] through a modification of the method described [11] for measuring swelling power of starch.

3. Result

The extruded snack was produced as described above in experimental design. Functional properties of snack were shown in Table 1, whereas characteristics of the commercial snacks were: LE of 206.29%, BD of 0.14 g/cm^3, WEI of 4.49 g gel/g, WSI of 30.61%.

Table 1: Effect of extrusion conditions on functional properties of products

Std	X1	X2	X3	X4	Response 1 (Y1)	Response 2 (Y2)	Response 3 (Y3)	Response 4 (Y4)
	Brewer's spent cassava level (%)	Barrel temp. (^oC)	Water level (%)	Main screw speed (Hz)	Lateral expansion (%)	Bulk density (g/cm^3)	WAI (g gel/g)	WSI (%)
1	4	120	2	25	157.98	0.15	6.16	19.15
2	8	120	2	25	134.67	0.21	7.55	12.07
3	4	150	2	25	122.13	0.16	8.03	18.87
4	8	150	2	25	160.71	0.18	6.81	10.71
5	6	135	1	20	126.16	0.12	5.20	15.52
6	6	135	3	20	121.34	0.15	5.93	18.24
7	6	135	1	30	118.19	0.14	4.65	21.25
8	6	135	3	30	111.72	0.15	4.91	16.31
9	4	135	2	20	136.13	0.13	`5.88	19.03
10	8	135	2	20	124.37	0.18	7.63	15.38
11	4	135	2	30	137.42	0.13	5.30	22.49
12	8	135	2	30	174.17	0.18	6.59	16.35
13	6	120	1	25	137.48	0.13	6.68	15.13
14	6	150	1	25	140.32	0.13	6.22	14.47
15	6	120	3	25	140.14	0.13	7.57	14.42
16	6	150	3	25	112.02	0.16	7.72	11.05
17	4	135	1	25	140.19	0.12	7.80	16.17
18	8	135	1	25	132.41	0.16	7.47	11.07
19	4	135	3	25	137.65	0.13	7.60	13.39
20	8	135	3	25	140.82	0.18	7.50	11.86
21	6	120	2	20	133.95	0.13	6.31	19.86
22	6	150	2	20	106.60	0.16	4.97	14.75
23	6	120	2	30	143.05	0.15	6.16	20.77
24	6	50	2	30	122.74	0.14	6.09	20.88
25	6	135	2	25	123.99	0.14	6.02	19.45
26	6	135	2	25	138.79	0.14	6.65	17.34
27	6	135	2	25	125.72	0.15	5.84	18.65
28	6	135	2	25	152.98	0.13	6.31	18.62
29	6	135	2	25	139.69	0.14	6.83	17.59

As shown in Table 1, Y1, Y2, Y3, Y4 ranged between 106.60 and 174.17; 0.19 and 0.21; 4.66 and 8.02; and 10.71 and 22.49, respectively. The regression coefficients (R^2) were observed to vary between 0.72 and 0.94, while the lack of fit values varied between 0.11 and 0.62, respectively (Result not shown). The lateral expansion (LE) and bulk density (BD) of extrudates seek to describe the degree of puffing undergone by the dough as it exits the extruder. LE considers expansion only in perpendicular direction to extrudate flow while BD considers expansion in all directions. The regression model explained 72.14 % of the total variability ($P \leq 0.05$) in LE of the snack under the tested extrusion variables. When extrusion cooked melts exit the die hole, they suddenly go from high pressure to atmospheric pressure. This pressure difference causes a flash-off of internal moisture and water vapour pressure, which is nucleated to form bubbles in the molten extrudates, allows the expansion of the melt. In this work, LE was observed to increase as barrel temperature and screw speed increases (Respon se surface plots, result not shown). Similar reports were discussed by [3], [9], [12] when added brewers spent grain in extrusion process. Under the tested extrusion variables, the LE ranged between 106.60 and 174.17 (%). Maximal LE value of the extrudate (174.17 %) was obtained at the maximum barrel temperature=135 ^oC, BSC = 8%, W=2% and MSS = 30Hz.

The result showed that product bulk density of the milled extrudates ranged from 0.12 to 0.21 g/cm^3 (Table 1). Similar to those reported for maize grits extrudates (0.09–0.32 g/cm^3); commercial snack products (rod-shaped, cheese powder-coated corn puffed extrudates, 0.160–0.238 g/cm^3) [13]; and chickpea flour-based snack (0.130 and 0.275 g/cm^3) [14]. The regression model explained 88.35% of the total variability ($P \leq 0.05$) in BD of snack extruded product under the tested extrusion variables. The level of BSC added in the extruder had the greatest influence on the extrudate BD. The extrudate BD was also reduced with increasing of BSC levels and it rose with increasing of barrel temperature. As the quantity of water in the extruder increased, BD of the extrudate decreased significantly.

WAI of The regression model explained 73.53% of the total variability ($P \leq 0.0329$) in WAI of the snack extruded under the tested extrusion variables. WAI of the extruded samples ranged from 4.65 to 8.02g gel/g of dry matter of the sample. Similar results of WAI of snack extruded from corn flour were obtained by Gomez and Aguilera (1984) in their investigations [15]. In the tested range of variables, the WAI increased with the increase in the BSC level, in the level of water added to the extruder and with a reduction in screw speed. Maximal WAI values of extrudates were obtained at BSC=4%, Temp=150 ^{o}C, MSS=25 Hz and W=2%.

Under the tested extrusion process variables, WSI significantly depends on BSC ($P \leq 0.0001$), Temp ($P \leq 0.0147$), W ($P \leq 0.047$) and MSS ($P \leq 0.0014$), quadratic term BSC^2 ($P \leq 0.0322$), Temp^2 ($P \leq 0.0001$), W^2($P \leq 0.0001$) and MSS^2 ($P \leq 0.0002$) and interactions of Temp*MSS($P \leq 0.0335$) and W*MSS ($P \leq 0.0039$).

Regression model explained 94.42% of the total variability ($P \leq 0.0001$) in WSI of ECM under the tested extrusion process variables. WSI of the snack product ranged from 10.71 to 22.49 (%). Under the tested extrusion variables, WSI decreased as BSC level and the quantity of water added to the extruder increased, and not clearly when the barrel temperature decreased and screw speed increased. Ainsworth *et al.* (2007) reported that increasing screw speed increased WSI because of increased solubility of more starch molecules [4]. This was also consistent with the result in [16]. Optimization was performed to obtain desired characteristics: maximum values of LE and WSI; closest possible to commercial values of BD, WAI. The overall optimized region was predicted as barrel temperature 121.25 ^{o}C, main screw speed 30Hz, BSC powder:4%, Water content: 1.88%. Snacks produced with optimal technical parameters was consumer-tested for most preferable flavour. Suitable flavours were selected for formulation of the snacks (Result not shown).

4. Conclusion

At certain levels of supplemented BSC (4% of BSC powder) no significant change of the extruded snack quality were shown. Optimal processing parameters were found: barrel temperature 121.25 ^{o}C, main screw speed 30Hz, water content: 1.88%. Suitable to customers preference formulas of spices were selected.

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