ABSTRACT: 333

CURRENT AND POTENTIAL USAGE OF SOYBEAN PRODUCTS AS FOOD IN SOUTH AFRICA

VAN DER MERWE R¹, VANBILJON A¹ & HUGO A²

¹Department of Plant Sciences, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Bloemfontein, 9300, South Africa
²Department of Microbial Biochemical and Food Biotechnology, Faculty of Natural and Agricultural Sciences, University of the Free State, PO Box 339, Bloemfontein, 9300, South Africa

E-mail: vandermerwe@ufs.ac.za

Soybean is the main vegetable oil crop in the world as it comprises more than 50% of the world’s total oilseed production. South Africa is the third largest consumer of soybean in the world, but in terms of seed production, the country ranks thirteenth internationally. During the past 10 years local soybean seed production increased three fold and exceeded sunflower seed production. This increase in production may be attributed to several factors; however the high demand for oil cake may be the main reason. In addition, commercial farmers became aware of the benefits of soybean in crop rotation systems with maize. Consumers pursue alternative protein sources that are economical, healthy and of high quality. Although a steady increase in seed production was observed, the country continues to import large quantities of soybean products in order to meet the demand for both animal and human use. During the previous production season (2011/2012), 63% of the total production delivered was domestically processed, while 6% was exported. Only 5% of the production was processed for human consumption, while 36% was processed for oil and oil cake and 22% for seed and feed. Soybean is a valuable crop as a source of dietary protein and vegetable oil for millions of people. Soybean seeds that are processed into defatted flakes, lecithin and dietary fibres are used in the manufacturing of a variety of processed foods and other food products. Defatted flakes form the basis for the production of flours, isolates and concentrates. These products are used as ingredients in various food, meat and nutritional food industries. These include bakery, beverage, cereals, dairy alternatives, infant formulas, meat products, poultry and seafood products, meat analogs, vegetarian and snack products. Soybean oil as a by-product after processing is used in a variety of processed foods, vegetable oil blends and margarine. Whole soybeans, cooked, baked and roasted, serve as high protein and dietary fibre food sources. In South Africa, thousands of people live in poor and rural areas and face malnutrition due to rising food prices. The production of high-quality and health promoting soybean meals that are economical will contribute to reduce hunger and increase food security in these areas. In this review, the current and prospective production, use and demand for soybean and its products for human consumption in South Africa will be addressed. The domestic processing capacity and constraints in production, local processing and supply to the industries utilizing soybean products will be deliberated.
CURRENT AND POTENTIAL USAGE OF SOYBEAN PRODUCTS AS FOOD IN SOUTH AFRICA

R van der Merwe
A van Biljon
A Hugo
• Background
• Aim
• Domestic production of soybean
• Total seed consumption and processing
• Application in human nutrition
• Soy human food market
• Breeding soybean for human food
• Conclusions
• Acknowledgements
BACKGROUND

- Numerous people in South Africa are poor, undernourished and many suffer from life-threatening diseases
- There is a need to increase production of wholesome food products that will combat poverty, malnutrition and ill health
- SA is food secure, but not household food secure
- Food insecurity is most severe in the rural areas where an estimated 70% of SA’s poor reside
• A major concern is the continuously rising of food prices

• During the previous 4 years the following price increases of protein food sources (given in percentage) were observed:

<table>
<thead>
<tr>
<th>Food Source</th>
<th>Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs</td>
<td>22% (1/2 dozen)</td>
</tr>
<tr>
<td>Fresh beef mince</td>
<td>19% per kg</td>
</tr>
<tr>
<td>Fresh whole chicken</td>
<td>11% per kg</td>
</tr>
<tr>
<td>Fresh full cream milk</td>
<td>2% (2 L)</td>
</tr>
</tbody>
</table>

(NAMC 2011)
Rising food prices may contribute to food insecurity, insufficient protein consumption and undernourishment.

Poor people cannot afford the current meat prices and many especially those living in rural areas do not have the facilities to store raw meat.

These people will buy meat alternatives that are cheap, nutritious and can be stored without refrigeration.
Soybeans contribute to the production of meat alternatives and other food products that are economical, of high-quality and health promoting.

Generally soy ingredients are used in the manufacturing of numerous foodstuffs and health products.

Soy products form part of the daily food, nutrition and health supplement intake of practically all South Africans.
• More and more people become aware of the health and nutritional benefits of soy products

• A wide range of soy foods and products are available to meet the needs of South Africans

• Vegetarians, lactose intolerant individuals include soy products as alternatives in their diets
Although the SA market for soybean is huge, the human food sector is insignificant compared to the animal feed market.

The following could contribute to the low amount of soybeans being utilised in the human food market:
1. **Insufficient seed/grain supply**

   The high demand of soybeans for animal feed production reduces the amount available for human consumption.

2. **Insufficient processing capacity**

   Infrastructure and technology dedicated to soy protein product processing is expensive and since the market for human consumption is small, little investment is being made in capacity expansion.
3. **Poor product quality of local soy protein products**

Some soy-based food manufacturers feel that locally processed soy protein products are of poor quality and not on the standard required for their specific needs.

Consequently, processed soy protein products are essentially imported and consumers can acquire high quality products that satisfy their needs.
Approaches to increase local production of high quality soy protein products are pursued by:

1. **Developing economical processing technologies**
   - With reduced processing steps
   - If some expensive processing steps can be removed, cost can be reduced

2. **Development of soybean varieties** with advanced compositional properties that require less processing
• With this approach, extensive processing steps, to remove unwanted components can be reduced
  – could reduce processing demand and cost

• In addition, the quality of locally produced soy protein products can be improved through breeding and development of food grade varieties
The aim of this survey was to analyse the local soy food market and to determine how plant breeding can contribute to the development of specific soybeans suitable for different food applications.
Area planted

- Sunflower has always been regarded the major oil crop produced in SA
- Sunflower comprises 14% and soybean 8% of the area designated to summer crops

DOMESTIC PRODUCTION OF SOYBEAN

5 year average = 3523883 ha

(SAGIS 2013)
• During the last 5 years the area planted with soybeans has shown a steady increase.
• During the previous season (2012), the area planted with soybean exceeded the area planted with sunflower.
Production

- South Africa ranks 12\textsuperscript{th} internationally for soybean seed production (FAO stats 2011)

- During the last 10 years domestic production increased almost five fold from 137000 ton (2003) to 650000 ton (2012) (SAGIS 2013)
The increase in local production is driven by several factors:

1. **Expanded area planted** – this area increased almost five fold during the last 10 years

2. **The growing demand for oil cake** by the animal feed industry (SA is a net importer of soybean meal and oil)
3. Expansion and upgrading of local processing capacity dedicated to soybean

4. Maize-soybean crop rotation programmes – growers are recognising the benefits of using soybean in crop rotation with maize

5. The development of local high yielding varieties that are adapted to SA environments
A total of 553100 ton of soybeans was locally consumed in 2012 (SAGIS 2013)

- Includes the soybeans locally processed (98%)
  - Oil cake/oil
  - Full fat (animal feed)
  - Human consumption

- Other applications (2%)
  - seed retained by farmers, seed released to end-consumers and seed for planting purposes
During the last 10 years the domestic soybean processing increased in total from 194000 ton to 540200 ton.
The 5 year average for domestically processed soybeans is **393480** ton
Local production and processing does not meet the demand for both animal feed and human consumption.

Large quantities of processed products domestically consumed are imported.

Over a 5 year period (2005-2010)
- 90% of soybean meal/oil cake - mainly from Argentina
- 94% of soybean oil was imported - mainly from Argentina and Brazil (NAMC 2011)
There is a growing interest in soybean production because of the nutritional value and health benefits of soy products.

Soybeans have the following nutritional components:

- **Protein**: 40%
- **Carbohydrates**: 35%
- **Oil**: 20%
- **Ash**: 5%
- **Typical composition of whole soybean**
APPLICATION IN HUMAN NUTRITION

Application in human nutrition

Whole soybean products

- Soymilk
- Tofu
- Okara
- Soy nuts
- Snack foods
- Yoghurt
- Soy sauce

Protein products

- Refined oil
- Vegetable oil blends
- Salad oils
- Margarine
- Lecithin by-product

Oil
Soybeans are processed into different soy protein products in order to be used in different foodstuffs and health products.

Four major categories are classified according to their protein content:

<table>
<thead>
<tr>
<th>Soy protein products</th>
<th>SOY FLOUR FULL FAT</th>
<th>SOY FLOUR DEFATTED</th>
<th>SOY PROTEIN CONCENTRATE</th>
<th>SOY PROTEIN ISOLATES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40-42% protein</td>
<td>50-54% protein</td>
<td>65-70% protein</td>
<td>90-92% protein</td>
</tr>
<tr>
<td></td>
<td>20% oil</td>
<td>1% oil</td>
<td>1% oil</td>
<td>1% oil</td>
</tr>
</tbody>
</table>

APPLICATION IN HUMAN NUTRITION
Soy protein products are texturised by various processes to produce TSPs that are used in a variety of end-products that have different applications.

### End-use markets

<table>
<thead>
<tr>
<th>Meat analogues / extenders</th>
<th>Dairy analogues</th>
<th>Bakery</th>
<th>Blended cereals/porridges</th>
<th>Health supplements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processed meats</td>
<td>Soymilk</td>
<td>Bread flour</td>
<td>Soups</td>
<td>Nutritional shakes</td>
</tr>
<tr>
<td>Cold meats</td>
<td>Beverages</td>
<td>Pre-mixes</td>
<td>Sauces</td>
<td>Snack bars</td>
</tr>
<tr>
<td>Soy mince</td>
<td>Smoothies</td>
<td></td>
<td></td>
<td>Meal replacers</td>
</tr>
<tr>
<td></td>
<td>Milkshakes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yoghurt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infant formulas</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
On a 5 year average, 28640 ton of soybeans was locally processed for human consumption (SAGIS 2013)

However, this volume does not satisfy the total demand needed in the human food sector

More than half of the soy market for human consumption relies on imports
In 2005, 34050 ton of soy, excluding oil cake, was imported (value R235 Million)

<table>
<thead>
<tr>
<th>Soy Product</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans</td>
<td>43%</td>
</tr>
<tr>
<td>Isolates</td>
<td>35%</td>
</tr>
<tr>
<td>TSP</td>
<td>13%</td>
</tr>
<tr>
<td>Concentrates</td>
<td>3%</td>
</tr>
<tr>
<td>Soy blends</td>
<td>5%</td>
</tr>
<tr>
<td>Flours</td>
<td>1%</td>
</tr>
</tbody>
</table>

(Soy Human Food Market) (BMI 2006)

Soy protein products are generally imported from South America, North America, the Far East and Europe.
In 2005 the total market for human sector was **49395 ton**

An overview of the soy market for human consumption by soy type for 2005

- Powdered soy concentrates: 9%
- Soy flours and meals: 15%
- Soy blends: 17%
- Soy protein isolates: 26%
- Texturised soy protein: 33%

(BMI 2006)
TSP and soy protein isolates together accounted for approximately 60% to the total market.

TSP, isolates and concentrates are generally used in the meat industry.

Isolates are also used for the manufacturing of soy-based foods:
- for the beverage, health food, soy-fortified porridges and cereal industries.
An overview of the soy market for human consumption by end-user for 2005

**End-user**

- **Protein**: 52%
- **Bakery**: 15%
- **Snack bars**: 0%
- **Health supplements**: 11%
- **Other markets**: 11%
- **Beverages**: 1%
- **Cereals**: 10%

**49395 ton**

(BMI 2006)
The protein market (52%)
- Processed meat products, especially emulsion meat products like polony and viennas
- Soy meat analogues consumed by vegetarians and low income population

The bakery market (15%)
- Mostly baked goods such as bread and bread rolls
- Pre-mixes also contributed a small amount
- Mainly full fat flour were used

(BMI 2006)
• **Health supplements (11%)**
  – Diet shakes, health and nutritional supplements
  – Mainly consumed by bodybuilders, people who want to lose weight and those recovering from hospital operations

• **Soy-blended cereals (10%)**
  – Consisted mostly of maize- and wheat-blended cereal products
  – Hot and cold cereals

(BMI 2006)
SOY HUMAN FOOD MARKET

• The beverages market (1.0%)
  – Included mostly soymilk, flavoured milk yoghurt, and powdered beverages
  – Soymilk is the most established soy analogue and shows good growth with increased consumer demand

• Snack bar market (0.1%)
  – Niche market and needs development

(BMI 2006)
SOY HUMAN FOOD MARKET

• The soy market for human consumption is growing due to the local demand for healthy and nutritious soy food products

• Between 2004 and 2009 the soy product market in SA showed an annual compound growth rate of 15.8% (Market Research.com)

• There is a concerted effort of numerous local and international manufacturers to bring soy ingredients and soy foods to the consumer
The following data for 2012 was obtained from an independent company that is an importer and distributor of soy products in SA.

<table>
<thead>
<tr>
<th>Soy protein product type</th>
<th>Import (ton)</th>
<th>Value (Rand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy concentrate and TSP (&lt;65% protein)</td>
<td>3168</td>
<td>28 million</td>
</tr>
<tr>
<td>Soy concentrate and TSP (&gt;65% protein)</td>
<td>3390</td>
<td>45 million</td>
</tr>
<tr>
<td>Soy isolates</td>
<td>11774</td>
<td>242 million</td>
</tr>
<tr>
<td>Lecithin</td>
<td>1698</td>
<td>29 million</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20030</strong></td>
<td><strong>344 million</strong></td>
</tr>
</tbody>
</table>
• The following data was obtained from local companies involved in manufacturing and retail of several soy products.

<table>
<thead>
<tr>
<th>Food market</th>
<th>Soy type</th>
<th>Source</th>
<th>End-product/application</th>
<th>Total annual demand (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meat</strong></td>
<td>Defatted white flakes</td>
<td>Imported</td>
<td>Soy mince meals</td>
<td>550</td>
</tr>
<tr>
<td>(Meat analogues)</td>
<td>Processed locally in TSP</td>
<td>• India</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Meat</strong></td>
<td>Isolates Concentrates</td>
<td>Imported</td>
<td>Cold meats</td>
<td>960</td>
</tr>
<tr>
<td>(Butchery Meat analogues)</td>
<td>TSP</td>
<td>• North America</td>
<td>Polony Russians Viennas Meat sausages</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Brazil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## SOY HUMAN FOOD MARKET

<table>
<thead>
<tr>
<th>Food market</th>
<th>Soy type</th>
<th>Source</th>
<th>End-product/application</th>
<th>Annual demand (ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beverages</strong></td>
<td>Full fat flour</td>
<td>Imported</td>
<td>Soymilk Smoothies</td>
<td>Not available</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• North America</td>
<td>Shakes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Brazil</td>
<td>Ice-cream</td>
<td></td>
</tr>
<tr>
<td><strong>Cereal/Instant porridge</strong></td>
<td>Full fat flour</td>
<td>Locally produced soybeans</td>
<td>Food products fortified with soy protein: Instant maize porridge Soup powders Sauce powders</td>
<td>2880</td>
</tr>
<tr>
<td>(Milling and soy product development)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# SOY FOOD MARKET

<table>
<thead>
<tr>
<th>Food market</th>
<th>Soy type</th>
<th>Source</th>
<th>End-product/application</th>
<th>Annual demand (ton)</th>
</tr>
</thead>
</table>
| Bakery (Milling and soy product development) | Full fat flour | Locally produced soybeans  | BREAD SOY  
  • full fat enzyme active soy flour  
  INFRASOY  
  • roasted full fat soy flour  
  INFRAGRAN  
  • roasted full fat grits  
  Supply to  
  • Bakery  
  • Meat  
  • Milk replacement  
  • Health food  
  • Snack  
  • Convenience food  
  • And other industries | 10000             |
It appears that

- From domestically produced soybeans mainly full fat soy flours and TSPs are manufactured
- Isolates, concentrates, different classes of soy flours and flakes and defatted variants are imported
BREEDING SOYBEAN FOR HUMAN FOOD

• Need for the development of soybean varieties for the human food market that will answer to both the demand of growers as well as consumers

• 80% of SA soybean production is GMO varieties (Roundup Ready)

• For some human food markets high yielding conventional (non-GMO) varieties that can meet the performance of GMO varieties are sought after

• Different soy food processors have different requirements with regard to the nutritional composition or functional properties of soy ingredients
Key breeding targets include:

• Breeding for important agronomical traits

• Breeding for improved nutritional and functional value

• Breeding for reduced negative compounds that cause undesirable flavours and “beany flavour”, flatulence and poor digestibility
Agronomical traits play a role when growers make cultivar choices and should be considered in breeding food grade soybeans:

- Yield potential
- Growth habit
- Maturity group type
- Shattering resistance
- Pod height
- Lodging resistance
- Resistance to pests, diseases and chemicals
BREEDING SOYBEAN FOR HUMAN FOOD

• Breeding of food grade soybeans are classified into the following categories:

1. Seed size
   – Large-seeded soybeans are most preferred for the production of soymilk, dairy alternatives and tofu

2. Seed appearance
   – Clear hilum
   – Yellow seed coat and cotyledon
   – Thin, strong seed coat
   – Preferred for the production of soymilk, dairy alternatives and tofu
3. Seeds with unique composition

• **Protein content and composition**
  – High protein (content ≥43%)
  – Increased protein/oil ratio
  – Eliminating/reducing unfavourable components
    • Lypoxygenase (reduce “beany” flavour during oxidation with lipids)
    • Trypsin inhibitor

• **Carbohydrates**
  – High sucrose
  – Sucrose content increased with 40%
  – Reduction in flatulence causing raffinose and stachyose to <1%
BREEDING SOYBEAN FOR HUMAN FOOD

- Conventional high protein and high sucrose varieties are preferred for producing
  - Whole soybeans
  - Full fat and low fat flours
  - Soymilk powder
    - Soymilk
    - Dairy analogues
    - Meat analogues
    - Baked goods
• Oil quality
  – Increased/reduced oil content
  – Oil content negatively correlated to protein content
  – Altering fatty acid composition
• Commodity soybean oil is composed of five major fatty acids:

**Oil fatty acid composition**

- Linoleic (C18:2) 54%
- Oleic (C18:1) 23%
- Palmitic (C16:0) 11%
- Stearic (C18:0) 4%
- Linolenic (C18:3) 8%
• Reduced polyunsaturated fatty acid content
  – Improves oxidative stability
  – Low linolenic acid (C18:3) soybean oil
  – High oleic acid (C18:1) soybean oil
  – High oleic and elevated stearic acid (C18:0) soybean oil

4. Breeding seeds high in functional components
  – High-isoflavone (>0.4%)
  – Enhanced tocopherol content and composition
CONCLUSIONS

• Although the soybean market for human consumption may be regarded insignificant compared to the animal feed market

• There is a huge demand for soybeans in the human food sector and the demand is increasing

• Substituting soy product imports with locally produced products as millions of rand are spent on acquiring those products from foreign countries
CONCLUSIONS

• Local processing capacity dedicated to manufacturing of soy protein products should be expanded/upgraded to meet demand for the production of soy based foods
  – There is a need to develop processing technology that is less expensive

• Niche markets for soy-based foods are established and will continue to grow

• Small holder farmers may provide an opportunity for producing soybeans for the food market and especially niche markets
CONCLUSIONS

• Farmers may be contracted by soy processors and negotiate for premiums when delivering high quality, non-GMO food grade soybeans.

• Breeding of conventional varieties with special compositional traits.

• Food grade varieties can contribute to:
  1. Reduction in soybean processing cost
     Some additional processing steps, could be omitted when using lipoxygenase free or reduced raffinose and stachyose varieties.
CONCLUSIONS

2. Production of high quality soy protein products that comply with the needs of the food manufacturers

3. Producing better tasting soy products that will be more pleasing for the consumer

4. Ultimately contribute to production of less expensive soy-based foods and products that satisfy the needs of all consumers
• There is however one big hurdle to overcome and that is to inform the man on the street about the good properties of soybean and to change the perception of Tom, Dick and Harry that think soy tastes “bad”

• Hopefully with the help of Olympic Hero’s such as Ryk Neethling, Chad le Clos and rugby hero Pat Lambie this can change…
ACKNOWLEDGEMENTS

- Danie Botha
- Cobus Crous
- Henry Davies
- Antony Jarvie
- Aalwyn de Lange
- Annetjie de Lange
- Tian du Toit
- Aalwyn Labuschagne
- Theuns Scheepers
- Dirk Strydom
- Fritz Teseling
- Francois van Schalkwyk
- Louis Verhoef
Thank You
Dankie