OPEN ACCESS

Middle East Research Journal of Engineering and Technology
ISSN: 2789-7737 (Print) & ISSN: 2958-2059 (Online)
Frequency: Bi-Monthly
DOI: 10.36348/merjet.2021.v01i01.010

KUWAIT SCHOLARS PUBLISHER
Website: http://www.kspublisher.com/
Email: office@kspublisher.com

Formative Investigations on Defatted Custard Guava Seed as a High-Dampness Meat Analogue Employing Extrusion Cooking

Sandeep Rani[1*], Tanuja Srivastava[2]
[1]Assistant Professor, Bhai Gurdas Group of Institutions, Sangrur, India
[2]Director, Bhai Gurdas Institute of Engineering and Technology, Sangrur, India

Abstract: The impact of animal meat intake at the environment and additionally on the fitness because of the increasing consciousness is a subject of discussion within the literate world. The changing definitions of the vegetarian ingredients have drifted the vegetarian populace to vegan products which can be absolutely devoid of any animal produce. Soy protein has emerged as an opportunity alternative; still there are demanding situations of production and non-availability of variety. Looking into the need of high protein wealthy plant-based totally meat analogue, the prevailing take a look at investigates the defatted custard guava seed protein as a meat analogue product. After the extraction of the proteins from the seeds of defatted custard guava, twin screw corotating extruder becomes hired for the improvement of high moisture meat analogues. The advanced protein meat analogue became analyzed for the rheological attributes, texture, thermal properties and color. The findings supplied an proof of incorporation of defatted custard guava seed protein within the extrudate as a stable product with protein content starting from 55.79% to 64.39%. The consistency and different attributes of the meat analogue have been quite in the applicable variety. The viscosity of the final product changed into determined to be 60 Pa.s, following a non-Newtonian nature of drift. The parameters like chewiness ranged from 7.77 N to 15.27 N, and the cohesiveness various from 0.42 to 0.63. The evolved meat analogue possessed the favored traits for a meat replacement advocated by using the diverse characterization and assessment parameters.

Keywords: Moisture Content; Extrusion; Meat substitute, Sensory Analysis.

Research Paper

***Corresponding Author:**
Sandeep Rani
Assistant Professor, Bhai Gurdas Group of Institutions, Sangrur, India

How to cite this paper:
Sandeep Rani & Tanuja Srivastava (2021). Formative Investigations on Defatted Custard Guava Seed as a High-Dampness Meat Analogue Employing Extrusion Cooking. *Middle East Res J. Eng. Technol, 1*(1): 61-67.

Article History:
| Submit: 03.11.2021 |
| Accepted: 14.12.2021 |
| Published: 31.12.2021 |

1. INTRODUCTION

Change in food habits has been considered as the simplest approach after comparing numerous strategies to improve the fitness of populace around the sector by altering the nutritional patterns which include lowering the intake of power and minimizing products acquired from animals. For making sure superior increase and improvement of people, most appropriate and apt manner is the well belief-out eating regimen dietary supplements primarily based mostly on plant supply and deciding on such kind of herbal foundation meals can conjointly help in prevention as well as treatment of various chronic and persistent diseases. The chance of several sicknesses which includes obesity, type-II diabetes, cancer and coronary heart ailment may be decreased down via growing the intake of plant food and lowering consumption of food from animal resources and also expectancies of a superb life can be greater wonderful. The meals primarily based on plant supply are more eco-friendly and ecological than the goods from animal assets. The hazard of Greenhouse Gas Emissions (GHG) is drastically lesser with the plant based totally definitely food merchandise compared to the animal derived foods. The fundamental reason at the back of this are the huge carbon footprints produced because of the producing of meals from animal belongings, in particular the pork. And moreover, the consumption of animal sourced food products by the people are the primary purpose within the lower back of the generation of their carbon footprints [1–3].

Meat analogs may be defined because the pre-packaged food merchandise rich in macromolecules including protein and have similar touch and makeup to that of the meat from animal source. Additionally, they may be flavoured with artificial flavouring sellers to provide them with a flavor just like that of hen, red meat, turkey or fish. It has also been noticed that in the past ten years, the selling of protein wealthy surrogates for meat has increased the advertising of meat analogs. Approximately, more than 33% of the Americans were reportedly shopping meat substitutes from the marketplace in preference to simple meat. Apart from their developing reputation and amongst vegetarians, non- vegetarians who plan to get rid of meat from their diet or folks who select the analogs as a wholesome alternative or as a part of greater eco-friendly nutritional complement are also attracted closer to the meat analogs [1, 4]. Apart from providing required proteins and enough degrees of dietary roughage, meat analogs own additional qualities which include presence of natural anti-oxidants and phytochemicals and also reducing down the saturated fatty acid content material and no cholesterol amount. Basically, the wheat or soy protein is the most important additives of meat analogs however a few quantity of mycoprotein, nuts, legumes or veggies can also be gift, at the same time as few of the meat analogs may additionally comprise a few components from animal source like as egg or milk [5]. The composition of vitamins used and the impact of surroundings can be the elements for growing variations inside the numerous protein food merchandise primarily based on animal source including chook, red meat, pork and so on. There is a scarcity of revealed medical facts comparing the environmental impact and nutritional benefits of meat analogs derived from absolutely exceptional macromolecular resources. But there is consensus at the need of plant-based meat analogs for those who are vegetarian and these analogs can be a nutritive and financial substitute for the majority of human beings [6, 7]. The generally acknowledged custard guava, with botanical call of Annona squamosa L. (Annonaceae), is said to be a pandemic tropical flora dispensed over Ecuador, Egypt, Mexico, India, elements of America, Peru, Bermuda, Brazil, Pakistan, and other tropical regions of the globe. In traditional medicine, Annona squamosa find its programs, and additionally its fruit is a superb dietary source. There are many medical reports handling the protein content of the leaves and seeds of the plant, however no observe has been traced for the beef analogue derived from the seed proteins [8]. Looking into the need of meat analogues and the non-availability of research on non- soya meat analogues, it became predicted to discover the ability of proteins extracted from deoiled custard guava seeds for the same [9].

2. MATERIALS AND METHOD

2.1 Raw Material

Source of the custard guava seeds (*Annona squamosa L.*) was the local market of Sailu, Distt. Parbhani (Maharashtra). Fully matured fruits with opened eyes with off white and green color were screened. Emphasi was made on the selection of seeds without any mechanical injury and visual marks of damage. To harvest the seeds from the food pulp, manual separation was done [9].

2.2 Extraction of Proteins from the Custard Guava Seeds

A targeted approach of the extraction of the proteins from the seeds was achieved as described by using Kumar and Sharma, 2016 [9]. A reaction surface methodology changed into employed to discover the most fulfilling conditions for the extraction of the proteins from the seeds. The situations had been observed to be using zero.6% w/w of sodium hydroxide in a solution with pH of 11 and the flour to solvent ratio of 1:60. The optimized technique fetched with the protein content material of 68.07% and protein yield of 18.69%.

2.3 Moisture Determination

To determine the moisture content material of the protein powder, slightly changed AACC approach, i.e., 44-15A was hired. In quick, the protein powder became weighed (three-five grams), the powder turned into located in a ceramic box and turned into placed in an oven, maintained at 103° C. The powder changed into located there for a length of 16 h, till no alternate within the mass became located. The moisture content material becomes stated as the mass distinction w.r.t. to the preliminary mass. The extruded merchandise have been harvested from the extruder, allowed to equilibrate with the room temperature, sealed in air-tight plastic baggage and deep freezed until utilization. For measurement of the moisture the samples were cut into the portions and executed for the moisture content material determination after thawing [6, 10].

2.4 Extrusion

A dual-screw extruder turned into employed (KETSE 20/40, M/s Brabender GmbH, Germany) to carry out the extrusion technique. The formerly said technique changed into employed for the extrusion [7, 11]. For the extrusion, a complete of 04 batches had been studied, i.e., protein to water ratios of 90% w/w, 80% w/w, 70% w/w and 60% w/w. For feeding the appropriate quantities of protein listen and water to the feeder, the feeder changed into pre-calibrated. The extrusion conditions had been fixed at the screw speed of 800 rpm and six temperature cycles as 40 °C, 70 °C, 130 °C, 150 °C, 140 °C and 140 °C. The mass glide charge of 95 g/min-1 and particular mechanical power of round 100 kJ/kg became used. A quick die of 2 mm diameter become used and the extruded product became dried at40 °C for 120 minutes and similarly packed in air tight poly-bags and saved in deep freezer.

2.5 Composition of the Meat Analogue

The Association of Official Analytical Chemists (AOAC, 2000) methods of protein amount, moisture content and ash were employed. AOAC method (Method No. 978.04) was used to determine the lipid content using the Soxhlet apparatus. The percentage of carbohydrate was determined by mass balance [12, 13].

2.6 Texture Profile Analysis (TPA)

TA.XT2i texture analyzer (Stable Micro Systems Ltd., UK) with 36 mm diameter cylindrical probe changed into employed to have a look at the texture profile of the samples. The previously said widespread system for texture evaluation became accompanied. The meat analogue becomes rehydrated in faucet water till no strains of dry fabric had been determined inside the middle of the pattern. The samples had been cut in the portions of 20 mm x 5 mm. various textural parameters had been reported by way of the software program hired within the system [7].

2.7 Viscosity

The American Association of Cereal Chemists (AACC) method was used to determine the viscosity of the developed meat analogue. Perkin Elmer viscometer was employed to determine this property. Around 3.5 grams of the product was weighed and mixed with 27 ml of water and allowed to absorb moisture. The sample was heated to 50 °C and then mixed for 10 s at 960 rpm. The mixture was maintained at 50 °C for 50 s. The temperature was increased at the rate of 12 °C/min and heated up to 130 °C. It was maintained at 130 °C for 2.5 minutes and then again cooled to the 50 °C [6].

2.8 Physicochemical and Functional Properties

Previously mentioned method become used to determine the crucial homes like water absorption (WAC), bulk density (BD) and oil absorption capacities (OAC) [14]. For the determination of rehydration ratio (% RR), round five g of the meat analogue was positioned in water (50 mL) for 60 minutes at the temperature of 20 °C. The equation hired for the willpower of %RR was as follows:

$\% RR = (X2 - X1)/X1 \times 100$

Where the mass of the sample after rehydration is represented as X2 and the preliminary mass is represented as X1. The particular volume of entire meat analogues was determined by way of rapeseed displacement AACC approach 10- 05.01.

2.9 Sensory Analysis

"A panel of 5 individuals finished the challenge after one-time training of not unusual edible products in terms of organoleptic attributes. The panelists evaluated the sample on an eleven factor scale, starting from 0-10. Verbal anchor points have been used to calibrate the panel's understanding of the scale. Physical references had been used for all of the attributes, where plantbased extruded samples needed to be as compared with meat. Panel overall performance turned into verified using Panel Check (version 1.4.1—Nofima Mat, Breivika, Ås, Norway). The list of the sensory attributes, definitions, and scale is pronounced some other place [7]. The chewiness of the sample turned into determined by means of chewing it until the mass is transformed into a swallow able shape by means of putting the pattern among the tooth. A total of 5 chews have been used as a reference. It was installed that the size had enough scale-points to differentiate the products, additionally to save you the avoidance of scale-give up anchors. For the descriptive sensory evaluation, quantities of 5 g of rehydrated meat analogues (in line with the instances identified for the TPA) were put in a pitcher box, codified by means of a three-digit alphanumeric code, after which served to every panelist accompanied with the aid of Williams' Latin rectangular layout. Sensory analysis was replicated on exclusive sessions. Each panelist completed the sensory assessment in a sensory room consistent with the ISO 8589:2007 [7]."

2.10 Statistical Analysis

"The data were subjected to one-way ANOVA followed by Tukey's HSD (honestly significant difference) test. Significant differences were determined at $p \leq 0.05$ by Minitab 17 Statistical Software (Minitab, Inc., State College, PA, USA) [1]."

3. RESULTS AND DISCUSSION

3.1 Extraction of Proteins from the Custard Guava Seeds

The protocol of the extraction of the custard guava protein has been already published and the response surface methodology was used to optimize the extraction process. A brief of the published results are presented here [9]. The conditions were found to be the use of 0.6% w/w of sodium hydroxide in a solution with pH of 11 and the flour to solvent ratio of 1:60. The optimized method fetched with the protein content of 68.07% and protein yield of 18.69%.

3.2Moisture Content

The variety of the moisture content material of the extracted protein became 5.39% to 6.17% and the moisture content inside the extruded meat analogue changed into inside the range of 60.19 % to 76.28%. The moisture content material of the extruded substances became falling within the favored variety of moisture for the milk-like merchandise, i.e., 70% to 75%, however, the product obtained with feed of 90% feed gave the bottom cost of the moisture content, i.e., 60.19%, while other three batches exhibited the favored goal product moisture cost and the findings were in consonance with the same research, even though concerning specific vegetarian protein bases [6].

3.3Composition of the Meat Analogue

The meat analogues have been evaluated for diverse nutrients using the usual protocols. The protein in the dry powder becomes 68.07% and the protein content in the 4 meat analogues ranged among 55.79 % to 64.39 %. The values of various nutrients had been stated inside the Table 1. Lipids constituted the 7.23 % of the protein powder and from 5.49 % to 6.87 % of the beef analogues. In the modern meat analogue products the stated cost of fat stages from three. 47 % to 20.0%, notwithstanding diverse processing steps [15]. The percent of carbohydrate in the apparent powder changed into 20.74 % and the ash cost changed into3.96 %. The carbohydrate content material within the exudates became discovered to be inside the range of 27.27 % and 37.11%, while the ash content material range become from 2.85% to 5.47% . The meat analogues supplied exact nutritive cost, as in all of the compositions; the quantity of protein changed into higher than the 50% of the entire mass of the product. The starch content was also proper and also desired in meat analogues as it enables in the extrusion procedure and additionally provide the fibrous texture to the meat analogues. The protein contents of similar advertised merchandise variety among 17.7 g/100 g and 25.0 g/100 g, advocating the prevailing merchandise provide good protein content material than such products [15, 16].

Table 1: The nutritional composition of the various products derived from defatted custard guava seeds

Component	**Pure Protein Extract**	**90% w/w Protein Extract**	**80 % w/w Protein Extract**	**70 % w/w Protein Extract**	**60 % w/w Protein Extract**
Protein (%)	68.07± 2.14	64.38 ± 3.08	60.36 ± 3.92	57.25± 4.21	55.78 ± 2.32
Lipids (%)	7.25± 0.69	5.4 ± 0.21	5.97 ± 0.17	4.75 ± 0.07	6.85± 0.41
Ash (%)	3.97 ± 0.21	2.85 ± 0.11	1.8 ± 0.07	2.54 ± 0.05	5.48 ± 0.37
Carbohydrates (%)	20.64 ± 1.93	27.28 ± 2.07	31.85 ± 0.09	35.56 ± 1.15	37.21 ± 1.13

Data expressed on dry matter. Different letters in the same row mean significant differences at p <0.05. n = 4.

3.4 Texture Profile Analysis (TPA), Physicochemical and Functional Properties

The numerous parameters studied underneath the headings of TPA, physiochemical and purposeful properties were represented inside the Table 2. It is really obvious that the values of hardness, cohesiveness, springiness, chewiness together with the values of bulk density, WAC, % RR and OAC have been of maximum significance for the crude protein powder. The statistics unequivocally advocates that the powder as such couldn't be appeared because the eatable choice, but the extruded products offered extensive reduction inside the values of hardness, cohesiveness, springiness, chewiness, indicating that they've the beef like/meals like attributes. The 90% w/w product provided the most values of the TPA parameters over the extruded compositions, indicating a higher diploma of muscle force and power is required to bite this fabric. As the composition of water become elevated these attributes decreased, indicating the convenience of chewing expanded. However, a outstanding truth is that the protein content additionally decreased inside the equal sample [17].

After the incorporation of water and extrusion, the bulk density decreased in a chronological manner, as expected as the fluffiness due to fibres and carbohydrates might have increased. The water absorption and oil absorption capabilities coupled with the rehydration ration also decreased with the increasing water content due to the swelling of the fibres and development of a network matrix.

Table 2: Textural, physicochemical and functional characterization of the crude protein and meat analogues

TPA, Physicochemical and Functional Properties	**Protein**	**90% Protein analogue**	**80% Protein Analogue**	**70% Protein Analogue**	**60% Protein Analogue**
Hardness (N) *	34.69 ± 3.93	23.53 ± 2.72^{a}	17.19 ± 3.27^{ab}	14.14 ± 2.15^{ab}	13.93 ± 1.50^{ab}
Cohesiveness *	1.24 ± 0.07	0.63 ± 0.02^{a}	0.53 ± 0.01^{ab}	0.44 ± 0.03^{abc}	0.42 ± 0.01^{ab}
Springiness *	1.19 ± 0.09	0.81 ± 0.06^{a}	0.73 ± 0.03^{ab}	0.64 ± 0.02^{abc}	0.57 ± 0.03^{abcd}
Chewiness (N) *	18.08 ± 1.17	15.26 ± 2.63^{a}	13.76 ± 1.52^{a}	8.29 ± 0.64^{abc}	7.77 ± 2.15^{abcd}
BD (g mL^{-1}) **	0.81 ± 0.05	0.63 ± 0.03^{a}	0.45 ± 0.02^{ab}	0.37 ± 0.01^{abc}	0.29 ± 0.03^{abcd}
WAC (g water g^{-1}) **	5.19 ± 0.08	3.19 ± 0.02^{a}	2.85 ± 0.13^{ab}	2.25 ± 0.08^{ab}	1.92 ± 0.01^{abcd}
RR (%) **	423.08 ± 18.75	323.47 ± 13.33^{a}	291.96 ± 19.17^{ab}	215.14 ± 10.98^{abc}	204.49 ± 7.53^{abc}
OAC (g oil g^{-1})	2.24 ± 0.17	1.45 ± 0.19^{a}	1.37 ± 0.09^{ab}	1.22± 0.18^{abc}	1.05 ±

Different letters in the same row mean significant differences at $p < 0.05$. * n = 15; ** n = 4. BD: bulk density; WAC: water absorption capacity; RR: rehydration ratio; OAC: oil absorption capacity. "a" represents the statistical difference with the values of the row in the column 2, "b" represents the statistical difference with the values of the row in the column 3, "c" represents the statistical difference with the values of the row in the column 4 and "d" represents the statistical difference with the values of the row in the column 5

These studies have provided a proof of the concept that the meat analogues with acceptable physicochemical, functional and textural attributes can be developed with simple extrusion technique.

3.5 Viscosity

Antioxidant activity of guava leaf extract and jellies (CJ and GJ) were tested against hydroxyl radical (*OH) and DPPH radical as shown in figure 2. Guava leaf extract was successful in scavenging DPPH* with 47.87% and 43.36% activity against *OH species. Te IC50 value to guava leaf extract against DPPH radical was 62.7 µg/µL. Upon testing the jellies, GJ was found to scavenge both the free radicals with efficiency of 42.38% and 33.45% respectively [28, 30].

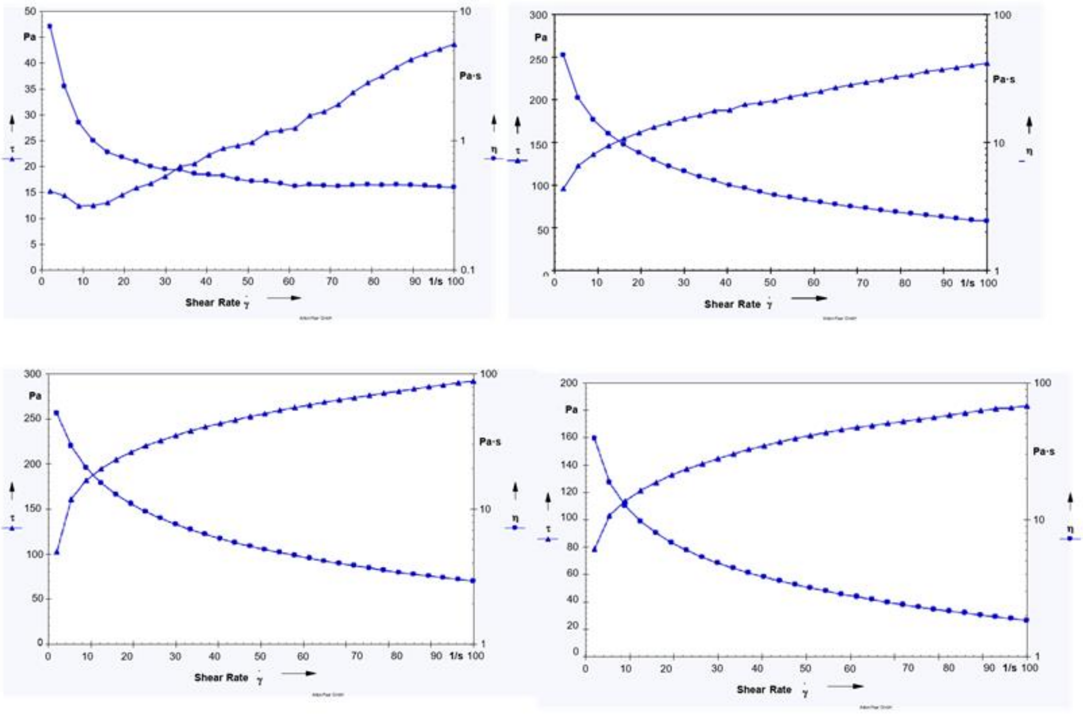

Figure 1: The rheogram showing the change in viscosity and shear stress as a function of varying shear rate for the crude protein (A), the meat analogue containing 90% w/w protein (B), the meat analogue containing 80% w/w protein (C), the meat analogue containing 70% w/w protein (D)

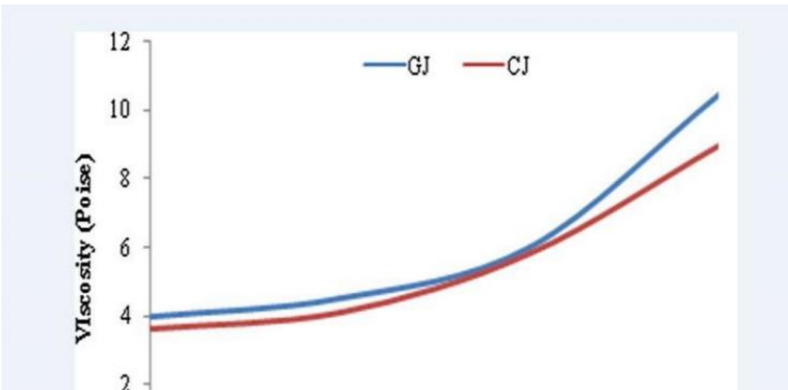

Figure 2: Antioxidant activity of guava leaf extract and jellies (CJ and GJ) were tested against hydroxyl radical (*OH) and DPPH radical

3.6 Sensory Evaluation of Jellies

The sensory attributes viz., colour, texture, taste, aroma and overall acceptability of two jellies, GJ and CJ were evaluated by serving the jellies to panelists who have assigned scores following the hedonic scale from 1 to 9. Both the jellies were pale in colour with smooth texture. Te score for colour of CJ and GJ was 6.7±0.47 and 6.95±0.69 respectively, whereas the score for taste was 7.3±0.47 and 7.7±0.86, respectively. CJ was sweet in taste and the GJ is moderately bitter and sour in taste. Te score for texture CJ and GJ was 8.26±0.64 and 8.35±0.49, respectively while; the score for aroma was 7.0 for both the jellies. Besides, the overall acceptability was 7.42±0.25 and 7.66±0.47 respectively for CJ and GJ (Fig. 3). GJ is rich in bioactive compounds having antioxidant and antimicrobial activities [4, 5].

Sensory Analysis

From the tactile examinations, the surface and shade of the created meat analogs looked like the meat and the sinewy nature was kept up with. The item with 90% w/w protein content was moderately challenging to bite, though the one with 60% w/w was practically supple in nature. The best enjoy ability was presented by the two structures, i.e., 80% w/w protein-based item and 70% w/w protein-based simple. None of the items offered any repulsive scent and the shade of the item was practically close to the tissue [20].

4. CONCLUSIONS

The removed concentrate from the defatted custard guava seeds contained 68.07% of proteins with a protein yield of 18.69%. The three meat analogs created were contained protein in the scope of 55.79% to 64.39% and the textural properties alongside the physicochemical attributes of the relative multitude of three pieces were in the adequate reach. The thickness investigation of the three clumps of the meat analogs followed non-Newtonian arrangement of stream, with every one of the structures satisfactory with an edge for the organization containing 80% w/w protein concentrate. The discoveries give an obvious proof to a nutritious and satisfactory meat simple got from the seeds of custard guava and have gigantic future commitments**.**

5. ACKNOWLEDGEMENTS

The research facilities provided by I.K.G. Punjab Technical University, Jalandhar and Bhai Gurdas Group of Institute, Sangrur for the present research investigations are duly acknowledged.

REFERENCES

1. Fresán, U., Mejia, M. A., Craig, W. J., Jaceldo-Siegl, K., & Sabaté, J. (2019). Meat analogs from different protein sources: a comparison of their sustainability and nutritional content. *Sustainability*, *11*(12), 3231.
2. Springmann, M., Wiebe, K., Mason-D'Croz, D., Sulser, T. B., Rayner, M., & Scarborough, P. (2018). Health and nutritional aspects of sustainable diet strategies and their association with environmental impacts: a global modelling analysis with country-level detail. *The Lancet Planetary Health*, *2*(10), e451-e461.
3. Grochowski, D. M., Uysal, S., Aktumsek, A., Granica, S., Zengin, G., Ceylan, R., ... & Tomczyk, M. (2017). In vitro enzyme inhibitory properties, antioxidant activities, and phytochemical profile of Potentilla thuringiaca. *Phytochemistry letters*, *20*, 365-372.
4. Flores, G., Wu, S. B., Negrin, A., & Kennelly, E. J. (2015). Chemical composition and antioxidant activity of seven cultivars of guava (Psidium guajava) fruits. *Food chemistry*, *170*, 327-335.
5. Kumar, M., Changan, S., Tomar, M., Prajapati, U., Saurabh, V., Hasan, M., ... & Mekhemar, M. (2021). Custard apple (Annona squamosa L.) leaves: Nutritional composition, phytochemical profile, and health-promoting biological activities. *Biomolecules*, *11*(5), 614.
6. Kumar, R., & Sharma, R. (2016). *Response Surface Methodology for Optimization of Protein Isolate from Defatted Custard Guava Seed (Annona Squamosa)*. Foundation of Computer Science (FCS).
7. Association, A. D. (2003). Position of the American Dietetic Association and Dietitians of Canada: vegetarian diets. *Can J Diet Pract Res*, 64, 62–81.
8. Hoek, A. C., Luning, P. A., Weijzen, P., Engels, W., Kok, F. J., & De Graaf, C. (2011). Replacement of meat by meat substitutes. A survey on person-and product-related factors in consumer acceptance. *Appetite*, *56*(3), 662-673.
9. Kyriakopoulou, K., Keppler, J. K., & van der Goot, A. J. (2021). Functionality of Ingredients and Additives in Plant-Based Meat Analogues. *Foods*, 10, 600.
10. Zahari, I., Ferawati, F., Helstad, A., Ahlström, C., Östbring, K., Rayner, M., & Purhagen, J. K. (2020). Development of high-moisture meat analogues with hemp and soy protein using extrusion cooking. *Foods*, *9*(6), 772.
11. De Angelis, D., Kaleda, A., Pasqualone, A., Vaikma, H., Tamm, M., Tammik, M. L., ... & Summo, C. (2020). Physicochemical and sensorial evaluation of meat analogues produced from dry-fractionated pea and oat proteins. *Foods*, *9*(12), 1754.
12. Singh, S. K., & Muthukumarappan, K. (2014). Effect of Different Extrusion Processing Parameters on Physical Properties of Soy White Flakes and High Protein Distillers Dried Grains-Based Extruded Aquafeeds. *J Food Res*, 3, 107.
13. Kaleda, A., Talvistu, K., Tamm, M., Viirma, M., Rosend, J., Tanilas, K., ... & Tammik, M. L.

(2020). Impact of fermentation and phytase treatment of pea-oat protein blend on physicochemical, sensory, and nutritional properties of extruded meat analogs. *Foods*, *9*(8), 1059. DOI: 10.3390/foods9081059.

14. Summo, C., De Angelis, D., Ricciardi, L., Caponio, F., Lotti, C., Pavan, S., & Pasqualone, A. (2019). Data on the chemical composition, bioactive compounds, fatty acid composition, physico-chemical and functional properties of a global chickpea collection. *Data in brief*, *27*, 104612. DOI: 10.1016/j.dib.2019.104612.
15. Singh, S. K., & Muthukumarappan, K. (2014). Effect of Different Extrusion Processing Parameters on Physical Properties of Soy White Flakes and High Protein Distillers Dried Grains-Based Extruded Aquafeeds. *J Food Res*, 3, 107.
16. Kaleda, A., Talvistu, K., Tamm, M., Viirma, M., Rosend, J., Tanilas, K., ... & Tammik, M. L. (2020). Impact of fermentation and phytase treatment of pea-oat protein blend on physicochemical, sensory, and nutritional properties of extruded meat analogs. *Foods*, *9*(8), 1059. DOI: 10.3390/foods9081059.
17. Summo, C., De Angelis, D., Ricciardi, L., Caponio, F., Lotti, C., Pavan, S., & Pasqualone, A. (2019). Data on the chemical composition, bioactive compounds, fatty acid composition, physico-chemical and functional properties of a global chickpea collection. *Data in brief*, *27*, 104612. DOI: 10.1016/j.dib.2019.104612.
18. Association of Official Analytical Chemists. *Association of Official Analytical Chemists, Association of Official Agricultural Chemists (US). Official Methods of Analysis of the Association of Official Analytical Chemists*., 1931.
19. Gray, J. A., & Bemiller, J. N. (2003). Bread Staling: Molecular Basis and Control. *Compr Rev Food Sci Food Saf*, 2, 1–21.
20. Bohrer, B. M. (2019). An investigation of the formulation and nutritional composition of modern meat analogue products. *Food Sci Hum Wellness*, 8, 320–9.
21. Lee, H. J., Yong, H. I., Kim, M., Choi, Y. S., & Jo, C. (2020). Status of meat alternatives and their potential role in the future meat market—A review. *Asian-Australasian journal of animal sciences*, *33*(10), 1533-43.
22. Ismail, I., Hwang, Y. H., & Joo, S. T. (2020). Meat analog as future food: A review. *J Anim Sci Technol*, 62, 111–20.
23. Bhatia, A., Singh, B., Raza, K., Wadhwa, S., & Katare, O. P. (2013). Tamoxifen-loaded lecithin organogel (LO) for topical application: development, optimization and characterization. *International Journal of Pharmaceutics*, *444*(1-2), 47-59.
24. McClements, D. J., Weiss, J., Kinchla, A. J., Nolden, A. A., & Grossmann, L. (2021). Methods for testing the quality attributes of plant-based foods: Meat-and processed-meat analogs. *Foods*, *10*(2), 260.
25. Pio Ávila, B., Cardozo, L. O., Alves, G. D., Gularte, M. A., Monks, J., & Elias, M. C. (2019). Consumers' sensory perception of food attributes: identifying the ideal formulation of gluten-and lactose-free brownie using sensory methodologies. *Journal of food science*, *84*(12), 3707-3716.
26. Naseer, S., Hussain, S., Naeem, N., Pervaiz, M., & Rahman, M. (2018). The phytochemistry and medicinal value of Psidium guajava (guava). *Clin. Phytosci.*, 4, 32.
27. Nantitanon, W., Yotsawimonwat, S., & Okonogi, S. (2010). Factors influencing antioxidant activities and total phenolic content of guava leaf extract. *LWT-Food Sci. Technol.*, 43, 1095–1103.
28. Gutiérrez, R. M. P., Mitchell, S., & Solis, R. V. (2008). Psidium guajava: A review of its traditional uses, phytochemistry and pharmacology. *J. Ethnopharmacol*, 117, 1–27. [CrossRef]
29. Fu, D., Huang, J., Li, K., Chen, Y., He, Y., Sun, Y., ... & Hu, Z. (2021). Dihydrotestosterone-induced hair regrowth inhibition by activating androgen receptor in C57BL6 mice simulates androgenetic alopecia. *Biomedicine & Pharmacotherapy*, *137*, 111247.
30. Bai, L., Takagi, S., Ando, T., Yoneyama, H., Ito, K., Mizugai, H., & Isogai, E. (2016). Antimicrobial activity of tea catechin against canine oral bacteria and the functional mechanisms. *Journal of Veterinary Medical Science*, *78*(9), 1439-1445.
31. Calvarro, J., Perez-Palacios, T., & Ruiz, J. (2016). Modification of gelatin functionality for culinary applications by using transglutaminase. *International journal of gastronomy and food science*, *5*, 27-32.
32. Díaz-de-Cerio, E., Gómez-Caravaca, A. M., Verardo, V., Fernández-Gutiérrez, A., & Segura-Carretero, A. (2016). Determination of guava (Psidium guajava L.) leaf phenolic compounds using HPLC-DAD-QTOF-MS. *Journal of Functional Foods*, *22*, 376-388.