Commodity Assessment and Safety of Secondary Soybean Flour

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Abstract. Data found in literature suggests soybean seeds are superior to many oilseed crops if compared by the content of proteins, fats, phosphatides, and some other nutrients. No other floral or faunal product has such a combination of protein, fat, carbohydrates, minerals, and vitamins. This paper proposes using secondary soybean flour as germ, shell, or cotyledon flour in food production. Lack of solid evidence-based data on how this material is used in food design is indicative of the lack of research in the area, making this paper relevant. The article presents a process of making secondary soybean flour. It also describes the chemical composition and energy content of such flour as found by the researchers’ tests. The paper concludes with the newly formulated requirements to flour quality and safety.

1. Introduction
Increasing the energy content and biological value of foods is a popular research topic today. Daily foods like bread and pastry are of particular interest. These are based on wheat flour, but its protein composition is not balanced in terms of amino acids: lysin and threonine. Secondary raw materials produced from soybean flour may improve the nutritional and biological value of such foods.

2. Relevance
Analysis of literature and patents shows that soybean flour byproducts: protein and carbohydrate flour, namely germ, shell, and cotyledon flour, has not yet been used to improve the nutritional and biological value of foods.

In this regard, there is no solid scientific evidence that could help design foods in this category. Thus, what makes this research relevant is that this topic has not yet been covered by researchers before.

The objectives hereof were to collect experimental data on the quality and safety of secondary soybean flour so as to use to design foods of improved nutritional and biological value.

3. Research essentials
The use of soybean flour in the food industry is on the rise. For instance, bakers combine it with other ingredients to replace skimmed milk powder. When complemented with soybean flour, bread gains in nutritional value and makes a nice-looking brown crust; besides, such bread has a longer shelf life. Adding up to 10% of soybean flour when making a pan loaf or hearth bread from Grade 1 or 2 flour
will increase the protein content by a factor of nearly 1.5, the energy value by 20%, and water absorption rate of flour and the product’s volume by 10% to 15%; it will also improve the elasticity, make a better-colored crumb, and increase the content of fiber, which is physiologically essential for normal digestion.

The authors hereof earlier designed a soybean flour production process that separated it into shell (S), germ (G), and cotyledon (C) flour. Analysis of the content of the secondary raw material showed the following distribution: 40% shell, 50% cotyledons (cereals), and 10% germs [1].

The authors have also developed a technology for recycling secondary soy material into soybean flour, which follows this algorithm: inspect the source material, grind it on a jet mill into flour, sieve it, then let it pass through sieves equipped with magnetic barriers to remove metallic impurities.

Figure 1 shows the entire process.

![Secondary soybean (flour) production chart.](image)

Research of the secondary soybean flour made from the byproducts of making full-fat flour and cereals showed the following chemical composition [3]: 5-6 water, 24.3-25.6 protein, 5-5.7 fat, 56.4-59.9 carbohydrates, and 3.9-4.2 minerals, g/100 g of flour (averaged). The energy value was 368.07 to 395.66 kcal/100 g; see Table 1 for the chemical composition of secondary soybean flour.

Thus, this byproduct of making full-fat soy flour is highly nutritional. Preliminary thermal treatment of the raw material breaks down the inhibitors of digestive enzymes that native soy contains [2]. Thus, the proposed material is of significant practical interest for the food industry.
Table 1. Chemical composition and energy value of secondary soybean flour.

| Product                        | Content, g/100g | Energy value, kcal/100 g |
|-------------------------------|----------------|--------------------------|
|                               | water | protein | fat | carbohydrates | minerals |
| Secondary soybean flour:      |       |         |     |              |          |
| cotyledon                     | 5.5   | 41.5    | 23.0| 30.0          | 4.7      |
| germ                          | 5.5   | 45.0    | 11.5| 41.0          | 3.7      |
| shell                         | 5.5   | 8.5     | 1.5 | 71.5          | 3.5      |

Based on this data, the authors hereby propose the following organoleptic, physical and chemical, microbiological, and safety requirements to secondary soybean flour, see Tables 2 to 5.

Table 2. Secondary soybean flour: organoleptic indicators.

| Metric                  | Value                                |
|-------------------------|--------------------------------------|
| Appearance and color    | Homogeneous brown powder, no lumps   |
| Taste and smell         | Pleasant nutty taste and smell, no foreign taste and smells |
| Mineral impurities      | No crunch when chewing water-soaked flour |

Table 3. Secondary soybean flour: physical and chemical indicators.

| Metric                                    | Required value |
|-------------------------------------------|----------------|
| Moisture content, %, max                  | 10.0           |
| Protein, %, min                           | 24.3           |
| Fat, %, min                               | 5.0            |
| Carbohydrates, %, min                     | 59.9           |
| Minerals, %, max                          | 4.0            |
| Particle size after grinding: remainder %, max after sieving through a Silk 35 sieve or a 33/36 PA polyamide sieve | 2.0 |
| Minimum passage through a Silk 43 sieve or a 45/50 PA polyamide sieve | 70.0 |
| Metal impurities, mg/kg, max              | 3.0            |
| Other foreign impurities                  | Not acceptable |

Table 4. Secondary soybean flour: microbiological indicators.

| Index | Product group | Total bacterial count, CFU/g, max | Product weight, g, within which the presence of these cultures is not acceptable | Mold, CFU/g, max |
|-------|---------------|-----------------------------------|---------------------------------------------------------------------------------|------------------|
| 1.9.5.2 | Soybean protein products | 5×10⁴ | 0.01 | 1.0 | 25.0 | 0.1 | 10.0 |
Table 5. Hygienic requirements to the quality and safety of foods and raw materials used in food production.

| Product            | Indicators                         | Acceptable limits, mg/kg | Note                           |
|--------------------|------------------------------------|--------------------------|--------------------------------|
| Secondary soybean flour | Toxic elements:                     |                          |                                |
|                    | lead                               | 0.2 on a dry basis        |                                |
|                    | arsenic                            | 0.2                      |                                |
|                    | cadmium                            | 0.1                      |                                |
|                    | mercury                            | 0.03                     |                                |
|                    | mycotoxins:                        |                          |                                |
|                    | aflatoxin B₁                        | 0.005                    |                                |
|                    | pesticides:                        |                          |                                |
|                    | hexachlorocyclohexane (α, β, γ-isomers) | 0.1                | on a dry basis                 |
|                    | DDT and its metabolites             | 0.01                     |                                |
|                    | Mercury-organic pesticides          | not acceptable           |                                |
|                    | Oligosaccharides                   | 2.0 %                    |                                |
|                    | Trypsin inhibitor                  | 0.5 %                    |                                |
|                    | Radionuclides:                     |                          |                                |
|                    | cesium-137                         | 130 Bq/kg on a dry basis |                                |
|                    | strontium-90                       | 80                       |                                |
|                    | Infestation with bread pests       | not acceptable           |                                |

4. Conclusions
These established requirements to the quality and safety of soybean flour serve as the foundation of the standards (specifications and process protocols) that regulate the use of this material in food production.

Thus, research presented herein has produced data and substantiated the use of secondary soybean flour to design foods of improved nutritional and biological value [4].

5. References
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