IMPACT OF ROASTING CONDITIONS ON THE QUALITY CHARACTERISTICS OF SOYA BEAN

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ABSTRACT
Effect of roasting on proximate content, some anti-nutritional and colour (L a* and b* values) attributes of soya bean flour were evaluated at roasting temperature of (160, 180 and 200°C) and roasting time of (5, 10, 15 and 20 min.). There were significant difference (p<0.05) among the values of protein and moisture content. These both decreased with increase in roasting temperature and time. The values ranged from 11.00-14.85% and 8.02- 16.03%, respectively. Fat content increased with increase in roasting temperature and time, with values between 21.00-59.00%. There was significant difference (p<0.05) in the anti nutrition evaluated. Trypsin inhibitor and saponin values decreased with increase in roasting temperature and time. These were between 0.00–0.50mg/100g and 16.67–106.67mg/100g, respectively. The L* values of roasted soya bean decreased with increased temperatures and time, while a* and b* behaved contrary. The most preferred range of roasting temperature and time combination for production of soya bean flour was 160-180°C at 15–20 min. This range had low anti-nutritional properties and colour close to the natural soya bean. At this condition, it may be incorporated into other flour products at varying percentages. The colour attributes could be used to monitor the roasting quality of soya bean flour at varying temperature and time combination.*

Keywords: Roasting, Temperature, Time, Soya Beans, Anti-nutrients

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1. INTRODUCTION

Soya beans, a less expensive, but rich source of good quality protein (40%) and fat (20%) ingredient for protein enrichment for ready to eat food products (Kulkarni, 1994;Blair, 2008) is a leguminous vegetable of the pea family that grows in tropical, sub-tropical and temperate climate (Fukushima, 1991). soya beans posses some biological active substances which may inhibit the availability of desired substances that are otherwise useful to the body. These includes: trypsin inhibitors, haemagglutinins, phytic acid, urease and goitrogens (Kulkarni, 1994;Blair, 2008; Famurewa and Raji, 2005). Some of these anti-nutritional factors can be partially or completely removed through processing and boiling (Loo, 1978; NAERLS, 1989; Enwere, 1998; Osho and Dashiell, 1998).
Roasting is a unit operation that uses dry heat, whether inform of an open flame, oven or other heat source (Vincent 2004; Emily *et al*., 2009). Roasting can enhance flavour through caramelization and maillard browning on the surface of the food (Cammarn *et al*., 1990; Vincent 2004; Emily *et al*., 2009). Roasting uses indirect, diffused heat (as in an oven) or near hot coals (Vincent 2004; Emily *et al*., 2009). The flavour and aroma depends upon the temperature and time of roasting beside the type of nuts and techniques applied (Birch *et al.* 2009). During roasting, the moisture content of most nuts was reduced (Emily *et al*., 2009) and the texture became less hard (Vincent 2004). The effect of roasting conditions on changes in colour were reported by several workers in their studies on peanuts (Cammerer and Kroh, 2009), hazelnuts (Özdemir *et al*., 2001; Özdemir and Devres, 2000b), sesame seeds (Kahyaoglu and Kaya 2006) and macadamias (Wall and Gentry, 2007). Other studies concentrated on the effect of roasting conditions on the nutritional compositions (Kashani and Valadon 1983; Kashani and Valadon 1984) and storage stability of pistachios nuts (Raei *et al*., 2009); Nikzadeh and Sedaghat, 2008).

Soya bean has been utilized and studied by previous works, most works focused on roasting of soya beans for the formulation of food products (Mridula *et al*, 2007) and also as supplement protein and energy source for infants and live stocks. The quality characteristics of the roasted soya beans used for formulation and supplementation and processing conditions combinations were not determined. This will be necessary for predictions and design of related process and equipment for the endeavour.

2. MATERIALS AND METHODOLOGY

Matured soya bean seeds were obtained from a local market (Sabo Market) in Ikorodu, Lagos State, Nigeria. An oven with temperature capacity of up to 260^{o}C was used for roasting of the soya bean seeds. A 3-phase (Q-Link) blender was used to mill the roasted soya bean seeds into flour, and Low density polyethylene (LDPE) bags for packaging of the roasted soya bean flour. The flow chart in Figure 1 shows the process of preparing the roasted flour and Table 1 the coding of the samples. The matured soya bean seeds were sorted and graded manually by removing damaged seeds, immature seeds, dirt, debris and uniformed sizes of the soya beans would be obtained. The geometric mean diameter (GMD) of the soya bean seeds for both roasted and un-roasted was determined. The moisture content of the soya bean seeds on dry bases were also determined before roasting and after roasting. Raw soya bean were placed in a wire mesh and dipped into water to soak for a specific period of time and allowed to drain off before roasting. The temperatures used were 160, 180 and 200^{0}C, while the roasting times were 5, 10, 15 and 20 mins. The roasted soya bean seeds were allowed to cool before dehulling manually and then grounded into flour and packaged in LDPE bags.

The grounded soya bean flour was evaluated for proximate composition (protein, fat and moisture content), colour and also anti-nutritional content.

Geometric Mean Diameter (GMD) of Raw And Roasted Soya Bean Seeds

GMD of raw and roasted samples were measured using venire caliper with least count of 0.02mm.

Matured soya bean seeds
↓
Cleaning/Sorting/Grading
↓
Conditioning
↓
Roasting (160, 180 and 200^{o}C for 5, 10, 15 and 20 min.)
↓
Cooling (to room temperature)
↓
Roasted Soya bean seeds
↓
Dehulling (Using wooden pestle and mortal)
↓
Grinding/Milling (Using a 3-phase Q link blender)
↓
Sieving ⟶ Coarse seeds out
↓
Roasted Soya bean Flour

Figure. 1: The production of roasted soya bean flour (Mridula *et al*, 2007) Modified

Geometric mean of the spatial dimensions (length, breath and thickness) was calculated as: equivalent diameter,
$(L \times B \times T)^{1/3}$……... (1) (Mridula *et al*, 2007).

Chemical Determination

Chemical analysis such as crude protein, fat and moisture content were determined by the method described by AOAC,(2005), while colour was determined by the method described by Mridula *et al.* (2007), and the anti-nutrients such as trypsin inhibitor and saponins were determined by the method described by Arntfield *et al*., (1985**)** and Harbone (1973).

Statistical Analysis

Statistical analysis was done for the data obtained using SPSS V.17.0 software and graphical representation by Sigma Plot V.10.0. Means and standard deviations were separated using Duncan's multiple range tests.

TABLE 1: Sample Coding

SAMPLES		CODES
Control, Unsoaked, Roasted at 160 ^{o}C for 5 min.	CU/160/5	S832
Control, Unsoaked, Roasted at 160 ^{o}C for 10 min.	CU/160/10	S744
Control, Unsoaked, Roasted at 160 ^{o}C for 15 min.	CU/160/15	S290
Control, Unsoaked, Roasted at 160 ^{o}C for 20 min.	CU/160/20	S613
Control, Unsoaked, Roasted at 180 ^{o}C for 5 min.	CU/180/5	S574
Control, Unsoaked, Roasted at 180 ^{o}C for 10 min.	CU/180/10	S372
Control, Unsoaked, Roasted at 180 ^{o}C for 15 min.s	CU/180/15	S626
Control, Unsoaked, Roasted at 180 ^{o}C for 20 min.	CU/180/20	S494
Control, Unsoaked, Roasted at 200 ^{o}C for 5 min.	CU/200/5	S898
Control, Unsoaked, Roasted at 200 ^{o}C for 10 min.	CU/200/10	S250
Control, Unsoaked, Roasted at 200 ^{o}C for 15 min.	CU/200/15	S587
Control, Unsoaked, Roasted at 200 ^{o}C for 20 min.	CU/200/20	S938
Soaked for 10seconds, Roasted at 160 ^{o}C for 5 min.	S10/160/5	S859
Soaked for 10seconds, Roasted at 160^{0}C for 10 min.	S10/160/10	S227
Soaked for 10seconds, Roasted at 160 ^{o}C for 15 min.	S10/160/15	S759
Soaked for 10seconds, Roasted at 160 ^{o}C for 20 min.	S10/160/20	S992
Soaked for 10seconds, Roasted at 180^{0}C for 5 min.	S10/180/5	S842
Soaked for 10seconds, Roasted at 180^{0}C for 10 min.	S10/180/10	S302
Soaked for 10seconds, Roasted at 180^{0}C for 15 min.	S10/180/15	S198
Soaked for 10seconds, Roasted at 180^{o}C for 20 min.	S10/180/20	S415
Soaked for 10seconds, Roasted at 200 ^{o}C for 5 min.	S10/200/5	S282
Soaked for 10seconds, Roasted at 200 ^{o}C for 10 min	S10/200/10	S565
Soaked for 10seconds, Roasted at 200 ^{o}C for 15 min.	S10/200/15	S615
Soaked for 10seconds, Roasted at 200 ^{o}C for 20 min.	S10/200/20	S973

3. RESULTS AND DISCUSSION

The changes in proximate composition (moisture, fat and protein content), anti-nutrients and colour attributes of roasted soy bean flour are presented in Tables 2, 3 and 4, respectively. The chemical composition revealed that roasting had a significant impact on the overall quality of grains. Protein content decreased with increase in roasting temperature and time for unsoaked and soaked soya flour. However, the protein content obtained were lower compared with the report by Seena *et al*., (2005) for mangrove legume *Canavalia cathartica*, but lesser compared with values obtained by Jideani *et al*., (2009) (33.3±1.3) for roasted *Tylosemia esculentum* flour, Ayoola and Adeyeye (2010) (18.40%) for heated groundnut seed flour. The protein contents obtained were very low after processing compared to the raw seeds (unprocessed). They were lower compared to seeds of wild legumes: winged bean (*Neonotonia wightii*, 20.6%) (Viswanathan *et al*., 2001), sword bean (*Canavalia gladiatata*, 26.8%) (Ekanayake *et al*., 1999), beach bean (*Canavalia maritime*, 27.1%) (Abbey and Ibeh, 1987), velvet bean (*Mucuna monosperma*, 23.5%) (Mohan and Janardhanan, 1995), green gram (*Phaseolus aureus*, 22.3%), black gram (*P. mungo*, 23.3%) (Gupta and Wagle, 1978), pigeon pea (*Cajanus cajan*, 19.4%), (Nwokolo, 1987), chick pea (*Cicer arietnum*, 20.7%) (Jambunathan and Singh, 1980) and cow pea (*Vigna unguiculata*, 22.5%) (Nwokolo and Oji, 1985), but they were higher than cereals like whole wheat flour (8.55%), parboiled rice (7.7%) and egg (12.6%) (Livsmedelsverk, 1988). The low protein content had a positive correlation with moisture content. The values were within range of values reported by Sudweeks *et al*., (1978) (13.7%) for roasted sorghum and roasted soya beans, Obiakor-okeke and Nnadi, (2014) (23.52±0.17), for African breadfruit, Olawepo *et al*., (2014), (25.13±0.06) for kenaf (*Hibiscus Cannabinus* L.) seed meal. The least protein content was observed in sample 973 (11.00±0.00%), while the highest protein content was observed in samples 282 (14.85±0.16%). The roasting temperature and time combination had a decreasing effect on the protein content of the roasted soya bean flour.

TABLE 2: Chemical Composition of Roasted Soya Bean Flour at Varying Roasting Temperature and Time

Roasting temperature	Roasting time	Code	Protein (%)	Fat (%)	Moisture (%)
UNSOAKED, ROASTED AT 160^{0}C					
160	5	S832	13.13±0.09^{fg}	29.00±1.41^{de}	11.98±0.04^{c}
	10	S744	13.11±0.16^{fg}	31.00±1.41^{ef}	10.04±0.06^{b}
	15	S290	13.03±0.03^{fg}	31.00±1.41^{ef}	9.99±0.02^{b}
	20	S613	12.86±0.16^{ef}	34.00±1.41^{fg}	8.02±0.03^{a}
UNSOAKED, ROASTED AT 180^{0}C					
180	5	S574	13.90±0.09^{i}	21.00±1.41^{b}	11.99±0.02^{c}
	10	S372	13.27±0.21^{gh}	39.00±1.41h^{i}	10.02±0.03^{b}
	15	S626	12.31±0.15^{c}	41.00±1.41^{i}	10.02±0.02^{b}
	20	S494	11.07±0.09^{a}	49.00±1.41^{j}	10.00±0.00^{b}
UNSOAKED, ROASTED AT 200^{0}C					
200	5	S898	14.22±0.16^{j}	26.50±2.12^{cd}	12.04±0.05^{c}
	10	S250	14.06±0.08^{ij}	29.00±1.41^{de}	12.00±0.00^{c}
	15	S587	13.46±0.16^{h}	31.00±1.41^{ef}	11.99±0.01^{c}

		20	S938	11.06±0.09^{a}	34.00±1.41^{fg}	10.02±0.03^{b}
	SOAKED, ROASTED AT 160^{0}C					
160		5	S859	12.66±0.16^{de}	14.00±1.41^{a}	16.03±0.04^{g}
		10	S227	12.51±0.15^{cd}	24.00±1.41^{bc}	15.99±0.02^{g}
		15	S759	11.11±0.14^{a}	26.50±2.12^{cd}	14.07±0.09^{ef}
		20	S992	11.05±0.07^{a}	46.00±1.41^{j}	13.93±0.09^{de}
	SOAKED, ROASTED AT 180^{0}C					
180		5	S842	13.04±0.01^{fg}	36.50±2.12^{gh}	15.99±0.02^{g}
		10	```S302	11.22±0.13^{a}	46.50±2.12^{j}	14.11±0.16^{ef}
		15	S198	11.10±0.14^{a}	54.00±1.41^{k}	14.00±0.00^{ef}
		20	S415	11.09±0.09^{a}	59.00±1.41^{l}	13.98±0.03^{def}
	UNSOAKED, ROASTED AT 200^{0}C					
200		5	S282	14.85±0.16^{k}	24.00±1.41^{bc}	15.97±0.050^{g}
		10	S565	13.08±0.09^{fg}	29.00±1.41^{de}	14.18±0.25^{f}
		15	S615	11.81±0.15^{b}	31.00±1.41^{ef}	14.12±0.17^{ef}
		20	S973	11.00±0.00^{a}	31.50±2.12^{ef}	13.77±0.33^{d}

***Mean ± standard deviation with different superscripts on the same column are significantly different at ($p<0.05$)**

TABLE 3: The Anti-Nutrients of Roasted Soya Bean Flour at Varying Roasting Temperature and Time

	Roasting temperature		Roasting time	Code	Trypsin(mg/100g)	Saponin(mg/100g)
	UNSOAKED, ROASTED AT 160^{0}C					
CONTROL	160		S832	832	0.42±0.23^{ij}	86.00±5.00^{hij}
			S744	744	0.22±0.03^{defgh}	85.00±0.00^{hij}
			S290	290	0.17±0.03^{bcdef}	35.00±0.00^{ab}
			S613	613	0.13±0.03^{bcd}	28.33±5.77^{ab}
	UNSOAKED, ROASTED AT 180^{0}C					
	180		S574	574	0.42±0.03^{jk}	91.67±5.77^{hijk}
			S372	372	0.25±0.05^{efgh}	86.67±5.77^{hij}
			S626	626	0.18±0.03^{cdefg}	53.33±2.89^{cdef}
			S494	494	0.12±0.03^{bcd}	41.67±5.77^{bcde}
	UNSOAKED, ROASTED AT 200^{0}C					
	200		S898	898	0.28±0.03^{ghi}	111.67±2.89^{kl}
			S250	250	0.18±0.03^{cdefg}	93.33±2.89^{hijk}
			S587	587	0.11±0.01^{bc}	83.33±2.89^{ghi}
			S938	938	0.07±0.03^{ab}	48.33±5.77^{bcde}
	SOAKED, ROASTED AT 160^{0}C					
	160		S859	859	0.43±0.03^{jk}	96.67±2.89^{ijk}
			S227	227	0.32±0.03^{hi}	75.00±0.00^{fghi}
			S759	759	0.17±0.03^{bcdef}	61.67±5.77^{efg}

SOAKED			S992	992	0.15±0.05^{bcde}	28.33±5.77^{ab}
	SOAKED, ROASTED AT 180^{0}C					
	180		S842	842	0.32±0.03^{hi}	76.67±54.27^{fghi}
			``S302	302	0.30±0.00^{hi}	61.67±5.77^{efg}
			S198	198	0.12±0.03^{bcd}	58.33±5.77^{def}
			S415	415	0.00±0.00^{a}	16.67±2.89^{a}
	SOAKED, ROASTED AT 200^{0}C					
	200		S282	282	0.50±0.00^{k}	106.67±2.89^{jkl}
			S565	565	0.50±0.00^{k}	123.33±2.89^{l}
			S615	615	0.27±0.03^{fgh}	63.33±2.89^{efg}
			S973	973	0.00±0.00^{a}	36.67±2.89^{abcd}

*Mean ± standard deviation with different superscripts on the same column are significantly different at ($p<0.05$)

TABLE 4: Colour Analysis of Roasted Soya Bean Flour at Varying Roasting Temperature And Time

			SAMPLE	L*VALUE	a*VALUE	b*VALUE
	UNSOAKED, ROASTED AT 160^{0}C					
CONTROL	160	5	S832	84.24±0.09^{0}	3.14±0.02^{f}	26.87±0.06^{ab}
		10	S744	81.67±0.24^{k}	1.92±0.01^{d}	27.09±0.35^{abc}
		15	S290	81.06±0.09^{j}	3.27±0.02^{f}	27.33±0.05^{bcde}
		20	S613	80.16±0.90^{i}	3.71±0.02^{gh}	27.54±0.06^{cdef}
	UNSOAKED, ROASTED AT 180^{0}C					
	180	5	S574	83.65±0.17^{mn}	1.59±0.02^{c}	27.71±0.19^{defg}
		10	S372	80.91±0.11^{j}	3.55±0.04^{g}	26.69±0.01^{a}
		15	S626	73.46±0.08^{f}	6.87±0.04^{k}	28.17±0.05^{ghi}
		20	S494	70.87±0.04^{e}	7.66±0.27^{l}	28.93±0.29^{j}
		UNSOAKED, ROASTED AT 200^{0}C				
	200	5	S898	79.28±0.14^{h}	3.79±0.16^{h}	27.24±0.13^{bcd}
		10	S250	68.92±0.31^{d}	8.11±0.13^{m}	28.96±0.19^{j}
		15	S587	65.20±0.56^{c}	9.47±0.12^{n}	29.61±0.15^{k}
		20	S938	56.64±0.26^{a}	10.85±0.23^{p}	29.66±0.03^{k}
	SOAKED, ROASTED AT 160^{0}C					
SOAKED	160	5	S859	84.04±0.01^{no}	0.83±0.05^{a}	27.26±0.81^{bcd}
		10	S227	83.93±0.26^{mno}	1.03±0.24^{b}	27.88±0.19^{efgh}
		15	S759	82.42±0.07^{l}	1.66±0.02^{c}	27.99±0.01f^{ghi}
		20	S992	81.59±0.49^{k}	1.91±0.06^{d}	28.30±0.01^{hi}
	SOAKED, ROASTED AT 180^{0}C					
	180	5	S842	84.02±0.06^{no}	0.74±0.10^{a}	27.13±0.25^{abc}
		10	```S302	83.65±0.19^{mn}	0.81±0.04^{a}	27.76±0.30^{defgh}
		15	S198	82.23±0.04^{l}	2.85±0.03^{e}	28.08±0.04^{fghi}
		20	S415	73.15±0.23^{f}	6.49±0.02^{j}	28.47±0.05^{ij}

	SOAKED, ROASTED AT 200^{0}C					
	200	5	S282	83.43 ± 0.42^{m}	1.09 ± 0.02^{b}	27.34 ± 0.92^{bcde}
		10	S565	75.00 ± 0.28^{g}	5.35 ± 0.08^{i}	27.64 ± 0.11^{cdefg}
		15	S615	65.05 ± 0.04^{c}	9.32 ± 0.02^{n}	29.75 ± 0.04^{k}
		20	S973	58.82 ± 0.04^{b}	10.61 ± 0.01^{o}	29.52 ± 0.36^{k}

***Mean ± standard deviation with different superscripts on the same column are significantly different at ($p<0.05$)**

The fat content increased with increase in roasting temperature and time for soaked and unsoaked samples while Protein content behaved contrarily, this is as shown in Figure 2. The fat content obtained were very high compared to the fat content reported by Seena *et al*., (2005) for mangrove legume *Canavalia cathartica*, Jideani *et al.* (2009) (40.3±1.6%) for roasted *Tylosemia esculentum* flour, Sudweeks *et al*., (1978) (5.6%) for roasted sorghum and roasted soya beans, Obiakor-Okeke and Nnadi, (2014) (11.95±0.70%), for effects of processing methods on the nutrient and anti-nutrient composition of African breadfruit, Olawepo *et al*., (2014), (12.37±0.04%) for effect of cooking and roasting on nutritional and anti-nutritional factors in kenaf (*Hibiscus Cannabinus* L.) seed meal, but were within the value reported by Ayoola and Adeyeye (2010) (40.07%) for heated groundnut seed flour and also higher than wild legumes: *Atylosia purpureus* (4.56%), *Canavalia gladiate* (9.3%), *Lablab purpureus* (8.33%), *N. wightii* (4.64%) and *V. trilobata* (12.3%), (Arinathan *et al.*, 2003). However, fat content of the raw (unprocessed) seeds were lesser compared to the fat content of the processed samples, which was also reported by Bressani *et al.*, (1987), that crude lipids of processed seeds was higher than most of the raw *Canavalia* spp. (1.60-1.80%). There was no significant difference ($p>0.05$) in samples S744, S290, S587, and S973, and also, S613 and S938, as well as S832, S250 and S565, including samples S372 and S626, S898 and S759, S494 and 302, while there was significant difference ($p<0.05$) between other samples. The least fat content (14.00±1.41%) was observed in sample S859, while the highest (59.00±1.41%) was observed in sample 415. The roasting temperature and time had an increasing effect of the fat content of the roasted soya bean flour.

The moisture content decreased linearly with increase in roasting temperature and time for unsoaked and soaked samples. The moisture content obtained were higher compared to the report by Seena *et al*., (2005) (8.61±0.3%) for mangrove legume *Canavalia cathartica*, Shakerardekani *et al*., (2011) for pistachio kernels, Jideani *et al.*, (2009) (6.8±0.3%) for *Tylosemia esculentum* flour (6.8±0.3), Ayoola and Adeyeye (2010) (1.07%) for heated groundnut seed flour, Olawepo *et al*., (2014), (5.20±0.10%) for effect of cooking and roasting on nutritional and anti-nutritional factors in kenaf (*Hibiscus Cannabinus L.*) seed meal. There was no significant difference ($p<0.05$) in samples S744, S290, S372, S626, 494 and S938, and also S832, S574, S898, S250 and S587, as well as S227, S859, S842 and S282 and also S759, S198, S302 and S615, while there was significant difference ($p<0.05$) between other samples. The least moisture content (8.02±0.03%) was observed in sample S613, while sample S859 had the highest moisture content (16.03±0.04%). The soaking time had an increasing effect on the moisture content of the soaked samples. The roasting temperature and time had a decreasing effect on the moisture content of the roasted soya bean flour.

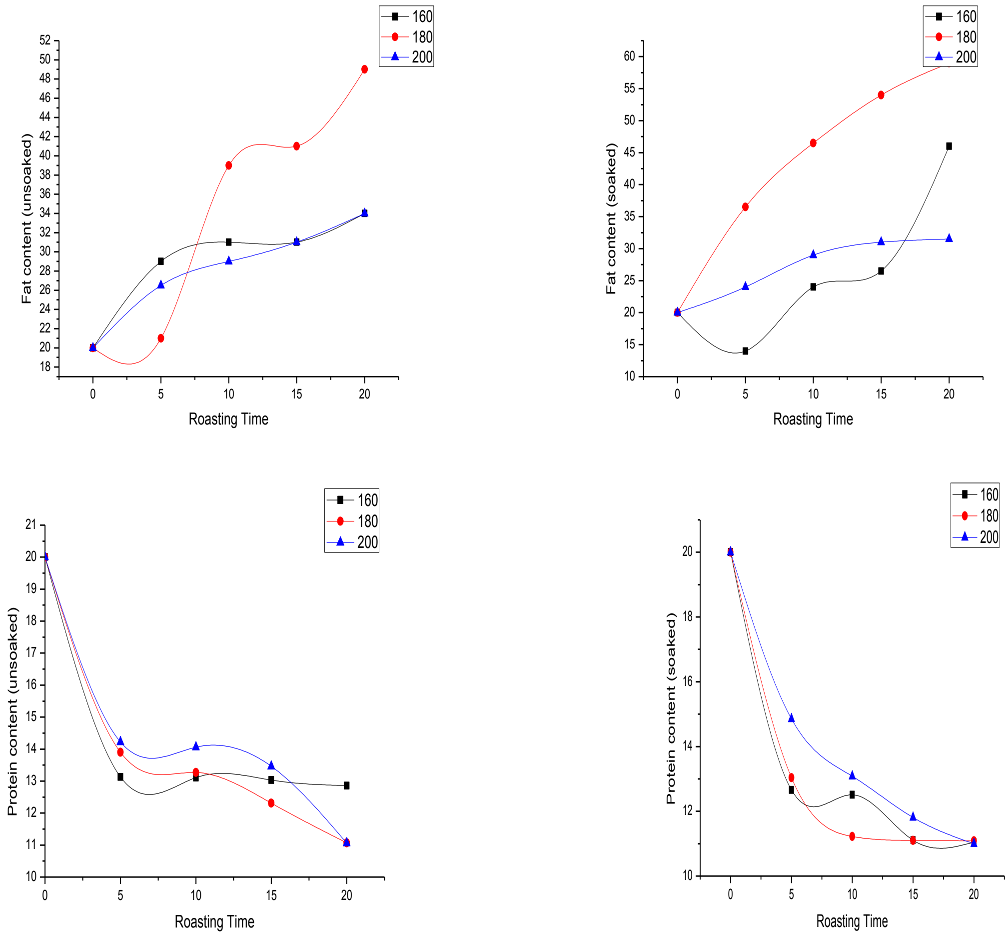

Figure 1: Roasting effect on some Chemical composition of Soaked and Unsoaked (control) soya beans flour

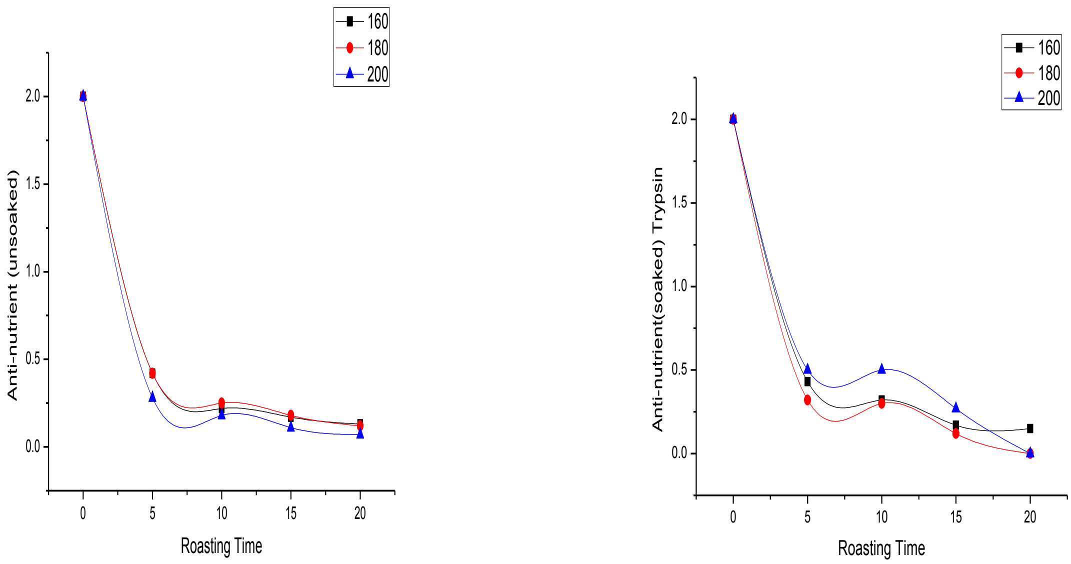

Figure. 2: Roasting effect on some Anti-Nutritional factors of Soaked and Unsoaked (control) soya beans flour

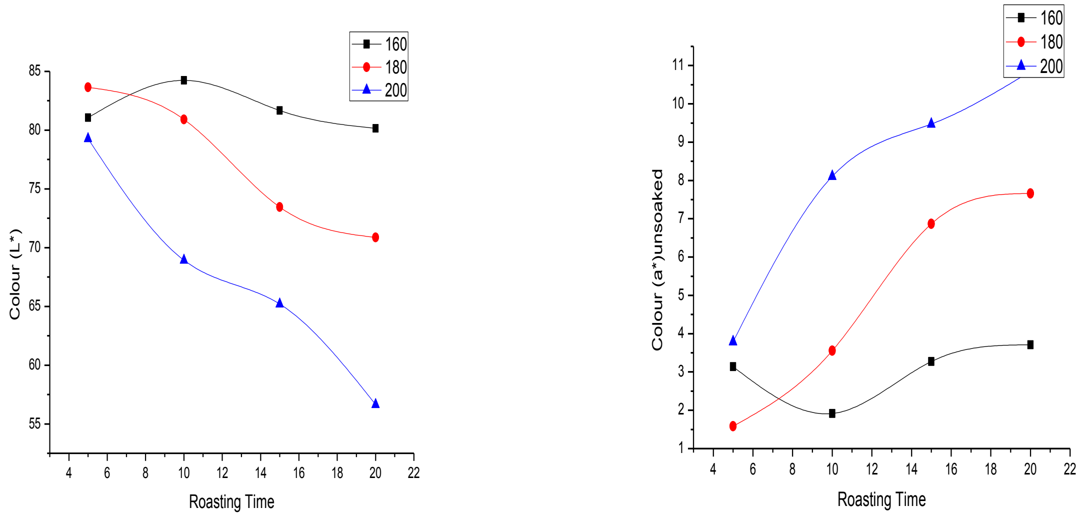

Figure. 3: Roasting effect on some colour parameters of Soaked and Unsoaked (control) soya beans flour (control) soya beans flour roasted at temperatures 160, 180 and 200^{0}C for Time of 5, 10, 15 and 20 minutes

Table: 2 above shows the anti-nutritional (trypsin inhibitor and saponin) factor of roasted soya bean flour at varying roasting temperature and time, and soaking time Anti-nutritional factors such as inhibitors, tannin, anti-vitamin, lectins, saponins are heat-labile (Liener, 2003). Soybean is reported to have nine types of saponin or its derivatives (Zhang and Popovich, 2008). The impacts of processing on saponins are rarely available in literature (Rickert *et al*., 2004). The trypsin inhibitor decreased with increase in roasting temperature and time for soaked and unsoaked samples, the least trypsin inhibitor was observed in samples S415 and S565 (0.00±0.00), while the highest was observed in sample S859 (0.43±0.03). The values obtained were within the range of values reported by Nzewi and Egbuonu, (2011), (0.16±0.08 – 0.77±0.09) for effects of boiling and roasting on some anti-nutritional factors of asparagus bean flour, but on the contrary, they were higher than the value reported by Olawepo *et al*. (2014), (0.11±0.00) for effect of cooking and roasting on nutritional and anti-nutritional factors in kenaf (*Hibiscus Cannabinus* L.) seed meal. The roasting temperature and time combination had a linear decreasing effect of the trypsin inhibitor of the roasted soya bean flour. This suggests that increasing the roasting time and temperature may ensure complete elimination of anti-nutrients in soya bean flour. Similarly, Nwosu *et al*. (2010) reported a time dependent reduction in phytate, tannins and trypsin inhibitor contents following cooking. The saponin also decreased with increase in roasting temperature and time for soaked and unsoaked samples. The least saponin was observed in sample S415 (16.67±5.77), while the highest value was observed in sample S282 (123.33±2.89). The roasting temperature and time combination had a linear decreasing effect of the saponin of the roasted soya bean flour, which was contrarily reported by Shivani et al., (2012). The researcher reported that roasting of soy flour also caused 23.38% increase in saponin content, but result obtained in this work was in accordance with (Kataria *et al*., 1988), for the effect of roasting in green gram where a reduction in saponin content was observed. Oenning *et al*., (1994) reported that saponins are relatively heat stable components, and the values reported by Balogun, (2013) (0.53 – 2.74) for effects of processing methods on anti-nutrient levels of (*Bauhinia Monandra*) Kurz Seed were very low compared to the values obtained for this research work, so also were the values reported by Mbah *et al*. (2012) (0.12±0.00 – 0.42±0.00) for effects of cooking methods (boiling and roasting) on nutrients and anti-nutrients content of *Moringa oleifera* seeds, but were contrary to the value reported by Shivani et al., (2012) (99.2±1.75). The soaking (conditioning) time had an increasing effect on the saponin of the soaked samples. There was no significant difference (p>0.05) in samples S832, S744 and S372, and also S494 and S938, S574 and S250, S290 and S613, as well as S759, S302 and S615, while there was significant difference (p<0.05) between other samples. Saponin was reported to have both beneficial and deleterious properties and to exhibit structure dependent biological activities (Price *et al*., 1987).

The influence of colour of food product in consumers' decision cannot be over emphasised. During roasting of most nuts, brown pigments generally increased as browning and caramelisation reactions are in progress (Sena *et al*., 2001). Roasting in general affects the colour of soy bean grain (Mrindula *et al*., 2007). Roasting temperature and time influence the changes in colour attributes of whole –kernels and ground states, but the effect of temperature is more important than time (Shakerardekani *et al*., 2011), and similar findings were reported by Demir *et al*., (2002) and Ozedemir and Devres (2000a), in their studies on hazelnuts. The result revealed that, for unsoaked soya beans flour, the L*values decreased with increase in roasting temperature and time, while the a*values increased with increase in roasting temperature and time, which resulted in the darkening of the soya beans at higher roasting temperature. This was similar to the work reported by Mridula *et al*., (2007), except for 160^{0}C that decreased between 5 and 10min, before increasing. The b*values, at 160^{0}C, had a linear decrease with increase in roasting temperature and time. There was a slight decrease between 5 and 10min. before increase with roasting temperature and time, at 200^{0}C.

4. CONCLUSION

Roasting of soya bean at different temperature and time affected the nutritional content (protein, fat and moisture content), anti-nutrient content (trypsin inhibitor and saponin) and colour attributes. The protein and moisture content decreased with increase in roasting temperature and time, while the fat content increased with increase in roasting temperature and time combination. Both the trypsin inhibitor and saponin decreased with increase in roasting temperature and time. The L*value for colour attributes decreased with increase in roasting temperature and time, while a* and b* value both increased with increase in roasting temperature and time combination. The most preferred range of roasting temperature and time combination for production of soya bean flour is 160^{0}C - 180^{0}C at 15 - 20min. because of the significant reduction in anti-nutritional properties and insignificant effect in the colour attributes.

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