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Control of Particle Size and the Use of Sensory Evaluation in the Process Standardization of Dambunnama: A Shredded, Dry Meat Product

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Abstract:
The specific aim of the study was to control the average sizes of meat shreds in the processing method of a traditional meat product Dambun Nama. Fresh beef from skeletal muscle with an average moisture content of 74% was used to produce the samples. Two samples (D1 and D2) were produced using the pounding or impact (Dakau) method, and the stirring or shearing (Tuqe) method respectively. The preliminary processing operations in the former method were modified by including hand sorting and screening of the shredded meat. Perforated steel screens were used, of mesh sizes 3, 4, 5, 6, with aperture openings of 0.265, 0.187, 0.157, 0.132 inches respectively. The shreds retained on mesh number 4 (D1), and the shreds of sample D2 were each separately stir fried at an average temperature of 108°C for 20 minutes and 30 minutes respectively. The samples were subjected to sensory analysis using a panel of fifteen members, based on a nine-point hedonic scale, to compare preferences in texture, taste, aroma, colour, and the overall acceptability. The data obtained was subjected to Analysis of Variance (ANOVA) and a post hoc analysis using Duncan's method to separate the means and determine the level of significance at 5% level. From the results, sample D1 had the highest means in all the parameters tested (8.07, 8.21, 8.21, 8.21, 8.27 respectively), which were significantly different ($P \leq 0.05$) with those of sample D2 (7.71, 7.93, 7.86, 7.43, 7.20 respectively). The study concluded that the use of uniform shred sizes in the preparation method of sample D1 resulted in a product with preferred sensory attributes. It was therefore suggested that the processing method and parameters of sample D1 could be adopted for the commercial production of Dambun Nama in Nigeria.

Keywords: *Dambunnama, skeletal muscle, shredding, screening, sensory attributes*

1. Introduction

Size distribution is often of critical importance to the way a material performs when in use (Albright, 2008) or during processing (Earle, 1983). In general, sieve analysis has been used for decades to monitor material quality based on particle size. It is the first choice in particle size analysis and quality control in the powder process control industry, due to its simplicity, efficiency and low cost (American Society for Testing and Materials: ASTM International, 2006; Glenammer Engineering, 2017). Sieving is a physical method of separating mixtures and it consists of passing a mixture of particles of different sizes through a sieve or a screen. The smaller particles pass through the pores of the sieve and the larger ones are retained by the sieve (Certified Analytical Sieves; CISA, 2020). A sieve analysis can be performed on any type of non-organic or organic granular material, including a wide range of manufactured powders, grains, and seeds. Being such a simple technique of particle sizing, it is probably the most common (Mcglinchey, 2005). Sieving, like all types of particle separation, does not produce an ideal separation. A small quantity of particles smaller than the nominal aperture of the sieve stays in the retained sample. Likewise, particles larger than the nominal aperture may be found in the fraction that has passed through the sieve because of over-dimensioned apertures (Retsch, 2009). Due to this inaccuracy, it is not possible to fix the optimal testing time for a determined sieving process. The time depends on the characteristics of the material, the volume of the initial sample, the intensity of the sieving, the nominal aperture of the sieve, the characteristics of the screening surface, and the environmental conditions (Albright, 2008; CISA, 2020). The separating action depends on the character of the particle being separated and the forces on the particle which cause the separation, and the important characteristics of the particles are size, shape and density (Earle, 1983). Sieving aids are used for very fine samples that tend to adhere together. They are used to make the sample sievable. A differentiation is made between mechanical sieving aids for eliminating molecular adhesive forces, and additives or methods that are used for greasy, sticky and oil-containing products(Retsch, 2009).A Sieve is generally made up of a metallic perforated plate that has either square, round, or rectangular holes, and the plate is soldered to a frame (*International Organization for Standardization;ISO, 2013).*

Meat is a nutritious, protein-rich food that is highly perishable and with a short shelf-life unless preservation methods are used (Heinz &Hautzinger, 2007). It contains a number of important nutrients that are needed by the human body for carrying out vital metabolic functions. These are proteins, fat, vitamins, minerals and other bioactive components, and small quantities of carbohydrates (Biesalski&Nohr, 2009; Yusuf, Igwegbe, Idakwo, & Ismail, 2019). Like all types of meat, beef or the meat from adult cattle, is an excellent source of high-quality protein, that contributes to the maintenance and growth of muscle mass (Lawrie&Ledward, 2006). Many people, especially elderly people, do not consume enough high-quality protein. Inadequate protein intake may accelerate and worsen age-related muscle wasting (Paddon-Jones, Short, Campbell, Volpi, & Wolfe 2008; Varman, & Sutherland, 1995). Shelf life and maintenance of meat quality are influenced by a number of interrelated factors including holding temperature, which can result in detrimental changes in the quality attributes (Nychas, Skandamis, Tassou, &Koutsomanis, 2008; Knipe& Rust, 2010). In Nigeria, there are different types of traditional ready to eat meat products made from beef, and there are also those that require further processing such as *Kamsa,* which is a smoke-dried red meat product, and *Jirga,* which is a salted, boiled, smoke dried meat product (Yusuf &Abubakar, 2011). In northern Nigeria, drying, salting, spicing, and smoking are the common traditional methods widely used in meat preservation (Igwegbe, Idakwo, Yusuf, Gervase, Maijalo, &Abubakar, 2019). Usually, high temperatures are applied along with any one or a combination of these methods, to cook or partially cook, reduce moisture content, or impart a desirable or preferred flavour to the meat product (Zulyadaini& Yusuf, 2015). When preserving meat locally, a combination of these processes is usually adopted. Example of the combined methods include smoke drying in the processing of *Kamsa*(Yusuf *et al.,* 2019), and using heat as an agent of moisture expulsion or dying in the processing of DambunNama (Eke, Ariahu, & Okonkwo, 2012). DambunNama is a shredded, dehydrated local meat product that is produced in most parts of northern Nigeria from the meat of ruminant animals or from poultry. It is usually prepared using either one of two common procedures, with variations in the process parameters. The product is locally prepared with the aim of extending the shelf life of meat, providing variety, and for its individual distinct texture and flavor (Yusuf, Igwegbe, Idakwo, Ahmad, & Sani, 2020). The potential of developing DambunNama into a conventional product with stable storage features requires the development and adoption of a standard procedure that gives precise and reproducible results. This will require the standardization of existing methods, and the generation of data on the raw materials, processing methods and parameters, and on the final product characteristics. The study was aimed at controlling the sizes of the meat shreds prior to stir frying. This will establish consistency in processing parameters, reproducibility and precision in the processing procedure, as well as the uniformity in quality of the end product. Sensory evaluation was used as a tool to assess the consumer preference between the two samples. The method of preparation of the most preferred sample is to be accepted as the standard method of production of DambunNama in Nigeria.

2. Materials and Methods

2.1. Sample Preparation

Fresh beef cuts from the skeletal muscle of the hind quarters of a medium aged healthy animal with an average moisture content of 70% was purchased from Kano main abattoir and used in producing the samples. Preliminary preparation operations included the complete trimming of surface fat and visible contamination, washing and mopping up of surface moisture, and cutting into pieces of approximately 2cm cubes. The meat pieces were then divided into two equal portions of 3000g each, one portion was labelled sample D1, while the other portion was labelled sample D2. The initial preparation methods for the two samples were similar with respect to the softening of the seasoned and spiced meat. Table 1 shows the ingredients used and their quantities, as it is obtained without alteration in most of the traditional basic ingredient formulation of DambunNama in Nigeria. The distinct difference in the samples occurred as a result of the variations in the preparation methods for obtaining the shred sizes of the final product. The local *Tuqe* method was adopted completely in the preparation of sample D2, while the procedure of the preparation of sample D1 differed from the local *Dakau*method in shred standardization through sieve analysis.

Ingredients	Quantity *Dakau*(D1)	Quantity *Tuqe* (D2)
Fresh Beef	33 3000g	33 3000g
Onions	200g	200g
Ginger	30g	30g
Salt	30g	30g
*NHVP	24g	24g
Water	150ml	150ml
Vegetable oil	60ml	60ml

Table 1: Quantities of Ingredients Used in Dakau and TuqeDambun Nama
Neutralized Hydrolyzed Vegetable Protein (NHVP); Maggi Cubes (Nestle Nig. PLC)

The fresh meat pieces for the two samples were separately cooked until each became very soft, evidenced by the easy piercing of a fork through a piece. The approximate weight of each of the two samples of the seasoned cooked meats before pounding was 3340g (D1). The pounding of sample D1 gave shreds of different sizes, with some hard tissue or tendons. The approximate weight of sample D1 after pounding was 3336g. After hand sorting to remove hard pieces, tendons, and fatty pieces, the weight of the shreds reduced to 3125.7g. The hand sorted sample D1 was then aired for one hour on a stainless-steel tray and a wooden spoon was periodically used to separate clumps. Sieves of mesh sizes 3, 4, 5 and 6 were used in the size sorting of the meat shreds. The retained shreds from mesh number 4, with an average shred size of 0.195 inches were adopted as sample D1 shreds. This is because their sizes compare well with the average shred size of the locally hand sorted *Dakau*sample, which had an average shred size range of between 0.191 to 0.221 inches. The stir frying was slow and gradual, with the average meat temperature not exceeding 110^{o}C, taken at 10 minutes intervals, until the shreds turn to a uniform golden brown colour, with no evidence of steam coming out of the pan. The product was then spread on a stainless-steel tray to aid in its cooling and the escape of any residual moisture. The flow chart for the preparation of sample D1 is shown below (**Figure 1**)

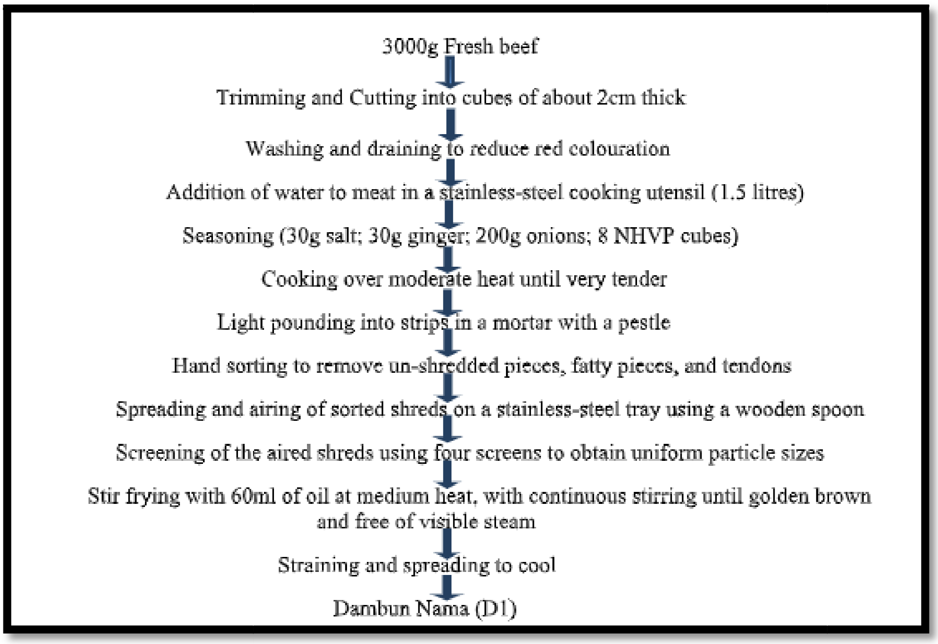

Figure 1: Flow Chart for the Preparation of Dambun Nama,Dakau Method (D1)

The traditional method of *Tuqe* or stirring, was adopted wholly in the preparation of sample D2 (**Figure 2**). The weight of the meat and ingredients before frying was 3338g. The softened meat was continuously stirred with the periodic addition of the oil. Therefore, as shreds were formed due to the stirring, they were also being stir-fried. Different sizes of shreds were formed, with some pieces of the meat not completely disintegrated when the frying process was terminated. The change of colour of the large shreds and pieces to golden brown was used as a yardstick for terminating the stir frying of sample D2. The product was then spread on a stainless-steel tray to cool down and allow for the escape of residual gases.

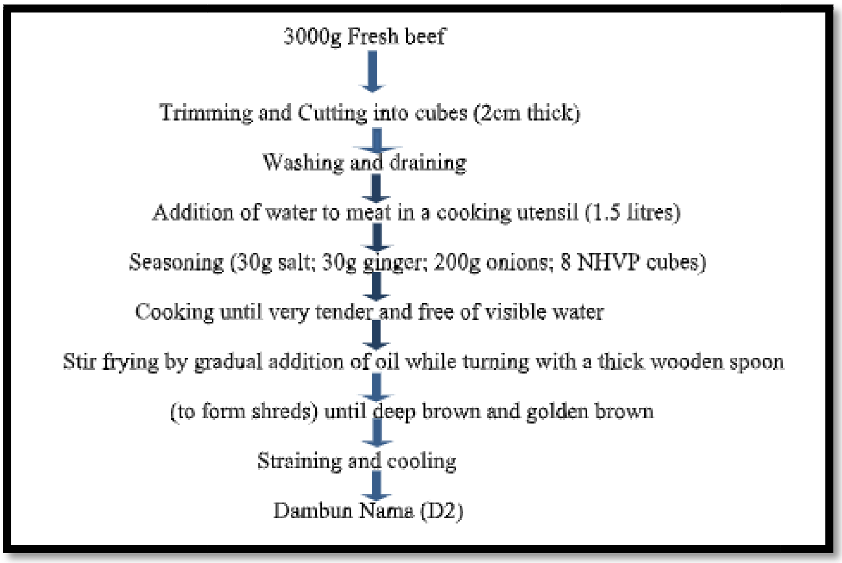

Figure 2: Flow Chart for Preparation of DambunNama, Tuqe Method

2.2. Sieve Analysis

The bulk of the pounded material of sample D1 served as the sample size for the sieveanalysis. To prepare the sample for screening, it was first hand sorted to remove un-shreddedpieces, fatty pieces, and tendons, which cumulatively weighed 210 grams. After that, it wasspread and aired for one hour with periodic stirring to separate aggloromatedpieces.

The hand sorted and aired sample (3126 grams) was then divided into 31 portions of approximately 100.8 grams each to permit each of the particles an opportunity to presentthemselves on the test sieve surface (QMJ Group Ltd, 2021).The selection of the sieves was based on obtaining particle sizes that had more uniform characteristics than thoseobtained in the traditional hand sorted DambunNama. For the sieving procedure, single sieving was carried out using the method outlined by Retsch (2009),with four test sieves of mesh sizes 3, 4, 5, and 6. These were used singly to determine the percentages of undersize and oversize. The sieves were made of metallic plates with rectangular apertures. The empty sieves were first weighed and the weights recorded. The none portion of the 31 portions was placed on the sieve with mesh number 6 that had adiameter of 20mm and sieving commenced for 5 minutes. The tapping and throw technique that is mostly characteristic ofthe hand sieving procedure was adopted. It involved a horizontal circular motion that overlaps a vertical motion which was created by the tapping impulse. The oversize of mesh number 6 was transferred to mesh number5, that of mesh number 5 to mesh number 4,andthat of mesh number 4 to mesh number3. The transfers were done after rigorous sieving for five minutes (Retsch, 2009). The sieving time of five minutes was adopted because during test sieving, it produced a difference in the weights of the undersize of less than 1% between the last two successive readings (Advantech Mfg, 2001) from all the four sieves. This procedure was repeated for the rest of the 30 portions. The sum weights of the oversize and undersize meat shreds from each sieve were determined after the sieving process. The cumulative method was used to weigh the sample retained in each sieve. This involved placing each sieve fraction in a tared stainless-steel plate and taking the weight. All fractions are subsequently added individually and the changing weights recorded without emptying out the pan or re-taring the scale. The amount retained is then calculated using the formula:

$\% \text{ Retained} = W_{sieve} / W_{total} \times 100$

Where $W_{sieve}$is the mass of the aggregate in the sieve, and $W_{total}$is the total mass of the aggregate. The cumulative percent of the aggregate retained in each sieve was calculated according to the method of Advantech Mfg (2001) and Retsch (2009), by first adding up the total amount of the aggregate retained in each sieve with the amount in the previous sieves. Then the cumulative percent of the aggregates passing through was calculated by subtracting the cumulative percent retained from 100.

%Cumulative Passing = 100%–%Cumulative Retained.

Presentation and analysis of the results data was made by directly plotting the sieve size versus percentage retained, and the sieve size versus percent cumulative on same axis.

2.3. Sensory Evaluation of the Products (D1 and D2)

The final stir-fried products of samples D1 and D2, were subjected to sensory assessment by a 15-member test panel, based on a nine-point hedonic scale ranging from 9 being extremely like to 1 being extremely dislike, respectively. The parameters tested were taste, texture, aroma, colour, and overall acceptability. The panelists were all healthy adults (males and females) that were semi trained on the process of sensory evaluation.

2.4. Statistical Analysis

Data obtained from the sensory evaluation was subjected to Analysis of Variance (ANOVA) to generate means, which were further subjected to T-test for preference testing at 5% significance level, to determine the differences in the parameters tested (Dean *et al.,* 2017; Lawless and Heyman, 2019).

3. Results and Discussion

3.1. Sieve Analysis

Size distribution is often of critical importance to the way a material performs when in use (Mcglinchey, 2005*).* Hand sorting of the pounded meat pieces was aimed at removing large pieces that could present a problem in the course of sieving, because (Mamlouk&Zaniewski, 1999) heavier particles tend to roll to the lowest portion and outer perimeter of the sieve thereby preventing effective sieving. Airing of the meat shreds was done to eliminate fluid bridges and adhesive forces as a result of residual moisture on the sample surface which contributed to the agglomeration of the shreds after pounding. Agglomerates falsify the particle size distribution, because particle collectives are measured instead of individual particleswith the result that the percentage of coarse particles istoo high(Restch,2009).

The sieving method that constituted of a back and forward movement of the sieve was meant to circulate the sample around the whole sieving surface (CISA, 2020; Grzechnik&Pitsch, 2004). The periodic tapping action that produced a vertical throwing motion overlaid with the horizontal circular motion aided in distributing the sample over the sieving surface (Mcglinchey, 2005; Restch, 2009), and facilitated the passing of the shreds through the apertures by reducing blinding or blocking. The throwing motion was also necessary because shreds had irregular shapes, but were assumed to be spherical (2001, Advantech Mfg; Albright, 2008) whose sizes can be narrowed down with the help of sieving.

The particles that were smaller than the openings passed through the sieve, while larger particles were retained.

The results of the sieve analysis of this study are presented in table 2. From the table, the results indicate that sieve with mesh size 3 retained 9.62% of the shreds, which constituted the biggest in size as compared to the rest of the shreds. The particles that passed through mesh number 3 had sizes close to the size of the nominal aperture of this sieve or much smaller.

Sieve Mesh Size	Sieve Size (µm)	Sieve Size (mm)	Mass of Shreds Retained in Each Sieve (g)	% Retained	% Cumulative
3	6730	6.73	300.6	9.62	99.99
4	4760	4.76	2617.1	83.72	90.37
5	4000	4.00	152	4.86	6.65
6	3360	3.36	56	1.79	1.79

Table 2: Results of Sieve Analysis of Sample D2 (Dakau)

Sieve with mesh size 4 retained 83.72% of the shreds, and a cumulative of 90.37%, which means that the shreds were a part of those that passed through mesh size 3, of which some were retained on mesh number 4, while those that passed through the latter had a cross section smaller than the mesh opening. It was also observed that mesh size 3 served as a relief sieve that removed some of the burden (Advantech Mfg, 2001) for mesh number 4 sieve, thereby increasing the effectiveness of subsequent sieving.

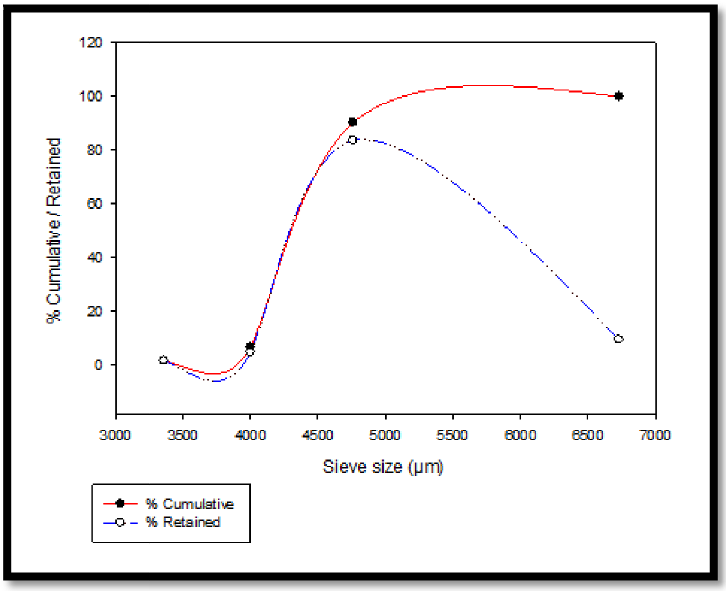

Figure 3: Particle Size Analysis

The bulk of the shreds (83.72%) were retained in mesh number 4, indicating that a high percentage of shreds had similar forms and sizes. This is responsible for important physical and chemical properties such as flowability and surface reaction (Restch, 2009). The use of sieve analysis in the modified Dakau method of DambunNama production was meant to set a standard for production and quality control, that will result in easy handling, low investment costs, with precise and reproducible results in a comparably short time.

3.2. Sensory Analysis

The results of the sensory assessments of the two products D1 and D2 used in the process standardization in this study are presented in Table 3. The results indicate that the parameter with the highest mean score was the overall acceptability of sample D1. The overall acceptability gives a summary of the acceptance of all the parameters tested in a sample, with high values indicating high acceptability (Watts, Ylimaki, Jeffry, & Elias, 1989). Therefore, the higher value of overall acceptability of sample D1 shows that it is most preferred over sample D2. This preference is indicated in the means obtained for taste, aroma, colour, and texture in sample D1, where all the means obtained were higher and significantly different with those of sample D2 as indicated in the table.

Sensory Property	Samples	
	D1(*Tuqe*)	**D2(*Dakau*)**
Texture	8.07 ± 0.68^a	7.71 ± 0.70^b
Taste	8.21 ± 0.65^a	7.93 ± 0.77^b
Aroma	8.21 ± 0.65^a	7.86 ± 0.72^b
Colour	8.21 ± 0.54^a	7.43 ± 0.47^b
O.A	8.27 ± 0.47^a	7.20 ± 0.66^b

Table 3: Comparison between the Two DambunNama Samples[1]

- Values are means of scores on the 9 point hedonic scale
- Means with similar superscripts in each row are not significantly different (P≤0.05)
- D1 = Pounded, fried DambunNama (Dakau Method)
- D2 = Stirred fried DambunNama (Tuqe Method)

- A.O = Overall Acceptability

In terms of texture, this preference could be attributed to the uniformity and the fluffiness of sample D1. Since texture is one of the most important attributes used by consumers to assess food quality (McKenna 2018; Watts et al., 1989), the texture of sample D1 played a very important role in its preference over sample D2. This is because the flow of food in the mouth and throat have a strong influence on the perception of quality (Menkov&Durakova, 2007; Maltin, Balcerzak, Tilley, &Delday, 2003). The particle sizes in sample D2 were uneven, which resulted in a different mouth-feel as compared to sample D1. This was obvious in the rough hand feel of the product, since the surface texture of a food material is often used to describe its surface characteristics (Chen, 2007).

From Table 3,the higher mean obtained in the sensory property of taste in sample D1 could be related to the uniformity in the particle sizes of the sample. However, in sample D2, different particle sizes were arbitrarily created as a result of the continuous stirring of the softened meat pieces. This endless combination of particle sizes constituted those that were fragile, which required minimal heat exposure and short processing times. The sample also constituted of medium and relatively large particle sizes that required moderate and long processing times respectively. The different combination of these particle sizes caused processing challenges in terms of the sensitivity of the fragile particles being prone to over-processing and heat damage (Tetra Pack, 2016; Ranken, 2002). The process duration and temperature of exposure of sample D2 resulted in giving its particles a golden brown, deep brown and random black colour. The random black particles were mostly small particles or shreds, which were the most affected by the temperature and time of processing. This resulted in their pyrolysis, a chemical degradation process that occur at high temperatures producing black solids or char (Cascarosa, Becker, Ferrante, Briens, Berruti, &Arauzo, 2011). Pyrolysis was prevented in sample D1 because of sorting and sieve analysis, which created uniform coloured particles of a golden brown colour. This was as a result of the minimum temperature and time of exposure that were crucial to the desired and consistent quality attributes.

4. Conclusion

Particle size in foodstuff crucially influences organoleptic properties, such as taste and mouthfeel. The particle size in the production of DambunNama plays an important role in determining the quality of the final product and plays a big role during moisture removal using heat processing. The study highlighted that the use of sieving to control uniformity in particle size, greatly affected the final quality of DambunNama. The controlled preparation methods and the final product characteristics of sample D1 (*Dakau*) resulted in its preference over sample D2 (*Tuqe*). The analyzed sensory data proved the preference of sample D1 in all the parameters tested including the overall acceptability. Therefore, for establishing precision and reproducibility in the processing method of DambunNama, and in the final product quality characteristics, the preparation method of sample D1 could be adopted as a standardized procedure of commercial production of DambunNama.

5. References

i. Advantech Manufacturing publication (2001). Test Sieving;Principles and Procedures. A Discussion of the Uses,Capabilities, and Limitations of Testing Sieves as Analytical Tools. New Berlin,Wisconsin 53151 2450 S Commerce Drive 262-786-1600 (800) 511-2096

ii. *Albright, L. (2008).* Albright's Chemical Engineering Handbook*. CRC Press. p. 1718.* ISBN 978-0-8247-5362-7*.*

iii. American Society for Testing and Materials (ASTM: 2006) International Standards Worldwide. *ASTM C136-06*.

iv. Analytical Instruments Specialists (ATA)Publication(2019). Basic Principles of Particle Size Analysis. Particle Science - Guide

v. Biesalski, H. K. &Nohr, D. (2009). The Nutritional Quality of Meat. In: J.P. Kerry &D. Ledward (Eds). Improving the Sensory and Nutritional Quality of Fresh Meat, 1st Edn.,Woodhead Publishing Ltd, Cambridge, England.

vi. Cascarosa, E., Becker, J., Ferrante, L., Briens, C., Berruti, F., &Arauzo, J., (2011). Pyrolysis of Meat-meal and Bone-meal Blends in a Mechanically Fluidized Reactor. *Journal of Analytical and Applied Pyrolysis,* 91(2):359-367

vii. Certified Analytical Sieves (CISA), (2020). Principles of Test Sieving; Sieving Technologies-Guide-Gramineous. Batzacs, 6, nave B, 08185 Llica de Vall, Barcelona.

viii. Chen, J. (2007). Surface Texture of Foods: Perception and Characterization. Critical Reviews in Food Science and Nutrition. Semantic Scholar. Published by Taylor & Francis, ISSN 1549-7852.

ix. Dean, A., Voss, D., &Draguljic, D. (2017). Design and Analysis of Experiments, 2nd Edn. Springer International Publishing, New York, USA

x. Earle, R.L. (1983). Unit Operations in Food Processing. Mechanical Separations; Sieving. Published by NZIFST (Inc.).

xi. Eke, M.O., Ariahu, C.C., &Okonkwo, T. M., (2012). Production and Quality Evaluation of Dambu-Nama, a Nigerian Dried Meat Product. *Nigerian Food Journal,* Vol 30, No 2.

xii. Heinz, G. &Hautzinger, P. (2007). Meat Processing Technology for Small-To Medium-Scale Producers. Food and Agriculture Organization (FAO) of the United Nations Regional Office for Asia and the Pacific, Bangkok.

xiii. Igwegbe, A.O., Idakwo, P.Y., Yusuf, H.L., Gervase A. I., Maijalo, A. I. &Abubakar F., (2019). Effects of Sodium Citrate and Garlic on Organoleptic Properties, ProximateComposition, Free Fatty Acid and Thiobarbituric Acid Levels of Treated Smoke-Dried Meat Stored at Ambient Temperatures. CPQ Medicine, 5(5), 01-14.

xiv. *International Organisation for Standardization (ISO, 2013).* Test sieves: Technical requirements and testing; Part 2: Test sieves of perforated metal plate*.ISO/TC 24/SC 8. p. 9.*

xv. Knipe, C. L., & Rust, R. E (2010). Thermal Processing of Ready-to-Eat Meat Products.Wiley Blackwell, A John Wiley & Sons, Ltd Publication, USA.

xvi. Lawless, H.T., &Heymann, H. (2010). Introduction. In Sensory Evaluation of Food: Principles and Practices, 2nd Edition

xvii. Lawrie, R. A. &Ledward, D. A. (2006). Lawrie's Meat Science 7th Edn.,Woodhead Publishing Ltd., Cambridge, England.

xviii. Maltin, C., Balcerzak, D., Tilley, R., &Delday, M. (2003). Determinants of meat quality: tenderness. Proceedings of the Nutrition Society, vol. 62, no. 2, pp. 337–347, 2003.

xix. Mamlouk, M.S.& J.P. Zaniewski, (1999). Materials for Civil and Construction Engineers, Addison-Wesley, Menlo Park CA.

xx. McKenna B.M. (2018). Texture in Foods Vol. 1. Published by Woodhead Publishing in Food Science and Technology, Cambridge, England.

xxi. Mcglinchey, D. (2005). Characterisation of bulk solids. CRC Press, p231

xxii. Menkov, N.D., &Durakova, A.G. (2007). Moisture Sorption Isotherms ofSesame Flour at Several Temperatures. *Food Technol. Biotechnol. 45* (1) 96–100.

xxiii. Nychas, G.J.E., &Skandamis, P.N., Tassou, C.C., and Koutsomanis, K.P. (2008). Meat Spoilage during Distribution. *Meat Sci., 78: 77-89. DO1:10. 1016/j.meatsci. 2007.06.020*

xxiv. Paddon-Jones, D., Short, K.R., Campbell, W.W., Volpi, E., &Wolfe, R.R. (2008). Role of Dietary Protein in the Sarcopenia of Aging. *Am J ClinNutr. 87(5)*:1562S-1566S.

xxv. QMJ Group Ltd (2017).Sieving Analysis.Published in the December 2017issue of QuarryManagement. The QMJ Group Ltd7 Regent StreetNottinghamNG1 5BSUnitedKingdom.

xxvi. Ranken, M.D. (2002). Handbook of Meat Product Technology. Oxford: Blackwell Science Ltd.

xxvii. Retsch publication (2009). Sieve Analysis in Quality Control: Taking a close look at quality. Retsch GmbH RheinischeStraße 3642781 HaanGermany

xxviii. Tetra Pack (2015). White Paper on: The Inside Story on Heat Treatment of Particulate Foods; Minimizing Damage when Processing Particles, Fibres, and Pulp. Summary of Challenges and Solutions. A Publication by Tetra Pack.

xxix. Varman, A. H. & Sutherland, J. P. (1995). Meat and Meat Products: Technology, Chemistryand Microbiology. 1st Edn. Chapman and Hall, London.

xxx. Watts, B.M., Ylimaki, G.L., Jeffery, L.E., &Elias, L.G. (1989). Basic Sensory methods for Food Evaluation. International development Research Center, P.O. Box 8500 Ottawa, Ontario, Canada, K1G 3H9. ISBN: 0-88936-563-6.

xxxi. Yusuf, H. L., Igwegbe, A. O., Idakwo, P. Y., Ahmad, G., & Sani, A. (2020). Physico- Chemical and Microbiological Analyses of a Smoke-dried Meat Product (Kamsa) During Six Months Storage Period. Agricultural Research and Technology Open Access Journal, 24(2):48-52.

xxxii. Yusuf, H.L., &Abubakar, U.M. (2011). A Study of the Moisture sorption characteristics of Kamsa (a smoke-dried meat product). *Biological and Environmental Sciences Journal for the Tropics.* Volume 8, Number 4.

xxxiii. Yusuf, H.L., Igwegbe, A.O., Idakwo P.Y., &Isma'il, B.B.(2019).Process Standardization using Sensory Evaluation of *Kamsa*: A Smoked-Dried Meat Product. Proceedings of the 43rd Conference and Annual General Meeting of NIFST. Pp 7-8

xxxiv. Zulyadaini, H., & Yusuf, H.L. (2015). Chemical and microbiological composition of salted, sundried, beef and mutton. *Biological and Environmental Sciences Journal for the Tropics* (BEST) 12(1), ISSN 0794 – 9057; 630 – 633.