A Project Report on

Textured Soy Protein Products

(Nuggets & Granules [*Soy Bari*])

INTRODUCTION

In general, there are several key issues associated with food processing such as screening and purification of ingredients, applying physical and chemical treatment aimed at adding food value, assuring safety and efficiency/convenience in use, and matching the product to consumers' tastes, preferences and habits. A wide range of ingredients combined in varying proportions along with diverse but specific treatment of these ingredients provides a vast range of possible permutations, which may be tailored to suit the needs, tastes, flavor palatability and food value depending on the specific target consumers.

Consumers' requirements to be addressed in processed foods fall into three major categories:

a) Taste, flavor, texture, convenience, food habits and economy;

b Food and nutrition values and palatability of a formulation for different target consumers from the point of view of health and nutrition;

c) Purity requirements, microbiological safety, nutritional quality/efficiency and regulatory norms-on-foods.

This article addresses all these aspects of developing processed soy foods, while focusing on textured vegetable products such as soy nuggets and granules. This article has been prepared considering a semi automatic extruder 1ine with 200 kg per hour capacity, 20 working hours per day and 300 workdays per year.

THE PRODUCT

Soy Bean

Soy bean, like any other pulses, is a leguminous crop but with high nutritional value. It has about 40 % good quality protein and 20% oil. Native to South East Africa and China, soybean was imported into the USA over fifty years ago and now has grown to be a principal agricultural produce of North America. Although a major producer of soybean, the USA uses very little soy protein as human food, although consumption is increasing. On the other hand, South East Asian countries use considerable quantities in the form of tofu, bean curd, soymilk, etc. Developed and developing countries alike are finding ever-increasing

consumer acceptance and use of soy as human food in various forms. The future is therefore bright for entry into this market.

Relevance to India

Soybean was imported into India about 35 years ago and was initially grown in some of the northern states like Uttar Pradesh, Madhya Pradesh and Bihar. It is now being increasingly grown in a larger number of states. The virtues and value addition potential of the crop has resulted in increasing acreage planted under this crop. Today, even southern states like Karnataka, Tamil Nadu and Andhra Pradesh have substantial areas under soybean cultivation. As a result, solvent extraction and other soybean processing industries have expanded considerably in these regions. Also, southern Maharashtra has grown into a strong soybean cultivating area with a good number of solvent extraction industries. In general, then, given the wide availability of the raw material, there are excellent opportunities for greatly increasing the processing of soybean for value addition foods.

Major soy producing states are Madhya Pradesh (61 % of total Indian production), Maharashtra (27%), Rajasthan (9%) and Andhra Pradesh (1%).

Extrusion Technology: A Means to Enrich Soya Foods

Extrusion cooking, one of the novel techniques of food processing with great versatility and a wide range of application, has great potential in the food industry in developing countries like India. Conventional thermal processing results in considerable loss of nutrients like B complex vitamins (losses of up to 15-60%) and certain minerals like calcium, iron and zinc. While extrusion cooking being a high temperature short time process causes minimum losses while yielding a better product. In addition to processing advantages and better nutritional quality, extrusion cooking produces a product with improved microbial quality, as the process destroys heat labile anti-nutritional factors and enzymes that cause problems during storage and deteriorate product quality.

Soybean, as it comes from the field, cannot be used directly for human consumption even if cooked like normal pulses, since it requires much higher pressurized cooking. Also, by simply cooking as a pulse, it has relatively less pleasant flavor and odor. In addition, raw or undercooked soybeans contain certain anti-nutritional factors, which are of course undesirable. Extrusion technology eliminates all these inhibiting factors. It cooks completely, thus requiring no repeat cooking. Unpleasant flavors are greatly removed and all anti-nutritional factors are completely eliminated, while nutritive values are maintained.

Extrusion of soybeans was first tried in the USA and patented. This technology was first bought to India by a missionary foundation, the 'Soya Products Research Association', in Bareilly (U.P State), for preparation of nutritional supplement food for feeding programs of the Government of India.

Commercial exploitation of soy protein as human food using extrusion technology was first realized by Mysore Snacks Foods Limited, Bangalore followed by the Khaira District Co-operative Milk Producers Union at Anand, both mainly for preparing foods for feeding programs. Commercial manufacturing and marketing of extruded products was started first with the launching of Meal Makers by Mysore Snack Foods. Voltas and others soon followed.

Unique Features of the Product (Granules and Nuggets)

There are a number of benefits associated with these and other extruded soy products:

- The process totally destroys anti-nutritional factors associated with soy, thus making the product completely safe for human consumption;
- The product is free of fat and cholesterol, while at the same time providing good quality protein, which is important for all age groups under all conditions or with any diet constraints;
- It is precooked and therefore does not require re-cooking. It becomes reformulated within minutes of mixing with desired dishes.
- Already cooked and controlled in sophisticated conditions, it is light and easily digested; it easily assimilates into the digestive system making ii highly palatable;
- The highly sophisticated and versatile extruder used for this process is automatic, thus helping greatly in ensuring hygienic conditions throughout whole processing. The product is microbiologically safe and secure;
- It is dry, hard and solid and is therefore quite convenient and safe to transport and store for well over one year, as long as it is out of reach of water or moisture;
- Extrusion cooking of soy yields a product which is 100% vegetarian, but which goes ideally with non-vegetarian preparations as well.
- The product is 50 - 52% protein on a dry basis, making it one of the richest protein foods available.
- The product is bland in the neat form and therefore blends beautifully with any sort of food preparation. It adapts itself naturally and completely and is therefore most versatile.

MARKET TRENDS

Soy nuggets or granules, technically termed textured soy protein (TSP), are a potent food product. They are versatile, economical and convenient for consumption by all classes of consumers on all occasions. In India, with its rapidly growing population, this product has unlimited potential. The product in bulk economy pack has already grown to a dominating position, setting a market trend.

Trends

Although this growth was initially slow, the acceptance of TSP as a principal ingredient in daily food has gained not only momentum over the years but has shown commendable penetration into different markets and among different classes. By its nature, the product goes exceptionally well with non-vegetarian and Indian spicy dishes. As the product is a convenient, protein-rich and affordable substitute to fresh vegetables, it has found particularly wide acceptance in regions and seasons that witness a scarcity of fresh vegetables. At the same time, usage is increasing among the middle classes, given

increasing health concerns. Yet, there are still many sizable pockets of the market that are unexploited and the potential for growth in the production and consumption of granules and nuggets is very great.

Bulk Commodity Segment

The bulk commodity segment has been expanding at a rate well over 10% annually despite only marginal promotional efforts. Production for this segment now stands at about 80,000 MT per year. As such, each year over 20,000 MT are added to this segment. Wide availability/distribution in the already-strong portions of the market has accounted for most of this growth. Regions of the country where the market is weaker have seen a slower pace of growth, especially when distribution has been poor. However, the emergence of a larger number of companies in the organized sector getting into this bulk field is bound to result in wider and more intensive distribution and promotion. The southern and western parts of the country, which are still under-exploited, will likely be the principal new markets for some of these new entrants into bulk nuggets and granules production. In the past few years eastern markers are growing very significantly for these products. Today, the bulk commodity market is dominated by Ruchi Soya Ltd., which has about 50% share of the segment.

Branded Market Segment

This segment has substantial value addition and better margins, and is more promotion-oriented. Ruchi Soya Ltd. (Nutrella™) currently has major market share. With new entrants launching their product in the market and promoting it, growth in the branded market of 30% per year for at least the next five years may be expected.

Scope for the Product: Demand Potential

Even with good growth in production/sales, there is still vast potential for much more sizing up. For example, in Maharastra and Gujarat, which are two major and relatively affluent markets, the potential for nuggets and granules is unexploited, at least on an organized scale. This unexploited market is potentially not less than 5,000 MT/month (conservative estimate). An aggressive company willing to promote / advertise would have scope for considerable profit. Also, the south in general is untouched. And this is a part of the country where it is generally believed that people are more accepting of new food ideas than, say, in the north.

Marketing Suggestions

Market conditions suggest that the product in 20 kg bulk bags should be first introduced, perhaps most profitably in the south and west regions. The branded product can be marketed in 250 gm printed carton packs. Marketing/advertising would be required, for example, demonstrations of special recipe preparations and use of the local print media.

MANUFACTURING PROCESS

Extrusion Technology

The extruder was first produced by Wengers in the USA. The machine consists of a barrel in which the food material (soybeans) is carried by a turning screw, and is subjected to intense frictional stress, which generates heat under high pressure. The heat and pressure reach a maximum by the time the food material reaches the terminal end, where it is ejected through the nozzle. The texture of the product undergoes considerable change during passage through the barrel, from globular to fibrous, and when the material comes out through the nozzles, it expands to give a porous texture preferred for human consumption. Due to the high pressure and high temperature cooking in the barrel, anti-nutritional factors get destroyed while maintaining the nutritional properties. The extruder is very flexible equipment. It can be used for any flour or combination of flours. The texture of the product can be varied from fully expanded, to tightly compact meat-like products. The length of the cooking barrels can be changed. As the product emerges, it is cut using suitable rotating cutter knives. The shape of the final product can be altered suitably be altering the dies and the cutting arrangement.

The Extrusion Process and Controls

1. The raw material for extrusion is deoiled soy flour usually supplied by the solvent extraction mills as flakes. The quality of the raw material has to be very carefully checked in a quality control laboratory. The Bureau of Indian Standards has formulated specifications for defatted edible grade soy flour. However, it is recommended that each manufacturing unit should have its own specifications, which may vary from product to product. Before the material is accepted, some of the criteria to be checked are colour, nitrogen content, fat, fibre, ash, and sand silica content. The quality of extrusion depends on these specifications.
2. When accepted, the material is passed through mills to get a uniform powdered grade and sieved to separate all foreign materials.
3. The material is then elevated to the mixing bins, where it is blended with other materials if needed and passed onto the extruder.
4. The material is fed to the extruder and a predetermined amount of water is injected. Then, the material is passed through the first part of the extruder where in it is mixed well to form dough. In the second part, the pressure is gradually increased. If necessary, some steam is also admitted at this stage.
5. In the final stage the temperature and steam pressure in the barrel increases when the material passes through the screws. Finally the material is ejected out of the fine nozzles as strands.
6. The emerging strands are cut to the shape and size as required by the revolving knives. The cut pieces are conveyed by a belt conveyer to the drying chamber where the material continuously passes over conveyer belt in a hot air drier.
7. The dried material is conveyed over magnetic screen systems to remove any iron particles, and taken to the nest of shaking sieves. After this, the material is graded.

8. The graded material is passed on to the packing room (which has to be kept clean and air conditioned), and either mechanically or manually packed in cardboard containers or bulk bags.
9. The final product before it goes into the packing room is sampled and tested in the quality control laboratory, to ensure that it meets all quality specifications.
10. By varying the composition of the mix at the stage of the mixing bin, before the material enters the extruder, it is possible to produce various types of foods.
11. The critical conditions in the process are:
    - Quality of the raw material and input rate, water flow rate;
    - Type of screw used, its quality and the die design;
    - Temperature conditions and movement of the material in the barrel;
    - The nature of the cutter and the speed of the cutting;
    - The design hot air drier and drying temperatures;
    - The quality control of raw materials, the finished product, the packing material, etc.

COMMON PROBLEMS WITH SINGLE SCREW EXTRUDERS

1. Long barrel extruder should be for TVP and short barrel extruder is for snacks.
2. Cut flight screw should be at the end with no spacing for making snacks. While for making TVP it should be (cut -flight) at the middle so that the material will get enough time for texturization. Also there should be at least six-inch spacer after the screw before die.
3. Extruders can be used to make soy fiber also. First soy hulls should be washed in running water then dried followed by dry, extrusion. Soy fiber can be used in bakery products.
4. A pre conditioner is must for making good quality TVP. Functions of a pre conditioner are for mixing water, raw material, and increase temperature to 60-80°C and holding. Length of pre conditioner should be 1-3 min.
5. For making FFSF pre conditioner is not required.
6. Depending on RM (for low PDI More retention time) Pre conditioning time varies.
    a. RM for TVP should be about 70 PDI/with 100 mesh.
7. Maximum of 0.5 of lecithin will improve texture and flow of raw material in extruders.
8. Additives:
    a. H_2O_2, titanium oxide to improve color
    b. Carmel for beef color
    c. NaOH for texturization.
9. Bulk density moisture content, temperature and pressure.
    a. Lower the moisture content lower will be the bulk density

b. Lower the temperature higher will be the bulk density.

c. Lower the pressure high bulk density.

10. To reduce pressure: increase holes in the die, lower shear locks, and reduce cut flights.
11. Vibratory screen at the end of drier can be used to collect uniform product.
12. Surging can due to inconsistent feeding. The feeding and die size and holes should be as per extruder capacity.
    a. Big capacity extruders but lower feeding.
    b. Feeding of RM should match extruder capacity,
    c. If last section is too hot (running cold water in the last section of barrel will solve surging).
13. Not more than 5%-extruded fines can be re used for extrusion.
14. Plastic liner bags with nitrogen flush and heat sealing will help to have better shelf life.

PLANT MACHINERY

The important items of plant and machinery required for the project are given listed below:

Sl.No.	DESCRIPTION
01	Main extruder with complete fittings
02	Plate Grinder mills
03	Granulator/flaker
04	Tray drier with electrical coil heaters
05	Weighing scales
06	Sealing machines
07	Bag stitching machines
08	Gravemetric filling Machines
09	Packing line fixtures
10	Quality control equipment
11	Generator set (optional)

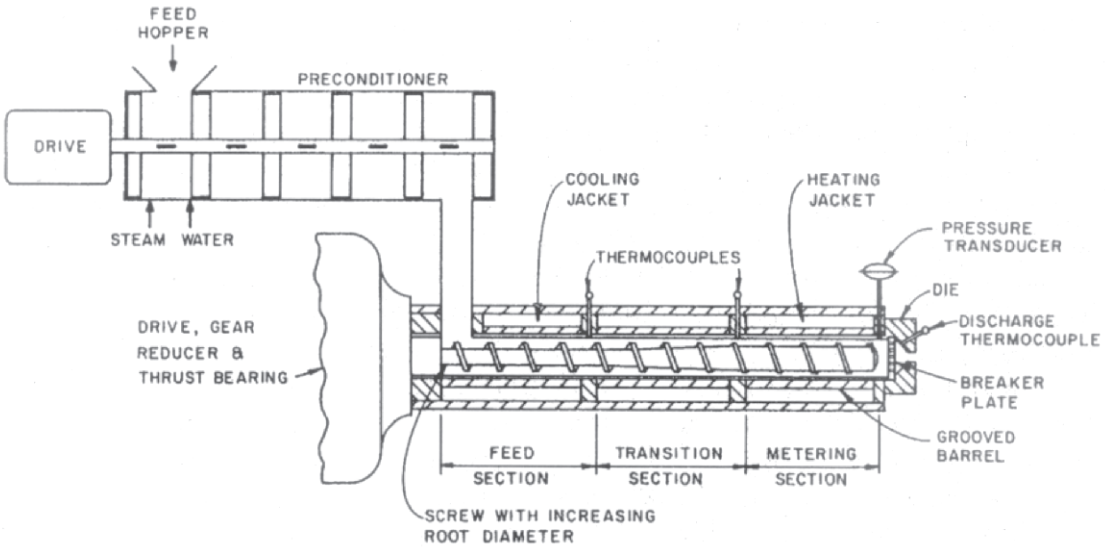
This plant and machinery is a semi-automatic fine and requires only 5/6 labourers per shift for production. Please see appendix VI for a sample TVP project.

PERSONNEL

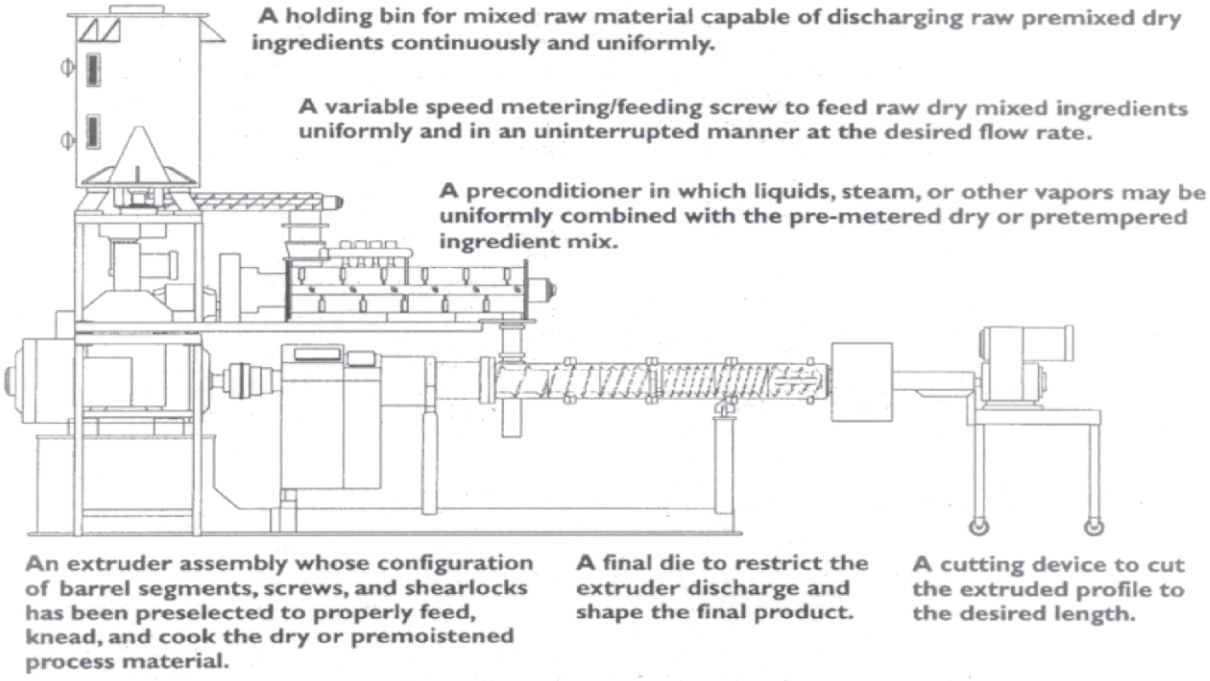
This project will require the following personnel to manage the production and quality control activities for 20 hrs productions per day:

PARTICULARS	NUMBER
Plant Manager	1
Shift supervisors/chemists	6
Skilled Workers	5
Semi - skilled workers	7
Unskilled worker's	9
TOTAL	**28**

Apendix I



Mechanical Features of Single-screw extruder (From: Extrusion Cooking, Mercier, C. Linko, P. and Harper, J.M. eds. American Association of Cereal Chemists, St. Paul, MN, 1989)



Complete Single-screw extruder configeration (Courtesy of Wenger Manufacturing Company, Sabetha, Kansas)

Apendix II

RAW MATERIAL

Edible grade defatted soy flour, obtained from cleaned and dehulled beans, is the principal input material. This is a by-product from solvent extraction plants. The material must meet the required norms and specifications, as the extruder is very sensitive to variations in the defatted soy flour. The quality of the end product depends upon these characteristics. Soy oil extraction activity is concentrated in the states of Madhya Pradesh and Uttar Pradesh, and, as a result, the major supply of raw material comes from these states.

The major suppliers of good quality raw material are:

- Ruchi Soya Industries — Indore
- General Foods Ltd. — Indore
- Prestige Foods Ltd. — Indore
- Rasoya Proteins Ltd. — Mumbai
- Shakti Soya Ltd. — Coimbatore
- Sonic Biochem — Indore
- Surya Agro Oils Ltd. — Bhopal
- Vippy Solvex Extractions Ltd. — Devas

In the last decade, soy cultivation in the states of Andhra Pradesh, Gujarat, Karnataka and Maharashtra has grown so much that oil extraction has also started in a big way and technology for developing edible grade defatted soy flour is also being mastered in these regions. Good quality-material should therefore be easily available from these units.

Indian and US Standards for Defatted Soy Flour

Characteristics	Indian Standard[1]	US Standard
Moisture (max)	9.0 %	8.0 %
*Protein (min)	48 %	50 %
*Total Ash (max)	7.2 %	6.5 %
*Acid Insoluble Ash	0.4 %	-
*Fat (max)	1.5 %	2.0 %
*Crude Fiber (max)	4.2 %	3.5 %
Aflatoxin ug/Kg (max)	30	-
Residual Solvent ppm (max)	170	-
Total Bact. Count /g (max)	50000	-
Cloforms /g (max)	10	-
Salmonella /g	Nil	-

1 IS: 7836: 1975; * Dry weight Basis

List of Edible Grade Defatted Soy Flour Manufacturers / Suppliers

Mr. Girish Matlani
Sonic Biochem Extractions
38, Patel Nagar
Indore 452 001
Tel. No 0731 2466456-58/2468638
Fax: 0731-2462564

Mr. Dinesh Agrawal or
Mr. Prabhudatta Jyotishi
General Foods Ltd.
101, Mahakosh House, Nath Mandir
7/5, South Tukoganj, Indore 452 001
Tel. No 0731 2513281-83 2528113(D)
Fax: 0731 2527250

Mr. Pramil L. Sisodia
Deputy General Manager - Sakthi Soya
180, Race Course Road,
Marchinaickenpalayam
Ambarampalayam (PO)
Pollachi 642 103
Tel: 04259 253256,57, 253355
Fax: 04259 253354

Mr. Prakash Mutha
Vippy Industries Ltd.
28, Industrial Area
Dewas 455 001
Tel. 07272 258885-46, 272156-57
Fax:07272 - 275552

Mr. Davish Jain
Managing Director
Prestige Foods Ltd.
30, Jaora Compound
M.Y.H. Road, Indore 452 011
Tel: 0731 2556530,33,34
Fax: 0731 2556531, 32

Mr. Anil Lonkar
Managing Director
Rasoya Proteins Ltd.
Plot No.1, Bajaj Nagar,
South Ambazari Road,
Nagpur 440 010
Tel: 0712 2231386, 2232395
Fax: 0712 2233379

Mr. Krishnan
Surya Agro Industries
Surya House
Z-5, Zone I, M.P. Nagar
Bhopal 462 001
Tel. No 0755-2556734/6/9
Fax: 0755-2556724

S.M. Dyechem Ltd.
3rd floor, 158, Zone-1,
Maharana Pratap Nagar,
Bhopal 462 001
Tel: 2557746, 2555699, 2555800, 2553846
Fax : 0755 - 2551036
Email: smd@bom4.vsnl.net.in

List of Extruder Suppliers

Mr. S.Krishna Murthy
Esskay Industries
No. 53 Infantry Road,
Behind Medinova, Bangalore 560 001
Tel: 080 2864650
Fax: 080 2861365
E-mail: esskayvo@vsnl.net

Mr. A.K. Bhudiraja
Ambika Agro Industries
12 Silver Park, Shiv Puri
New Delhi 110 051
Tel: 011 22410924
09814275727

Mr. C.V. Surendran
Spectoms Engineering Pvt. Ltd
Makarpura Station Road, Maneja,
Vadodara - 390013 India
Phone : 91-265-2642641
Fax : 91-265-2644592
Products: Extruders

MR. MD. Akhtar Ali Gaur
A. S. Engineering Works
A 49B, SEC 10,
NOIDA - 201301
Phone: 91-120-2523756
Fax: 91-120-2520344 / 2523756

M. Son Industries
D-33, Sector-2,
NOIDA - 201301
India
Phone: 91-120 2552177

Mr. Agarwal Pavankumar
Swastik Products,
9/1/3. Lonar vashate,
Kolhapur
Phone : +91-231-667936
Fax: +91-231-680167

Mr. Manjeet Singh Arora
Reliance Engineering Works
Plot # 117
Opposite ESI Hospital
Industrial Area Phase II
Chandigarh 160 002
Tel: 0172 652467, 400056, 605682
Mobile: 09814694065; 874919; 3135599
Fax: 610814

Mr. Aasha Singh
Gurunanak engineering Works
D 107
Sect 7, NOIDA
Tel: 2542530; 2519360
Fax: 2535160
Products: Extruders

Fun Snacks Pvt. Ltd.
D-115, Okhla Industrial Area, Phase-I,
New Delhi - 110020
India
Phone : 91-11-6813158
Fax : 91-11-6818548
E-mail: gopal@del2.vsnl.net.in

Mr. S. Mukharjee
Basic Tech Pvt. Ltd.
2-2B, Nandy Street
Calcutta 700 020
Tel: 033 24635067; 24644616; 24641866

S.S. Engineering works
B-25, Khanpur Ext
Devli Road, New Delhi 110 062
Tel: 26081475
Works: 250 Shutter Wala Gali
Khanpur, New Delhi 110 062

Cost Benefit Analysis of an economy TVP Plant*

Capital Investment	
Cost of Equipment (Capacity 200 kg/hr)	800,000
Cost of Dryer	150,000
Working capital	50,000
Packaging equipment	100,000
Pre operational expenses	25,000
Total	**1,125,000**

Monthly expenses 8hr/day	
Interest on Loan @ 12% pa (Laon 85% of CI)	10,367
Rent	10,000
Other Expenses	5,000
Sub-Total	25,367

In Rupees			
Manpower	**TVP**	**Snacks**	**Instant wheat meal**
Two marketing executives 2*5000	10,000	10,000	10,000
Two Production in-charges 2*4000	8,000	8,000	8,000
Raw material	225,000	183,000	90,500
Cost of Electricity @ Rs. 3.5/KW	16,250	16,250	16,250
Water, Sewer & Maintenance	7,000	7,000	7,000
Depreciation @ 15% pa	13,125	13,125	13,125
Publicity Rs. 0.5 per pack	37,500	37,500	25,000
Misc. Expense	20,000	20,000	20,000
Sub-Total	336,875	294,875	189,875
Total Expenses / Month	362,242	320,242	215,242

	TVP	**Snacks**	**Instant wheat meal**
Production (kg/month)	15,000.00	15,000.00	10,000
Cost of Production (rs/kg)	24.15	21.35	21.52
No of packets per month (200 gm)	75,000.00	75,000.00	50,000.00
Cost of Packaging (Rs./pack)	150,000.00	75,000.00	100,000.00
Net Cost of Production/pack	6.83	5.27	6.30
Sales Tax 8%	1.28	0.96	1.12
Profit margin 15%	2.40	1.80	2.10
Dealer price (margin 10%)	12.11	9.23	10.92
Retailer price (margin 20%)	15.31	11.63	13.72
MRP	16.00	12.00	14.00
Profit per month	180,000.00	135,000.00	105,000.00
Net profit per month	420,000.00	240,010.00	105,017.00
Annual Net profit	5,040,000.00	2,880,118.00	1,260,209.00
Return on Investment (ROI)	448%	256%	112%

*: These estimations are made on hypothetical basis only, assuming that plant may run at 100% capacity and sale of produce.