

Development of Full-Fatted Soybean-Based Food Products as Meat Alternatives

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Abstract

It was emphasized in the research and development initiative of the Department of Agriculture that soybeans are one of the most versatile high-value crops that can help solve the chronic problems of hunger and malnutrition. The Department of

Agriculture plans to expand soybean production in the Philippines. The Road Map aims to establish knowledge-based and farmer-friendly research facilities for soybean production and its development in the strategic areas in the country.

A study on consumer behavior towards soybean-based products was conducted, followed by the development of three soybean-based products as a meat alternative, including Soybean-based Burger Patty, Soybean-based Sweet Longanisa, and Soybean-based Nuggets. Sensory evaluation among consumer panelists was done to evaluate the characteristics of soybean-based meat alternative products as to color, mouthfeel, taste, texture, and overall acceptability. The most acceptable formulation of each of the meat alternatives was subjected to nutrient analysis, cost analysis, and shelf-life testing.

Regardless of their sociodemographic background, most of the respondents indicated their willingness to purchase soybean-based products when available in the market. Psychological, sensory, and marketing factors highly affect the respondent's preference and purchase of soybean-based meat alternatives. Fifty untrained panels using a complete block randomized sampling technique were invited to evaluate the samples. Results showed that the most acceptable formulation of the Full-fatted Soybean-based Burger Patty and Longganisa were rated liked moderately acceptable, and the Full-fatted Soybean-based Nuggets were rated as very much in terms of overall acceptability, color, mouthfeel, taste, and texture. The formulated soybean-based products have considerable amounts of nutrients, particularly protein, sodium, potassium, and calcium. The shelf-life analysis for a 6-point rejection level to the overall acceptability of the products showed a shelf life of 8 weeks. The resulting cost analysis shows that the estimated selling price range is still lower compared to other similar commercially available products on the market. The soybean-based nuggets had the biggest price advantage, as it is almost half of the average meat-based commercial product. Training and a technology transfer were conducted on processing full-fatted soybean-based food products.

Keywords: *Full-fatted soybean, Meat alternatives, food development, shelf life, cost analysis*

Introduction

Soybean (*Glycine max*) has a wide range of geographical adaptations, a unique chemical composition, good nutritional value, and functional health benefits (Singh, 2010). It is a good source of energy, carbohydrates, fiber, and unsaturated fat. It contains a protein that is necessary for the growth and maintenance of cells and tissues, carbohydrates that provide energy, minimal

saturated fats that may help prevent cardiovascular diseases, phytochemicals that prevent cancer, and vitamins and minerals that boost overall health promotion.

Consumers are increasingly aware of the healthfulness of soybased foods. It has become an important commodity. Going green is rapidly being acknowledged as a favorable competitive strategy in the hospitality sector, notably on the supply side of the tourism industry, which is seeking to incorporate sustainable practices (Baluyot, 2024).

The consumption of vegetable proteins in food products has been increasing over the years because of animal diseases, the global shortage of animal protein, strong demand for wholesome and religious (halal) food, and economic reasons. A meat-based diet requires a significantly greater amount of environmental resources per calorie compared to a more grain-based diet i.e., 2 to 15 kg of plant foods are needed to produce 1 kg of meat. Developing new food products that are attractive to consumers is a challenge. However, it is even more complex when these new foods are meant as a substitute for products that are highly appreciated and accepted, like meat.

This challenge was accepted to develop new sustainable meat substitutes to reduce the negative environmental impact of industrial-scale meat production for human consumption. Happily, there is an increasing importance of legume and oilseed proteins in the manufacturing of various functional food products due to their high-protein content. However, the greatest obstacle to utilizing these legumes and oilseeds is the presence of antinutrients, though these can be successfully removed or inactivated by employing certain processing methods. Legumes and oilseeds provide well-balanced amino acid profiles when consumed with cereals.

Soybean proteins, wheat gluten, cottonseed proteins, and other plant proteins have been used successfully for the preparation of meat alternatives. Texturized vegetable proteins can substitute meat products while providing an economical, functional, and high-protein food ingredient or can be consumed directly as a meat alternative.

This project provides an alternative nutritious meat as well as promotes a healthy lifestyle to the consumers. The developed Full-fatted Soybean-based Food products technology was also transferred to the adopted community, the Kibungan Employees Multipurpose Cooperative (KEMPC), Poblacion, Kibungan, Benguet, to provide additional income at the same time while introducing a nutritious meat alternative.

The average worldwide yields for soybean crops in 2010 were 2.5 tons per hectare. The three largest producers had an average nationwide soybean crop yield of about 3 tons per hectare. The most productive soybean farms in the world in 2010 were in Turkey, with a nationwide average farm yield of 3.7 tons per hectare. The world record for soybean yield is 10.8 tons per hectare, demonstrated in 2010 by Kip Cullers, a farmer in Purdy, Missouri. Total commercial production of soybeans in 2010 was 261.6 million metric tons (Mmt) worldwide, harvested from 102.4 million hectares (which comprises around 2% of the planet's agricultural land). The U.S. was the leading producer of soybeans, producing just over one-third of the world's total.

Local soybean production is very small. Almost all available soybeans are imported. The main sources are the USA, Brazil, and Argentina. Since the mid-90s, when the yearly supply exceeded 100,000 tons, most of the soybeans have been

destined for oil extraction. The drop in volume in the past three years may be due to the slowdown in this industry. The volume of soybeans for direct usage, whether for feed or food, is probably less than 100,000 tons per year. The food soybeans are sourced mostly from Canada and China. Around 11,500 tons per year are imported from Canada, as reported by the Canadian Soybean Exporters' Association for 2006-2008.

Soybean areas have remained less than a thousand hectares since the late 90s. The larger areas planted in the past can be attributed to the aggressive promotion by both the public and private

sectors. At present, though, most of the production areas are found only in the two municipalities of Surigao del

Sur: Tago and San Miguel.

Dolojon (2015) cited in his study on the development of soybean butterscotch that soybean (*Glycine Max*), also called the soybean in Europe, is a legume species native to East Asia that including the Philippines. It is known as an exceptional source of essential nutrients needed by the body. It can be eaten either raw or processed. Fermented soy foods include soy sauce, bean paste, natto, tempeh, and others. Traditional nonfermented food uses of soybeans include soymilk which tofu and tofu skin are made, which are highly perishable.

Philippine soybean blog spot 2017 reported that the production trend of soybean is now the world's most important legume crop and the sixth of all cultivated crop in terms of total harvest, and the most widely produced oilseed grown in diverse climates worldwide. The Food and Agriculture Organization (FAO) classified it as an oilseed rather than a pulse. The United States, Argentina, Brazil, China, and India are the world's largest soybean producers and represent more than 90% of global soybean production.

The Cagayan Valley Organic Soybean Development Program in Support of Food and Nutrition Security in the Philippines created an awareness of the importance of soybeans for humans, livestock, and soil health in the valley through soybean production, food utilization, and processing in the uplands and highland farming communities. Further,

soybeans are beneficial as an intercrop and a rotating crop for rice. It also lowers dependence on potential disease-causing and expensive animal-based protein foods, resulting in improved household health and nutrition. Notably, farming households and young children were evidenced as already having learned to consume soybeans for reasons of a healthy food lifestyle (Aquino, 2014).

Hoek (2011) proved in his study on the replacement of meat with meat substitutes that consumer acceptance was largely determined by attitudes and beliefs towards meat substitutes and food neophobia. Key barriers for non-users and light/medium-users were the unfamiliarity with meat substitutes and the lower sensory attractiveness compared to meat. The first development with soy meat substitutes failed because it was not able to meet the sensory expectations of consumers. The soy flavor dominated. The goal of the meat alternative is to mimic the taste and consistency of animal meat.

The Philippine Soybean Roadmap 2010-2014, crafted by the Department of Agriculture, entitled "Building Sustainable Soybean Industry in the Philippines," aims to build a strong soybean production industry that is community-based and sustainable, and to establish a viable product processing industry through public-private partnership was evident to sustain soybean product development.

It was further emphasized in the research and development initiative of the Department of Agriculture in 2010 that soybeans are one of the most versatile high-value crops that can help solve the chronic problems of hunger and malnutrition. Also, as mentioned by Director Dante S. De Lima of the High-Value Crop Development Program, soybean is a legume that is a short-term, sun-loving crop that has a great potential to adapt to extreme climate and at the same time be a source of healthy and nutritious food for the future. The Department of Agriculture plans to expand soybean production in the Philippines. The Road Map aims to establish knowledge-based and farmer-friendly research facilities for soybean production and its development in the strategic production areas in the country. Support infrastructure and an incentive system are available that empower small farming communities to become productive units of soybeans and strong partnerships with the private sector in the processing and marketing of soy-based products in the local and international markets.

Consumers are increasingly aware of the healthfulness of soybased foods they consume and consider such a health attribute when making soy food purchasing decisions (United Soybean Board, 2007). Consumer demand for meat alternatives has grown over the last years as customers have been on a journey of realization concerning how their lifestyle choices and purchases affect our planet. An elevated number of customers are switching to plant-based diets for plenty of reasons, including shielding animals, preserving the environment, fashionable health concerns, or changing flavor preferences. As more purchasers seek these options, the market for plantbased proteins is rapidly developing and extending past North America. The global market for non-soy, gluten-loose plantbased total proteins is projected to be \$1. Five billion in 2022. As a result, manufacturers are searching for plant-based total proteins that offer functional, sustainable, and dietary attributes, including non-GMO and certified organic options. (forbes.com, 2019).

A study published in “The American Journal of Clinical Nutrition” in 2005 reported that people who obtained approximately 30 percent of their daily calories from low-fat, protein-rich sources ate fewer calories overall, felt fuller, and successfully lost weight. Soybean is a staple food with a very high protein content at 36.49 grams per 3.5 ounces; they do contain a notable amount of dietary fats.

While soybeans are by no means a high-fat food, at 9 grams per 3.5 ounces, they do contain a notable amount of dietary fat. However, these fats are primarily the “good” kind; in a single serving, you’ll take in 2 grams of monounsaturated fat and 5 grams of polyunsaturated fat. The American Heart Association recommends that the majority of the fats we eat be monounsaturated and polyunsaturated. Just over 1 gram of soybeans’ total fat is the saturated variety, which has been linked to heart disease.

Moisture in foods occurs in two forms: the water bound to ingredients in the foods (proteins, salt, sugars), and free or unbound water that is available. Water activity (A_w) describes the water available for microbial growth. Water activity is a measure of how efficiently the water present can take part in a chemical reaction. The overall water activity would be reduced if half of the water is so tightly bound to a protein molecule that it could not take part in a hydrolysis reaction (Sandulachi, 2012). The water activity measurement provides important information regarding the possibility of microbiological growth on the surface. Free water in food products is responsible for the growth of undesirable organisms such as bacteria or fungi, which produce toxins or other harmful substances. Water activity ranges from 0 (bone dry) to 1.0 (pure water). When the water activity is smaller than 0.9, most molds are inhibited. Most microorganisms cease growing if water activity is smaller than 0.6. As such, the reduction of water activity will retard the growth of microorganisms, nonenzymatic browning, and enzymatic reactions (Kasai, 2014). Water could be controlled by processes such as removing water (drying or freezing) and by adding salt (curing).

The nutrients protein, fat, and carbohydrates are the macronutrients that the body needs in larger amounts to function properly. All of these nutrients provide the body with energy measured in the form of calories or kilocalories. Aside from providing energy, all of these macronutrients have specific roles in the body to function properly. Protein is a body-building nutrient that is necessary for the body to grow, build, and repair tissues. Carbohydrates are hydrolyzed into glucose as the main source of energy for the body, yielding 4 kcal/gram. Specific organs, such as the brain, need glucose as the sole source of energy. Fat is the concentrated source of energy, providing 9 kcal/gram. Fat is the storage form of energy. It also cushions the vital organs, a precursor for the synthesis of certain hormones, and helps maintain cell membrane integrity.

However, excessive intake of fat, specifically saturated and trans fats, is known to increase the risk for cardiovascular diseases. Saturated fats come from animal sources, while trans fats come from margarine, baked, and fried foods. It is the objective of this study to develop soybean-based food products as meat alternatives with lower amounts of fat, particularly saturated fat.

The mineral sodium is of interest in a diet. It is the major cation in the extracellular fluid that maintains fluid and acid-base balance, but an excessive intake of this accumulates in the extracellular fluid, resulting in edema. Excess intake of sodium can raise blood pressure or hypertension, a major risk factor for heart disease. Calcium is another major mineral essential for human nutrition. The body needs calcium to maintain strong bones and carry out vital processes such as muscular contraction, blood coagulation, nerve transmission, and enzyme activation. On the other hand, potassium is the principal cation in intracellular fluids. It maintains fluid and electrolyte balance. It is also important for carbohydrate and protein metabolism. Iron is the only micromineral analyzed in this study. Iron is the most abundant trace element in the body. One of the most important functions of iron is in hemoglobin formation, a component of the red blood cells, the carrier of oxygen needed for cellular respiration (Ruiz, A., and Claudio, V., 2010). Iron deficiency anemia (IDA) is the most prevalent micronutrient deficiency affecting a large proportion of the population in the Philippines (Palanog *et al.*, 2019).

Grinding involves cutting food using tools or devices. The ancient tools used for grinding food, which are still in vogue, are the mortar and pestle and the grinding stone. A mortar is a stone cup, while a pestle is an oval-to-cylindrical-shaped stone that is used to pound food. This technique is used for grinding small to medium quantities of food. The food is pounded using a pounding stone or a pounding stick. This practice is still in vogue in India, Pakistan, and a few oriental cultures. Modern-day methods of grinding employ devices such as a mixer, blender, food processor, and an electrical grinder. Grinding can be of two types: dry grinding and wet grinding. Dry grinding is where ingredients containing no moisture are ground with the help of grinding tools or devices.

Grinding is a method of food processing where big chunks or particles of food are cut into fine pieces or bits. It could be done for various reasons. Ground food becomes more mixable with other ingredients. It is employed to process different varieties of foods. Grinding can be done with wet or moist food as well as with dry food. Grinding wet or moist food is called wetgrinding, and grinding dry food is called dry-grinding. Grinding can be done using a food processor, mixer, or grinder (IFOODTV, 2014).

Food preservation involves different food processing steps to maintain the food quality at the desired level to achieve maximum benefits and nutritional values. Methods of food preservation include planting, harvesting, refining, packaging, and food distribution. The key objectives of food preservation are to overcome unsuitable agricultural planning (Amit *et al.*, 2017).

In recent years, the techniques to combat food spoilage have become sophisticated and have gradually evolved into a highly interdisciplinary science. Highly advanced technologies like irradiation, high-pressure technology, and hurdle technology are used to preserve food items. This study used to freeze as a method to prolong the shelf life of the Soybean-based food products developed.

Gluten might be characterized as the 'strong, viscous, flexible proteinaceous material prepared as a result acquired by confinement of starch from wheat flour. A natural definition may incorporate the sources of the gluten–protein mindboggling as being gotten from the 'capacity proteins of the wheat grain' (Shewry and Halford, 2002). The last advance of gluten extraction is the drying of the gluten extricate. Drying of the gluten extricate has received significant consideration from scientists since high-temperature drying regularly effectively affects the gluten functionality (Czuchajowska and Paszczynska, 1996). For business gluten creation, the gluten is dried with high-temperature air, though in the research facility, freezing and vacuum drying have been accounted for to deliver gluten with better usefulness for bread making (Esteller *et al.*, 2005). Gluten-containing grains and foods make up a large portion of modern-day diets, with an estimated intake in Western diets of around 5–20 grams per day.

The gluten protein networks vary because of different components and sizes, and variability caused by genotype, growing conditions, and technological processes. The structures and interactions of this matrix contribute to the unique properties of gluten. The resulting functions are essential to determining the dough quality of bread and other baked products. Gluten is heat-stable and can act as a binding and extending agent and is commonly used as an additive in processed foods for improved texture, moisture retention, and flavor. Gliadin contains peptide sequences that are highly resistant to gastric, pancreatic, and intestinal proteolytic digestion in the gastrointestinal tract. The average daily gluten intake in a Western diet is thought to be 5-20 g/day and has been implicated in several disorders. Gluten-containing grains (wheat, rye, barley, and oats) are important staple foods. Gluten is among the most complex protein networks and plays a key role in determining the rheological dough properties. Products, beverages, dairy products, and others. The objective of this study is to develop full-fatted soybean-based food products as meat alternatives.

Materials and methods

The study utilized both qualitative and experimental methods of research to determine the consumer behavior toward fullfatted soybean-based products as a meat alternative, product development of three (3) full-fatted soybean meat alternatives, and pilot testing and commercialization of full-fatted soybean meat alternative products. Three (3) formulations for each meat alternative were tested. Each of these soybean-based products was subjected to sensory evaluation and consumer panel testing.

Determination of an acceptable soybean-based formulation was conducted through the use of the Hedonic Scale. The most acceptable formulation of each of the meat alternatives was subjected to chemical and nutrient analysis, cost analysis, and shelf-life testing. Results were used in crafting the nutrition facts.

Determine the consumer behavior on full-fat soybean-based products as meat alternatives

A deductive approach was used in this study. The descriptive method was the strategy used. The researchers made use of a structured survey questionnaire with two parts. The first part of the survey questionnaire contains questions related to sociodemographic including age, educational level, household size, occupation, and monthly household income of the respondents.

The second part of the questionnaire deals with the respondent's perception and willingness to purchase soybeanbased products as meat alternatives if these are available in the market. The respondents were asked to rate how psychological (individual) factors, sensory (product-specific) factors and marketing (environment) factors affect their preference or purchase of soybean-based food products.

Product development of full-fatted soybean-based products as meat alternatives

The researchers made use of a Structured Survey questionnaire with three parts. The first part of the survey questionnaire contains questions related to the sociodemographic characteristics, such as name, sex, age, and occupation of the consumer panelists. The second part of the questionnaire deals with the consumer panelists' acceptability in terms of overall acceptability, color, mouthfeel, taste, and texture. The third part of the questionnaire contains questions that deal with the product formulation, which they like the most among the formulation of the Soybean-based Full-fatted Food product as a meat alternative.

Physical and nutritional properties of the full-fatted soybean-based products as meat alternatives

The physical and nutritional properties that were considered in the study are the moisture content, water activity, and the macronutrients protein, fat, and total carbohydrates. The minerals sodium, calcium, potassium, and iron were also included in the analyses. These were analyzed at the

Regional Standards and Testing Laboratory at the Department of Science and Technology Regional Office No.1. This testing laboratory is PAB-accredited. Other micronutrients, such as the other minerals and vitamins, were not analyzed due to logistics brought about by the community quarantine during the COVID-19 pandemic.

Cost analysis of full-fatted soybean-based products as meat alternatives

Quantitative data were used in the study in the form of a cost analysis. The results of the cost analysis are also presented in descriptive form. The direct material cost components were computed based on the actual purchase price of the ingredients and the amount used for the standardized formulation. The labor cost component was based on the prevailing wage rates in the area. The production overhead cost is set as a percentage of labor cost. The established production cost is then used for other cost analysis methods, such as the break-even point and sensitivity analysis, to determine the financial viability of the product formulations.

Shelf-life analysis of full-fatted soybean-based products as meat alternatives

The three soybean-based products that were developed, namely: The full-fat soybean-based Longanisa, the Soybean-based burger patty, and the Soybean-based Nuggets, were wrapped in 250 portions and stored in the freezer. The method was used to determine at which time the expert will reject the full-fatted soybean-based food products as on their appearance, color, texture, taste, odor, and overall acceptability. The researcher made use of structured survey questions related to the sensorial factor of the products. A microbial test was used to confirm if the products are safe to consume during the trial period.

Storage temperature and sampling times

To study the effect of storage temperature, shelf-life experiments were conducted at -18 °C to -30 °C storage temperatures and were selected according to which product was likely to fail. The resulting sampling time at each temperature was, at -18 °C: 0,7,14,21,28,35,42,49, and 56 days; samples were manufactured for each of the sampling times and stored at the corresponding temperature. As samples belonged to different batches, the sensory panelists performed a triangular test to ensure that there was no significant difference between a sample of the previous batch (kept at -18 °C) and that of the following batches. The study was carried out in one stage.

Sensory analysis

The sensory shelf-life test is designed to validate the length of time that a product will remain at the same level of acceptability or have no change in the desired sensory characteristics of the product, ensuring the level of desired sensory characteristics over the entire life of a product. Changes in sensory properties are very sensitive to consumers rejecting products. Some product properties are too complicated to measure objectively.

Moreover, instrumental measurement alone cannot indicate consumer acceptability or rejection. It is very important to ensure no change in sensory properties since consumers want to pay for desired sensory characteristics at their acceptable level.

The Shelf-life discrimination test panel consists of eight assessors with years of experience in line with food and nutrition instruction to identify defects most likely to appear as a result of prolonged storage. A preliminary test was performed, in which three samples were presented to the assessors who had to write down the descriptor that made those samples different. By open discussion with the panel, leader assessors agreed on the best descriptor to differentiate the stored sample from the fresh sample: soybean-based food products' dryness and off flavor, or encompassed flavors such as moldy, acid, or rancid. The testing was carried out in a sensory laboratory equipped with daylight-type lighting. 5 grams per sample were given in a ceramic odorless tray at room temperature. Water was used for rinsing between samples. For scoring 9 points hedonic scale was used.

Statistical analysis

Analysis of variance (ANOVA) was performed on the data obtained for each sample from the sensory panelists, considering the storage time. Survival analysis methodology was used to estimate the shelf life of the full-fatted soybean-based food products at -18°C .

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Microbiological analysis

The subject underwent the process of Serial dilution to determine the estimated colonies of the organism of an unknown sample in serial dilution, the density of the colonies is reduced in each step for easy calculation of the concentration of the cells from the original solution by calculating the dilution over the entire series. The serial dilution process was performed to avoid having to pipette a very small volume ($1:10\ \mu\text{l}$) to make a dilution of a solution. By diluting a sample in a controlled manner, we can determine the number of colonies in the Petri dish.

Pilot testing and commercialization of full-fatted soybean-based products as meat alternatives

A descriptive qualitative exploratory research design was used for the study. In this study, the phenomenon observed was the experiences of the adoptees and the top management on the developed full-fatted soybean-based products as meat alternatives concerning the impact and different challenges affecting them after the training, as well as the strategies and initiatives to be employed for the commercialization of the three developed soybean-based products, namely, soybean longanisa, soybean burger patty, and soybean nuggets. Narratives/ scripts were utilized to capture the localized and contextualized experiences of adoptees and the top management of KEMPC.

Six female adoptees and two from the top management, specifically the Board of Directors-Chairman, and the KEMPC Manager, were interviewed. The age of the respondents ranges from 30 – 50 years old, and all of them are currently on-call employees in KEMPC

The study used semi-structured interview guide questions. Two (2) different questionnaires were utilized. Each questionnaire exposed their experiences after adopting the transferred technology was crafted according to the participants (adoptees and top management). technology was crafted according to the participants (adoptees and top management). First, the adoptees' interview was framed to This includes their demographic profile, the impact and challenges experienced after the training, and strategies to be employed for commercialization.

Second, the top management interview was designed to validate the responses of adoptees as well as the challenges experienced in adopting the technology, and strategies to be employed for commercialization and marketing. Also, the challenges and recommendations on marketing and commercialization were probed. Conventional and unconventional ways of data gathering were observed in the implementation of the study. Personal data on soybean-based meat alternatives when available in the market.

The psychological (individual) factors that will affect their purchase of soybean-based food products include their income, occupation, and health condition. The respondents also consider the freshness of the product and quantity per pack as important factors that will highly influence

their collection. Face-to-face interviews and focus group discussions were conducted with the aid of the guide questions.

Results and discussion

Product development of full-fatted soybean-based products as meat alternatives

Locally non-GMO soybeans were used for experimentation because of their characteristics. The basis of selecting the ingredients is locally grown non-GMO soybeans. The developed soybean flour was used as a base ingredient for the development of a full-fat soybean-based food product as a meat alternative. The overall acceptability was considered in the study.

Sensory evaluation

The three locally produced full-fat soybean-based meat food products as meat alternatives were presented to fifty (50) untrained panelists to be evaluated in terms of overall acceptability, color, mouthfeel, taste, and texture.

Full-fatted soybean-based burger patty

The overall acceptability of the soybean burger patty in the overall acceptability suggests that two of the three samples were significantly different from one sample, although they are all evaluated as being “Like Moderately” by the panelists.

With the discovery of the purple color by William Henry Perkins in 1856, the first synthetic color of purple became a big factor; it became historically favored in the food industry and routinely added to colorless or color loss during the processes. Colors in food acceptability and palatability are an indispensable factor (Corradini, 2019). The three treatments do not significantly differ, and the mean score is equivalent to “Like Very Much” in terms of their color. A small difference in mean shows that the 603=70% percent formulation got the highest mean in terms of color, which is 7.56, followed by 404 =50%, and 439=90%. This shows how color affects the acceptability of food to the consumer.

In terms of the mouth feel, the products got a descriptive equivalent of “Like Moderately”. All three formulations are acceptable to the consumer panelists. Treatment 404=50% formulation is not significantly different from 603 =70% formulation, but significantly different from 439=90%. Taste is a wide range of combinations of the five basic flavors when we eat. Prescott explains that taste matters. The brain distinguished the chemical qualities of food in the mouth based on the information the taste bud provides to the brain. .

The level of acceptability of the soybean-based food products in terms of taste, the result of the three formulations, was acceptable with the descriptive equivalent of “Like Very Much”. This implied a favorable result for Full fatted soybean-based burger patty, as all three treatments are acceptable considering the result of the acceptability of the untrained panelists to the product presented, and can be produced commercially based on its taste.

The texture of the product plays a very important role in the consumers’ acceptance. There are a few studies dealing with the effect of texture attributes on food acceptability. Meullenet (2004) access to the importance of texture in comparison to flavor was 0.89 with the group; the study showed that texture was especially important in food that is bland in flavor.

The level of acceptability in terms of the texture of the soybean-based food products as a meat alternative, among the three formulations, the 603=70% formulation got the highest acceptability with the descriptive equivalent of “like moderately”; however, 603= 70% is not significantly different from 404=50%. It indicates that they almost had the same texture, but the 439=90% was significantly different from 603=70% with the least acceptability among the three, which indicates that the most acceptable was the 603=70% even though they all got the descriptive equivalent of “Like Very Much”. This implies that the treatment has the potential to imitate the texture of nuggets that we can buy commercially.

The frequency of likeness of Soybean-based Burger Patty that 603=70% and 404=50% which got an equal percentage with 48% and 603 with the least with 16%. The result shows the difference among the three formulations, that the 439=90% Soybean formulation has the least likeness, which was accurately supported by the tables above, that treatment 439 is significantly different from the two formulations. Thus, the treatments 404=50% and 603=70% have almost the same qualities with a small difference in their acceptability.

The demographic variables, such as sex, age, occupation, and employment, that have a strong relationship to consumer purchase were considered in the study. The result shows that sex, age, and occupation are not significantly different in liking the soybean-based Burger Patty. Thus, this indicates that the soybean-based Burger patty is acceptable to different types of consumers in terms of sex, age, and occupation.

Nuggets

Overall acceptability of food is very important as well as color, flavor, and texture (Cardello, 1994; Love1994). The

Level of Overall acceptability of the soybean-based Nuggets, showed that the three formulations show no significance in the overall acceptability with the descriptive equivalent of "Like Moderately" thus the three formulations have a slight difference, the treatment 896=50% formulation has the highest acceptability among the three with 7.60 followed by 387=90% with the mean of 7.48 and 757=70% with a mean of 7.40.

Color has been a very important factor in food since ancient times. Colorants were used in Egyptian cities around 1500 BC by adding natural color to improve the products' appearance, for example, grape color, Saffron, and many more (Natural Colorant for Food: A healthy Alternative 2019). The level of acceptability of soybeanbased food nuggets in terms of Color shows that two among the three got "Like Very Much" descriptive equivalent, and the least with "Like Moderately".

Thus, the result was in consonance with the Natural Colorant for Food: A Healthy Alternative, that even without the use of the commercial colorant, organic color from other ingredients may be used to improve the acceptability of a food.

Chicken nuggets' satisfying mouthfeel provides an appealing characteristic. An article stated that the factor contributing to the sensory experience of a consumer by providing a goldenbrown color, moist interior, and pleasant aroma contributes to the satisfying mouth feel of common chicken Nuggets.

The acceptability level of the full-fatted soybean-based burger patty in terms of mouthfeel shows that all three treatments are not significantly different from each other in terms of mouthfeel. However, among the three, the treatment 896= (50%) got the highest mean result with 7.62, followed by 387= (90%) with 7.54, and 757= (70%) with the least result of 7.46 with the descriptive equivalent of "Like Very Much". The results suggest that the soybean-based nuggets likely reach the potential mouthfeel similar to the commercial chicken nuggets available in the market.

The acceptability of taste is one of the key qualities of a food product. According to the Science of Taste (2015), Nuggets with high nutritional value, low in cholesterol, good textural properties, nice flavor, and taste profile will become the favorite choice in terms of their acceptability (Behrends *et al.*,

2005; Calkin and Hodgen, 2007). The acceptability of Soybean-based Nuggets in terms of taste, comparing the mean score of the three formulations, shows that treatment 896 = 50% has 7.52 "Like Very Much", 757=70% (7.14), and 387=90% (7.20), both described as "Liked Much". However, the three treatments are not statistically different from each other on the level of

acceptability in terms of taste. Taste is one of the key sensory qualities of a food product. As indicated by the consumer respondents, the taste would highly affect their preference for the purchase of soybean-based products. Thus, result shows that all the consumer panelists are satisfied with the taste of the Soybean-based nuggets.

Texture

The Korean J Food Anim Resource (2015) stated that the appearance and texture (crispiness) and golden color are very important to the consumers. The level of acceptability of the Soybean-based Nuggets in terms of Texture based on comparison of the three formulations shows that there is no significant difference between the three treatments; however treatment 387=90% Soybean-based formulation got the highest score of 7.44, followed by 896=50% soybean formulation and 757=70% soybean-based formulation with the descriptive equivalent of "Like Moderately". The results show that the difference in texture among the three formulations is very small (0.8 to 0.12) and not significant with each other.

The Frequency of likeness of the Soybean-based Nuggets shows that among the three formulations, the percentage of likeness of treatment 896=50% Soybean-based Nuggets is the highest among the three formulations (42%), followed by 757=70% with thirty percent (30%), and 387=90% with twenty-eight percent (28%). The likeness of said formulation was supported by the results in terms of color, mouth feel, taste, and texture that show a significant factor in liking the 387=50 % soybean-based formulation.

The association of the respondent's demographic profile with the likeness of the Soybean-based Nuggets showed no significant difference in the likeness of Soybean-based Nuggets between male and female respondents. According to Karen Bronso et al. (2012), women are more conservative in food choice and more likely health health-conscious. Health is strongly linked to basic life values and purchase motives. The association of the consumer age was differentiated into three stages: early adult, midlife, and mature adult. Results show that there is no significant difference among the three stages, which means that the Soybean-based is acceptable to all ages. The result shows that the association of the consumers' demographic profile in terms of occupation is not significantly different across each category, which means that the occupation of the consumer is not associated with liking the Soybean-based Nuggets.

Longanisa

According to McWilliams (1974), acceptance of food is based on the impression the product makes on the senses. Just the thought of the sausage makes up for something they expect from sensing the product. The panelists are expected to taste the beany flavor. The overall acceptability of the Soybeanbased food product as a meat alternative showed that the treatments are not significantly different from each other with a sig of 0.896 and the descriptive equivalent of "Like Moderately".

The result implies that all three treatments are not different from each other in terms of overall acceptability, with the descriptive equivalent of "Like Moderately". The result was supported by different factors affecting the overall acceptability of the product.

The level of acceptability of the Soybean-based Sweet Longanisa in terms of Color shows that there is no significant difference among and between the three treatments, with the descriptive equivalent of "Like very much". Bennion (1980) stated that the eye appeal of the food is contributed to by such qualities as color that can stimulate a person's appetite.

The result implies that all three treatments are very much acceptable in terms of color, that the product exudes or replicates the Color of the meat-based ordinary Commercial Longaniza in the market.

The acceptability of the Soybean-based Longanisa in terms of Mouthfeel, that the three treatments is not significantly different from each other as they perceived almost the same mean score with a statistical equivalent range of 6.94 -6.76 with a descriptive equivalent of “Like Moderately”. This implies that the three treatments are almost the same in terms of Mouth feel, and the different percentages of treatment are not significantly observed. All the treatments are acceptable and replicate a similar mouthfeel to commercial Longanisa.

The level of acceptability of the soybean-based Sweet longaniza in terms of Taste shows that the three treatments are likely the same, as the result indicates no significant difference between all the treatments. This claim was supported with the sig score of 0.885. This result implies that the three formulations are accepted by the consumers; however, it indicates that even though 531 = (50%) is the most picked by the respondents, the small difference between and among the other treatments is not significantly different, and most likely they are similar to each other. This may indicate that all three treatments taste similar and are acceptable to the consumers.

All the treatments do not differ significantly from one another. This implies that the level of acceptability of the texture of the full-fatted soybean-based Sweet Longanisa is the same. Generally, they possess a similar texture. However, treatment 531 is the most acceptable treatment with a mean of 6.94, suggesting that treatment 531 (50%) should be used in producing the product in terms of texture, as it was the most accepted by the consumer panelists.

The frequency of likeness of the full-fat soybean-based longganisa revealed that all three treatments are equally chosen by the untrained panelists with a small difference of 2% which implies that all three treatments are acceptable.

The association of the demographic profile of the untrained panelists in terms of sex, age, and occupation shows that the demographic profile of the untrained panel is not significantly associated with the likeness of the Soybean-based Longanisa. It implies that the demographic profile of the consumer does not affect the likeness of the respondents towards the Fullfatted Soybean-based Sweet Longanisa. Regardless of the sex, age, and occupation, the Full-fatted Soybean-based Sweet Longanisa is acceptable.

Physical and nutritional properties of the full-fatted soybean-based products as meat alternatives

The physical and nutritional properties that were considered in the study are the moisture content, water activity, and the macronutrients protein, fat, and total carbohydrates. The minerals sodium, calcium, potassium, and iron were also included in the analyses. These were analyzed at the Regional

Standards and Testing Laboratory at the Department of Science and Technology Regional Office No.1. This testing laboratory is PAB-accredited. Other micronutrients, such as the other minerals and vitamins, were not analyzed due to logistics brought about by the community quarantine during the COVID-19 pandemic.

Moisture in foods occurs in two forms: the water bound to ingredients in the foods (proteins, salt, sugars), and free or unbound water that is available. Water activity (A_w) describes the water available for microbial growth. Water activity is a measure of how efficiently the water present can take part in a chemical reaction. The overall water activity would be reduced if half of the water is so tightly bound to a protein molecule that it could not take part in a hydrolysis reaction (Sandulachi, 2012). The water activity measurement provides important information regarding the possibility of microbiological growth on the surface. Free water in food products is responsible for the growth of undesirable organisms such as bacteria or fungi, which produce toxins or other harmful substances. Water activity ranges from 0 (bone dry) to 1.0 (pure water). When the water activity is smaller than 0.9, most molds are inhibited. Most microorganisms cease growing if the

water activity is smaller than 0.6. As such, the reduction of water activity will retard the growth of microorganisms, non-enzymatic browning, and enzymatic reactions (Kasai, 2014). Water could be controlled by processes such as removing water (drying or freezing), and by adding salt (curing).

The nutrients protein, fat, and carbohydrates are the macronutrients that the body needs in larger amounts to function properly. All of these nutrients provide the body with energy measured in the form of calories or kilocalories. Aside from providing energy, all of these macronutrients have specific roles in the body to function properly. Protein is a body-building nutrient that is necessary for the body to grow, build, and repair tissues. Carbohydrates are hydrolyzed into glucose as the main source of energy for the body, yielding 4 kcal/gram. Specific organs, such as the brain, need glucose as the sole source of energy. Fat is the concentrated source of energy, providing 9 kcal/gram. Fat is the storage form of energy. It also cushions the vital organs, a precursor for the synthesis of certain hormones, and helps maintain cell membrane integrity. However, excessive intake of fat, specifically saturated and trans fats, is known to increase the risk for cardiovascular diseases. Saturated fats come from animal sources, while trans fats come from margarine, baked, and fried foods. It is the objective of this study to develop soybean-based food products as meat alternatives with lower amounts of fat, particularly saturated fat.

The mineral sodium is of interest in a diet. It is the major cation in the extracellular fluid that maintains fluid and acidbase balance, but an excessive intake of this cation accumulates in the extracellular fluid, resulting in edema. Excess intake of sodium can raise blood pressure or hypertension, a major risk factor for heart disease. Calcium is another major mineral essential for human nutrition. The body needs calcium to maintain strong bones and carry out vital processes such as muscular contraction, blood coagulation, nerve transmission, and enzyme activation. On the other hand, potassium is the principal cation in intracellular fluids. It maintains fluid and electrolyte balance. It is also important for carbohydrate and protein metabolism. Iron is the only micromineral analyzed in this study. Iron is the most abundant trace element in the body. One of the most important functions of iron is in hemoglobin formation, a component of the red blood cells, the carrier of oxygen needed for cellular respiration (Ruiz, A., and Claudio, V., 2010). Iron-deficiency anemia (IDA) is the most prevalent micronutrient deficiency affecting a large proportion of the population in the Philippines (Palanog *et al.*, 2019).

Moisture content

Moisture content is a measurement of the total amount of water contained in a food. It is useful in determining the dry weight of food and its ingredients. The moisture content of a food has a direct effect on the way the food is processed and its appearance, mouthfeel, and texture (Bogart, 2018). For the three soybean-based food products developed as meat alternatives, the result of the analyses shows that the raw or uncooked products have a considerable amount of moisture. Soybean-based Patties have the most with 57.75 g/100g, followed by Soybean-based Longanisa with 50.38g/100g and

Soybean-based Nuggets with 48.99g/100g.

It is expected that the moisture content will be lessened when these products are cooked due to evaporation during cooking. Proper cooking temperature, however, is important for soybean-based food products to have the proper moistness, texture, and mouthfeel

Water activity

Water activity (A_w) is an important factor in food product development because it affects the texture, taste, appearance, safety, and shelf life of foods. Results of the analysis show that the water activity of the three soybean-based food products is relatively high, as follows: Soybean-based Longanisa, 0.95, Soybean-based Patties, 0.95; and Soybean-based Nuggets,

0.96.

This is similar to the study of Lewicki (2009) cited by Kasaai (2014) that the water activity of fresh foods (meats, seafood, fresh fruits, and vegetables) is high and close to 1. As stipulated, high water activity favors the growth of microorganisms such as bacteria, fungi, and molds, which results in the deterioration of the products if not controlled. According to the US Food and Drug Administration, foods with a water activity above 0.95 will provide sufficient moisture to support the growth of bacteria, yeasts, and molds. Bacteria such as *Salmonella*, *Clostridium botulinum*, *Serratia*, and *Lactobacillus* grow at a water activity ranging from 0.91-0.95, while *Pseudomonas*, *Escherichia*, *Clostridium perfringens*, and *Klebsiella* grow at 0.95 to 1.0 (Bogart, H., 2018). The water activity increases with

temperature (US FDA). Hence, it is recommended that soybean-based products be kept refrigerated or frozen to reduce water activity and prevent the growth of microorganisms, to prolong the shelf-life.

Macro-nutrient content

The three Soybean-based food products have a considerable amount of protein. Soybean-based Patties have 23.43 g/100 grams, Soybean-based Nuggets with 21.97 g/100 grams, and Soybean-based *Longanisa* with 20.42 g/100 grams. The amount of protein of the three soybean-based products is higher than full meat Hamburger Patty with 16.6g/100 grams, Chicken Nuggets with 15.5g/100 grams, and Pork *Longanisa* with 10.7g/100 grams as analyzed by the Food and Nutrition Research Institute, Department of Science and Technology (The Philippine Food Composition Tables, 1997).

The most acceptable formulation of the Soybean-based Patties has 200 grams of soybean textured, Soybean-based Nuggets have 240 grams of soybean flour, and Soybean-based *Longanisa* has 160 grams of textured soybean as the main ingredients. Soybean is a good source of protein. Soy protein has a very significant amino acid composition as it complements that of cereal. Although soybeans are deficient in methionine, one of the essential amino acids, they contain sufficient lysine to complement the lysine deficiency of cereals

(Lajalo and Genevese, 2002, cited by Sharma et al., 2014). Soybean-based meat alternatives are best taken with cereals such as rice in a meal to get all eight essential amino acids needed to build and repair body tissues for growth and development, and regulation of body processes.

For carbohydrates, the Soybean-based *Longanisa* has the most with 16.02 g/100 grams, followed by Soybean-based Nuggets with 15.97 g/100 grams, and the Soybean-based Patties have the least with 8.42 g/100 grams. Soybean seeds are also a good source of carbohydrates providing 35.9 grams/100 grams (The Philippine Food Composition Table, 1997). Aside from the soybeans that have contributed the most carbohydrates, the brown sugar added to the Soybeanbased *Longanisa* has provided additional carbohydrates since brown sugar provides 98.7 g/100 grams. For Soybeanbased Nuggets, the bread crumbs have provided a considerable amount of carbohydrates.

For fat, Soybean-based Nuggets and *Longanisa* have more fat content than Soybean-based Patties, 10.79g/100 grams, 10.47 g/100 grams, and 7.94 g/100 grams, respectively. Soybeans have a lower amount of fat content (17.2 g/100g). The pork added to the formulation of Soybean-based *Longanisa* and Soybeanbased Nuggets, as well as the cooking oil and chicken egg added to all three products, have contributed to the fat content of these meat alternatives. However, the fat contents are much lower when compared to the usual Pork *Longanisa* with 60.0 g/100 grams, Chicken Nuggets, 11.2 g/100 grams, and Hamburger Patties, 29.2g/100 grams (The Philippine Food Composition Tables, 1997).

Mineral content

The sodium content of Soybean-based Longanisa is the highest at 550mg/100grams, followed by Soybean-based Patties, 469 mg/100 grams, and Soybean-based Nuggets, 430 mg/100 grams. The Adequate Intake (AI) for sodium is 500 mg per day for adults aged 19 years to ≥ 70 years old based on the 2015 Philippine Dietary Reference Intakes (PDRI) (2018 Food and Nutrition Research Institute-DOST).

Adequate Intake is the daily nutrient intake level that is based on an observed or experimentally-determined approximation of the average intake by a group of apparently healthy people that are assumed to sustain a defined nutritional state (FNRI-DOST, 2018). Additionally, the FNRI-DOST recommendation is to limit sodium intake to <2 grams in adults, about the WHO Guideline on Sodium Intake for Adults and Children (2012). It must be emphasized that excessive intake of sodium has been shown to increase blood pressure, such as milk, sardines, dried anchovies, and small fish and leading to hypertension. In the Dietary Approaches to cheese should be included in the diet. Stop Hypertension (DASH) to lower or control high blood pressure. Foods high in sodium should be Legumes, including soybeans, are rich sources of limited. The DASHsodium diet recommends cutting potassium. The three Soybean-based products back sodium at 1,500 milligrams a day (about 2/3 developed have a considerable amount of teaspoon). People who followed the DASH-Sodium potassium.

Soybean-based Patties have 624 g/100 plan lowered their blood pressure (Beckerman, 2021). grams followed by Soybean-based Nuggets with the consumption of just enough amount (100-200 531g/100 grams and Soybeanbased Longanisa grams) of these soybean-based products will provide 469 g/100 grams. Considering the sodium needs of the body. recommended amount for Adequate Intake (AI) of 2000 mg/day of potassium for adults, the Calcium content is highest in Soybean-based Patties consumption of 100 grams of these products with 49 g/100 grams, and Soybean-based Longanisa, namely, Soybeanbased Patties, will provide 31.2 % has the least with 28 g/100 grams.

The calcium of Adequate Intake level, Soybean-based Nuggets contents are lower compared with usual Hamburger provide 26.55%, and Soybean-based Longanisa, Patty (114g/100grams), Pork Longanisa (25 23.45%. The recommendation of the Food and g/100grams) and Chicken Nuggets (48 g/100 grams) Nutrition Research Institute- Department of as analyzed by the Food and Nutrition Research Science and Technology is to increase the intake of Institute indicated in the the1997 Philippine Food potassium to 3,510 mg. in adults about the WHO Composition Table. To provide the Recommended

Guideline on Potassium Intake for Adults and Nutrient Intake (RNI) of 750 mg of calcium per day, Children (2012). Hence, the intake of greater amounts for adults aged 19 years to ≥ 70 years old, as well as the amounts of these products, will warrant the intake RNI for other age groups, other calcium-rich foods with adequate potassium.

For the trace element iron, results show that the three soybeanbased products developed will provide a negligible amount. The Recommended Nutrient Intake of iron for adult females aged 19-49 years old is 28 mg/ day; 50- ≥ 70 years old, 10 mg/day, and for adult males aged 19- ≥ 70 years old,12 mg/day. The products will have to be consumed with other rich sources of iron to provide the daily iron needs.

Nutrition facts of the soybean-based food products per serving size

The nutrition facts for labeling the three soybean-based products were determined. The nutrition facts will inform consumers about the nutrient content and help them choose a healthy diet. Serving sizes are standardized to make it easier to compare with similar foods. The serving size reflects the amount that people typically eat, but it is not the recommended amount that a person

should eat. The % Daily Value (%DV) is the percentage of the Daily Value for each nutrient in a serving of food. The Daily Values are reference amounts of nutrients to consume or not exceed each day. The % DV shows how much a nutrient in a serving of food contributes to a total diet (US FDA).

The nutrient content per serving size (50 grams/serving) of the three soybean-based products was calculated. For energy, one serving of Soybean-based Patties provides 90 kcal. Soybean-based Nuggets will provide 120 kcal. And one serving of Soybeanbased *longanisa* will provide 110 kcal. Soybean-based Patties have the least amount of total fat with 3g/50 grams. One serving of Soybean Longanisa will provide

the most sodium, with 275 grams. and total carbohydrate with 8 grams.

One serving of Soybean-based Patties will provide the most protein and potassium, with 11g. and 310 mg, respectively. One serving of Soybean-based Patties and Soybean-based Nuggets will provide the same amount of calcium, with 20mg. The percent Daily Value based on a 2000-kilocalorie diet for some nutrients to include total fat, total carbohydrate, and sodium.

Cost analysis of full-fatted soybean-based products as meat alternatives

The cost analysis is performed first by looking at the production cost components of each product. The total production cost is composed of the direct materials, direct labor, and production overhead. Break-even analysis is applied next to determine the point at which profits are expected. Finally, sensitivity analysis is used to project the production cost and selling price in the future after considering various economic variables.

Direct materials cost

Direct materials are those materials and supplies that are consumed during the production of a product, and which are directly identified with such product or form part of it. The direct materials cost was calculated based on the bill of materials and the number of ingredients used for each product formulation. The direct materials cost allocation for one production batch of the three product formulations, namely Soybean-based Burger Patty composed of 70% soybean, Soybean-based Longganiza (Chorizo) comprising 50% soybean, and Soybean-based Nuggets with 90% soybean component. The cost per unit column is calculated by dividing the purchase price of each ingredient by its total unit of measure, which is grams for dry ones and milliliters for liquids. It is then multiplied by the actual quantity of ingredients used. Also, the cost of the soybean component of each product formulation, the textured soybean base, is calculated.

Each production batch yields an output of 510 grams for Soybean-based Burger Patty, 590 grams for Soybean-based Longganiza (Chorizo), and 570 grams for Soybean-based Nuggets, respectively. The total cost allocation is then apportioned based on the 250-gram weight of each product when packaged. The direct materials cost component, therefore, per 250 grams is computed at Php 31.98 for Soybean-based Burger Patty, Php 34.96 for Soybean-based Longganiza (Chorizo), and Php 25.98 for Soybean based Nuggets, respectively, as presented in Table 35. Concerning the Full fatted Textured Soybean Base, one batch produces 2,400 grams of output with a materials cost of Php 197.46.

This is the basic component of all three products. It takes an hour to produce one batch of output. It has a direct labor cost allocation of Php 47.50 and an overhead of Php 19.00 allocated based on 40% of labor. The total production cost of a Fullfatted Textured Soybean Base is Php 263.96 per batch or Php 0.11 per gram. This means that 1,000 grams of the soybean base have a cost of Php 109.98.

Direct labor and production overhead cost

Direct labor refers to the salaries and wages paid to workers directly involved in the manufacture of a specific product. The direct labor component is computed based on the minimum wage in the Cordillera Administrative Region of Php 380 per day or Php 47.50 per

hour (DOLE, 2022). It is estimated that an hour is needed to produce three batches of Soybean Burger Patty and Soybean nuggets. On the other hand, two and a half batches of Soybean Sweet Longganisa are produced in an hour. The labor allocation is then computed at Php 7.76 for the Burger Patty, Php 8.05 for the Sweet Longganisa, and Php 6.94 for the Nuggets. The production overhead component is applied at 40% of the cost of direct materials. The overhead cost encompasses all other indirect expenses such as cooking gas, utilities, depreciation of equipment and machinery used, rent, normal spoilage and wastage, packaging materials, and other selling and administrative expenses that can be traced to the product that are not otherwise part of direct materials or direct labor.

The contribution margin shows how much additional revenue is generated by making each additional unit product after the company has reached the breakeven point and is computed by deducting all variable costs from the selling price. Variable cost is a cost that varies concerning production volume. Table 40 reveals that 109, 142, and 195 units of Soybean burger patties, longganisa, and nuggets, respectively, have to be sold to break even. That involves monthly sales totaling Php 25,247.93 for all three products to cover the fixed monthly expenses estimated at Php 8,000. It is broken down into Php 7,000 hypothetical rent for the production area, depreciation of machinery and equipment of Php 833.33, and the remaining Php 166.67 representing other fixed expenses.

Sensitivity analysis

Price changes have an impact not only on the company itself but also on its suppliers and competitors. The price of a product may change depending on many factors but the most obvious reason is its changing production cost. The company's market share is conditioned not only by brand building but also by the right pricing decisions and price changes, the selection of which can be made using sensitivity analysis (Majerova, 2015).

Kubjatkova (2020) posited that sensitivity analysis is based on an explicit representation of the influence of risk factors on the effects of the project or profit, expressed, for example, by the profitability of the project or by market share. A sensitivity analysis for three years is conducted as part of the cost analysis to reflect the effect of inflation and other risks on the three products. This will aid in many facets of decision-making making such as cost control, looking for cheaper sources of raw materials, devising appropriate marketing strategies, and other relevant business decisions. The estimates are based on trends in the increase of all aspects of production.

Concerning the direct materials cost, the average meat inflation rate computed from the data published by the National Economic Development Authority (NEDA) for the last two years (2020-21) and the first six months of the year (2022) of 8.58% was used in projecting the price of meat as a raw material. The average general food inflation rate for the same period of 3.79% is used to adjust the cost of the other remaining ingredients. The same inflation rates were also used to project year three and four production costs. The average inflation rates are presented in the appendices. Concerning the direct labor cost, the hourly rate is increased to Php 50 for the second and third years of operations and is projected to increase further to Php 54.29 in the fourth year of operations.

This complies with the minimum wage second tranche increase to Php 400 per day starting January 2023 based on Wage Order Number RB-CAR-21 issued by the Regional Tripartite Wages and Productivity Board of the Department of Labor and Employment applicable to private sector workers in certain areas of Cordillera Administrative Region such as Baguio City, Tabuk City, and the Municipality of La Trinidad (DOLE, 2021). The minimum wage effective June 14, 2022, is Php 380 per day.

For year four, a labor rate increase of 8.57% is estimated based on the labor rate increase used in the Wage Order Number RBCAR-21. The Production Overhead follows the increase in the direct

labor cost, where it is based at 40%. The projected production cost and estimated selling price for years two, three, and four. The details of the computation of projected production costs are found in the appendices.

It can be inferred that there is a slight increase in the cost and selling price for the future production periods caused by the abnormally high inflation rate experienced by the country, which started from the end of 2020, displaying the effects of the COVID-19 pandemic.

The actual production cost and selling price of Php 42.85 and Php 64.27, respectively, for Soybean Burger Patty, and it is projected to cost Php 49.83 and sell at Php 74.75 by year 4 of operations, with an increase of 16.29%. For the Soybean Sweet Longganisa, its actual production cost and estimated selling price of Php 46.23 and Php 69.34, respectively, are projected to increase to Php 54.29 and sell at Php 81.44 by year 4 of operations, with an increase of 17.43%. For the Soybean Nuggets with a production cost and selling price of Php 35.70 and Php 69.34, it is projected to cost Php 41.16 and sell at Php 61.74 by year 4 of operations that from the actual production cost and selling price of Php 42.85 and Php 64.27, respectively for Soybean Burger Patty and it is projected to cost Php 49.83 and sell at Php 74.75 by year 4 of operations with an increase of 16.29%. For the Soybean Sweet Longganisa, its actual production cost and estimated selling price of Php 46.23 and Php 69.34, respectively, are projected to increase to Php 54.29 and sell at Php 81.44 by year 4 of operations, with an increase of 17.43%. For the Soybean Nuggets, with a production cost and selling price of Php 35.70 increase of 15.29%.

Shelf-life analysis of full-fatted soybean-based products as meat alternatives

The food product samples underwent the process of Serial dilution to determine the estimated colonies of the organism of an unknown sample. In serial dilution, the density of the colonies is reduced in each step for easy calculation of the concentration of the cells from the original solution by calculating the dilution over the entire series. The serial dilution process was performed to avoid having to pipette a very small volume (1:10 μ l) to make a dilution of a solution. Diluting a sample in a controlled manner, we can determine the number of samples present number of colonies in the Petri film.

Period of trial

The result of the rapid aerobic count and rapid yeast and mold count of the soybean-based Sweet Longanisa shows a significant countable range of colonies by the reciprocal of the dilution used. The change of microbial count at week 9 at 331×10^3 shows a controlled environment for the product sample during the stages of the processing of the product, which shows a satisfactory level of food safety concern. The duration of the soybean-based burger patty during the period of trial. A trace of the aerobic count was detected at week 5 at 36×10^3 until week 9 with 69×10^3 thus a guide in calculating the Shelf life of food (New Zealand food safety Authority) indicates in the Guidelines for the microbiological examination of ready-to-eat food that the level 2 where the product was categorized and has a microbiological quality (CFU per gram) of $<10^6$ to $\geq 10^7$. Thus, results show minimal aerobic count, which indicates that the product is safe for consumption until the time of trial.

Microbial changes in Soybean-based nuggets' initial count of the rapid aerobic microbial count was at a low level, while they increased during the time; however, it did not reach the maximum limit of $<10^6$ to $\geq 10^7$ after the 9-week trial duration. The opening of the environment might cause the rapid growth of microbes. However, it could be inferred from the water activity a_w level of the soybean-based food products, where the a_w of the product relates to the susceptibility to spoilage.

The survival analysis estimation of shelf life, as expected, shelf life decreases when the storage duration increases. Considering the shelf-life for a 6-point rejection level to the overall

acceptability of the products, the statistical analysis showed a shelf life of 8 weeks, even when the study was carried out for 9 weeks.

Pilot testing and commercialization of full-fatted soybean-based products as meat alternatives***Technology Transfer/Training conducted***

The transfer of technology to identified/interested households/entrepreneurs for the adoption of the technology is one way to promote alternative meat products for a healthier lifestyle, as well as for additional livelihood opportunities. The training was conducted among ten (10) participants from the Kibungan Employees Multipurpose Cooperatives (KEMPC), Kibungan, Benguet. During the training, lectures on consumer behavior and nutrient analysis, demonstration, and return demonstration on the three (3) developed full-fatted soybean-based food products were conducted.

Focus Group Discussion/Interview on the Adoption and Commercialization

During the focus group, discussion and interview with the six (6) trained/adoptees and two (2) officers of the Kibungan Employees Multipurpose Cooperatives (KEMPC), Kibungan, Benguet on July 26, 2022, on the adoption and commercialization of the developed full-fatted soybean-based food products as meat alternatives, majority of the participants shared that they need assistance in marketing the soybean-based products. The majority of the participants mentioned that the lack of soybean supplies in the region, particularly in the Municipality of Kibungan, is the main challenge for them as adoptees.

Conclusions

In general, consumers in the locality, regardless of age, sex, educational attainment, and household income, are willing to buy soybean-based products as meat alternatives when available. Following the multidisciplinary model of the main factors affecting consumer behavior in a food domain, psychological (individual), sensory (product-specific), and marketing (environment) factors will highly affect the preference and purchase of soybean-based food products as meat alternatives among consumers in Baguio City and Benguet Province.

The nutritional value, health benefits, affordability, and taste of the product are the top-most important factors that are considered by consumers. Soybean foods and soybean products (especially fermented soyfoods) exhibit significant contributions to human welfare.

This study was conducted to increase the utilization of locally Non-GMO Soybean in the Philippines. Specifically, it aimed to produce Soybean-based food products as a meat alternative and determine the most acceptable formulation in terms of color, mouthfeel, taste, texture, and overall acceptability. Three different treatments were produced based on the preparation of three different soybean-based meat alternatives.

These were made using different methods of preparing the products. Three Full-fatted soybean-based products as meat alternatives were developed, namely: Full-fatted Soybean-based Burger Patty, Full-fatted Soybean-based Sweet Longanisa, and Full-fatted Soybean-based Nuggets. Three formulations for each product were subjected to sensory evaluation among 50 untrained consumer panelists to determine consumer acceptability in terms of color, mouthfeel, texture, taste, and overall acceptability, using a randomized complete block design.

The result of the study showed that the three developed full-fat soybean-based products were acceptable to the consumer panelists. Furthermore, the three developed full-fat soybean-based products have considerable amounts of nutrients, particularly protein, potassium, and sodium. The shelf-life analysis for a 6-point rejection level to the overall acceptability of the products showed a shelf life of 8 weeks. The cost analysis shows that the estimated selling price range is still lower compared to other similar commercially available products in the market. The soybean-based nuggets had the biggest price advantage as it is almost half of the average meat-based commercial product.

Based on the findings of the study, it is concluded that there is a great potential for the full-fatted soybean-based food product as a meat alternative to be viable in Baguio and Benguet, as well as in other areas. This conclusion is based on the prevailing condition of the high acceptability of the products, thus can be promoted as a healthy food.

Recommendations

1. Based on the findings of the study, the full-fatted soybeanbased food products as meat alternatives should be made accessible by having these products available in the wet market or being supplied directly by local entrepreneurs.
2. The soybean-based food products should be properly labeled to include the nutritional value and health benefits.
3. Farmers in the region and nearby regions are encouraged to plant soybeans.
4. Conduct a further study of the full-fat soybean-based food product as a meat alternative.

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