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Development of soybean chips incorporated with moringa leaf powder and tomato powder

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Abstract
There is growing interest in soybean products, mainly snacks. Soy snacks are available on the market but snacks from germinated soybean are limited. The objectives of this research were to develop soybean chips incorporated with moringa leaf powder and tomato powder, to investigate the effects of cooking methods (baking and frying) on quality attributes of developed chips, to study the physical, nutritional and sensory characteristics of developed chips. The moisture, protein, crude fibre and ash contents of flour from soybean germinated for 0-5 days ranged from 4.6 to 6.0%, 42 to 45%, 12 to 18.6% and 3.2 to 4.59%, respectively. Soybean chips (1 mm thickness) were prepared from five-day germinated soybean seeds with incorporation of moringa leaf powder (1%, 2%, 3%) and tomato powder (1%, 2%, 3%) with varying cooking methods. Baking and frying were conducted at 105 °C and 160 °C respectively. Based on sensory evaluation the soybean chips incorporated with 1% moringa leaf powder and 2% tomato powder is more acceptable with frying method. Texture and colour measurements were carried out for the developed soybean chips incorporated with 1% moringa leaf powder and 2% tomato powder. Hardness of soya chips were found around 2.6N and 3.6N respectively for frying and baking. The colour compounds - L*, a* and b* values were found as 58.29 and 47.61; 7.28 and 6.8; and 33.77 and 31.14 for frying and baking methods, respectively. In conclusion, the soybean chip made from germinated soybean seeds with incorporation of 1% moringa leaf powder and 2% tomato powder obtained more nutritive values and good acceptance from sensory evaluation.

Keywords: Baking, chips, frying, germination, hardness, nutritional, physical properties, sensory evaluation, soybean

Introduction
Soybean is one of the major oilseed crops in India. Soybean has become an important oilseed crop in India in a very short period with approximately 10-million ha area under its cultivation. India is divided into five agro-climatic zones for soybean cultivation. These are northern hill zone, northern plain zone, north eastern zone, central zone, and southern zone. There are specific varieties released for each zone which are suited to their agro-climatic conditions (Dinesh, 2013) [5].

It is superior to all other plant food because it has a good balance of all essential amino acids and contains proper amount of methionine. Soybean is therefore, not only known for its nutritional components but also provides significant health related benefits. Soybean is known as miracle golden bean. Soybean protein is economical and preeminent than the high-priced meat protein and so it is considered as the best source of protein in a vegetarian diet. Considering its nutritional attributes, mainly its high protein and fat content provided with the significant potential for cost-effective improvement of daily diets, helps in substantial reduction of protein-energy malnutrition (Goel *et al*., 2018) [9]. It contains good amount of essential macro nutrients for regulating good nutrition which includes protein (40%), carbohydrates (18%) and fat (18%). The moisture content is 9 percent and fibre are 10 percent with other micro nutrients (5%) like folic acid, calcium, potassium and iron.

Protein content is 30-45 percent with a good source of all indispensable amino acids with a digestibility value of 91.41 percent. The protein content is six times more than the rice grains and four times higher than the wheat. (Serrem *et al*., 2011) [22].

Because of its high nutritional potential, it’s not only preferred by vegetarians but also the non-vegetarian people of all age groups.

Soybeans possess the most scientific interests, due to the presence of phytoestrogens such as isoflavones, which have been linked to the lower cholesterol levels, anti-cancer capabilities, and the risk of cardiovascular diseases (He *et al.*, 2013) [15].

Beany flavor is generated mainly by aldehydes, ketones, alcohols, and other small molecular volatile compounds. The main reason for the beany flavor in soybean protein is that the unsaturated fatty acids (linoleic and linolenic acids) rich in soybean are easily oxidized to form hydroperoxides under the action of lipoxygenase, which are then further degraded to form aldehydes, ketones, and alcohols. There are several heat stable and heat labile anti-nutritional or toxic and potentially toxic factors. These include trypsin inhibitor, phytohaemaggluttins, goitrogens, cynogenetic glycosides, antivitamin factors, metal binding constituents, estrogenic factors, toxic amino acids, lathyrogens, flavogens and unidentified growth inhibitors. These factors in seeds of many legumes and cereals could give rise to problems in nutrition. Some details of the anti-nutritional factor are given hereafter. Protease (Trypsin) and amylase inhibitors: Protein modification by enzymes yields products with improved nutritional, functional and organoleptic properties and aids a variety of processing operations.

protease (trypsin) inhibitor activity than other cereals. In high- lysine corn barley, that activity is higher than in the corresponding normal varieties. Bread wheat has nearly twice as much trypsin inhibitor activity as other wheat. However, that activity is much lower in cereals than in legumes. For example, total protein inhibitor in barley normally is about 0.45 g/kg, whereas in defatted soy flour it is more than 32 g/kg (Dmello *et al.*, 1991) [6]. Application includes processes for meat flavour development and tenderization, continues bread making and modification of cracker and cookie texture, malt supplementation and chill proofing in brewing industry, and hydrolysis of protein gel to lower viscosity for concentration or filteration. The desired degree of hydrolysis or percentage of peptide bonds hydrolyse varies considerably with the different food processing operations.

Germination is done to boost the nutritive value and to inactivate the anti-nutritional components or the undesirable substances namely trypsin inhibitors, phytic acid, oligosaccharides and components with lipoxygenase activity that is present in it. It is an effective and value-added technological approach in order to enhance the nutritional quality of soybeans in Asian countries due to its digestibility.

Moringa (*Moringa oleifera* Lam) is a type of local medicinal Indian herb which has turn out to be familiar in the tropical and subtropical countries. *Moringa oleifera* is shown in scientific division to become from Kingdom: Plantae, Division: Magnoliphyta, Class: Magnoliopsida, Order: Brassicales, Family: Moringaceae, Genus: *Moringa*, Species: *M. oleifera* (Fahey, 2005) [7].

Moringa oleifera is one of the vegetables of the Brassica order and belongs to the family Moringaceae. The Moringaceae is a single genus family with 13 known species. *Moringa oleifera* is a small native tree of the sub-Himalayan regions of North West India, which is now indigenous to many regions in Africa, Arabic, South East Asia, The Pacific and Caribbean Islands and South America. Traditionally, besides being a daily used vegetable among people of these regions, the Moringa is also widely known and used for its health benefits. Among commoners, it has earned its name as 'the miracle tree' due to its amazing healing abilities for various ailments and even some chronic diseases.

The Moringa's incredible medicinal usage which is claimed by many cultures and communities based on real-life experiences are now slowly being confirmed by science. Through research, the Moringa was found to contain many essential nutrients, for instance, vitamins, minerals, amino acids, beta-carotene, antioxidants, anti-inflammatory nutrients and omega 3 and 6 fatty acids (Fahey, 2005; Hsu *et al*., 2006) [7, 16].

Tomato is important vegetable crop grown worldwide. When there is seasonal glut farmer doesn't fetch good price moreover a big share of crop produce is spoiled and become a waste due to lack of proper processing and storage. However, it can be processed to value added products. Fruit and vegetable powders obtained by drying to a certain moisture level are an ideal addition to soups, sauces, marinades, baby foods, dips, extruded cereal products, fruit purees, and fillings for frozen toaster snacks (Francis and Phelps, 2003; Pszczola, 2003) [8, 18} owing to their characteristic color, flavor and water binding properties. However, drying had been used commercially to prepare fruit powders, but many of the important nutrients are degraded during thermal processing of food (Goula *et al*., 2006; Goula and Adampoulos, 2005) [11, 10].

Soybean role in human health appears to be limited because of several limiting factors such as beany flavour, low protein digestibility due to high anti-nutritional factors. The availability of soybean snack products with different flavours is limited in the market. It has been suggested that germination is cheaper and more effective technology that can improve the quality of legumes by increasing their nutritional value. The reason for choosing this project is to develop a product from soybean with high nutitional availability and increase its nutritional values by incorporating moringa leaf powder and tomato powder.

Materials and Methods

The ingredients were used for preparation soybean chips incorporated with moringa leaf powder and tomato powder are soybean, baking poder, salt, moringa leaf powder and tomato powder.

Preparation of Germinated soybean powder

Soybean seeds are procured washed and soaked for 4h in de-ionized water at room temperature. The soaked seeds were germinated for 5 days at room temperature. After germination, the skin of soybean seeds was removed and washed before drying. The germinated soybeans were dried in an oven for 24h at 40 °C. The dried seeds are ground and passed through the mesh to get uniform particle size.The procedure for the preparation of germinated soybean flour is shown in Fig.1

Procurement of soybeans
↓
Washing
↓
Soaking
↓
Germination (5 Days)
↓
Washing
↓
Drying (40 °C/24 h)
↓
Milling
↓
Sieving

Fig 1: Flow chart for Preparation of germinated soybean flour

Preparation of Moringa leaf powder

The moringa leaves were taken from local trees. Leaves are separated from stems, and they are washed. The washed leaves are shadow dried under fans. The dried leaves are ground and passed through mesh to get uniform particle size. The procedure for the preparation of moringa leaf powder is shown in Fig. 2

Procurement of moringa stems
↓
Separating leaves from stems
↓
Washing
↓
Shadow drying
↓
Grinding
↓
Sieving

Fig 2: Flowchart for the preparation of moringa leaf powder

Preparation of Tomato powder

The tomatoes were procured from college. They are washed and cut into slices. The slices are then dried in tray drier at the temperature of 70 °C for 10h. The dried slices are then ground in a grinder. The powder was then passed through a sieve to get uniform particle size. The procedure for the preparation of tomato powder is shown in Fig. 3

Procurement of tomatoes
↓
Grading and washing
↓
Slicing
↓
Drying (70 °C/10 h)
↓
Grinding
↓
Sieving

Fig 3: Flowchart for the preparation of tomato powder

The chip preparation from the germinated soybean flour is as follows. Dough was prepared by mixing dried germinated soybean flour with table salt (1.5 g/100 g), baking powder (1.5 g/100 g) and water. The dough was flattened (1mm) using rolling pin and cut to get desired shape chips. The chips were then subjected to two different cooking methods. Chips were baked in an oven at 105 °C and fried in oil at 160 °C.

Raw materials
↓
Dough making
↓
Flattening dough
↓
Cutting into shapes
↓
Baking ((105 °C/10 min) | Frying (160 ℃)

Fig 4: Preparation of standard chips

Preparation of Chips by Incorporating Powders:

The ingredients used for preparation of chips by incorporating powders are germinated soybean flour, baking powder, salt, oil, moringa leaf powder and tomato powder. The ingredients are well mixed as per the formulations and the chips are made using two cooking methods.

Table 1: Standardization of ingredients with moringa leaf powder

Ingredients	F_1	F_2	F_3
Soybean flour	96 g	95 g	94 g
Salt	1.5 g	1.5 g	1.5 g
Baking powder	1.5 g	1.5 g	1.5 g
Moringa leaf powder	1 g	2 g	3 g

As per the above compositions four samples were prepared among them one is control sample and three of them are incorporated with moringa leaf powder.

From sensory evaluation of chips, we got good acceptance to chips with 1% moringa leaf powder. It has more taste and mouth feel. Further to enhance the flavour profile of the chips, the tomato powder is added as shown table 2.

Table 2: Standardization of ingredients with moringa leaf powder and tomato Powder

Ingredients	T_1	T_2	T_3
Soybean flour	95 g	94 g	93 g
Salt	1.5 g	1.5 g	1.5 g
Baking powder	1.5 g	1.5 g	1.5 g
Moringa leaf powder	1 g	1 g	1g
Tomato powder	1 g	2 g	3 g

Proximate analysis of developed chips

Estimation of Moisture

Moisture content is the quantity of water contained in a food material (John Bogart, 2018). The amount of moisture present in given food sample was determined by using standard methods, given by (AOAC, 2005).

The equipment used is Hot air oven which is shown in plate.3.10 and the specifications are given in Table 3.

1. Weigh exactly about 10 g of food sample into pre-sterilized Petri dish with lid. Note down the exact weight.
2. Dry in an oven at 100-105 °C till constant weight is obtained.
3. Cool in a desiccator and note the weight.
4. Repeat this twice and note the results. The formula used to estimate the moisture content is as follows:

$$\text{Moisture (\%)} = \frac{Ws-(W2-W1)}{Ws} \times 100$$

Where,

W_S=weight of the sample

W_1=weight of the Petri plate

W_2=weight of Petri plate after drying

Estimation of Ash content: Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a foodstuff (Harshali Patel, 2017). The total ash content of given food sample was determined by using (AOAC, 2005) method. The equipment used is muffle furnace .

1. Set the temperature of the muffle furnace to 600 °C and heat crucibles for 1 hour and transfer into a desiccator, cool them to room temperature and weigh (W_1).
2. Weigh about 5-10 g of sample into the crucible of known weight (W_s).
3. Heat the crucible cautiously at low flame until the material begins to char, and continue till charring is complete.
4. Then transfer the crucible to muffle furnace which is already heated to 550 °C – 600 °C continue ashing until a light grey or white ash is obtained. It require 4-6 hrs
5. Transfer the crucibles into the desiccators and cool them to room temperature and weigh (W_2) Weigh immediately to prevent moisture absorption.
6. Continue ashing, if a portion of ash is not completely ashed.
7. Repeat the experiment. The formula used to estimate the ash content is as follows:

$$\text{Ash (\%)} = \frac{W2-W1}{Ws} \times 100$$

Where,

W_S = weight of the sample

W_1 = weight of the crucible

W_2 = weight of the sample after ashing

Estimation of Fat content: The amount of fat was determined by using Soxhlet apparatus method given by (AOAC, 2000). The equipment used is Soxhlet apparatus is shown in plate 3.11 and specifications were given in table 3.

1. The dry sample (5-10 g) is weighed accurately into a thimble (made with Whattman No.1 paper-AOAC technique) and placed in the Soxhlet apparatus.
2. It is extracted with petroleum ether for about 16 hours.
3. The ether extract is filtered into a weighed beaker.
4. The flask is rinsed 4-5 times with small quantities of petroleum ether added to the beaker.
5. Petroleum ether is removed by evaporation and the flask with the residue dried in an oven at 80-100 °C, cooled in a desiccator and weighed.

Estimation of Protein Content: The protein content was estimated by Kjeldahl AOAC method. (200N g/Kg = (ml of HCL – ml blank) × Normality × 14.01) Weigh

Estimation of Crude Fibre: Weigh out 2 to 3 g of defatted, dry sample. Place in the flask and add 200 ml boiling sulphuric acid solution concentration (1,25%), when the acid concentration 5% should be taken (50 ml) of acid and (150 ml) of distilled water until the concentration reduces.

1. Attach the condenser and bring to boiling point in one minute; if necessary, add antifoam. Boil for exactly 30 minutes, maintaining the volume of solution constant by add heat distilled water and swirling the flask periodically to remove particles adhering to the sides.
2. Lining the Buchner funnel with the filter paper and boiling water. At the same time, at the end of the boiling period, remove the flask, let rest one minute and filter the contents carefully, using suction or vacuum. Filtration should be carried out in less than 10 minutes. Wash the filter paper with boiling water.
3. Transfer the residue to the flask using a retort containing 200 ml of boiling NaOH solution parts of nitrogen in proteins and making Saponification with the fat.
4. Preheat the filtration crucible with boiling water and carefully filter the hydrolyzed mixture after letting it rest for 1 min.
5. Wash the residue with boiling water, with the HCI solution and then again with boiling water, finishing with three washes with petroleum ether. Place the crucible in a oven set at 105 °C for 12 hours then cool in dryer.
6. Quickly weigh the crucible with the residue inside (do not handle them) and place in the crucible furnace at 550 °C for 3 hours. Leave to cool in a dryer and weigh them again.

Calculations

$$\text{Crude fiber \%} = \frac{100\,(A-B)}{C}$$

Where:

A = weight of crucible with dry residue (g)

B = weight of crucible with ash (g)

C = weight of sample (g)

Sensory evaluation

Sensory evaluation of eating quality is a direct and ultimate method for evaluating the final product (Oberoi, 2007). The sensory evaluation of muffins was carried out by a 20-member semi trained panel to know the overall acceptability and for evaluation of final product comprised of under graduate students and academic staff members of the faculty who had some previous experience in sensory evaluation. The panel members were requested in measuring the terms identifying sensory characteristics. Judgments were made through rating products on a 9-point hedonic scale with corresponding descriptive terms ranging from 9 like extremely to 1 dislike extremely with respect to the different quality attributes such as flavor, color, appearance, texture and overall acceptability.

Results and Discussion

Effect of Germination of Nutritional values of Raw materials: The moisture content of germinated soybean was higher than non-germinated soybean. The hydration of soybean may account for the rise in moisture content of sprouted soybean. during germination process, soybean absorbed moisture from the surroundings so as to commence metabolic process, which increased the moisture content of the sprouted soybean.

Table 3: Proximate analysis of raw materials per 100 g sample

Nutrients	Soybean seeds	Germinated Soybean seeds	Moringa leaf powder	Tomato powder
Moisture content (%, w.b.)	4.6±0.8	6±0.26	5.02±0.19	5.68±0.71
Crude Protein (%)	42±0.2	45±0.66	19.36±0.18	12.19±0.51
Crude fat (%)	18±0.7	13±0.81	3.61±0.25	2.11±0.19
Carbohydrates (%)	20.2±2.59	12.81±2.12	38.46±0.83	37.67±4.41
Crude fiber (%)	12±0.59	18.6±0.27	26.01±0.17	7.9±2
Ash (%)	3.2±0.3	4.59±0.12	7.99±0.04	9.76±1

From the table 3, it is observed that there is an increase in crude protein content, the reason behind this may be due to loss of dry weight as some carbohydrates and fats are utilized during respiration but also some amino acids are synthesized during germination. This may also be due to partial hydrolysis of the soluble or inaccessible proteins during germination. Degradation of these storage proteins releases polypeptides within the seed matrix leading to the improvement of protein digestibility.

The decrease in fat and carbohydrates may be due the reason that they could be used as an energy source to start germination. And the increase in dietary fibre was reported to be mostly due to changes in the polysaccharides found in the cell wall such as cellulose, glucose and mannose, suggesting that the changes were due to an increase in the cellular structure of the seed during germination.

The increase in ash content can be due to an increase in the activity of phytase enzyme during sprouting. The increased activity of enzyme phytase caused the hydrolysis of phytic acid making the mineral free, and increase the minerals as well as ash contents of germinated soybean.

Development of Soybean Chips

Soybean chips were made using two cooking methods i.e., baking and frying. Moringa leaf powder is incorporated in chips in 1%, 2% and 3%. And based on the sensory evaluation, chips incorporated with 1% moringa leaf powder is considered as chips with good sensory acceptance. And further to increase the flavour of the chips, tomato powder is incorporated in 1%, 2% and 3%.

Development of baked soybean chips incorporated with moringa leaf powder

The soybean chips were prepared by incorporating moringa leaf powder in 1%, 2% and 3%. The baking was done at 105 °C/10 min. The resulting samples were labeled as B1, B2, and B3 (Shown in Fig. 5), corresponding to the formulations containing 1%, 2%, and 3% moringa leaf powder, respectively.

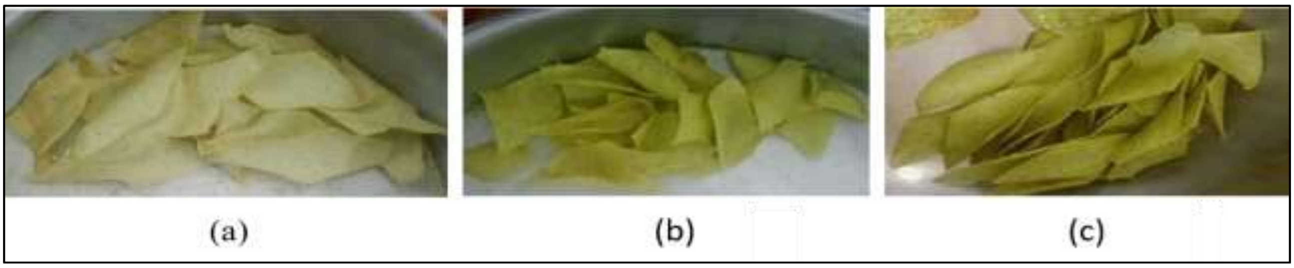

Fig 5: Developed soybean chips incorporated with moringa leaf powder (baking): (a) F1 Formulation; (b) F2 Formulation; (c) F3 Formulation

Table 4: Mean sensory score of baked soybean chips incorporated with moringa leaf powder

Sample	Colour	Texture	Flavour	Appearance	Taste	Overall acceptance
Control sample	7.3	6.2	5.0	6.4	5.6	5.8
B_1	7.1	6.5	7.4	6.7	6.2	6.4
B_2	6.8	6.4	6.3	6.7	5.6	5.8
B_3	5.3	6.5	5.3	6.2	5.4	5.4

From the results table 4, it was observed that the soybean chips incorporated with 1% moringa leaf powder has got good acceptance with the overall acceptance 6.4. The colour, texture, flavour, appearance and taste scores for B_1 are 7.1, 6.5, 7.4, 6.7 and 6.2 respectively. The low sensory score for remaining formulation might be due to increase in bitterness with the increase in moringa leaf powder percentage. Based on this result we can conclude that the chips made with 1% incorporation of moringa leaf powder has got highest overall score for baking method.

Development of fried soybean chips incorporated with moringa leaf powder

The soybean chips were prepared by incorporating moringa leaf powder in 1%, 2% and 3%. The frying was done at 160 °C. The resulting samples were F_1, F_2 and F_3 with the formulation of 1%, 2% and 3% moringa leaf powder respectively.

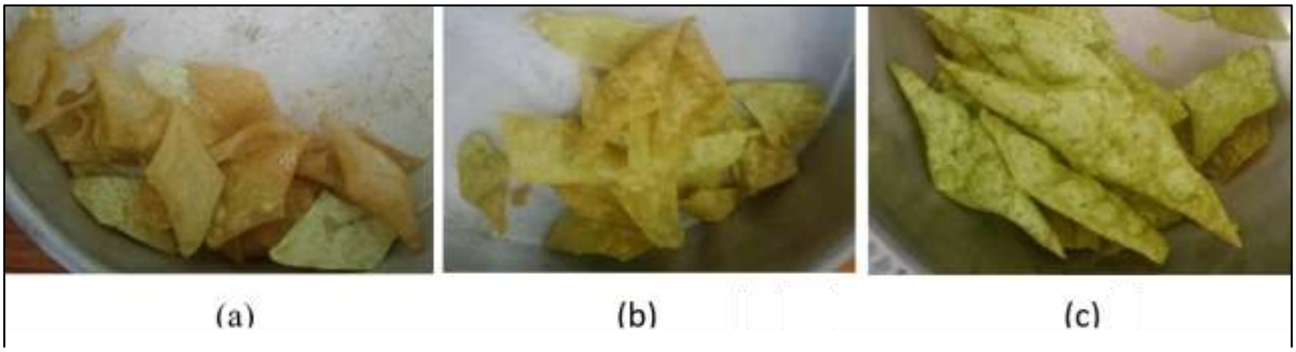

Fig 6: Developed soybean chips incorporated with moringa leaf powder (frying): (a) F1 Formulation; (b) F2 Formulation; (c) F3 Formulation

Table 5: Mean sensory score of fried soybean chips incorporated with moringa leaf powder

Sample	Colour	Texture	Flavour	Appearance	Taste	Overall acceptance
Control sample	7.2	7.6	7.4	8.1	7.4	7.2
F_1	8.3	8.1	7.4	8.4	7.9	7.8
F_2	8.3	8.4	7.3	8.2	7.1	7.6
F_3	7.3	8.4	7.1	7.2	6.3	7.1

The table 5 shows that there is more sensory acceptance to fried chips than baked chips. Through the results we can conclude that the chips made with 1% moringa leaf powder got high overall acceptance with 7.8. The reason for the low sensory score for the remaining formulations might be the increase in the bitterness same as in case of baked chips. The colour, texture, flavour, appearance and taste for F_1 are 8.3, 8.1, 7.4, 8.4 and 7.9 respectively.

Development of baked soybean chips incorporated with moringa leaf powder and tomato powder:

Based on the results of the developed soybean chips incorporated with moringa leaf powder, we can conclude that chips made with 1% moringa leaf powder is accepted more than other formulations. To get good flavour, tomato powder is incorporated to the chips with 1% moringa leaf powder, in 1%, 2% and 3%.

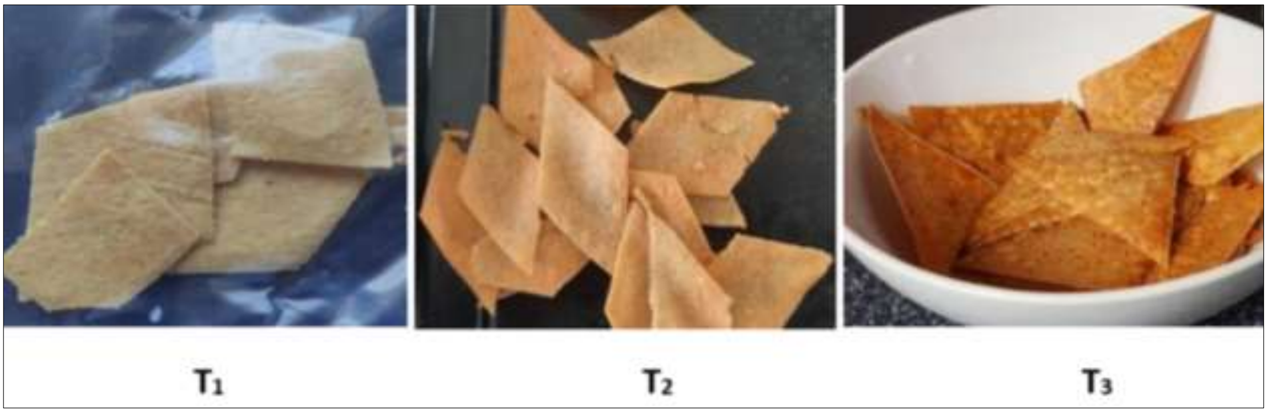

Fig 7: Developed soybean chips incorporated with moringa leaf powder and tomato powder (baking): (a) 1% Tomato powder (T1); (b) 2% Tomato powder (T2); (c) 3% Tomato powder (T3)

Sensory evaluation was done to the chips developed with the incorporation of tomato powder in 1%, 2% and 3%. 20 members were selected to do sensory evaluation with 9-point hedonic scale.

Table 6: Mean sensory score of baked soybean chips incorporated with moringa leaf powder and tomato powder

Sample	Colour	Texture	Flavour	Appearance	Taste	Overall acceptance
T_1	7.2	6.8	7.5	6.8	6.4	6.5
T_2	7.3	6.9	7.6	6.9	6.6	6.8
T_3	7.4	7.0	7.5	7.0	6.4	6.6

From the table 6, it was concluded that the chips made with 2% tomato powder has got high overall acceptance. The colour, texture, flavour and taste has got high score for T2 with the values 7.3, 6.9, 7.6 and 6.6 respectively. The acceptance for 2% is high may be due to the reason that 3% tomato powder is masking the soybean flavour in the chips.

Development of fried soybean chips incorporated with moringa leaf powder and tomato powder:

The developed formulation was also done by frying method at 160 °C. The formulations are T_1, T_2 and T_3 with 1%, 2% and 3% tomato powder respectively.

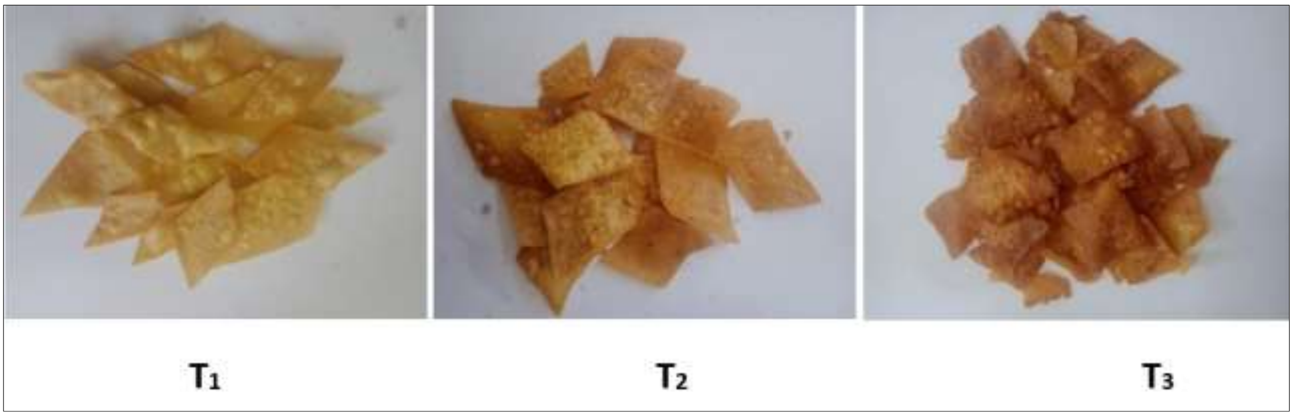

Fig 8: Developed soybean chips incorporated with moringa leaf powder and tomato powder (frying): (a) 1% Tomato powder (T1); (b) 2% Tomato powder (T2); (c) 3% Tomato powder (T3)

Sensory evaluation is done to the developed chips, by 20 members selected panellists. The evaluation was done by using 9-point hedonic scale.

Table 7: Mean sensory score of fried soybean chips incorporated with moringa leaf powder and tomato powder

Sample	Colour	Texture	Flavour	Appearance	Taste	Overall acceptance
T_1	8.4	8.2	7.5	8.5	8.0	7.9
T_2	8.5	8.5	8.0	8.3	8.2	8.3
T_3	8.3	8.4	7.8	8.2	7.8	7.8

From the sensory results (Table 7), it is conculded that the chips made by incorporating 2% tomato powder is accepted with high overall acceptance score 8.3. The colour, texture, flavour and taste was rated high for T_2 with the values 8.5, 8.5, 8.0 and 8.2 respectively.

Physical properties of developed soybean chips incorporated with moringa leaf powder and tomato powder

Physical properties are indicative of the quality characteristics. The parameters like Hardness, color L*, color a* and color b* were evaluated for soybean chips incorporated with moringa leaf powder and tomato powder.

Table 8: Hardness of soybean chips incorporated with moringa leaf powder and tomato powder

Hardness (N)	Frying	Baking
Control sample	2.3	3.2
T_1	2.5	3.5
T_2	2.	3.6
T_3	2.9	3.7

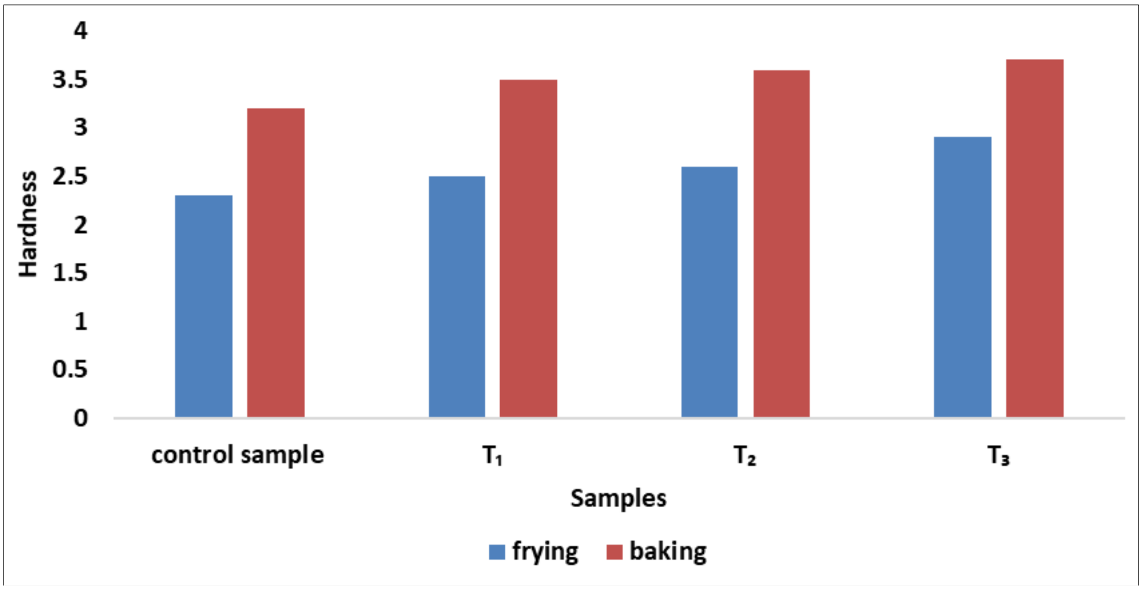

Fig 9: Hardness of soybean chips incorporated with moringa leaf powder and tomato powder

The results shows that the hardness of baked chips is higher compared with frying chips. And the hardness increases with increase in tomato powder concentration. A higher hardness values indicates that more force is required for breaking. The harder texture of baked chips may be due to the incomplete starch gelatinization during baking process. Frying takes place rapidly and is much more efficient heat transfer process than baking.

Table 9: Colour L*of soybean chips incorporated with moringa leaf powder and tomato powder

Colour L*	Frying	Baking
Control sample	87.9	75.5
T_1	67.9	59.27
T_2	58.29	47.61
T_3	50.6	39.59

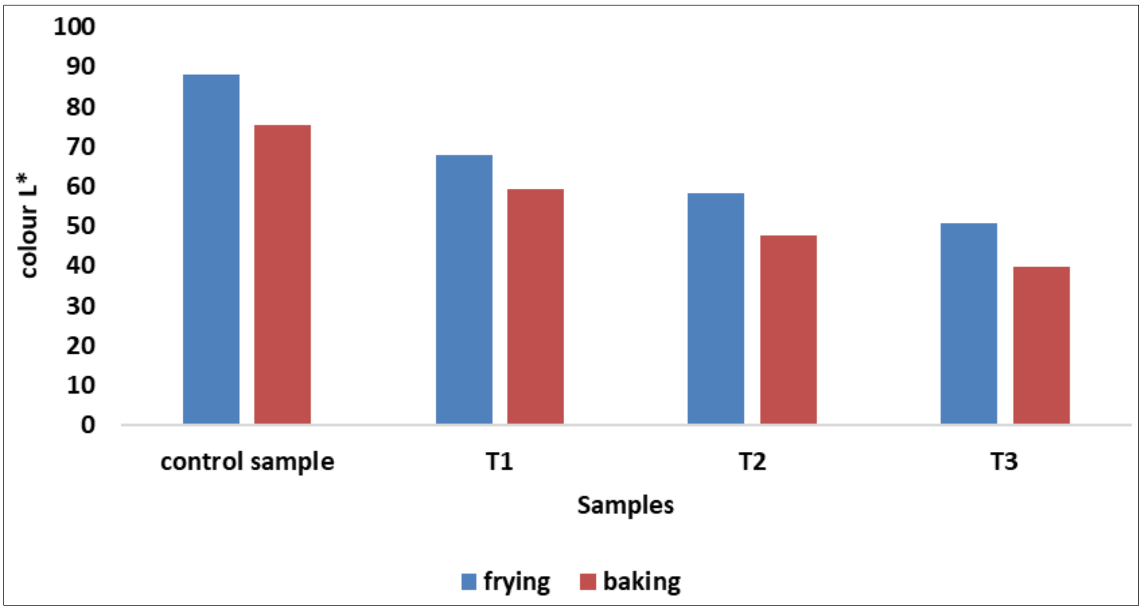

Fig 10: Colour L*of soybean chips incorporated with moringa leaf powder and tomato powder

It was observed that the colour L* of formulations control sample, T_1, T_2 and T_3 of soybean chips incorporated with moringa leaf powder and tomato powder from the table 4. The L* values of the chips has been decreased which might be due to the non-enzymatic reaction during cooking process. As there is no oxygen available during frying, the reason behind the dark colour to fried chips might be because of Maillard reaction. The colour L* was observed to be increasing as the tomato powder incorporation is increased. The chips made with frying method has got high values than chips made with baking.

Table 10: Colour a*of soybean chips incorporated with moringa leaf powder and tomato powder

Colour a*	Frying	Baking
Control sample	3.2	2.1
T_1	4.7	4.1
T_2	7.28	6.8
T_3	9.14	8.37

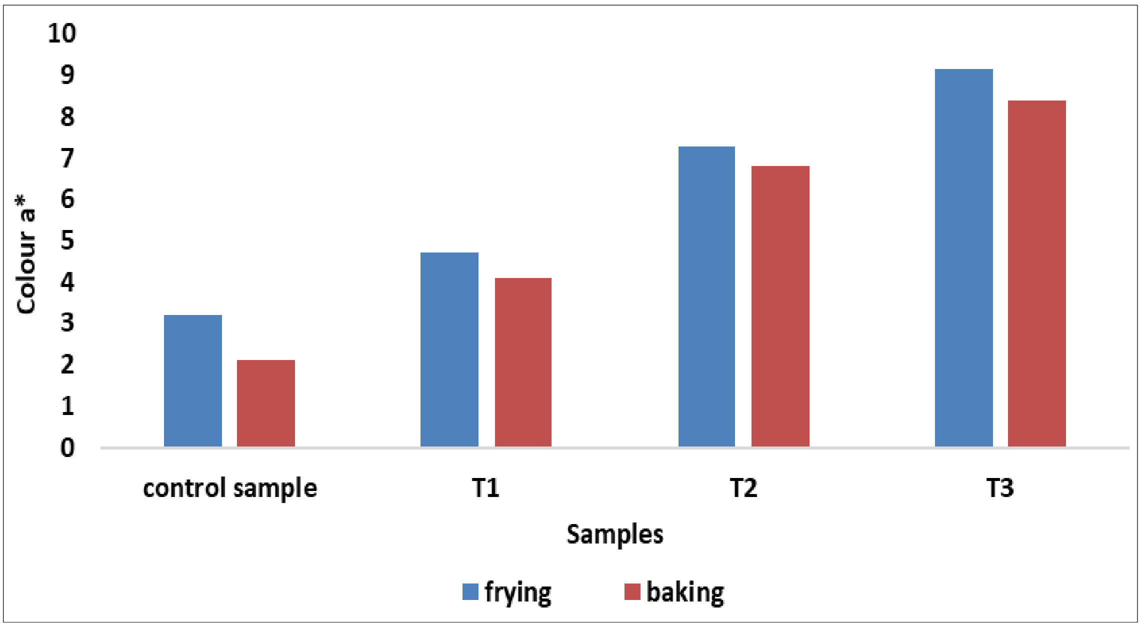

Fig 11: Colour a* of soybean chips incorporated with moringa leaf powder and tomato powder

It was observed that the values of colour a* is increased with the increase in concentration of tomato powder. Colour a* represents the chromaticity. Negative a* corresponds with green, positive a* corresponds with red. From the graph we can observe that the chips with frying method have got more a* value than chips made with baking method, representing the good colour improvement with the incorporation of tomato powder by frying method.

Table 11: Colour b* of soybean chips incorporated with moringa leaf powder and tomato powder

Colour b*	Frying	Baking
Control sample	62.6	57.5
T_1	40.21	39.9
T_2	33.77	31.14
T_3	30.29	29.54

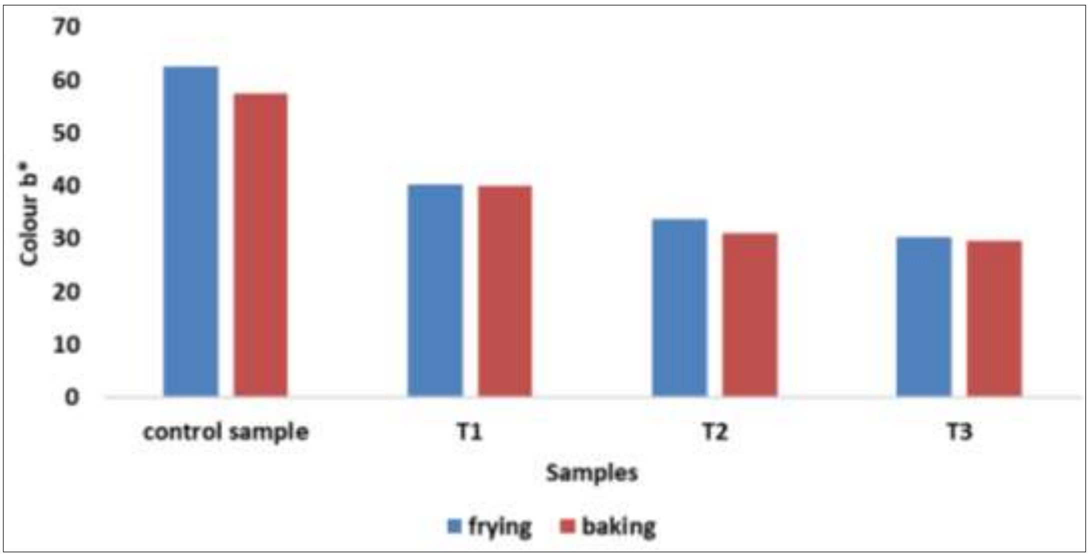

Fig 12: Colour b* of soybean chips incorporated with moringa leaf powder and tomato powder

It was observed that the values of colour b* is decreased with the increase in concentration of tomato powder. Colour b* represents the chromaticty. Negative a* corresponds with blue, positive b* corresponds with yellow. From the graph we can observe that the chips with frying method has got more b* value than chips made with baking method, representing the good colour improvement with the incorporation of tomato powder by frying method.

Nutritional analysis of prepared chips

Based on the results obtained from sensory evaluation, the chips developed by incorporating 1% moringa leaf powder and 2% tomato powder can be concluded as the final developed product with good sensory acceptance. The parameters like moisture content, carbohydrates, protein content, crude fat, crude fiber and ash were evaluated in proximate analysis and the results were shown in the table 12.

Table 12: Proximate analysis of soybean chips per 100 g sample

Nutrients	Fried chips		Baked chips	
	Control sample	T_2	Control sample	T_2
Moisture content (% d.b)	2.81	2.77	2.85	2.82
Crude protein (%)	46.27	47.12	47.49	48.98
Crude fat (%)	18.29	17.52	14.11	14.74
Carbohydrates (%)	10.74	6.81	12.59	7.01
Crude fibre (%)	17.26	19.81	17.47	19.94
Ash (%)	4.63	5.97	5.49	6.51

The protein content increased in the developed chips when compared with the control sample. This prototype chips can be considered as low-calorie chip as we can observe that the carbohydrates percentage is decreased in the final product. The moisture, crude fat is decreased in the developed product. The crude fibre and ash content has been increased in the developed product.

The protein content of fried chips and baked chips are 47.12 and 48.98 respectively. The lowest carbohydrate content can be observed in the final fried chips with 6.81%.

Conclusion

Development of soybean chips incorporated with moringa leaf powder and tomato powder the chips were prepared with germinated soybean, moringa leaf powder and tomato powder. Six formulations of soybean chips were prepared. The six formulations were F_1, F_2, F_3, T_1, T_2 and T_3 contains moinga leaf powder and tomato powder in different proportions. The formulated chips were tested for physical characteristics (Texture Profile Analysis, Colour), nutrient composition, and sensory attributes. Acceptability of all the chips was carried out by using 9 point hedonic scale.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper

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