

DEVELOPMENT OF GLUTEN-FREE-VEGAN SAUSAGE AND EVALUATION OF ITS PHYSIOCHEMICAL, NUTRITIONAL, AND SENSORY CHARACTERISTICS

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ABSTRACT

The gluten-free vegan sausage is made from ingredients that are both plant-based and gluten-free in order to produce a product that has the same texture, flavor, and appearance as meat sausage and to meet rising consumer demand for wholesale meals. The main ingredients used to make the sausage are white beans, walnuts, and gluten-free oats. The components are chosen, combined, manually shaped, and frozen. Each sausage is wrapped and twisted in parchment paper, steamed, and then deep-fried until browned. The samples are then examined for physical, proximate, shelf life, pH, and a gluten test. The finished product contained the following amounts of energy (231.2 kcal), Protein (11.97 g/100 g), Ash (2.39 g/100 g), Fat (8.69 g/100 g), and Moisture (50.47 g/100 g). The semi-trained sensory panelist evaluated sensory perception using a 9-point hedonic scale rating system. This gluten-free, vegan sausage is good for the environment and for human health and can be a suitable alternative to meat sausage.

Keywords: Gluten-free, Walnuts, Oats, White beans, Vegan Sausage.

1. INTRODUCTION

Veganism is a way of life (philosophy of life) and has been well-established in a few years; more and more consumers are approaching and adopting this new lifestyle (Costa et al., 2019), mainly young people (mostly teenagers). Vegans unlike other consumers, are demanders of high-quality products. They prefer to buy and consume organic foods, “free of”, sustainable foods (local foods, among others (Niederle et al., 2020). Plant-based meat substitutes are gaining popularity. Sausage is an animal-based emulsion-type product that is made from finely chopped meat from various sources (beef, pork, mutton, etc.) (Keerthana Priya et al., 2022 & Bouvard et al., 2015).

Vegan sausages are meat-free substitutes made of a range of plant-based ingredients that have the flavor and texture of meat. To recreate the delicious flavor of conventional sausages, these ingredients like legumes, beans, nuts, and mushrooms mixed with a variety of seasonings, herbs, and spices. To achieve the desired texture and juiciness, additional ingredients such as vegetable oils, starches (potato or tapioca), and binding agents (like methylcellulose) are employed. For extra taste and texture, some vegan sausages could also include veggies like peppers or onions. This mixture is stable and binds water and traps fat, giving the finished product its distinctive texture. Since certain vegetable proteins cannot accurately mimic the spreadability of the meat product due to its unique structure (food matrix), imitation of meat products is extremely challenging. Due to this, it needs to find other options, such as dietary fibers, gums, and mucilage from vegetables, in order to obtain the desired texture (Mosso et al., 2020). Today, it is possible to create tastes and smells that are nearly identical to those of the original products using targeted molecular-sensory techniques. Despite this, the textures, oral processing, friction, and bolus formation of the products clearly show the molecular differences between them. This is shown here through concrete, interconnected examples and experiments, underpinned by molecular models. (Clayton et al., 2018).

White beans (belong to family Fabaceae) provide a good source of protein, an excellent source of fiber and several essential nutrients (Biesiekierski., 2017). They are brimming with lysine-rich proteins. A good source of folate, magnesium, and vitamin B6, among other elements, is white beans.

Gluten free oats, a protein called avenins protects against antibodies against gliadin in gluten-free oats, which are also free of gluten. The use of high-purity gluten-free oats will allow the production of safe gluten-free foods, providing nutritional and health-promoting benefits to gluten-intolerant people. (Aparicio-García et al., 2021).

Walnuts (family Juglandaceae) have vitamin b9, folic acid, and a few carbohydrates, the majority of which are fiber. Walnuts are a high-calorie, energy-dense nut, with most of their calories coming from fat, like other nuts. Additionally, it supports the immune system, heart, bone, and nerve health (TC Pimentel., 2021& Biesiekierski., 2017).

Chia seeds (Lamiaceae) contains omega-3 fatty acids, iron calcium, and anti-oxidants. They may lessen risk factors for heart disease diabetes and digestive health (TC Pimentel., 2021).

cumin (parsley), the flavor and aroma of white cumin are both warm and bitter. Vitamins B and E, Iron, and antioxidants that stabilize free radicals are abundant in it (Fatima et al., 2018). It helps in irritable bowel syndrome.

Black pepper (Piperaceae), Its spiciness is due to the chemical compound piperine, (Newerli-Guz et al., 2022) which is a different kind of spicy from the capsaicin characteristic of chili peppers. Black pepper is more than just a flavor enhancer for food. Antioxidants like piperine are supposed to strengthen the immune system and lower the risk of chronic diseases like atherosclerosis, cardiovascular disease, and neurological disorders (Newerli-Guz et al., 2022)

The rich essential oils of fennel seed (Umbelliferae) give additional flavour to the sausage. It has vitamin C, anti-microbial properties, and potent antioxidants like quercetin, limonene, and chlorogenic acid (Javed et al., 2020). The primary goal of this research is to assess the sausage's physical and chemical traits, including its moisture, pH level, cooking yield, nutritional information (carbohydrates, proteins, fats, ash, fiber, and calories), as well as its chewability, taste, appearance, and color.

2.0 MATERIALS AND METHODOLOGY

2.1 MATERIALS

The ingredients used to develop gluten-free vegan sausage are White beans (boiled)(270g), Smoked paprika(5.0g), Italian seasoning (4.2g), Salt(3.4g), Ground cumin(2.4g), Cayenne pepper (1.0g), Black pepper (6g), Fennel seeds (3.0g), Oats (gluten-free) (90g), Walnuts (60g), Onion (60g), Garlic Cloves(3 no's), Chia seeds(32g), Tomato paste (21.25g), soy-sauce(8g), Onion powder (12.0g) which was purchased from a local Market in Chennai.

2.2 PREPARATION OF GLUTEN FREE VEGAN SAUSAGE

The pulverized chia seeds were combined with 1/4 cup of water in a small bowl, and the mixture was left for 5 minutes to thicken. The tinned white beans were thoroughly rinsed in a strainer before being drained and then dried with paper towels. It was ensured for complete drying. With the use of a processor or blender, the walnuts are combined with the oats, all the essential materials are added along with the additional ingredients to the food processor and blended homogeneously to ensure that it will not be sticky; if it is, the oat flour was mixed to reduce the stickiness. Manually, 6–7 sausages are made and corrected for their shape. The sausages are then kept on parchment

paper and placed in the refrigerator for about 20 minutes. Each sausage is wrapped in parchment paper and tin foil, with the ends twisted like candy wrappers. Then place in a steamer basket or pan for around 35 minutes. A skillet was preheated and later added with cooking oil and the sausages were brushed on each side with a little oil. Turning occasionally, sausages are then fried for about 7 to 10 minutes, or until browned and thoroughly cooked.

Table –1: FORMULATION OF GLUTEN-FREE VEGAN SAUSAGE

Raw materials	Unit(gram)	Raw materials	Unit(gram)	Raw materials	Unit(gram)
White beans	30 g	Soy sauce	5.0g	Black pepper	3.4g
Oats (gluten-free)	20g	Onion powder	1.8g	Fennel seeds	4.0g
walnuts	20g	Smoked paprika	1.5g	Cayenne pepper	1.2g
Onion	5.0g	Italian seasoning	2.0g	Tomato sauce	4.3g
Garlic cloves	2.5g	salt	2.5g	Water	250 ml
Chia seeds	3.0g	Ground cumin	3.0g		

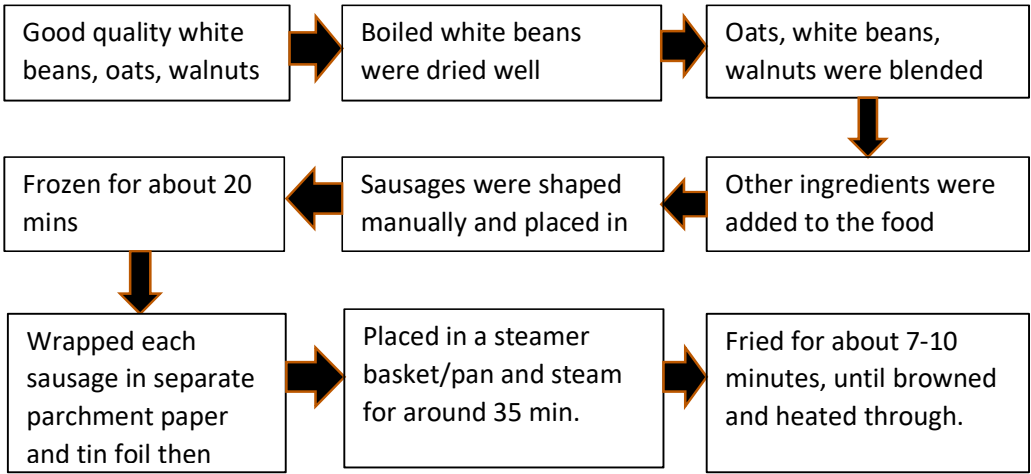


Fig 1: Experimental flow chart



Fig.2 Sausage wrapped in parchment paper



Fig.3 Raw sausage



Fig.4 Frozen Sausage



Fig. 5 Cooked Sausage

2.3 PHYSIOCHEMICAL ANALYSIS

2.3.1 MOISTURE CONTENT DETERMINATION

The moisture content of the control and sample can be determined by this formula.

Moisture content= Initial weight of sample – final weight of sample/sample weight x 100

2 .3.2 FAT CONTENT DETERMINATION

The fat content was determined using Soxhlet apparatus extraction described by AOAC 2016, method 920.85).

Fat content (%) = weight loss / weight sample × 100

2.3.3 ASH CONTENT DETERMINATION

Ash content was determined by AOAC 2016, Method 923.03 (Liu. K 2019).

Ash content (%) = weight of the sample after ashing /weight of the sample before ashing × 100

2.3.4 PROTEIN CONTENT DETERMINATION

The protein content of the sample was determined using the micro Kjeldahl method as described by IS: 7219:1973 (RA:2015) (Gorissen et al., 2018)

Crude protein (%) = % Nitrogen × 6.2.

2.3.5 CARBOHYDRATE

The carbohydrate content of the samples was determined by the standard ALPL/FD/SOP/065 method using the formula.

Carbohydrate (%) = 100 - (% moisture + % ash + % crude fiber + % crude protein + % fat)

2.3.6 TOTAL ENERGY

The total energy of each sample was determined by this formula.

Total energy (kcal/100g) = (% carbohydrates × 4) + (% protein × 4) + (% fat × 9)

2.3.7 GLUTEN TEST

The vegan sausage was tested for gluten using IS: 1155:1968(RA;2015).

2.4 SENSORY ANALYSIS

The sensory attribute of the sausage was given to 10-15 semi-trained panelists. A 9-point hedonic scale rating was used to produce by 10 panelists. rating - 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely.

2.5 pH LEVEL

The scientific community has established and widely recognized the impact of pH on food stability and preservation. Even while a food's pH is crucial for microbial growth, it also impacts many functional aspects of food, including color, flavor, and texture. A total of 10 g of cooked sausage will be homogenized in 90 ml of water to ascertain the pH, which will then be measured using a pH meter.

3.0 RESULTS AND DISCUSSION

3.1 PROXIMATE ANALYSIS

The produced sausage's moisture content ranged from 50.47 to 66.84, with a notable difference between the control and sample. While the control had the greatest moisture content, the sample had the lowest. This contributes to shelf-life extension. White beans and oats were added, which led to the high protein level that was discovered. Due to the presence of walnuts, which are the visible fat in the sausage, the sample's fat level was higher than the controls. Ash levels in the sample and the control are 2.39 and 2.14, respectively. Compared to the control (29.82), the sample's (10.20) carbohydrate content is incredibly low. In comparison to the control (160.43), the sample had a greater energy content (231.20).

Table 2 - Proximate analysis

Parameter	Moisture g/100g	Protein g/100g	Fat g/100g	Ash g/100g	Carbohydrate g/100g	Energy kcal
Control	59.84	9.89	9.42	2.14	29.82	160.43
Sample	50.47	11.97	8.69	2.39	10.20	231.21

3.2 pH level

The pH level is low in the sample (5.17) compared to the control (6.00).

Table 3- pH test

Parameter	pH
Control	6.00
Sample	5.17

3.3 GLUTEN TEST

Table 5: Gluten Test

The vegan sausage was tested for gluten using IS: 1155:1968(RA;2015). The BDL (below the deductible low) represents the gluten content that is absent in the product. The unit for gluten is ppm (pass per million).

Parameter	Result (ppm)
Gluten	BDL (Below Desired Level)

3.4 SENSORY ANALYSIS

The findings of the sensory evaluation show that, depending on the supplementation amounts, there are substantial differences in taste, consistency, and general acceptance among the sample. The fact that the substances employed in the two products were completely different is what caused the sensory analysis to differ. The experimental sample's overall sensory analysis is higher than that of the control sample. The graph below shows the sensory panel members' average hedonic ratings for the sausage.

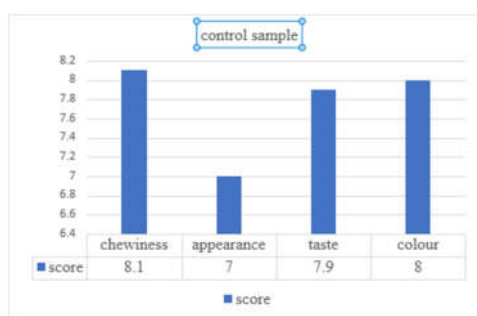


Fig.6 Graphical representation of Control sample

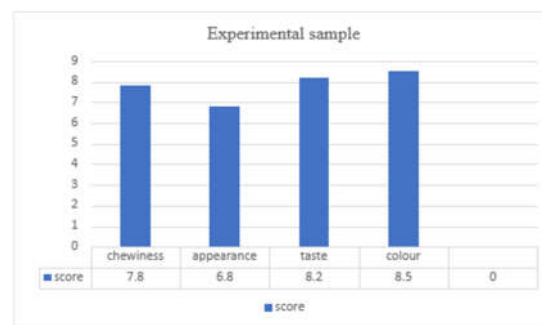


Fig.7 Graphical representation of Experimental

4. CONCLUSION

The demand for vegan sausage gluten-free products will rise as vegan consumers become more prevalent. By the way, this also contributes to a decrease in meat consumption, which may have a positive effect on the environment. The goal of this research is to create vegan gluten-free sausage that gluten-intolerant people can eat. The unique ingredients utilized to make the sausage, such as walnuts, oats, and beans, could be a good substitute because they are high in protein and fiber, and the generated vegan sausage exhibited good sensory and physiochemical qualities.

5. RECOMMENDATION

Based on the study's findings, it can be said that a cleaner production method can be used to create an eco-friendly, vegan product with lower emission of CO₂ from producing 1kg of sausage can be determined. There is no addition of preservatives, artificial flavors, or any soy additives. Coconut flour and other related natural additives can be also added to products without affecting their characteristics.

6. REFERENCES

1. Costa, I., Gill, P. R., Morda, R., & Ali, L. (2019). "More than a diet": A qualitative investigation of young vegan Women's relationship to food. *Appetite*, 143, 104418.
2. Niederle, P., & Schubert, M. N. (2020). How does veganism contribute to shape sustainable food systems? Practices, meanings and identities of vegan restaurants in Porto Alegre, Brazil. *Journal of Rural studies*, 78, 304-313.
3. Mosso, A. L., LeBlanc, J. G., Motta, C., Castanheira, I., Ribotta, P., & Sammán, N. (2020). Effect of fermentation in nutritional, textural and sensorial parameters of vegan-spread products using a probiotic folate-producing *Lactobacillus sakei* strain. *LWT*, 127, 109339.
4. Aparicio-García, N., Martínez-Villaluenga, C., Frias, J., & Peñas, E. (2021). Sprouted oat as a potential gluten-free ingredient with enhanced nutritional and bioactive properties. *Food Chemistry*, 338, 127972.
5. Fatima, T., Beenish, N. B., Gani, G., Qadri, T., & Bhat, T. A. (2018). Antioxidant potential and health benefits of cumin. *J Med Plants Stud*, 6, 232-236.
6. Javed, R., Hanif, M. A., Ayub, M. A., & Rehman, R. (2020). Fennel. In *Medicinal Plants of South Asia* (pp. 241-256). Elsevier.
7. Newerli-Guz, J., & Śmiechowska, M. (2022). Health Benefits and Risks of Consuming Spices on the Example of Black Pepper and Cinnamon. *Foods*, 11(18), 2746.
8. Clayton, E.M. R., Specht, E. A., Welch, D. R., & Berke, A. P. (2018) addressing global protein demand through diversification and innovation: An introduction to plant-based and clean meat. In L. Melton, F. Shahidi, & P. Varelis (Eds.), *Encyclopedia of food chemistry*.
9. De Angelis, D., Kaleda, A., Pasqualone, A., Vaikma, H., Tamm, M., Tammik, M.- L., Squeo, G., & Summo, C. (2020). Physicochemical and sensorial evaluation of meat analogues produced from dry-fractionated pea and oat proteins. *Foods*, 9(12), 1754.
10. Dekkers, B. L., Boom, R. M., & van der Goot, A. J. (2018). Structuring processes for meat analogues. *Trends in Food Science and Technology*, 81, 25–36.
11. Keerthana Priya, R., Rawson, A., Vidhyalakshmi, R., & Jagan Mohan, R. (2022). Development of vegan sausage using banana floret (*Musa paradisiaca*) and jackfruit (*Artocarpus heterophyllus* Lam.) as a meat substitute: Evaluation of textural, physico-chemical and sensory characteristics. *Journal of Food Processing and Preservation*, 46(1), e16118.
12. Varieties of Black Pepper - agriinfo.in
13. Kyriakopoulou, K., Keppler, J. K., & van der Goot, A. J. (2021). Functionality of ingredients and additives in plant-based meat analogues. *Foods*, 10(3), 600.

14. Riazi, F.; Zeynali, F.; Hoseini, E.; Behmadi, H.; Savadkoohi, S. Oxidation phenomena and color properties of grape pomace on nitrite-reduced meat emulsion systems. *MEAT Sci.* **2016**, 121, 350–358.
15. TC Pimentel, WKA da Costa, CE Barão... - *Food Research ...*, 2021 – Elsevier
16. JR Biesiekierski - *Journal of gastroenterology and hepatology*, 2017 - Wiley Online Library.
17. Barreca, D., Nabavi, S. M., Sureda, A., Rasekhian, M., Raciti, R., Silva, A. S., ... & Mandalari, G. (2020). Almonds (*Prunus dulcis* Mill. DA web): A source of nutrients and health-promoting compounds. *Nutrients*, 12(3), 672.
18. Liu, K. (2019). Effects of sample size, dry ashing temperature and duration on determination of ash content in algae and other biomass. *Algal Research*, 40, 101486.
19. Gorissen, S. H., Crombag, J. J., Senden, J. M., Waterval, W. H., Bierau, J., Verdijk, L. B., & van Loon, L. J. (2018). Protein content and amino acid composition of commercially available plant-based protein isolates. *Amino acids*, 50, 1685-1695.