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Effect of incorporation of full fat soy flour on the quality of noodles

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Abstract

Noodles are a type of food typically made from unleavened dough which is rolled flat and cut, stretched or extruded into long strips or strings. It has a good market potential. However, the presently available noodles provided low protein quality. With the constituents of good quality protein and phytochemicals (isoflavonon), soybean has been accepted as the functional foods that have a potentially positive effect on health beyond basic nutrition. Considering its demand and nutritional contribution, a study was conducted to develop noodle by incorporating different levels such as 0,20,30,40 and 50 percent of full fat soy flour. Mean scores for appearance, texture, aroma, taste, colour and overall acceptability ranged from 4.06 to 3.93, 3.86 to 3.66, 3.53 to 3.33, 3.86 to 3.63, 3.86 to 3.66 and 4.00 to 3.63. Scores for sensory attributes were recorded for soy noodles of 30 per cent. Less score was observed for higher level of soy flour incorporated soy noodles and least was in control noodles. Shelf-life stability of the developed products in different packaging materials for a period of three months at room temperatures was undertaken along with the analysis for nutrients and microbial counts of the stored products. Soy noodles (20%) stored in polyethylene covers had higher scores for sensory attributes during storage compared to 30 per cent soy noodles stored in corrugated paper box. When compared to normal noodles, soy noodles showed higher protein (17.42per cent), fat (5.6 per cent), ash (1.54 per cent) and fiber (1.04 per cent) content, but lower CHO (65.29 per cent) and energy (377.64 Kcal) content. More number of yeast counts (23x10²) were recorded in soy noodles stored in polyethylene covers followed by corrugated paper boxes.

Keywords: Value added soy noodles, sensory evaluation, packaging and storage, nutrient and microbial analysis

1. Introduction

Extrusion technology has been used to process different food raw materials. Extrusion technology allows processing and providing a wide range of shaped, pre-cooked-textured foods with single machine. Noodles were invented in China. Noodles are ready to prepare product that are popular among several group of consumers the ancient, millet-based noodles were found in a sealed, overturned bowl. The Asian diet is inseparable from the consumption of noodles. This food is not only popular in Asia but has also been widely accepted in various parts of the world. Noodles, especially, Asian noodles are generally made various raw materials such as wheat flour, rice flour, buckwheat flour or starch derived from rice, wheat, mung bean, tapioca, sweet potato, sago or corn of which has different nutritional and textural characteristics (Hou, 2020) ^[15]. However, it has a low nutritional content, as the raw materials are mostly flour based. Noodles are high in carbohydrates and calories (Park & Liu, 2023) ^[27] but low in protein, fiber, vitamins and minerals (Olorunsogo *et al.*, 2023) ^[25]. Such nutritional imbalances can lead to various complications, such as malnutrition and metabolic disorders, if consumed over a long period (Park & Liu, 2023) ^[27]. With the increasing awareness of the importance of a healthy diet, there is an urgent need to improve the quality of noodles, especially their nutritional value. Prasad *et al.* (2007) ^[28] fortified soy flour to sorghum and extruded product obtained had been rated as very good. The ratings with respect to taste and overall acceptability of extruded product were significantly higher than other combinations. Addition of soy flour to corn and potato caused appreciable reduction in hardness, compared to full fat flour, but obtained better expansion of the sample (Kulkarni *et al.*, 1997) ^[19]. Addition of minimal to rice flours reduced the stickiness of

the extruded rice noodles. The extruded product from the mixture of rice flour, modified starch and emulsifier obtained high score (Charutigon *et al.*, 2008) [7]. Standardized products sensory scores like color was significantly affected in cooked extruded products but stickiness of pasta significantly decreased as the level of defatted soy flour and soy protein concentrate (15-45%) increased (Limroongreungrat & Huang, 2007), Shanthi *et al.* (2005) [22, 32] found that addition of soy flour of the composite mix reduced the color scores, but didn't significantly change in flavor, texture and taste of pasta products were noticed.

Soybean (*Glycine max* (L) Merrill) for a long time known as one of the principal food crops and has paramount importance in Indian agriculture and oil industry. Soybean belongs to family leguminosae and sub family papilionidae (Chauhan & Chauhan, 2007) [8]. It can be easily cultivated in a short duration of 80-90 days and it grows well on almost all types of soils both under irrigated and rain fed conditions. It increases soil fertility through fixation of atmospheric nitrogen. It is bushy in nature with a hard and thick stem. It bears pods on the main stem close to the ground.

Cereals like rice, wheat, maize and millets are staple food grains for majority of population around the world. These are rich sources of carbohydrates and supply calories and other nutrients to the consumers. Apart from value addition by processing to traditional products from these grains, development of newer products offers variety, convenience, quality, cost, efficiency and scope for increasing the nutritional value. (Sowbhagya & Ali, 2001) [34].

The ultimate goal of any new product is its acceptability for maximum utilization and the acceptability can only be attained through its sensory attributes. Though flavor and mouth feel are major proponent, other sensory characteristics of food also contribute significantly to our responses to food. Visual cues permit the identification of food but through repeated dietary experience evokes an anticipated set of oral sensation.

Most snack foods being cereal based are either poor sources of protein or contain proteins of poor nutritional quality. The quality protein in such products could substantially be improved through blending of the cereal component with legumes. Optimum incorporation of soybean/dhal/flour incorporation in snacks increases protein quality. Soybean is preferred because of its low cost, accessibility, widely varying functional properties and high content of good quality protein, rapid industrialization and urbanization and changes in eating habits of Indian people lead to very high demand for ready-to-use snack products (Mangaraj *et al.* 2013) [23].

Noodles are ready to eat product that are popular among several group of consumers. Noodles are one of the staple foods consumed in many Asian countries. Instant noodles have become internationally recognized food, and worldwide consumption is on the rise. Many researchers are exploring the potential of noodle fortification as an effective public health intervention and improve its nutritional properties. The properties of instant noodles like taste, nutrition, convenience, safety, longer shelf life, and reasonable price have made them popular (Pakhare *et al.* 2016) [26]. However, the presently available noodles provided low protein quality. With the constituents of good quality protein and phytochemicals (isoflavone), soybean

has been accepted as the functional foods that have a potentially positive effect on health beyond basic nutrition. (Mangaraj *et al.*, 2018) [24]. Considering all these factors this study was undertaken with the following objectives. The primary aim of this study was to standardize the Processing procedure of full fat soybean flour-based Noodle. Secondly to assess the nutritional composition of the value-added Noodle products. Thirdly to study the packaging effect on the shelf-life nature of the best accepted Noodle product. Considering all these factors this study was undertaken with the following objectives. The primary aim of this study was to standardize the Processing procedure of full fat soybean flour-based Noodle. Secondly to assess the nutritional composition of the value-added Noodle products. Thirdly to study the packaging effect on the shelf-life nature of the best accepted Noodle product.

2. Materials and Methods

The present study entitled was carried out in the department of Food Science and Nutrition, University of Agricultural Sciences, Bangalore, Karnataka. The study was aimed to develop traditional Noodle product of cereal and pulse flour incorporated by utilizing soybean full fat flour. The details of materials and methods used are presented as follows.

2.1 Procurement of Raw Materials

Soy variety JS-335 of AICRP used for present investigation. Soy variety was collected from Tumkur district (Karnataka State) soybean growing farmers. The grains were cleaned manually and stored at ambient condition for further investigations.

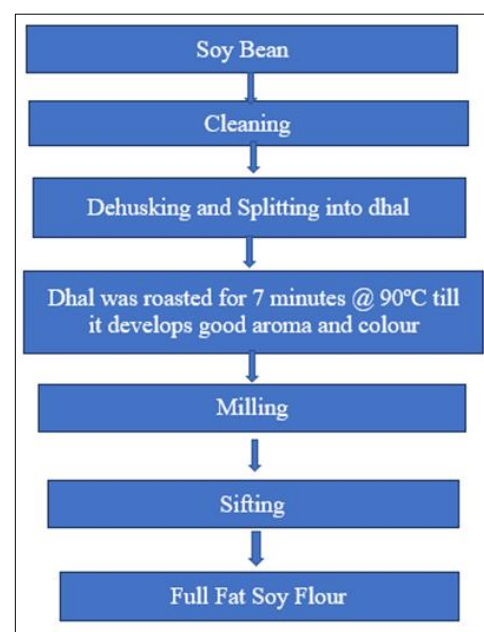


Fig 1: Preparation of full fat Soybean

- Prepare Soy dhal from cleaned Soyseeds
- Roast Soy seeds till “7 minutes at 90° C till it develops good aroma and colour” then mill into flour using domestic flour miller in the lab at room temperature.
- Pack and store the sifted flour

2.2 Development of Value-Added Products

Suitability of Soy bean in daily foods was studied by incorporating soy bean in the form of flour in common

cereal/pulse based traditional foods of Karnataka. Products were developed by employing different methods of cooking such as boiling. Accordingly, the Product was chosen included Noodles. The selection and finalization of products for the study involved the main ingredient of the selected recipe was substituted with soy flour in varying levels of 0, 20, 30, 40 or 50 per cent.

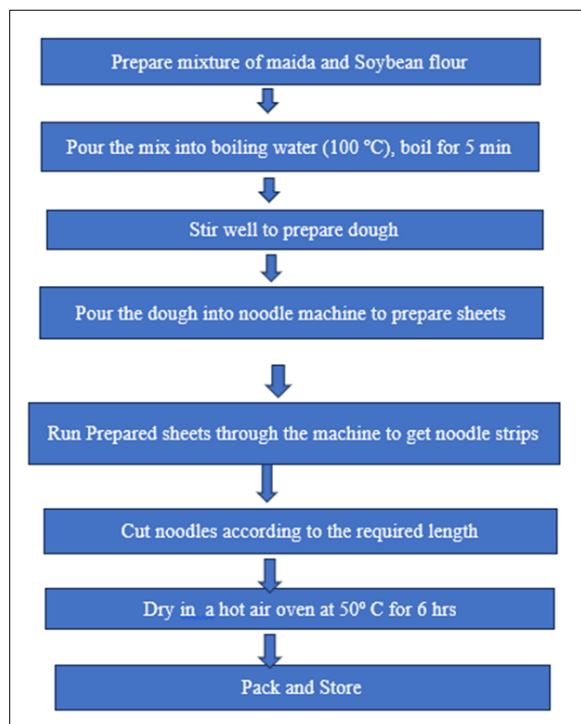


Fig 2: Preparation of soybean noodles

- Prepare mixture of Soy flour with maida
- Add the mixtures to boiling water(100° C) and prepare dough
- Pass the dough in to roller and make sheets.
- Pass the sheets in to extruder to cut in to noodle strips
- Prepared noodles using machine was cut in to required length
- Dry in the dryer at 50° C for 5 hours and pack in polyethylene bags

Sensory Evaluation: Profile of sensory characteristics was performed by a panel of fifteen experts at every month for a period of three consecutive months. Boiled form of noodles were subjected to sensory evaluation. Products were assessed for appearance, texture, taste, aroma/flavour, color and overall acceptability using five-point hedonic scale. "Every month for the duration of 3 months" with the same set of panelists using the three letters coded test samples by Paired Comparison sensory test method

Score Card: The products were evaluated for their sensory attributes by a panel of fifteen semi trained judges, using a five-point hedonic scale. Scoring pattern followed as 5-Highly acceptable, 4-Moderately acceptable, 3-Slightly acceptable, 2-Fairly acceptable, and 1-Poorly acceptable. (Amerine *et al.*, 1965) The sensory parameters studied were appearance, texture, taste, aroma/flavor, colour and overall acceptability.

2.3 Packaging of Soybean value added Products

Packaging materials used were polyethylene covers and corrugated paper board for storage studies. Soybean value added products such as soy noodles was packed in polythene covers and heat-sealed using machine. Noodle was stored using corrugated paper board.

2.4 Storage Study in Different Packages

To evaluate the stability of the noodle formulation, samples were stored at room temperatures 25-30°C for up to 90 days. These products were stored in separate polyethylene covers and corrugated paper boxes in triplicates. The samples were evaluated at different time intervals (0, 30, 60, and 90 for acceptability of physical and organoleptic properties by a panel of 15 trained judges (Fuad & Prabhasankar, 2012) [16]. These products subjected for chemical and microbial analysis after three months of storage. To assess the shelf life of the value-added products, the following studies were carried out. Only 90 days at room temperature, no controlled humidity or temperature monitoring.

2.5 Organoleptic Evaluation of Soy Bean Value Added Products

The organoleptic evaluation of Soy value added products stored in two different packaging materials under normal storage conditions was done every month by panel judges of 15 semi-trained judges for appearance, texture, taste, aroma/flavor, color and overall acceptability monthly by using a score card for a period of three months (Fig-3) "Semi-trained judges" (Masters and doctoral scholars who were having the subject knowledge of Food Product Development and Sensory Science: Principles and Application in Food Science).



Fig 3: Sensory evaluation of soybean value added products

2.6 Microbial Analysis

Microbial contamination was estimated by analyzing microbial load in soy bean value added products by using Nutrient Agar (Na) for bacteria and spores, Martin's Rose Bengal Agar (MRBA) for moulds/Fungi and for yeast, Davis yeast salt agar, following the dilution pour plate method. The three dilutions 10⁻² were used for analyzing bacteria, mould, spores and yeast respectively. The Soy value added products were analyzed for the total bacterial counts, yeast moulds and spores after 90 days of storage period.

2.7 Chemical Analysis

2.7.1 Chemical Analysis of Whole Raw Soybean Seeds

Whole raw soy seeds were pulverized in a commercial mill. The flour was sieved through 60mm mesh sieve for analysis of protein, phosphorous, potassium, calcium, magnesium, tannin, phytates, *in vitro* calcium and iron bio accessibility.

2.7.2 Effect of Domestic Method of Processing on Nutrients

The common house hold methods of processing used were germination and roasting. These processing methods were purely domestic methods where no chemical or special equipments were used. The methods and techniques are briefly explained below.

a) Roasting

b) Germination

a) Roasting: Soybean seeds were roasted till seeds started developing aroma. Roasted seeds were pulverized in a commercial mill. The flour was sieved through 60mm sieve for analysis of protein, phosphorous, potassium, calcium, magnesium, tannin, phytates, *in vitro* calcium and iron bio accessibility

b) Germination: Soybean seeds were steeped in triple the volume of water for 12 hours. Soaked seeds were washed, drained and wrapped in muslin cloth and stored in ambient temperature for germination (48-72 hours). The spouted seeds were air dried, devegetated manually. Dried seeds were pulverized and sieved through 60mm sieve for analysis of protein, phosphorous, potassium, calcium, magnesium, tannin, phytates, *in vitro* calcium and iron bio accessibility.

2.7.3 Chemical Analysis of Value-Added Products

Developed soy value added products namely Soy vermicelli, Soy noodles, Soy papad, Soy multimix, Soy laddu were drawn for chemical analysis. Chemical analysis was carried out for moisture, protein, fat, fiber, minerals, (ash) by following standard procedures as indicated below.

Estimation of moisture (Raghuramulu *et al.*, 2003) [30]

About 10 grams of sample was weighed in to a pre weighed petri plates and dried in an oven at 60°C to a constant weight and cooled in a desiccator. The process of heating and cooling was repeated till a constant weight was achieved.

$$\text{Per cent Moisture} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Weight of sample}} \times 100$$

Estimation of Protein (AOAC, 1980) [3]

The total protein content of the dried sample was estimated as per cent total nitrogen by the micro-kjeldhal method.

Total protein was then calculated by multiplying the per cent nitrogen by the factor of 6.25.

$$\text{Protein \%} = \frac{\text{Titre value} \times \text{Normality of HCl} \times 14.007 \times 6.25 \times 100}{\text{Sample weight} \times 1000}$$

Estimation of Fat (AOAC, 1980) [3]

Fat was estimated as crude ether extract using moisture free samples. The solvent was removed by evaporation and the residue of fat was weighed.

$$\text{Fat \%} = \frac{\text{Weight of ether extracts (g)}}{\text{Weight of sample used (g)}} \times 100$$

Estimation of Ash (AOAC, 1980) [3]

About 5 gram of sample was weighed accurately in to previously weighed crucible. The crucibles were heated first over a low flame till all the material was completely charred for about 3 ½ hours at about 600°C. It is then cooled in a desiccator and weighed. To ensure completion of ashing the crucible was again heated in the muffle furnace for ½ hour, cooled and weighed. This was repeated till two consecutive weights were same and the ash was almost white or grayish white in color.

$$\text{Percent Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Estimation of crude fiber (AOAC, 1980) [3]

Crude fibre of the sample was estimated by using moisture and fat free samples and expressed as gram per 100 g or per cent of the samples used.

Computation of carbohydrates (Raghuramulu *et al.*, 2003) [30]

- Carbohydrate content was computed by difference method
- Carbohydrate per cent = 100 - {Protein (g) + Fat (g) + Fiber (g) + Ash (g) + Moisture (g)}

Computation of energy (Raghuramulu *et al.*, 2003) [30]

- Energy was computed as follows.
- Energy (Kcal) = (Protein (g) × 4) + (carbohydrates (g) × 4) + (fat (g) × 9)

Computation of micro nutrients of the Soybean value added products (Gopalan *et al.*, 1999) [12]:

Micro nutrients of noodles, was computed using NIN food tables.

2.8 Designing of Nutrition Labels: Labeling of the Soy value added products was done according to the modified guidelines by Lambert *et al.* (1994) [20].

2.9 Cost Benefit Ratio of the Products: Local market price of all the ingredients used was taken to calculate the cost of the product developed. The cost of 100g of product was estimated using the formula in consultation with the staff of the dept. of Horticulture, UAS, Bangalore. Apart from fixed cost and variable cost, interest on working capital and interest on investment was also taken into consideration. Twenty-five per cent as commission/profit over the cost of production was calculated for all the products under study.

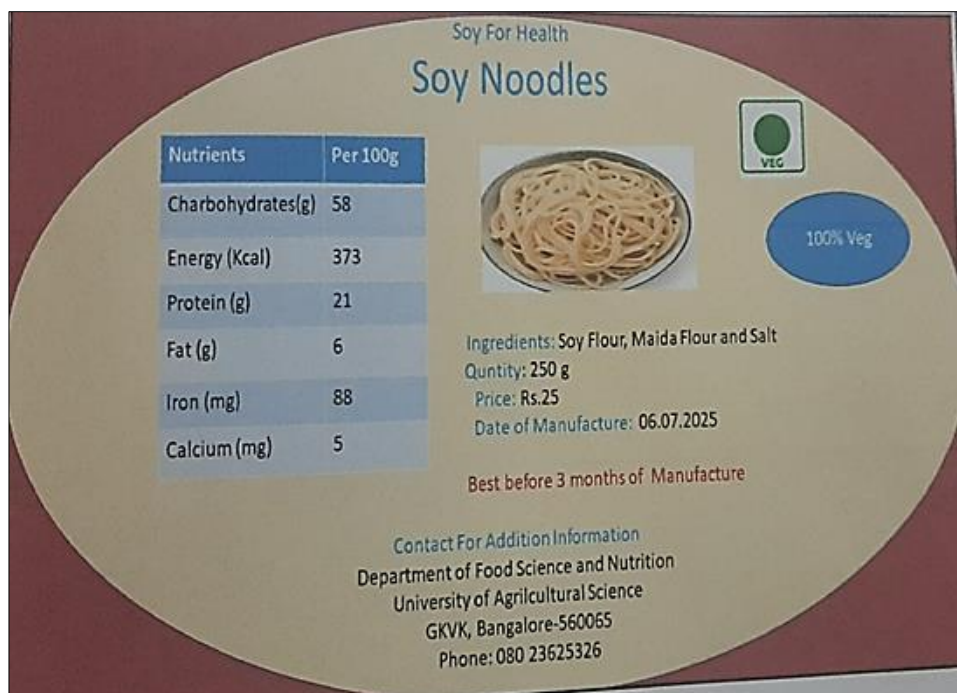


Fig 4: Nutrition labels of soybean value added products

3. Results and Discussion

Indians use variety of pulses in the form of dhals, grams and oil seeds and they have habituated to these traditionally used pulses, though they have characteristics aroma and flavour. Whereas soybean varieties differ in their physico-chemical characteristics and these variations largely influence the quality characteristics such as contents of protein, fat, minerals, phenols, color and flavor of products prepared from the seeds. However, the digestibility and nutritive value of soybean can be further improved by processing. Like any other food grains or pulses, soybean needs processing in the factory or in the kitchen or partly in both through heating, flavoring, de-flavoring and re-flavoring, mixing and spicing of soybean products which can be made

more palatable, digestible and nutritious. In the present investigation, evaluation of JS-335 variety of soybean was performed with respect to different processing techniques. Out of which seven products were standardized and evaluated. Products were subjected to storage for three months.

3.1 Effect of Domestic Processing Techniques on Nutrients

Legumes are commonly subjected to different processing techniques for various purposes such as to reduce cooking time, to make it more palatable with changes in organoleptic characteristics. Some processing methods alter the amount of nutrients present in them.

Table 1: Effect of processing on the composition of Soy flour

Nutrients/100g	Soy raw flour	Soy roasted flour	Soy germinated flour
Protein (g)	40.65	38.61 (-5.01g %)	43.60 (+7.25g %)
Calcium (mg)	275	150 (-45.45mg %)	325 (+18.18mg %)
Potassium (mg)	1310	990 (-24.42mg %)	1560 (+19.08mg %)
Phosphorous (mg)	700	660 (-5.71mg %)	840 (+20mg %)
Tannin (mg)	10.04	7.48 (-25.49mg %)	9.04 (-9.96mg %)
Phytate (mg)	34.46	26.24 (-23.85mg %)	17.94 (-47.93mg %)
Invitro Calcium (mg)	18.50	30.50 (+64.86mg %)	20.50 (+10.81mg %)
Invitro Iron (mg)	8.50	13.90 (+63.52mg %)	9.60 (+12.94mg %)

Effect of processing on the composition of soy flour is presented in Table-1. Although all the treatments such as roasting and germination affected the composition of soy flours, the protein, calcium, potassium, phosphorous, tannin and phytate contents are affected by roasting and germination. Roasting decreased the protein (38.6g %), calcium (150mg %), potassium (990mg %), phosphorous (660mg %) and tannin (7.48mg %) than raw soybean flour. But in contrast, germination treatment increases the protein (43.6g %), calcium (325mg %), potassium (1560mg %), phosphorous (840mg %) and tannin (9.04mg %). Non nutrients were also affected by processing techniques, such as roasting and germination which reduced the phytate

(26.2mg% and 17.9mg% respectively). But *in vitro* calcium and Iron was increased by roasting (30.50mg%, 13.9mg %) and germination (20.5mg% and 9.6mg %).

Sharma et al 2014^[33] conducted a study on the biochemical estimation of raw and processed soybean. He found the results in the present study that, the content of moisture, protein, fat, fiber and minerals is estimated and a comparison of these in the raw and processed samples has been done. Most of the processing techniques increased the protein content in the range of 43 to 47 g/100 g, while soaking reduced the protein content from 43 to 42 g/100 g. Soaking and germination also decreased the fat, fiber content in the range from 18 to 13 g/100 g and 4.8 to 6.00

g/100 g respectively. Roasting alone increased the fiber, ash, carbohydrate contents in the range 5.06 to 6.00 g/100 g, 5.5 to 6.0 g/100 g and 20 to 33 g/100 g respectively. All processing techniques showed an increase in calcium and iron in the range of 245 to 270 mg/100 g, 9.6 to 12.4 mg/100 g, except soaking which showed decrease in calcium and iron content in a range of 245 to 239 mg/100 g respectively. Roasting significantly increases the nutritive value of soybean, so roasted soy flour (RSF) was blended with wheat flour for making noodles. RSF flour at 10, 20, 30, 40, and 50% was used to partially replace wheat flour in noodle formulation, and products thus made were evaluated for sensory quality by a trained panel of five experts.

Similar results were also found in the effect of incorporating soy flour as the quality characteristics of papad with black gram and green gram in different proportions to prepare papad and studied the proximate composition by Deshpande *et al.* (2005) [10]. Results showed that addition of Soy increased the level of protein, fat and ash but resulted in the decrease of carbohydrates.

Vijaykumar *et al.* (2009) [37] studied the impact of millet flour blend incorporation on different characteristics of chapati and glycemic index. Results showed that the incorporation of millet flour blend and soy flour improved the quality of chapati in terms of nutrient density, Glycemic response and taste. Soy flour incorporation had potential health benefits with superior nutritional composition.

Noodles: Effect of storage period on sensory quality of noodles in different packaging materials is presented in Table-2. Results revealed that mean scores for appearance,

texture, aroma, taste, colour and overall acceptability ranged from 4.06 to 3.93, 3.86 to 3.66, 3.53 to 3.33, 3.86 to 3.63, 3.86 to 3.66 and 4.00 to 3.63. Scores of sensory attributes of noodles were higher in the first month followed by successive storage period, but all the sensory attributes showed statistically non-significant. (Table 2).

Soy noodles (20%) stored in polyethylene covers had higher scores for sensory attributes during storage compared to 30 per cent soy noodles stored in corrugated paper box. Highest scores for sensory attributes were recorded for soy noodles of 20 per cent. Less score was observed for 30 per cent soy noodles and least was in control noodles. Lower soy incorporated soy noodles (20%) packed in polyethylene covers had recorded the highest scores for sensory attributes followed by 30 per cent soy noodles in the corrugated paper box, but in control noodles stored in corrugated paper box showed better scores compared to noodles stored in polyethylene covers.

Similar study was conducted by Sharma *et al* (2014) [33], they found that More than 30% incorporation of Roasted Soy Flour (RSF) resulted in decrease in length and thickness of noodles due to loss of binding capacity with the increased proportion of RSF. The overall acceptability scores for four types of noodles including control and those containing RSF in proportions of 10, 20 and 30 per cent, were 8.4, 8.4, 8.3 and 8.3 respectively out of 9, while the values for other blends having higher proportions of 40 per cent and 50 per cent of RSF, reduced to 6 to 5.6. The panel members also reported that more than 30% incorporation of RSF, led to bean type aftertaste. The noodles prepared using RSF up to 30% were therefore found to be fairly acceptable.

Table 2: Effect of storage period on sensory quality of soy noodles in different packaging materials

Mean sensory scores																		
	Appearance			Texture			Aroma			Taste			Colour			Over All Acceptability		
Storage Months																		
1	4.06			3.86			3.53			3.86			3.86			4.00		
2	3.90			3.80			3.56			3.73			3.86			3.80		
3	3.93			3.66			3.33			3.63			3.66			3.63		
F-ratio	0.3161 ^{NS}			0.5799 ^{NS}			1.2186 ^{NS}			0.7872 ^{NS}			0.6685 ^{NS}			1.8358 ^{NS}		
SE _M ±	0.1569			0.1337			0.1143			0.1319			0.1392			0.1355		
CD (5%)	0.4411			0.3761			0.3215			0.3711			0.3914			0.3811		
Packages																		
Polyethylene	4.02			3.91			3.53			3.68			3.75			3.91		
Paper box	3.91			3.64			3.42			3.80			3.84			3.71		
F-ratio	0.3764 ^{NS}			2.9822 ^{NS}			0.7085 ^{NS}			0.5319 ^{NS}			0.3061 ^{NS}			1.6341 ^{NS}		
SE _M ±	0.1281			0.1092			0.0933			0.1077			0.1136			0.1106		
CD (5%)	0.3602			0.3071			0.2625			0.3030			0.3196			0.3112		
Month x Package																		
M1 Poly1	4.13			4.00			3.66			3.80			3.73			4.00		
M2 Poly2	4.00			4.00			3.60			3.73			3.93			4.00		
M3 Poly3	3.93			3.73			3.33			3.53			3.60			3.73		
M1 Pb1	4.00			3.73			3.40			3.93			4.00			4.00		
M2 Pb2	3.80			3.60			3.53			3.73			3.80			3.60		
M3 Pb3	3.93			3.60			3.33			3.73			3.73			3.53		
F-ratio	0.1054 ^{NS}			0.2485 ^{NS}			0.3684 ^{NS}			0.1490 ^{NS}			0.5355 ^{NS}			0.5446 ^{NS}		
SE _M ±	0.2218			0.1891			0.1617			0.1866			0.1968			0.1916		
CD (5%)	0.6239			0.5319			0.4547			0.5248			0.5535			0.5389		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
Polyethylene control	3.5	3.5	3.1	3.4	3.3	3.3	3.0	3.2	2.8	3.2	3.1	3.0	3.5	3.2	3.0	3.4	3.2	3.0
Corrugated paper box control	3.8	3.6	3.3	3.4	3.4	3.3	3.1	2.9	2.9	3.4	3.2	3.1	3.5	3.2	3.0	3.7	3.4	3.2

- **M1:** Polyethylene packaging material used to store Noodles to one month
- **M2:** Polyethylene packaging material used to store Noodles to two months
- **M3:** Polyethylene packaging material used to store Noodles to three months

Similarly, Huh et al (2019) ^[14] conducted a study to develop healthy gluten-free noodles, soy flour was used as a raw material. Hydroxypropyl methylcellulose (HPMC) at different percentages was added to soy flour based on 10% tapioca as a gluten replacement: HPMC at 0% (S), 0.5% (SH1), 1.0% (SH2) and 1.5% (SH3). For soy suspension without any additive, there was no peak viscosity. The addition of tapioca and HPMC increased its peak viscosity to 104 cP and 134 cP, respectively. With the addition of HPMC, the water absorption capacity of the soy noodle was increased from 202% for S to 208% for SH3, while the cooking loss rate was reduced from 24% for S to 22% for SH3. The hardness of the soy noodle was increased from 0.54 N for S to 0.77 N for SH3 which was similar to the hardness of soy noodle with gluten (SG) (0.73 N). SH3 had the highest tensile strength of 439 N/cm², followed by SG (359 N/cm²) and S (188 N/cm²). Thus, HPMC at 1.5% has potential to replace gluten to develop gluten-free soy-based noodles.

Similar study was conducted by Chen *et al.* (2021) ^[9] and they reported that, Effects of part replacement (0, 10, 20, 30 g/100 g) of rice by finger millet (FM) on nutritional properties, sensory properties, *in vitro* digestion and antioxidant properties of composite rice noodles (CRN) were investigated. A 20% blend of FM with rice was selected best used in the rice noodle formulation on basis of sensory evaluation. Rice noodles thus formulated showed low breaking rate (13.33%) and cooking loss rates (14.60%), high content of protein (5.58%), dietary fiber (2.64%), calcium (67.47 mg/100 g), potassium (67.31%

mg/100 g), magnesium (24.72 mg/100 g) and phosphorus (99.35 mg/100 g).

Similar study was conducted by Mangaraj et al 2018 ^[24] on Development of Nutritious Healthy Noodles Incorporating Soy Based Functional Food Ingredients. The textural quality results obtained for S-1, S-2, S-3 test samples and control noodles are presented in Fig. 5. In control sample, there was slightly higher in hardness and less in gumminess as compared to all three substitutions (10% DFSE, 10% FFSF, and 8% SPI). The texture of extruded product depends mainly on the processing parameters, but chemical composition of the ingredients is also important. The high content of protein might have affected characteristics of the starch matrix (i.e., the viscoelastic properties of molten extrudate) so that it no longer holds water vapor, resulting in higher break strength. Significant ($P < 0.05$) change in hardness of control samples was found than rest samples may be due to low protein content (8.27%) which agrees with the report by Leonel *et al.* 2010 and Singh *et al.* (1998) ^[21, 35] reported that addition of fatty acids alters the physical and chemical properties of starchy foods. The springiness in S1-S3 is more elastic to control noodle, which means, these noodles easy to bounce back to its original position. Gumminess is the energy required to disintegrate a semisolid food to a state ready for swallowing and is a combination of hardness and cohesiveness (Mangaraj et al 2018) ^[24]. The gumminess in S1-S3 noodle is pastier than control noodle as there was significant difference ($P < 0.05$) between them. Chewiness is a combination of hardness, cohesiveness, and elasticity. In this study, control noodle is tougher than S1-S3 due to the significant existence between them. The higher value of chewiness, gumminess, cohesiveness and springiness of samples (1-3) may be due to low fat and high carbohydrate content which caused to form inclusion compounds with amylose, with the hydrocarbon portion of the lipid located within the helical cavity of amylose. This agrees with the report by Kaur & Singh (2000) ^[18, 35].



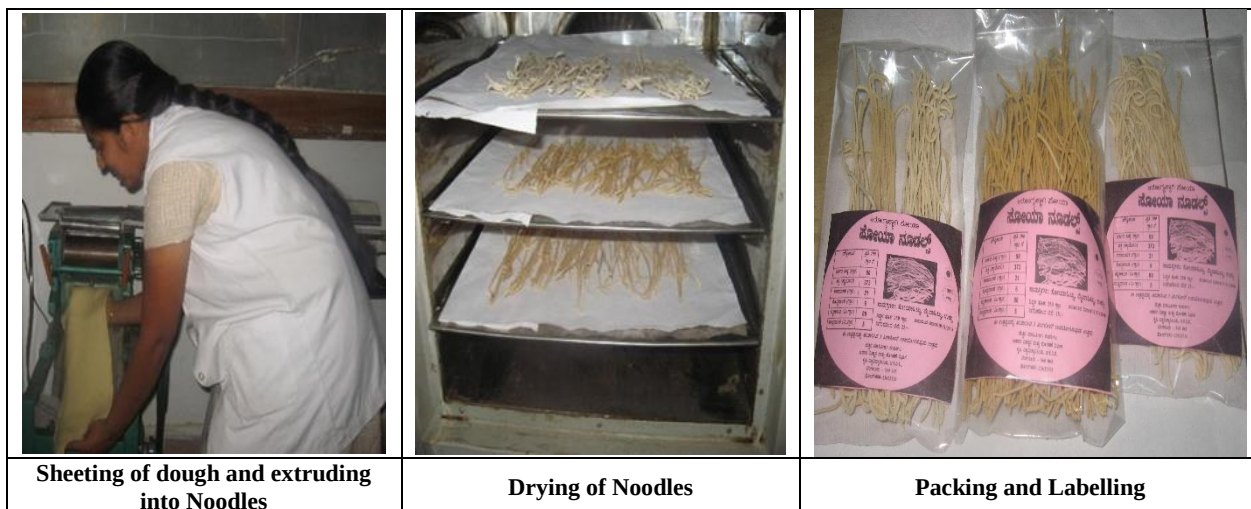


Fig 5: Steps involved in preparation of soybean noodles

Table 3: Effect of storage period (90 days) on nutrients in value added products stored in different packaging materials please check the table

Type of package	Products	Moisture (g)	Protein (g)	Fat (g)	Ash (g)	Crude Fibre (g)	CHO (g)	Energy (Kcal)
Polyethylene covers	Soy noodles	10.20	16.97	5.40	1.24	0.90	65.29	377.64
	Control	12.15	6.48	0.35	0.50	-	80.52	351.15
Corrugated paper box	Soy noodles	10.45	17.42	5.60	1.54	1.04	63.95	375.88
	Control	12.10	6.66	0.43	0.50	-	80.31	351.75

It was found that among the nutrient's moisture (10.45%), protein (17.42%), fat (5.6%), ash (1.54%) and crude fiber (1.04%) contents of soy noodles stored in corrugated paper box recorded higher values than products stored in polyethylene covers (Table3).

Moisture content was higher in control noodles but in contrast protein and fat contents were high in soy noodles compared to control noodles. Crude fiber content was not detected in control noodles.

Carbohydrate (65.29%) and energy (377.64kcal) yield was highest in noodles stored in polyethylene covers than corrugated paper box (63.95% and 375.88kcal). When compared to control noodles, soy noodles showed higher carbohydrate (80%) but yielded less energy (351kcal).

Similar study was conducted by Mangaraj et al 2018 [24]. The study aimed to develop protein enriched soy noodles with Full Fat Soy Flour (FFSF), Defatted Soy Flour (DFSF), and Soy Protein Isolate (SPI) that has acceptable characteristics and contained soy protein 47.0%, 43.2% and 90% respectively of the amount recommended by ICMR/NIN per serving. The DFSF, FFSF and SPI were substituted in wheat flour using 5%, 10%, 15% and 20%,

where SPI was also substitute at 8%. It was observed that the level of DFSF, FFSF and SPI substitution was acceptable from the panelist at 10%, 10% and 8% containing 16.91%, 16.69% and 16.87% protein respectively. The noodles packaged in PET-MET/LDPE and MET-MET/LDPE was not affected by moisture and the product was highly acceptable in comparison to LDPE and PP. To lead a nutritious and healthy life, consumer should take soy fortified noodles into their dai-ly diet. Patil *et al.* (1990) [29] concluded that soy flakes could be stored safely for five months without appreciable rise in free fatty acid. The polyethylene bags and tins were found quite suitable for storage since the product contained about 20 per cent oil. Bargale *et al.* (1991) [5] observed that LDPE packs with higher thickness (125 microns), stored soy flakes safely for 45 days and that with lower thickness (62.5 microns) for 30 days. Laminated with 12-micron polyester/0.009 mm, al-foil/150-gauge LDPE may be preferred over other packages, for its lower water vapor and gas transmission rate, better tensile strength, flexibility and printability for short-term storage of soy flakes under warm climatic conditions.

Table 4: Micronutrient composition of soy value added products

Name of the Nutrients mg/100g	Maida flour	Full Fat Soy flour	Soy noodles (30%)
Calcium	15	275	88
Phosphorous	108	700	292
Iron	4.6	5.4	5
Magnesium	22	247	90
Sodium	1.75	11	7
Potassium	78	1310	91
Copper	--	245	0.52
Manganese	--	2.07	01
Molybdenum	---	0.31	0.01
Zinc	0.7	3.58	01
Chromium	--	3	0.01
Sulphur	--	86	81
Chlorine	--	0.04	33

Table-4. reveals micro-nutrient composition of soy value added products. Soy Noodle had maximum calcium level (88mg) than control sample. Phosphorus content (292mg), Iron (5mg), Magnesium (90mg), potassium (91mg), and sulphur (81mg) and chlorine content was 33mg recorded in #0 percent soy flour incorporated soy noodles than control maida flour.

Similar study was conducted by Awasthi *et al.* (1998)^[4] and studied the properties of products based on soybean, cereals, tubers with varied oil, protein and starch contents. Biscuits containing 15% DSF with Chhana whey and skim milk had greater amount of available lysine (3.12 to 3.32%). *In vitro* digestibility of 15% soy-biscuits ranged from 78.12 to 79.57%. Both 15% soy biscuits containing chhana whey and skim milk had higher protein content (12.92 - 13.12%) and had high calorific value of 460 KCal /100gm. Biscuits containing 15% DSF with Chhana whey/skim milk had high calcium (46.13-49.85% g/100gm), phosphorous (198.22-199.37 mg/100g) and Iron (11.21 to 11.32 mg/100g).

Ayustaningwarno (2025)^[1] conducted a review. His review explores strategies to improve the quality of noodles through substitution and fortification. Substitution is replacing the main ingredient with a more nutrient-denser alternative, such as sweet potato starch, which has been shown to improve the nutritional content of noodles, such as fibre and beta carotene. Meanwhile, fortification is the addition of micronutrients to food products to restore or enhance levels of micronutrients that are not present in the food, which is usually done during the production process. However, substitution and fortification have their challenges. The substitution method usually causes a decrease in the physical quality of the noodles, due to changes in the raw materials, thus reducing consumer acceptance of the final product. Meanwhile, fortified nutrients usually undergo considerable degradation during production, reducing their effectiveness. Further research and development should focus on new methods to help maintain physical quality while minimizing the loss of fortified or substituted nutrients.

Microbial study: It is well known that microorganisms under conducive conditions grow on food and spoil it. Pathogenic microorganisms also contaminate and multiply in food to higher level and cause infection or produce toxins which upon consumption can cause food poisoning. Different types of microorganisms responsible for food borne illness are viruses, bacteria, yeasts, molds and protozoa. Biological contamination of food plays an important role in the transmission of diseases to humans.

Table 5. Microbial counts (10^{-2} cfu/g) of different Soy value added products stored for a period of 90 days in different packaging materials

Soy value added products	Polyethylene cover	Corrugated Paper box
Mould		
Noodles	0.00	0.00
Yeast		
Noodles	23	13.5
Bacterial counts		
Noodles	23	5.5
Spores		
Noodles	12.5	5

Molds: Maximum number of mold count was recorded in value added products stored in polyethylene covers (0.05 to

0.45×10^{-2}) than paper box. But noodles did not show the mold counts in any of the stored packaging products (Table5).

The total microbial count on the first day was less than 10 CFU/g, which increased over time. The microbial count at room temperature was lesser than at higher storage temperatures. As expected, the total microbial count of the samples increased over time. To increase stability, the water content of the product has to decrease. (Shahabinijad *et al* 2024)^[31].

Yeast: Higher number of yeast counts was observed in products stored in polyethylene covers (1.15 to 23×10^{-2}) followed by products stored in corrugated paper box (11 to 13.5×10^{-2}), among the products noodles showed more number of yeast counts (23×10^{-2}) than other microbes. **Bacteria:** Products stored in polyethylene covers showed higher number of bacterial count (1.60 to 23×10^{-2}) than products stored in other packaging materials. Among the products noodles had higher bacterial count (23×10^{-2}). **Spores:** Products stored in polyethylene covers showed higher number (0.2 to 19×10^{-2}) of spores count than products stored in other packages. With regard to the soy Noodles 12.5×10^{-2} spores counts were recorded. But mould counts were not appeared in stored Soy noodles.

Similar shelf-life study was conducted by undertaking microbial study of noodles packed in different packaging material's viz. HDPE and LDPE by Pakhare 2016 and results showed that^[26].

Though TPC of HDPE packed noodles was between 0.1×10^2 and 0.35×10^2 CFU/gm during whole tenure of study. The yeast and mold count was ranged from 0.06×10^2 to 0.12×10^2 CFU/gm. Simultaneously LDPE packed noodles showed TPC from 0.1×10^2 to 0.42×10^2 CFU/gm and yeast and mold was between 0.06×10^2 and 0.26×10^2 CFU/gm while study. The comprehensive study of shelf life demonstrates that HDPE packed noodles have better shelf life than LDPE packed noodles as it having less microbial growth.

The present study reflects the preparation of a commonly consumed staple food, noodles, using composite flours such as wheat, sweet potato and sago that is nutritionally enriched with essential minerals and fibers having various health benefits. Noodles were prepared using blends of wheat, sweet potato and sago flours in different proportions of 100:00:00, 90:05:05, 85:10:05, 80:15:05, 85:05:10, 80:10:10 and 75:15:10 to formulate seven samples named as S0, S1, S2, S3, S4, S5 and S6. These formulated noodle samples were packed in polyethylene bags and subjected to shelf-life studies for microbial and oxidative analysis at 0 days, 30 days, 60 days and 90 days of storage at room temperature. Results showed that even after 90 days of shelf life.

There was no remarkable change in the texture, flavor, yeast and mould growth also E.Coli. However, slight gradual increases were observed in total plate count, moisture content, free fatty acid and peroxide value. Therefore, the prepared noodle exhibited shelf stability, preserving their quality for upto 90 days at room temperature and hold promise for popularity among health conscious individuals. Another study conducted by Devaraju *et al.*, (2006)^[11] and he concluded that there is no coliform count development in pasta products during three months of storage period. Chandrasekhar *et al.*, (2003)^[6] evaluated microbial load of fore most widely and frequently consumed foods. Coliforms

were present in all the samples of food (16 to 25 MPN/g). Faecal coliforms were found in all the samples except homemade foods, indicating relative inferior quality of outside food. The least microbial contamination was found in omelette samples. Water samples used for cooking and drinking purposes collected from street vendors revealed

high density of coliforms (860/ml) followed by restaurant samples (560/ml). Home water sample showed least (120/ml) of *E. coli* but not fecal coliform.

a) Investment or Fixed cost

Table 6: Cost of production and selling of soy noodles

Essential equipments	Price (Rs)	Economic life (Years)	Depreciation / Year	Depreciation / Month	Depreciation / Day
Electronic balance	5000	8	800	66.67	2.22
Vessels	3000	8	480	40.00	1.33
Hot air oven	25000	10	5000	416.67	13.89
Gas stove	3000	10	480	40.00	1.33
Sealing machine	850	8	136	11.33	0.38
Noodle machine	48000	10	9600	800	26.67
Total	84,850	-			45.82

- Depreciation / Year = Price of Essential equipment x 0.02
- Depreciation / Month = (Value of Depreciation/Year)/12
- Depreciation / Day = (Value of Depreciation/Month)/30
- Interest on Investment@12.75% = 84850×0.1275
- = 10818/year
- = 901.53/month
- = 30.05/day
- Total Investment/day = Depreciation/day + Interest on Investment
- = 45.82 + 30.05
- Total Investment = Rs 75.87/day

b) Variable cost

Variable items	Price (Rs/Kg)	Quantity (Kgs)	Cost of 10Kg production
Maida flour	18	7	126
Soy flour	34	3	102
Salt	9	0.25	2.25
Gas	330	0.5	12.69
Electricity	4/unit	10 units	40
Packing & Labeling	0.25 + 0.25/piece	40 + 40 pieces	20
Labour	60	1 / 2 day	120
Water	15/month	Required amount	0.50
Delivery charges	100	100 / person/day	100
Total			523.44

- Interest on Variable cost @12.75% = 523.44×0.1275
- = 66.73/year
- = 5.56/month
- = 0.21/day
- Total Variable cost /day = Variable cost/day + Interest on variable cost
- = $523.44 + 0.21$
- = 523.65
- Total production cost = Fixed cost + Variable cost + Profit
- = $74.87 + 523.65 + 25\%$
- = $599.53 + 25\%$
- = $599.53 + (599.53 \times 0.25)$
- = $599.53 + 149.88$
- = $749.41 / 9.5 \text{ Kg}$
- Unit cost = 78.88 / Kg
- Selling cost = 100 / Kg
- Profit = (Selling cost - unit cost) + 25% profit/kg
- Profit = $(100 - 79) + 16$
- Profit = Rs 37/kg

Stree shakti group's (SHG) are mutual help organizations formed by a group of people together to help each other and are essentially democratic in nature (Hagenbuch, 1958) [13]. Weekly savings and micro credit to rural women encouraging them to enter in to entrepreneurial activities.

Entrepreneur is a business leader, disequilibrating force, bearer of borrower's risk who has a role in fastening of economic growth and development. Entrepreneurship is one of the most important inputs in the economic development of a country or a region.

Similar study conducted by Velusamy *et al.* (2008) [36] and he reported that out of 16 SHG's, three SHG's were engaged in value addition activities such as jack fruit RTS beverages, vegetable pickling and preparation of weaning foods and most of them sold their products to nearby families. Trainees prepared 3000 ml of fruit juice every day and earned Rs:2500/- per month from RTS beverage, 24 kg of pickle per month and earned Rs:2000/- per month, 50 kg of weaning food per month and obtained income of Rs:3000/- per month.

Similar study conducted by Ntukidem *et al* 2023 [17]. Gluten-free noodles developed from composite blends of rice flour (X1), soybean flour (X2), corn starch (X3) and potato starch (X4) using I-optimal mixture design were evaluated for their quality and sensory attributes. All the statistically significant terms such as R², F value and lack of fit show the adequacy of the model. It is also reported that soybean flour had a significant impact on the protein, carbohydrate, appearance, texture, taste and overall acceptability of rice soy noodles. Current research suggests the effect of corn and potato starch had a significant ($P < 0.05$) effect on the textural attribute of gluten-free noodles. Furthermore, due to their

high protein level, these noodles can be used as part of mid-day meals to overcome the problem of protein energy malnutrition.

4. Conclusion

The value-added soy products developed in the present study being nutrient dense with good acceptability and storage stability could serve as a good substitute to fulfill the nutrients needs of vast population. The cost of the developed products would also ensure its affordability by all class of people. Keep concise and evidence-based.

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Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

References

1. Ayustaningwarno F, Suryaputra A, Anjani G. A review of enhancing noodle quality: Fortification with micronutrients and substitution with nutrient-dense alternative. *J Food Sci.* 2025;90(1):e17677. <https://doi.org/10.1111/1750-3841.17677>
2. Amerine MA, Pangborn RM, Roessler EB. Principles of sensory evaluation of food. New York: Academic Press; 1965. <https://doi.org/10.1016/C2013-0-08141-7>
3. Association of Official Analytical Chemists (AOAC). Official methods of analysis. 13th ed. Washington, DC: Association of Official Analytical Chemists; 1980. <https://www.aoac.org/official-methods-of-analysis/>
4. Awasthi P, Yadav MC. Effect of incorporation of liquid dairy by-products on nutritional quality of soy biscuits. In: Proceedings of the 4th International Food Convention; Mysore, India; 1998. p. 174. <https://arccjournals.com/journal/asian-journal-of-dairy-and-food-research/ARCC5546>
5. Bargale PC, Joshi KC, Jha K. Storability of soy flakes in different packaging materials under warm conditions. *Indian J Nutr Diet.* 1991;28(5):140-145. <https://doi.org/10.37648/ijnd.v28i5.14851>
6. Chandrasekhar U, Kowsalya S, Ladha P. Proximate composition, microbial and chemical contamination of street vended foods versus homemade and restaurant foods from Kochi, Kerala. *J Food Sci Technol.* 2003;40(1):58-62. https://www.researchgate.net/publication/289652104_Proximate_Composition_Microbial_and_Chemical_Contamination_of_Street_Vended_Foods_Versus_Home-Made_and_Restaurant_Foods_from_Kochi_Kerala
7. Charutigon C, Jitpupakdree J, Namsree P, Rungsardthong V. Effect of processing conditions and the use of modified starch and monoglyceride on some properties of extruded rice vermicelli. *LWT Food Sci Technol.* 2008;41(4):642-651. <https://doi.org/10.1016/j.lwt.2007.04.009>
8. Chauhan OP, Chauhan GS. Anti nutrients in soybean at different stages of soy milk production. *J Food Sci Technol.* 2007;44(4):378-380. <https://www.cabidigitallibrary.org/doi/full/10.5555/20073149825>
9. Chen J, Wang L, Xiao P, Li C, Zhou H, Liu D. Incorporation of finger millet affects *in vitro* starch digestion, nutritional, antioxidative and sensory properties of rice noodles. *LWT.* 2021;147:112145. <https://doi.org/10.1016/j.lwt.2021.112145>
10. Deshpande S, Jha K, Singh V, Varghese S. Studies on soybean blended papads with blackgram (*Phaseolus mungo*) and greengram (*Phaseolus aureus*). *Indian J Nutr Diet.* 2005. <https://informaticsjournals.co.in/index.php/ijnd/article/view/6469>
11. Devaraju B, Begum M, Begum S, Vidya K. Storage and microbial quality of pasta from finger millet composite flour. *Indian Food Packer.* 2006;60(4):141-145. <https://agris.fao.org/search/en/records/IN2007000155>
12. Gopalan C, Rama Sastri BV, Balasubramanian SC. Nutritive value of Indian foods. Hyderabad: National Institute of Nutrition, Indian Council of Medical Research; 1999. <https://library.wur.nl/WebQuery/titel/337579>
13. Hagenbuch W. Social economics. London: James Nisbet & Co. Ltd.; 1958. <https://www.worldcat.org/title/social-economics/oclc/2211070>
14. Huh HJ, Shin WK, Kim Y. Textural and cooking qualities of noodles made with soy flour and hydroxypropyl methylcellulose. *Int Food Res J.* 2019;26(2):421-428. [http://www.ifrj.upm.edu.my/26%20\(02\)%202019/\(07\).pdf](http://www.ifrj.upm.edu.my/26%20(02)%202019/(07).pdf)
15. Hou GG. Introduction to Asian noodles. In: Hou GG, editor. Asian noodle manufacturing: Ingredients, technology, and quality. Cambridge: Woodhead Publishing; 2020. p. 1-12. <https://doi.org/10.1016/B978-0-12-812873-2.00001-7>
16. Fuad T, Prabhasankar P. Influences of India's local wheat varieties and additives on quality of pasta. *Food Bioprocess Technol.* 2012;5(5):1743-1755. <https://doi.org/10.1007/s11947-011-0679-3>
17. Ntukidem OJ, Barber LI, Emelike NJT. Optimization of ingredients for the production of noodles made from rice flour, soybean flour, corn and potato starch - I-optimal mixture design. *Afr J Food Sci Technol.* 2023;14(7):1-13. <https://doi.org/10.14303/ajfst.2023.031>
18. Kaur K, Singh N. Amylose-lipid complex formation during cooking of rice flour. *Food Chem.* 2000;71(4):511-517. [https://doi.org/10.1016/S0308-8146\(00\)00202-8](https://doi.org/10.1016/S0308-8146(00)00202-8)
19. Kulkarni SD, Joshi KC, Venkatraj J, Venkatraghavan U. Extrusion cooking of soy-cereal and tuber blends: Product properties. *J Food Sci Technol.* 1997;34(6):509-512. <https://pmc.ncbi.nlm.nih.gov/articles/PMC3550890/>

20. Lambert EI, Kalpan AH, Kolasky WJ, Dotzlel MM. Easy-to-read guide for nutrition labeling for dietary supplements. Washington, DC: Council for Responsible Nutrition; 1994.
<https://www.ncbi.nlm.nih.gov/books/NBK208873/>
21. Leonel M, Martins JC, Mischan MM. Produção de snacks funcionais à base de farinha de soja e polvilho azedo. *Cienc Rural*. 2010;40(6):1418-1423.
<https://doi.org/10.1590/S0103-84782010000600024>
22. Limroongreungrat K, Huang YW. Pasta products made from sweet potato fortified with soy protein. *LWT Food Sci Technol*. 2007;40(2):200-206.
<https://doi.org/10.1016/j.lwt.2005.09.012>
23. Mangaraj S, Stripathi MK, Ali N. Handbook of nutraceuticals and functional food: Soybean as an example. New Delhi: Satish Serial Publication; 2013.
<https://www.scribd.com/doc/120613065/Handbook-of-Nutraceuticals-and-Functional-Foods>
24. Mangaraj S, Swain S, Deshpande SS. Development of nutritious healthy noodles incorporating soy based functional food ingredients. *J Food Sci Nutr*. 2018;4(1):100028.
<https://doi.org/10.24966/FSN-1076/100028>
25. Olorunsogo ST, Adebayo SE, Orhevba BA, Awoyinka TB. Development, optimization and characterization of enriched noodles. *J Agric Food Res*. 2023;14:100651.
<https://doi.org/10.1016/j.jafr.2023.100651>
26. Pakhare KN, Dagadkhair AC, Udachan IS, Andhale RA. Studies on preparation and quality of nutritious noodles by incorporation of defatted rice bran and soy flour. *J Food Process Technol*. 2016;7(10):629.
<https://doi.org/10.4172/2157-7110.1000629>
27. Park S, Liu M. A positive causal relationship between noodle intake and metabolic syndrome: A two-sample Mendelian randomization study. *Nutrients*. 2023;15(9):2091. <https://doi.org/10.3390/nu15092091>
28. Prasad NN, Swamy MS, Sha BST, Semwal AD. Protein quality of sorghum-soy based extruded snack food. *J Food Sci Technol*. 2007;44(2):165-167.
https://www.researchgate.net/publication/287447440_Protein_quality_of_sorghum-soy_based_extruded_snack_food
29. Patil RT, Shukla BD, Gandhi AP. Studies on shelf life and acceptability of soyflakes. *Indian J Nutr Diet*. 1990.
<https://www.informaticsjournals.co.in/index.php/ijnd/article/view/7838>
30. Raghuramulu N, Nair KM, Sundaram KS. A manual of laboratory techniques. Hyderabad: National Institute of Nutrition, Indian Council of Medical Research; 2003.
https://www.nin.res.in/priced_publications.html
31. Shahabinijad F, Ghorbani M, Abbaszadeh S, Nejatian M, Taghdir M. Functional instant noodle formulation for emergency conditions: Sensory and stability characteristics. *Food Sci Nutr*. 2024;12(7):4605-4614.
<https://doi.org/10.1002/fsn3.4062>
32. Shanthi P, Johnkennedy Z, Parvathi K, Malathi D, Thangavel K, Raghavan GSV. Studies on wheat based composite flour for pasta products. *Indian J Nutr Diet*. 2005;42(11):503-508.
<https://informaticsjournals.co.in/index.php/ijnd/article/view/4841>
33. Sharma D, Gupta R, Joshi I. Nutrient analysis of raw and processed soybean and development of value-added soybean noodles. *Inventi Rapid Life Style*. 2014;2014(1):1-5.
34. Sowbhagya CM, Ali SZ. Vermicelli noodles and their quality assessment. *J Food Sci Technol*. 2001;38(5):423-432. <http://eprint.cftri.res.in/1444/>
35. Singh N, Cairns P, Morris VJ, Smith AC. Physical properties of extruded wheat starch-additive mixtures. *Cereal Chem*. 1998;75(3):325-330.
<https://doi.org/10.1094/CCHEM.1998.75.3.325>
36. Velusamy R, Sathiah N, Manjula. Case study of SHGs on value addition training. In: Self-help groups for rural upliftment: Emerging extension issues and strategies; Tiruchirapalli, Tamil Nadu; 2008. p. 95.
37. Vijaykumar PT, Mohankumar JB, Jaganmohan R. Quality evaluation of chapatti from millet flour blend incorporated composite flour. *Indian J Nutr Diet*. 2009;46(4):144-154.
<https://doi.org/10.21048/ijnd.2009.46.4.4381>