[24]. Table 2 below shows the amino acid composition of *Aduwa protein* meal, defatted protein meal, and protein concentrate. The essential amino acid (EAA) content in these samples ranged from 37.35% - to 47.84%, with APM having a significant ($p>0.05$) high value followed by APC. This revealed that *Aduwa* protein meals (APM) and the extracted concentrate (APC) are good-quality sources of protein. Similarly, (AAA) aromatic amino acids, hydrophobic amino acids (HAA) and positively charged amino acids (PCAA) in the samples ranged from 5.24% - 10.56%, 39.96% - 40.95%, and 15.90% - 17.00%, respectively, and the APC sample was significantly ($p>0.05$) high even in values hence potential bioactive sample special as anti-oxidant and anti-hypertensive bioactive ingredients. A high concentration of hydrophobic amino acid (HAA) in the APC has implications for the structural and bioactive behaviors of the proteins [25]. The observation may be linked to many functional amino groups present, as indicated by the FTIR results.

The value for sulphur-amino acids ranged from 3.1% - 3.2%, with APM with the highest content implicated as a better antioxidant sample as well. The trend in sulphur amino acids may have influenced the antioxidant properties of studied samples. The tryptophan content ranged from 1.16% - 1.18%, which was higher compared to the 0.1% and 0.12% reported for okra seed flours and isolated okra proteins [1]. Similarly, histidine content ranged from 3.00% - 3.39%, and the APC sample had the highest value. However, the differences in amino acid content between the meal, defatted meal, and concentrate could be attributed to the additional varied techniques applied during the production of the APC concentrate [26].

Table 2. Amino acids profile of *Aduwa* Meal, Defatted *Aduwa* meal, and Protein Concentrate

	APM	DAM	APC
Leucine	12.01a	8.60b	8.47b
Lysine	8.41a	5.32b	5.35b
Isoleucine	5.62a	4.50b	4.55b
Phenylalanine	2.50c	5.15a	5.06b
Trytophan	1.78a	1.18b	1.16c
Valine	7.49a	5.02b	5.06b
Methionine	2.21a	1.58b	1.62b
Proline	1.59b	4.01a	4.10a
Arginine	3.75b	8.07a	8.26a
Tyrosine	0.96c	4.09b	4.12a
Histidine	3.75a	3.00c	3.39b
Cystine	1.01b	1.52a	1.53a
Alanine	4.80c	5.02b	5.27a

	APM	DAM	APC
Glutamic acid	8.65a	18.22b	18.08c
Glycine	8.21a	4.11c	4.26b
Threonine	5.86a	4.81b	3.86c
Serine	7.49a	4.82c	4.93b
Aspartic acid	13.93a	10.99b	10.93b
AAA	5.24c	10.42a	10.34b
BCAA	25.12a	18.12b	18.08b
HAA	39.96b	40.67a	40.95a
PCAA	15.90c	16.39b	17.00a
NCAA	35.93c	38.84a	37.80b
SCAA	3.22a	3.10b	3.15c
EAA	47.84a	37.98b	37.35c7

Legend: Apm= Aduwa Meal, Dam= Defatted meal, Apc=Aduwa Concentrate, Aromatic amino acid (AAA) = phenylalanine, tryptophan and tyrosine, Branched-chain amino acids (BCAA) = leucine, isoleucine, valine, Hydrophobic amino acids (HAA) = alanine, valine, isoleucine, leucine, tyrosine, phenylalanine, tryptophan, proline, methionine, and cysteine, Positively charged amino acids (PCAA) = arginine, histidine, lysine, Negatively charged amino acids (NCAA) = aspartic, glutamic, threonine, serine, Sulphur containing amino acids (SCAA) = methionine, cysteine, Essential amino acids (EAA) = histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine;

Solubility profiles of (*Balanites eaqpytiacal*) derived protein products: Our study shows the solubility profile of Aduwa protein meals (APM) and concentrate (APC) at different pH values. The result indicated that all samples were soluble at pH 3.0, with the percent solubility of the proteins decreasing progressively as the pH was adjusted from 3 to 5. Approximately 61.00% of Aduwa meals were soluble at pH 3, but the protein concentrate demonstrated the lowest solubility at the same pH. Typically, one would expect the protein concentrate to exhibit better solubility in acidic conditions; however, the observed low solubility of APC when it was pH 3 compared to APM may be a result of the increase in protein aggregates at this acidic pH, which may have reduced solubility [27], suggesting that APM sample is better functional ingredient (FI) to formulating beverage drink compare to APC due to the APC low solubility at acidic region. A similar result was reported for okra seed meal and protein isolate when the okra isolate showed poor solubility in the acidic pH region [1]. Beyond pH 3, APM did not show significant changes in solubility, even as the pH increased from 3 - 9. The defatted meal (DAM) and protein concentrate (APC) had low solubility values between 22% and 20.4% at pH 5, but solubility was observed to increase progressively to pH 9. This observation aligned with results reported for walnut protein, where increased negative charge in an alkaline environment was able to enhance solubility [28]. The low solubility in APC when pH was 5 suggests its proximity to the isoelectric point. Generally, solubility decreases as pH approaches the isoelectric point and then increases in alkaline conditions. Losses of electrostatic repulsion

when the pH was 5 have facilitated protein concentration and increased protein-protein interaction. High bulk density and larger aggregate diameters can lead to protein precipitation [29]. The differences in solubility patterns between APM and APC may be due to isoelectric precipitation in the concentrate and the amount of protein available, influenced by thermal pretreatment and denaturation. In the basic region, soluble protein levels were as follows: 61.5% for APM, 22% for DAM, and 41% for APC. However, APM was soluble compared to DAM and APC in acidic conditions. However reverse trend was observed in basic conditions. However, the poor solubility of the protein concentrate (APC) could pose disadvantages for APC sample utilization as an ingredient in making functional beverages (FB).

Foam properties of (*Balanites eaqpytiacal*) derived protein products

Foaming capacity: Our study illustrates the influence of pH at 3, 5, 7, and 9, and sample concentration at 10, 15, and 20) *mg/mL* on the foaming capacity of the Aduwa-derived samples. At a sample concentration of 10 mg/ml, the *Aduwa* protein meal (APM) exhibited significantly ($p>0.05$) the highest foaming capacity at pH when it was 5, while the poorest was observed at pH 3, which was not significantly different ($p > 0.05$) from the value obtained when the pH was 7, foaming capacity of the defatted meal (DAM) decreased progressively as the pH increased from 3 - 9 with increase in sample concentration. In contrast, the protein concentrate (APC) displayed an increase in foaming capacity as the pH shifted towards the basic region. This trend aligned with an increase in the net charge of the samples in the neutral and basic pH ranges, leading to enhanced protein-protein repulsion and increased protein flexibility. As proteins become more flexible, their ability to accommodate air bubbles improves, which could result in greater foaming capacity at higher pH levels, hence making APC a better mayonnaise and cake functional ingredient (FI). Similar patterns have been reported in the foaming capacities of fenugreek seeds, Bambara seeds, and walnut protein isolates [30-31, 21].

As the sample concentration increased from 20 to 60 *mg/ml,* APM demonstrated a significant ($p>0.05$) increase in foaming capacity at acidic and basic pH values. However, foaming formation at pH 5 decreased substantially. For both the defatted meal (DAM) and protein concentrate (APC) samples, the initial increase in foaming capacity was observed up to 40 *mg/ml,* followed by a decrease. This pattern may be explained from the point where protein crowding started, while the increase in protein concentration is necessary to generate adequate foam. It was observed that concentrations beyond 40 *mg/ml* may lead to the formation of excess protein micelles, reducing the ability to generate foams in DAM and APC [32] and [33].

The high foaming capacity of samples, particularly APM, DAM, and APC, in the basic regions and at higher sample concentrations may be attributed to the formation of large charges at these pH values, which encouraged the development of interfacial membranes. The formation of these larger interfacial membranes within the protein molecules may enhance solubility, leading to increased foam formation [34]. These samples are better functional ingredients (FI) at higher concentrations and, therefore, are encouraged by small-scale food processing entrepreneurs to use them as functional ingredients to add values in terms of health and improve mechanistic properties of the food matrixes [35]

Foaming stability: Foaming stability refers to the ability of foam to maintain its shape and volume over time, which is crucial for applications in beverages, coffee, and the baking industries. Our study shows sample ability, *Aduwa* meal (APM), defatted meal (DAM), and Aduwa concentrate (APC) in relation to sample concentration (20, 40, and 60) *mg/mL* and pH levels 3, 5, 7, and 9 stability foams At sample concentration of 20 *mg/mL,* foam stability was significantly ($p>0.05$) high when pH

range was within acidic but decreased progressively as the pH was shifted toward the base regions in APM and DAM samples. Notably, foam stability values for APM and DAM were greater for APC in 20 *mg/mL,* concentration. This pattern may be attributed to the formation of stable molecular layers at the air-water interface, which may have enhanced the texture, stability, and elasticity of the foams. Similar findings have been reported for rapeseed flours and proteins. Here, (DAM) and (APC) samples exhibited significant and greater foam stabilities than APC, as observed by [36] as a behavioral principle. With sample concentration increase from 20 *mg/mL* to 60 *mg/mL*, it was observed that foam stability improved when the pH was 7 and 9 compared to when the pH was 3 and 5. This suggests that the protein molecules generate adequate charge densities at these pH values, facilitating the formation of strong interfacial membranes [34]. Additionally, the foam stability was observed to be high at a sample concentration of 60 mg/mL and at elevated pH levels, indicating that sample concentrations are beneficial, as they provide more protein molecules to enhance the intermolecular cohesiveness of the foams formed [37]. The samples demonstrated varying patterns of foam stability depending on pH and sample concentration, which can be linked to differences in their structural-functional properties, particularly in terms of surface dispersibility and stability of functional molecules (FM) before ingestion.

Emulsion Properties of (*Balanites eaqpytiacal*) derived protein products

Emulsion Capacity: Our study shows the emulsifying capacity of *Aduwa* protein meal (APM), defatted *Aduwa* meal (DAM), and *Aduwa* protein concentrate (APC) across different pH levels and sample concentrations. These results from the emulsion study using an Aduwa-derived sample underscore the importance of both pH and sample concentration in determining the emulsion capacity of Aduwa-derived protein sources, highlighting their potential applications in food formulations where stable emulsions are required. At a sample concentration of 10 *mg/mL,* both the *Aduwa* meal and protein concentrate exhibited significant ($p<0.05$) poor emulsion capacity when pH was at 3.0. In contrast, higher emulsion capacities were recorded at pH levels ranging from 5 - 9. This increase may be attributed to the formation of more charge densities around 5-9 pH values, which enhanced the ability of sample protein to interact with oil and form stable emulsions [38]. At the highest concentration of 20 *mg/mL,* the emulsion capacity of the *Aduwa* meal peaked at pH 7.0, while the defatted *Aduwa* meal showed optimal emulsion capacity when pH was 5 and 7, respectively. For the protein concentrate sample (APC), the highest emulsion capacity was observed when the acid-based balance was 7.0, reflecting the ability of this functional ingredient (FI) to be used or applied in various food formulations judging from its high emulsion capacity at neutral pH. Interestingly, the overall emulsifying capacities of the samples were slightly low when the concentration was high, likely due to protein overcrowding. Protein overcrowding can disrupt interfacial properties, leading to less effective emulsification capacitation [34].

Emulsifying Stability: The emulsion stability of *Aduwa* protein meal (APM) and defatted *Aduwa* meal (DAM) displayed a similar trend of concentration, with the highest emulsion stability, which was observed with pH 5 and 9. The pattern of emulsion stability for these samples closely mirrored that of the protein concentrate (APC) stability stabilized at pH 7.0, but when the sample concentration was increased to 15 mg/ml, at pH 9.0 emulsion stability significantly ($p<0.05$) diminished, whereas the emulsion formed at pH 7.0 remained notably robust, particularly for APM and APC samples. At a concentration of fifty (50 mg/ml) and pH 5.0, the emulsifying stability of APM and APC was significantly ($P>0.05$) stronger, but DAM and APC achieved the highest and most significant ($p>0.05|$) stability at pH 9.0. Emulsion stability is crucial as it reflects the protein's

ability to interact with and stabilize immiscible phases, thereby preventing phase separation [36). These findings suggested that 10 mg/ml serves as a maximum for creating sufficient interfacial tension to stabilize the emulsion formed by these samples and that could support bioactive molecules during the food use of these samples [39]. This has emphasized the importance of both pH and sample concentration in optimizing the functional properties of Aduwa-derived proteins for potential food applications

CONCLUSION

Bioactive ingredients (BI) are often encrypted and offer useful and healthy properties that are beyond basic nutrition, such as antioxidative effects, disease prevention, and disease management with the potential to lower disease risk [35]. Functional food is characterized by bioactive material derived via a careful and selective extraction process that has both physical attributes and physiological mechanistic attributes on food and food systems. FTIR results highlighted various functional groups in the samples, suggesting that differences in processing and protein modifications had played a significant role. Amino acid analysis indicated that Aduwa protein meal (APM) had a higher EAA (essential amino acid) while *Aduwa* protein APC was rich in HAA (hydrophobic amino acid); this influenced the structural-functional characteristics of the APC sample. The sample solvent-solvent interaction profile indicated that these proteins may not be ideal for use in acidic beverages or drinks. Foaming capacity tests showed that APC had a high foaming capacity at basic pH levels, particularly at pH 7, likely due to increased charge density promoting the formation of extensive interfacial membranes. Emulsion properties shifted with pH on *the Aduwa sample change in concentration; this has established that a* concentration of 10 mg/ml was optimal for achieving emulsion with good stability. Overall, the findings suggest that *Aduwa* seed meal DAM and concentrates APC have huge potential for use as ingredients in food product development from their functional and bioactive behaviour, especially of DAM and APC samples. The result of this work is an opening or avenue for Aduwa-derived protein products to be incorporated into various culinary applications and will improve the functional attributes and antioxidant properties of the food product.

Abbreviation	Meaning
APM	Aduwa protein Meal
DAM	Defatted Aduwa meal
APC	Aduwa protein Concentrate
FTIR	Fourier transform infrared
AAA	Aromatic amino acid
HAA	Hydrophobic amino acid
SCAA	Sulphur containing amino acid
EAA	Essential amino acid
FP	Functional property
FB	Functional beverage
FI	Functional ingredient
FM	Functional molecules
SFP	Structure functional properties
BI	Bioactive ingredient

Funding: This research was funded by Tet FUND under the Federal University Gashua, Yobe state

Acknowledgment: I sincerely acknowledge the Tet FUND under the Federal University Gashua and specifically the Department of Home Science and Management for fund and study leave to embark on this tangible work.

Conflict of interest: Conflict of interest Ogori Akama Friday declares that he has no conflict of interest. Girgih T. A. and Abu Joseph Oneh were technical partners. Eke Ojotu Micheal supported in review and final draft.

Author Contributions: Ogori Akama Friday, Data curation, investigation, writing of first original draft Data curation, Review, and editing. Eke Mike Ojotu, Project administration, Supervision, and review. Girgih T. A, Investigation, supervision of third original drafting, and editing. Abu Joseph Oneh, Data curation, second original Draft, editing, and review

REFERENCES

1. Nnamezie A, Famuwagun A, Akinsola A, Gbadamosi S. Characterization of okra seed flours, protein concentrate, protein isolate and enzymatic hydrolysates. *Food Production, Processing and Nutrition*. 2021; 3:14. DOI: https://doi.org/10.1186/s43014-021-00059-9
2. Famuwagun A, Alashi A, Gbadamosi S, Taiwo K, Oyedele D, Adebooye O, et al. Comparative study of the structural and functional properties of protein isolates prepared from edible vegetable leaves. *International Journal of Food Properties*. 2020;23(1):955-970. DOI: https://doi.org/10.1080/10942912.2020.1772285
3. Wu H, Wang Q, Ma T, Ren J. Comparative studies on the functional properties of various protein concentrate preparations of peanut protein. *Food Research International*. 2009; 42: 343-348.
4. Alireza S, Bhagya S. Effect of recovery method on the different properties of the mustard protein. *World Journal of Dairy & Food Sciences*. 2009; 4: 100-106.
5. Famuwagun A, Gbadamosi S. Studies on the proximate composition, functional properties, and effect of pH and salt concentrations on some functional properties of ackee apple aril flours. *Ife Journal of Science*. 2016; 18(3).
6. Gbadamosi S, Famuwagun A. Proximate, functional and antioxidant properties of Kariya (Hildergardia barterii) protein hydrolysates obtained by enzymatic hydrolysis of fermented kariya protein isolates. *British Biotechnology Journal*. 2016; 14(3): 1-14. DOI: https://doi.org/10.9734/BJAST/2016/25781
7. Ogori AF, Makinde OJ, Joeguluba O. Effects of Balanites aegyptiaca (Del) seed cake on hematological and serum biochemical indices of growing rabbits. *Arch Food Nutr Sci*. 2018; 2: 010-015.
8. Eromosele IC, Eromosele CO, Akintoye AO. Characterization of oils and chemical analyses of the seeds of wild plants. *Plant Food Hum Nutr*. 1994; 46: 361-365. DOI: https://doi.org/10.1007/BF01088437
9. Obidah W, Margaret SN, Godfrey OT, Abdullahi UW. Toxicity of crude Balanites aegyptiaca seed oil in rats. *Journal of American Science*. 2009; 5(6): 13-16.
10. Lqari H, Vioque J, Pedroche J, Millan F. Lupinus angustifolius protein isolates: chemical composition, functional properties and protein characterization. *Food Chem*. 2002; 76: 349-356.
11. Ogunwolu SO, Henshaw FO, Mock H, Santros A, Awonorin SO. Functional properties of protein concentrates and isolates produced from cashew (Anacardium occidentale L.) nut. *Food Chemistry*. 2009; 115: 852-858.
12. Yoshie-Stark Y, Wada Y, Wäsche A. Chemical composition, functional properties, and bioactivities of rapeseed protein isolates. *Food Chem*. 2008; 107: 32-39. DOI: https://doi.org/10.1016/j.foodchem.2007.06.061
13. Barbin DF, Natsch A, Müller RK. Improvement of functional properties of rapeseed protein concentrates produced via alcoholic processes by thermal and mechanical treatments. *Journal of Food Processing and Preservation*. 2011; 35: 369-375.

14a. Gbadamosi SO, Abiose SH, Aluko RE. Amino acid profile, protein digestibility, thermal and functional properties of ionophore nut (Tetracarpidium ionophore) defatted flour, protein concentrate, and isolates. *International Journal of Food Science and Technology*. 2012; 47: 731-739.

14b. Gbadamosi SO, Abiose SH, Aluko RE. Solubilization, amino acid composition, and electrophoretic characterization of ionophore nut proteins. *International Food Research Journal*. 2012; 19(2): 651-656.

15. Girgih AT, Udenigwe CC, Aluko RE. In vitro antioxidant properties of hemp seed (Cannabis sativa L.) protein hydrolysate fractions. *J Am Oil Chem Soc*. 2011; 88: 381-389.

16. Markwell MAC, Haas SM, Biebar LL, Tolbert NE. A modification of the Lowry procedure to simplify protein determination in membranes and protein samples. *Analytical Biochemistry*. 1978; 87: 206-211.
17. Chavan UD, Mckenzie DB, Shahidi F. Functional properties of protein isolates from beach pea (Lathyrus maritimus L.). *Food Chem*. 2001; 74: 177-187.
18. Mohamed MA, Salleh WNW, Jaafar J, Mohd Hir ZA, Rosmi MS, Mutalib MA. Regenerated cellulose membrane as bio-template for in-situ growth of visible-light-driven C-modified mesoporous titania. *Carbohydr Polym*. 2016; 146: 166-173.
19. Chen XY, Ru Y, Chen FL, Wang XC, Zhao XY, Ao Q. FTIR spectroscopic characterization of soy proteins obtained through AOT reverse micelles. *Food Hydrocolloids*. 2013; 31(2): 435-437. DOI: https://doi.org/10.1016/j.foodhyd.2012.11.017
20. Saguer E, Alvarez P, Ismail AA. Heat-induced denaturation/aggregation of porcine plasma and its fractions studied by FTIR spectroscopy. *Food Hydrocolloids*. 2012; 27(1): 208-219. DOI: https://doi.org/10.1016/j.foodhyd.2011.06.012
21. Zhang Z, Jetsrisuparb K, Wokaun A, Gubler L. Study of nitrile-containing proton exchange membranes prepared by radiation grafting: performance and degradation in the polymer electrolyte fuel cell. *J Power Sources*. 2017; 243: 306-316. DOI: https://doi.org/10.1021/acselectrochem.4c00123
22. Zhao XY, Chen FS, Xue WT, Li LT. FTIR spectra studies on the secondary structures of soybean 7S and 11S globulins using AOT reverse micellar extraction. *Food Hydrocolloids*. 2008; 22: 568-575. DOI: https://doi.org/10.1007/s11746-015-2657-9
23. Barron C, Parker ML, Mills ENC, Rouau X, Wilson RH. FT-IR imaging of wheat endosperm cell walls in situ reveals compositional and architectural heterogeneity related to grain hardness. *Planta*. 2005; 220(5): 667-677. DOI: https://doi.org/10.1007/s00425-004-1383-6
24. Mohize MAK, Malomo SA, He R, Aluko RE. Structural and functional properties of hemp seed protein products. *J Food Sci*. 2014; 79: 1512-1521. DOI: https://doi.org/10.1111/1750-3841.12537
25. Yu GC, Lv J, He H, Huang W, Han Y. Hepatoprotective effects of corn peptides against carbon tetrachloride-induced liver injury in mice. *Journal of Food Biochemistry*. 2012; 36: 458-464. DOI: https://doi.org/10.1111/j.1745-4514.2012.00596.x
26. Rajapakse N, Mendis E, Jung WK, Je JY, Kim SK. Purification tool to improve the functional properties of rapeseed (Brassica campestris var. toria) and sesame seed (Sesamum indicum) meals. *International Journal of Food Science and Nutrition*. 2005; 53: 93-98.
27. Molina D, Coetzee FM, Lawrence S, Giles CL, Gori M. Focused crawling using context graphs. In: Proceedings of the Twenty-sixth International Conference on Very Large Databases. 2002. DOI: https://doi.org/10.1016/j.foodchem.02.068.
28. Mao X, Hua Y. Composition, structure and functional properties of protein concentrates and isolates produced from walnut (Juglans regia L.). *Molecular Sciences*. 2012; 13: 1561-1581.
29. Singh RP, Anderson BA. The major types of food spoilage: an overview. In: Understanding and Measuring the Shelf-life of Food. 2004; 3-23.
30. Nasri M. Antioxidant and free radical-scavenging activities of smooth hound (Mustelus mustelus) muscle protein hydrolysates obtained by gastrointestinal proteases. *Food Chem*. 2009; 114: 1198-1205.
31. Lawal OS, Adebowale KO. Effect of acetylation and succinylation on solubility profile, water absorption capacity, oil absorption capacity and emulsifying properties of mucuna bean (Mucuna pruriens) protein concentrate. *Nahrung/Food*. 2005; 48(2): 129-136.
32. Tang CH, Ten Z, Wang XS, Yang XQ. Physicochemical and functional properties of hemp (Cannabis sativa L.) protein isolate. *J Agric Food Chem*. 2006; 54: 8945-8950.
33. Yu L, Haley S, Perret J, Haris M, Wilson J, Qian M. Free radicals scavenging properties of wheat extracts. *Journal of Agriculture and Food Chemistry*. 2007; 50: 1619-1624. DOI: https://doi.org/10.1021/jf070429
34. Ijarotimi OS, Malomo SA, Fagbemi TN, Osundahunsi OF, Aluko RE. Structural and functional properties of Buchholzia coriacea seed flour and protein concentrate at different pH and protein concentrations. *Food Hydrocolloids*. 2018; 74: 275-288. DOI: https://doi.org/10.1016/j.foodhyd.2017.08.018
35. Martirosyan DM, Stratton S. Quantum and tempus theories of function food science in practice. *Functional Food Science*. 2023; 3(5): 55-62. DOI: https://doi.org/10.31989/ffs.v3i5.1122
36. Mahajan A, Dua S, Bhardwaj S. Simple physical treatment as an effective radical scavenging peptide from fermented mussel sauce and its antioxidant properties. *Food Research International*. 2002; 8: 175-182.
37. Malomo SA, Aluko RE. A comparative study of the structural and functional properties of isolated hemp seed (Cannabis sativa L.) albumin and globulin fractions. *Food Hydrocolloids*.

2015; 43: 743-752.

38. Malomo SA, He R, Aluko RE. Structural and functional properties of hemp seed protein products. *Journal of Food Science*. 2014; 79: 1512-1521.
39. Martirosyan DM, Lampert T, Lee M. A comprehensive review on the role of food bioactive compounds in functional food science. *Functional Food Science*. 2022; 3(2): 64-79. DOI: https://doi.org/10.31989/ffs.v2i3.906