Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 1129-1132
Received: 06-11-2018
Accepted: 09-12-2018

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

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Abstract
The effects of the of tortilla chips with de-fatted soy flour as 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% final oil content. Sorghum flour (SF) was replaced with 0, 10, 20 and 30% and Nixtamalized corn flour (NCF) 0,5,10 and 15% de-fatted soy flour (DFSF). Overall, fried tortilla chips were harder and thicker. 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" flavors in any of the sample. Up to DFSF with SF and NCF (100:20:10%) would be recommended.

Keywords: Soybean, sorghum, nixtamalized corn flour, masa, fried tortilla chips, baked tortilla chips

Introduction
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 flavor 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) [11].

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) [6].

Soy protein is a subject of intense investigation and has had a increasing role in human nutrition over the last few decades (Riaz 2001) [10]. Health benefits include: reduced blood pressure, lower cholesterol levels and improved bone health (Adelekun *et al*. 2005) [1]. Soy protein also contains all nine essential amino acids (Riaz 1999) [9].

Defatted soy flour is obtained from solvent extracted flakes, and contains less than 1% oil. Full-fat soy flour is made from un-extracted, dehulled beans, and contains about 18% to 20% 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% and 9%. High-fat soy flour can also be produced by adding back soybean oil to defatted flour at the level of 15%. 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 up to 15%.

Material and Method
Procurement of raw material
Soy bean, 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, Colorimeter, Sheeter, Cracking mill, Tumbler technique, Soxhlet apparatus, Microkjeldhal apparatus, Sieve.

Preparation of Flour

Flow sheet for preparation of sorghum flour

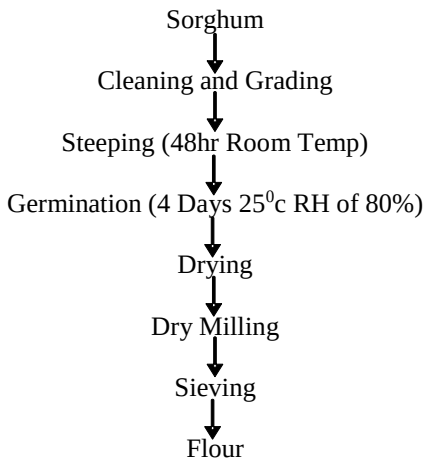

Fig 1: Preparation of sorghum flour

Flow sheet for preparation of De-fatted soy flour

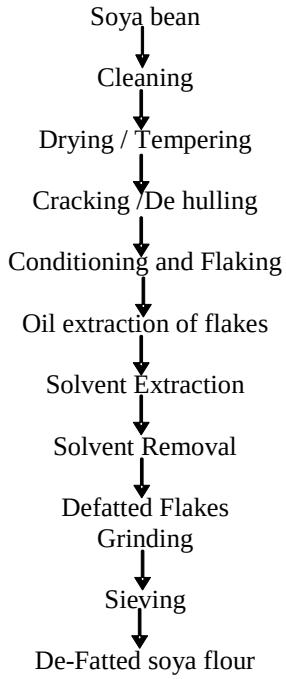

Fig 2: Preparation of De-fatted soya flour

Tortilla chip preparation

Flow sheet for preparation of masa

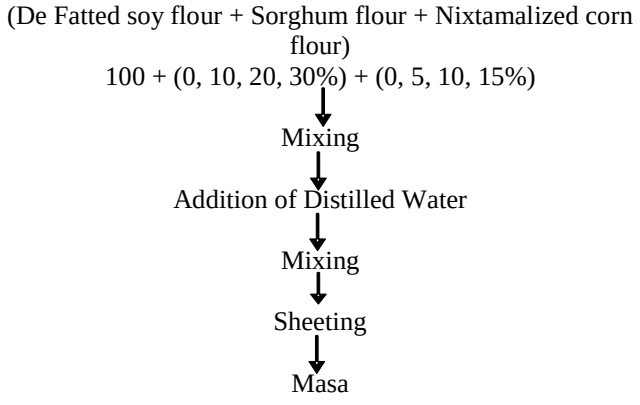

Fig 3: Preparation of masa

Flow sheet for preparation of fried tortilla chip

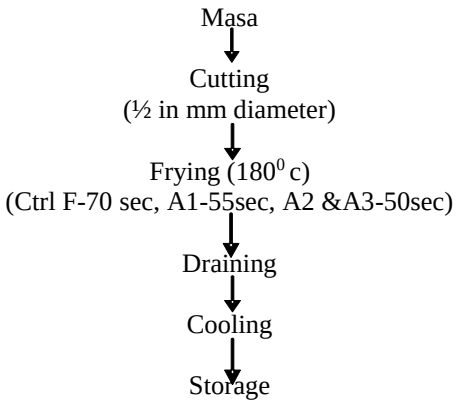

Fig 4: Preparation of fried tortilla chips

Table 1: Treatment plan

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

Physico-chemical analysis

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

Results and Discussion

Phyico-Chemical analysis of fried tortilla chips

Protein, moisture and oil percent of fried tortilla chips

Protein content of fried tortilla chips ranged from 8.3 to 20.8%. The protein content of sample control F-8.03%, A1 is 13.2%, A2 is 16.9% and A3 is 20.8% increase the protein level because the soy is the rich source of protein content. Similar results were found that Che man *et al*. (1992) [3].

Oil content of fried tortilla chips ranged from 21.4 to 25.9%. The oil content of sample Control F-21.4%, A1-21.7%, A2-22.4%,A3-25.9% fortification had the highest level of oil Similar results were seen by Adelakun *et al*. (2005) [1].

Moisture content of fried tortilla chip ranged from 1.8 to 2.2%.The moisture content of sample Ctrl F-1.96%, A1-1.84% and A2-1.98%and A3-2.21%. Similar result were found that Cosgrove (2002) [4].

Table 2: Moisture, protein and oil % of fried 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.

The correlation of protein, moisture, oil levels and fried 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 sample are most acceptable treatments of all Adelekun *et al*. (2005) [1].

For flavor acceptability, there were no differences found among 100:30:15% 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) [8].

There were no differences found in flavor intensity among treatments. Also, this attribute obtained the lowest scores in the hedonic scale when compared to the other attributes. This indicates that no beany flavors were found when tortilla chips were fortified with soy flour. In cookies, Buck *et al*. (1987) [1] 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 between100:30:15% DFSF with SF and NCF and 100:20:10% DFSF with SF and NCF sample is more acceptable in texture and crunchiness acceptability.

Table 3: Sensory attributes of fried tortilla chips

Sample	Composite flour (DFSF: SF: NCF %)	Friability	Crunchiness	Flavor Intensity	Flavor Acceptability	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.

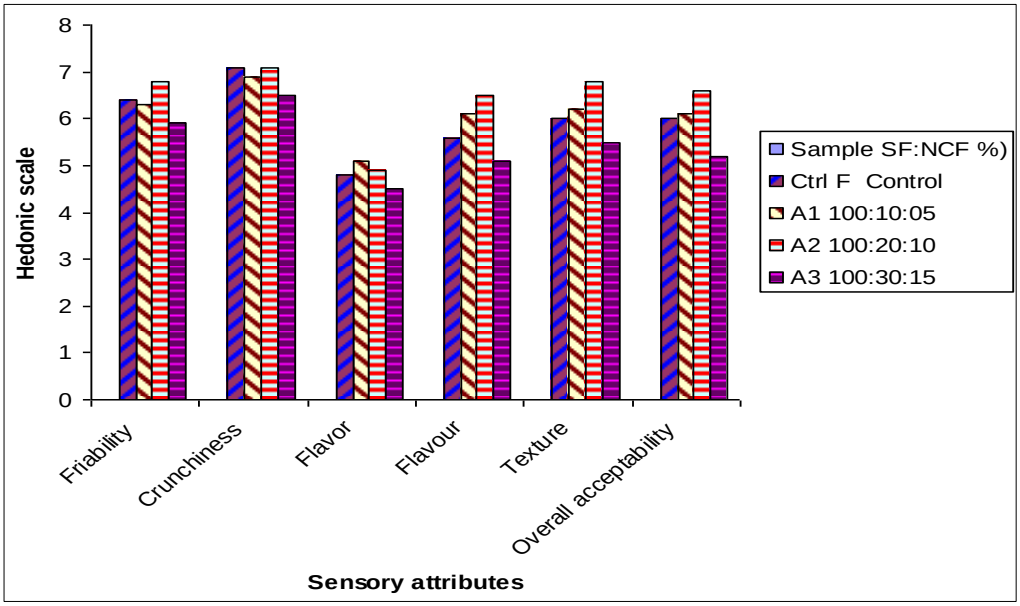

Fig 5: Sensory attributes in fried tortilla chips.

Thickness of fried tortilla chips

Thickness of fried tortilla chips ranged from 1.2-1.7mm**.**The thickness of Control F-1.7, A1-1.6 and A2-1.4 and A3-1.5mm.

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

Table 4: Thickness of fried 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

Texture of fried tortilla chips

The force comparison between fried and baked tortilla chips show 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.

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, it tries to 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 (McDonough 2006) [7].

Table 5: Correlation between force and thickness of fried tortilla chips

Sample	Force (N)
Ctrl F	20
A1	18
A2	13
A3	15

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