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RESEARCH PAPER

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Development of fried and baked tortilla chips with defatted soy flour and sorghum flour

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SUMMARY :

The effects of the fortification of tortilla chips with de-fatted soy flour as well as baking and frying processes on the properties of tortilla chips were evaluated. Sensory characteristics, texture, thickness, color, protein and oil content were evaluated. Sensory properties were evaluated using a nine point hedonic scale. Soybeans were obtain partially defatted soy flour of 0.79 per cent final oil content. Sorghum flour (SF) was replaced with 0, 10, 20 and 30 per cent and Nixtamalized corn flour (NCF) 0,5,10 and 15 per cent de-fatted soy flour (DFSF). Overall, fried tortilla chips were harder and thicker than baked tortilla chips. Fried tortilla chips with DFSF with SF and NCF (100:20:10%) and DFSF with SF and NCF (100:30:15%) soy flour substitution required less force to break. Protein increased linearly in baked and fried tortilla chips where DFSF with SF and NCF (100:30:15%) resulted in the highest protein level. In fried tortilla chips, DFSF with SF and NCF (100:20:10%) had the highest sensory scores overall. DFSF with SF and NCF (100:20:10%) fortification in fried tortilla chips were the most acceptable of all. In all treatments, regardless of type of processing, panelists could not detect any "beany" flavours in any of the sample. Upto DFSF with SF and NCF (100:20:10%) would be recommended.

KEY WORDS : Soybean, Sorghum ,Nixtamalized corn flour, Masa, Fried tortilla chips, Baked tortilla chips

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Tortilla was first created by either the Aztecs or the Zapotecs. The Zapotecs were an ancient civilization that existed near Oaxaca in the Monte Alban ruins. They created Totopochtli by roasting tortillas on a flat grill. This tortilla had a shelf-life of one or two days. The fried tortilla was referred to as a tostado which improved the flavour and extended storage time. If the tostados were cut into pieces they were called Totopos. The tostados allowed them to travel large distances and still have food . Tortilla chips are baked and then fried which gives the chip a firmer texture Quintero-Fuentes (1997).

Products made out of soy are becoming very popular to increase protein content. According to the FDA, adding more soy to the diet reduces the risk of heart disease, cancer and decreases discomfort in menopausal women. Twenty five grams of soy combined with a diet low in saturated oil and cholesterol may reduce the risk of heart disease (Lusas, 2002).

Soy protein is a subject of intense investigation and has had a increasing role in human nutrition over the last few decades (Riaz, 2001). Health benefits include: reduced blood pressure, lower cholesterol levels and improved bone health (Adelekun *et al.,* 2005). Soy protein also contains all nine essential amino acids (Riaz, 1999).

Defatted soy flour is obtained from solvent extracted flakes, and contains less than 1 per cent oil. Full-fat soy flour is made from un-extracted, dehulled beans and contains about 18 per cent to 20 per cent oil. Due to its high oil content, a specialized alpine fine impact mill must be used for grinding rather than the more common hammer mill. Low-fat soy flour is made by adding back some oil to defatted soy flour. The lipid content varies according to specifications, usually between 4.5 per cent and 9 per cent. High-fat soy flour can also be produced by adding back soybean oil to defatted flour at the level of 15 per cent. Lecithinated soy flour is made by adding soybean lecithin to defatted, low-fat or high-fat soy flours to increase their dispersibility and impart emulsifying properties. The lecithin content varies upto 15 per cent.

EXPERIMENTAL METHODS

Procurment of raw material:

Soybean, sorghum, oil, nixtamalized corn flour purchased in local market Aurangabad, Maharashtra. India.

Processing equipment used:

Gas-fired three-tier oven, Air impingement oven, cooker, aspirator, cabinet tray dryer, flaker, vernier caliper, mixer, colourimeter, sheeter, cracking mill, tumbler technique, soxhlet apparatus, microkjeldhal apparatus, sieve.

Preparation of flour:

Flow sheet for preparation of sorghum flour:

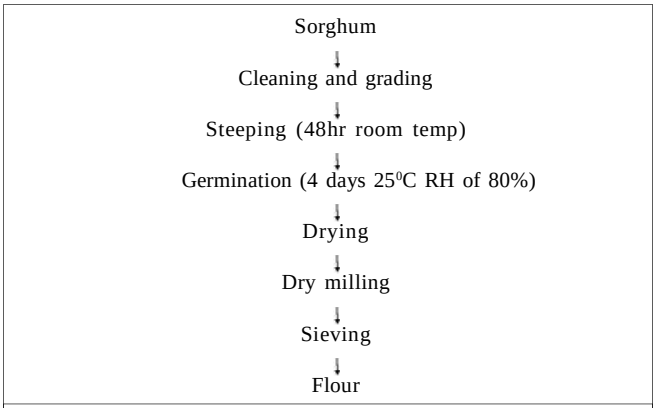

Fig. A: Preparation of sorghum flour

Flow sheet for preparation of De-fatted soy flour:

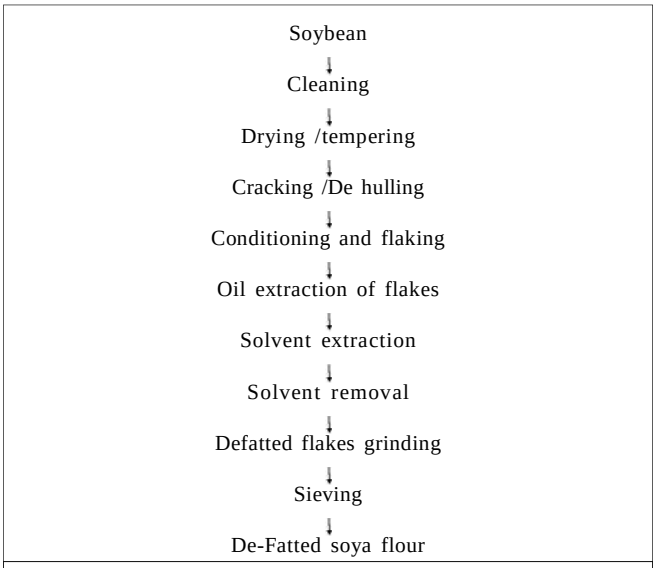

Fig. B : Preparation of De-fatted soya flour

Tortilla chip preparation:

Flow sheet for preparation of masa:

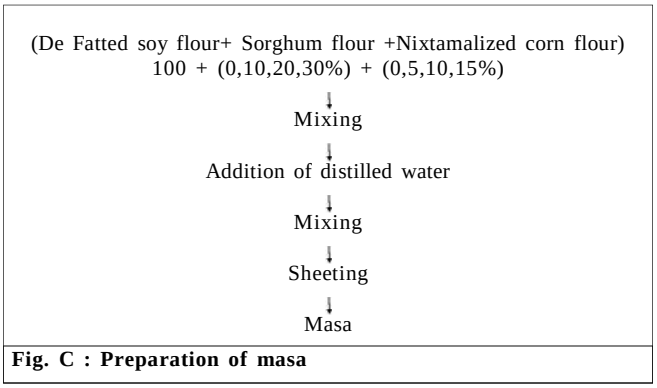

Fig. C : Preparation of masa

Table A: Treatment plan

Ingredients	Ctrl F frying	Sample A1	Sample A2	Sample A3	Ctrl B baking	Sample B1	Sample B2	Sample B3
De-fatted soy flour (g)	250	250	250	250	250	250	250	250
Sorghum flour (g)	-	25	50	75	-	25	50	75
Nixtamilazed corn flour (g)	-	12.5	25	37.5	-	12.5	25	37.5
Oil	Frying	Frying	Frying	Frying	-	-	-	-
Distilled water(ml)	275	275	290	290	275	275	290	290
Salt (g)	1	1	1	1	1	1	1	1

Flow sheet for preparation of fried tortilla chip:

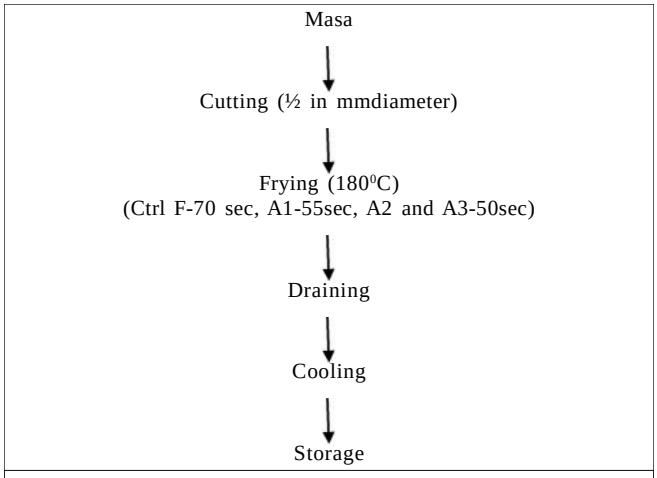

Fig. D : Preparation of fried tortilla chips

Flow sheet for preparation of baked tortilla chips preparation:

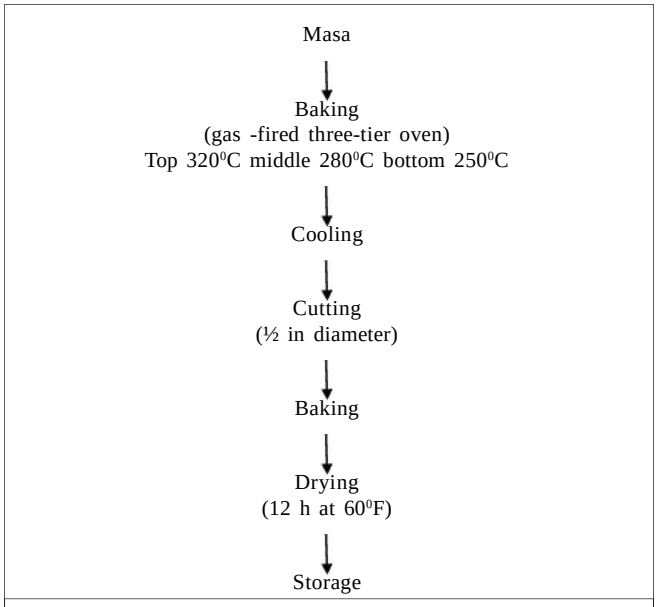

Fig. E : Preparation of baked tortilla chips

Physico-chemical analysis

Moisture, Fat, Protein, Ash, Texture analysis, Color, Breakage susceptablity, Sensory evaluation, Statistical analysis.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Phyico-chemical analysis of fried and baked tortilla chips:

Protein, moisture and oil per cent of fried tortilla chips:

Protein content of fried tortilla chipsranged from 8.3 to 20.8 per cent. The protein content of sample control F-8.03 per cent, A1 is 13.2 per cent, A2 is 16.9 per cent and A3 is 20.8 per cent increase the protein level because the soy is the rich source of protein content. Similar results were found that Che Man *et al.* (1992).

Oil content of fried tortilla chips ranged from 21.4 to 25.9 per cent. The oil content of sample control F-21.4 per cent, A1-21.7 per cent, A2-22.4 per cent, A3-25.9

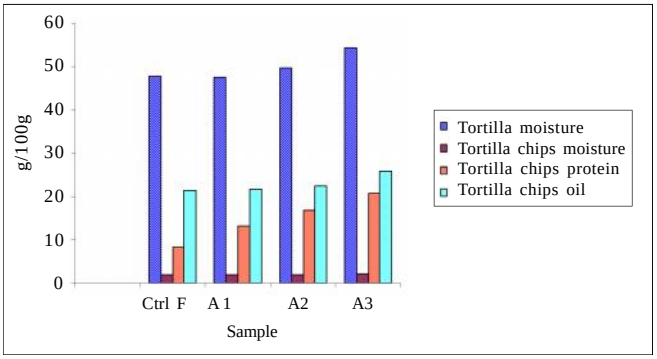

Fig. 1 : The correlation of protein, moisture, oil levels and fried tortilla chips

per cent fortification had the highest level of oil Similar results were seen by Adelakun *et al.* (2005).

Moisture content of fried tortilla chip ranged from 1.8 to 2.2 per cent. The moisture content of sample Ctrl F-1.96 per cent, A1-1.84 per cent and A2-1.98 per cent and A3-2.21 per cent. Similar result were found that Cosgrove (2002).

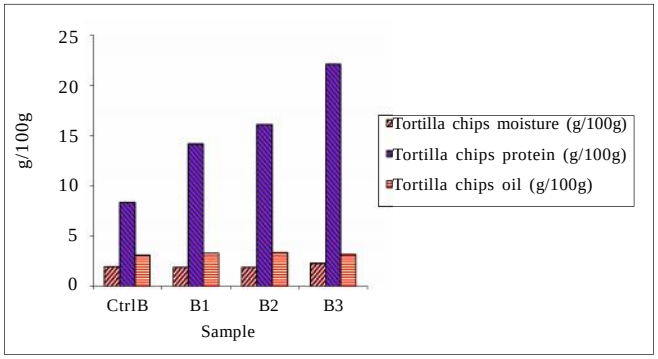

Fig. 2 : The correlation of protein, moisture, oil levels and baked tortilla chips

Protein, moisture and oil content of baked tortilla chips:

Moisture content of baked tortilla chips ranged from 1.90-2.03 per cent. The moisture content of control B-1.95 per cent, B1-1.92 per cent and B2-1.90 per cent and B3-2.3 per cent increase the protein level because the soy is the rich source of protein content. Similar result found in (Quintero-Fuentes, 1997).

Protein content of baked tortilla chips range from 8.4-22.1 per cent. The protein content of sample Ctrl B-.8.4 per cent, B1-14.2 per cent, B2-16.1 per cent, B3-22.1 per cent.

Oil content for baked tortilla chips ranged from 3.1 to 3.4 per cent. B1- 3.3 per cent, B2-3.4 per cent and

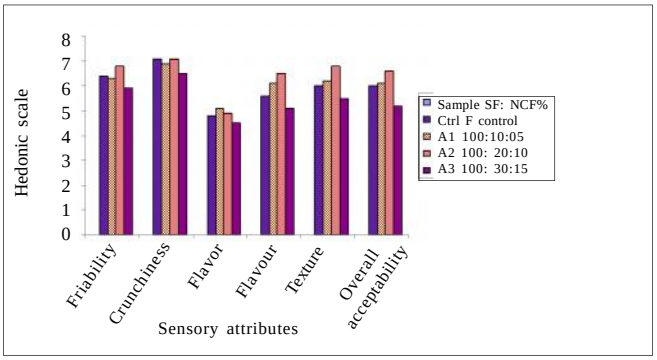

Fig. 3 : Sensory attributes infried tortilla chips

Table 1 : Moisture, proteinand oil per cent offried tortilla chips

Treatment (DFSF:SF:NSF)	Tortilla chips moisture (g/100g)	Tortilla chips protein (g/100g)	Tortilla chips oil (g/100g)
Ctrl F	1.96	8.3	21.4
A1 (100:10:5)	1.84	13.2	21.7
A2 (100:20:10)	1.98	16.9	22.4
A3 (100:30:15)	2.21	20.8	25.9

DFSF=De-fatted soy flour, SF=Sorghum flour, NCF= Nixtamalized corn flour

Table 2 : Moisture (%), protein (%) and oil (%) of baked tortilla chips

Treatment (DFSF:SF:NCF)	Tortilla chips moisture (g/100g)	Tortilla chips protein (g/100g)	Tortilla chips oil (g/100g)
Ctrl B	1.95	8.4	3.1
B1 (100:10:5)	1.92	14.2	3.3
B2 (100:20:10)	1.90	16.1	3.4
B3 (100:30:15)	2.3	22.1	3.2

DFSF=De-fatted soy flour, SF=Sorghum flour, NCF= Nixtamalized corn flour

Table 3 : Sensory attributes of fried tortilla chips

Sample	Composite flour (DFSF: SF:NCF %)	Friability	Crunchiness	Flavour Intensity	Flavour acceptablity	Texture	Overall acceptability
Ctrl F	Control	6.4	7.1	4.8	5.6	6.0	6.0
A1	100:10:5	6.3	6.9	5.1	6.1	6.2	6.1
A2	100:20:10	6.8	7.1	4.9	6.5	6.8	6.6
A3	100:30:15	5.9	6.5	4.5	5.1	5.5	5.2

DFSF=De-fatted soy flour, SF=Sorghum flour, NCF= Nixtamalized corn flour

Table 4 : Sensory attributes baked tortilla chips

Sample	Composite flour (DFSF:SF:NCF)	Friability	Crunchiness	Flavour Intensity	Flavour acceptablity	Texture	Overall acceptability
Ctrl B	Control	2.5	2.9	2.4	2.9	2.8	2.7
B1	100:10:5	2.7	4.3	2.6	2.8	2.7	2.9
B2	100:20:10	3.9	5.6	2.9	3.5	3.9	3.9
B3	100:30:15	3.2	4.2	3.0	2.9	3.1	3.2

B3-3.2 per cent oil on a dry basis similar result found in.

Sensory analysis of fried and baked tortilla chips:

Fried tortilla chips:

For overall acceptability, only significant differences were found between 100:30:15% DFSF with SF and NCF and 100:20:10% DFSF with SF and NCF the sampleare most acceptable treatments of all Adelekun *et al.* (2005).

For flavour acceptability, there were no differences found among100:30:15% DFSF with SF and NCF and 100:20:10% DFSF with SF and NCF the sample are most acceptable for flavour acceptability similar result found in Payumo *et al.* (1982).

There were no differences found in flavour intensity among treatments. Also, this attribute obtained the lowest scores inthe hedonic scale when compared to the other attributes. This indicates that no beany flavours were found when tortilla chips were fortified with soy flour. Incookies, Buck *et al.* (1987) found that 100:20:10% DFSF with SF and NCF of fortification was less strong.

For texture and crunchiness acceptability the only significant differences were found between 100:30:15% DFSF with SF and NCF and 100:20:10% DFSF with SF and NCF sample is more acceptable in texture and crunchiness acceptability.

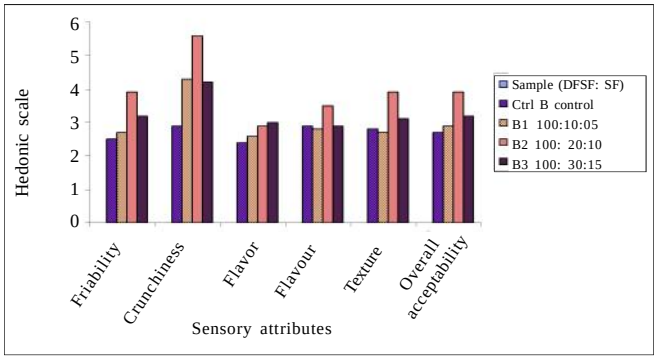

Fig. 4 : Sensory attributes inbaked tortilla chips

Baked tortilla chips:

Overall acceptability, flavour acceptability, flavour intensity, texture acceptability, crunchiness and friability. For overall acceptability, 100:20:10 per cent DFSF with SF and NCF and 100:30:15 per cent DFSF with SF and NCF scored the highest. However, because the highest score was 3.9, this indicates that these chips were not acceptable by consumers.

There were no differences found among treatments for flavour acceptability (highest score =3.5) and flavour intensity (highest score=3.0). Basedon these scores, these chips were not liked by consumers. For texture acceptability and crunchiness, 100:20:10%DFSF with SF and NCF had the highest scores and was significantly different from the other treatments Liu (1999).

For friability, significant differences were found 100:20:10% DFSF with SF and NCF had the highest score of 3.9 which indicates that overall, these chips were not friable. These resultsare reflected in Table 4.

Thickness of fried and baked tortilla chips:

Thickness of fried tortilla chips ranged from1.2-1.7 mm. The thickness of control F-1.7,A1-1.6 and A2-1.4 and A3-1.5 mm.

Thickness of baked tortilla chips ranged from 1.1-1.2 mm. The moisture content of control B-1.2, B1-1.2 and B2-1.2 and B3-1.1mm.

Table 5 : Thickness of fried and baked tortilla chips

Treatment (DFSF:SF:NCF)	Tortilla chips (mm)
Control F	1.7
A1 (100:10:5)	1.6
A2 (100:20:10)	1.4
A3 (100:30:15)	1.5
Control B	1.2
B1(100:10:5)	1.2
B2(100:20:10)	1.1
B3(100:30:15)	1.2

Texture of fried and baked tortilla chips:

The force comparison between fried and baked

tortilla chips show Fig 5. Overall, fried tortilla chips had higher force and work than baked tortilla chips. These results were expected since fried tortilla chips were thicker than baked tortilla chips.The thicker the tortilla chip, the more force and work it will take to break it. An interaction was seen between processing method vs. DFSF with SF and NCF. Differences in texture were mainly caused by frying and/or baking more so than the DFSF with SF and NCF fortification.

Table 6: Correlation between force and thickness offried and baked tortilla chips

Sample	Force (N)
Ctrl F	20
A1	18
A2	13
A3	15
Ctrl B	12
B1	11
B2	10
B3	11

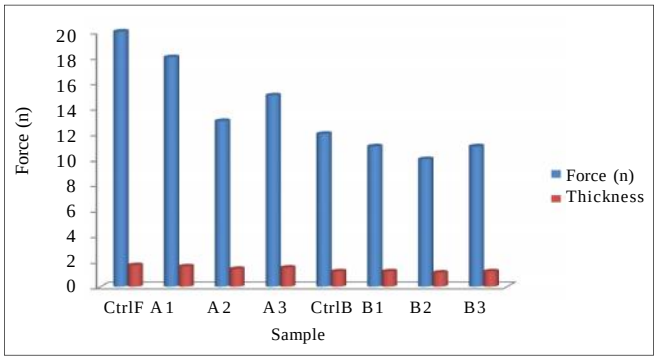

Fig. 5 : Correlation between force and thickness offried and baked tortilla chips

Soy caused expansion in both products .There was more natural expansion in the fried product than in the baked product. This result was expected because when water is "trapped" under extreme heat, ittriesto quickly escape and so it forms channels and creates more expansion. DFSF with SF and NCF created more air cells and, therefore, more expansion. Soy behaves in this way in most products by creating a more foamy structure in products that have been fortified with soy flour. Soy should be softer and easier to break in both processes (Mc Donough, 2006).

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