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Full Length Research Paper

A comparative study of three drying methods for preservation of the giant African snail (*Achatina achatina*) meat

Felix Narku Engmann[1, 2]*, William Otoo Ellis[3], Victoria P. Dzogbefia[3], Ma Yong-Kun[1], Ernest Abano[1, 4], and John Owusu[1, 5]

[1]School of Food and Biological Engineering, Jiangsu University, 301 Xuefu Road, Zhenjiang 212013, China.
[2]Department of Hotel, Catering and Institutional Management, Kumasi Polytechnic, Kumasi, Ghana.
[3]Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
[4]Agricultural Engineering Department, University of Cape Coast, Cape Coast, Ghana.
[5]Hospitality Department, Koforidua Polytechnic, Koforidua, Ghana.

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The meat of the giant African snail (*Achatina achatina*) was preserved utilising solar drying, tray drying, and traditional hot air/smoking method. The study compared the effectiveness of the three drying methods on the basis of the nutritional, microbiological and sensory attributes of the dried snail samples. In addition, the cost and operational requirements of the three dryers were evaluated. Results obtained showed that, protein (89.92±0.49%), fat (4.76±0.13%), ash (3.84±0.30%), and energy (1729.92±8.09 kJ/100g) were highest in the dried sample from the traditional hot air/smoke dryer, but was lowest in total carbohydrate (1.48±0.06%), all on dry matter basis. In addition, the sample dried using the traditional hot air/smoke dryer, comparatively had least microbial numbers after drying and throughout the storage period of 30 weeks with good sensory attributes making it the most preferred method for drying snail meat.

Key words: Giant African snail, hot air/smoke drying, tray drying, solar drying.

INTRODUCTION

The Giant African snail belongs to the two genera; *Achatina* and *Archachatina.* In West Africa and other parts of Africa, snail meat has traditionally been a major ingredient in the diet of people living in the forest belt (Beckett, 1964; Cobbinah, 1993). Snail populations are highest during the rainy season when they are collected in large quantities by rural communities and can be very cheap, but become scarce and expensive during the dry season when they aestivate and are difficult to find (Ahmed and Raut, 2008; Asibey, 1986; Rahman and Raut, 2010; Wilson, 2007).

*Corresponding author. E-mail: felitexgh@yahoo.com. Tel: +8613952858074.

Additionally, there are not many snail farms to augment that which are picked from the forest soil during the dry season. Moreover, the continuous depletion of forests and other biological snail predators, had led to reduction in snail population and availability, and therefore snail farming is being encouraged (Appiah et al., 2009; Hadfield, 1986).

Many research work done on the Giant African snail had focussed mainly on identifying suitable feeding materials to boost meat yield as well as determining the nutritional composition of various species from the two genera *Achatina* and *Archachatina* (Ademolu et al., 2004; Fagbuaro et al., 2006).

Traditionally in Ghana, snail meat is preserved by first eviscerating the flesh from the shell and separating the edible portion from the other viscera for further

Figure 1. Modified "Chorkor smoker" ('Tech dryer') with a cabinet, used for hot smoke-drying of farm- reared Giant African snail (*Achatina achatina*) meat.

processing. Long sticks (about 1 m in length) with sharpened ends are used to pass through the meat so they get attached for easy handling. These are then dried in the sun for a period, and finally dried over mild fire. The sticks, bearing the dried snail meat, are kept in sacks until sold or ready for use. These processes expose the meat to environmental and microbiological contaminating agents.

Analysis of traditionally dried *Achatina achatina* meat samples indicated high microbial load (CBUD contract No: CBUD/AFC/017, Department of Biochemistry and Biotechnology, KNUST, unpublished). Moreover, preliminary microbial determination by the authors of sampled traditionally dried *A. achatina* samples, showed they contained enormous numbers of both aerobic bacteria (1.25×10^{14} cfu/g) and moulds (9.2×10^{14} cfu/g).

The unavailability throughout the year, coupled with acclaimed health benefits, had led to many countries encouraging the rearing of snail to alleviate poverty and to address malnutrition due to protein deficiency at the rural and sub-urban areas (Akinnusi, 1998; Thiengo et al., 2007; Appiah et al., 2009).

The objective of this study was to investigate and identify a suitable drying method to preserve snail meat that will ensure good nutritional content, low microbial population and good sensory attributes over a considerable period of time. The drying methods employed were tray drying using a tray dryer, solar drying using a tent solar dryer, and traditional hot air/smoke drying using a modified "Chorkor smoker" ("Tech dryer"). The dried snail meat samples were analysed to evaluate the effect of each drying method on the proximate and energy, sensory characteristics, and microbiological quality of the snail meat. A comparative analysis of the dryers was also done.

MATERIALS AND METHODS

Source and sample preparation

Snails for this work were obtained from snail farms in Kumasi, Ghana. They were sorted to remove dead snails and foreign materials. The snails were then washed with potable water and heated in water at 60°C for 20 min to aid evisceration.

Drying methods

The tray dryer, electrically powered, was set to operate at 80°C. The come-up time was one hour, after which the metal trays, loaded with the snail meat, were introduced into it. To ensure uniformity in drying, the snails were turned hourly with the positions of the trays being swapped – top trays brought lower and lower ones sent up. The temperature of the tray dryer was maintained between 75 and 80°C.

The "Tech dryer", a modified "Chorkor smoker", was specially built for this work and it had two parts: the stove and cabinet compartments (Figure 1). The stove portion was made, using partially burnt bricks, and the cabinet compartment was mounted on

it. The cabinet portion was an enclosed wooden chamber containing layers of trays (wooden frames with wire mesh beneath). The enclosed cabinet had a small vent at the top for smoke and moisture expulsion. The normal "Chorkor smoker" has no such enclosure. Firewood was burnt in the stove for about 20 min to heat up the stove. Dried hardwood was used as this gives good smoke and to avoid gums associated with soft wood (Daun, 1979).

Temperature control was achieved by withdrawing or adding firewood and checking the temperature using a thermocouple. Upon attaining a temperature of 80°C the trays, with the snail meat spread on it, were introduced into the cabinet and the cabinet temperature maintained between 75 and 80°C. The snails were turned and tray positions changed hourly. Drying was completed for both the tray and solar drying methods when the snail meat became brittle-dry.

The tent solar dryer was used for the solar drying method. Average maximum temperature attained within the tent was 50°C during the day, but dropped to about 30°C in the evening. The snails were turned after every 24 h until drying was completed. Dried snail samples from the three drying methods were packaged in rigid plastic containers and stored at 24±1°C.

Sample preparation and analyses conducted

The dried snail meat was milled into fine powder before being used for analysis. Proximate, microbiological, and sensory analyses were conducted on the snail samples. Each parameter was determined in triplicate.

Proximate and energy

The recommended methods of the Association of Official Analytical Chemists (AOAC 1999) were used for the proximate analysis. Moisture was determined using a thermostatically controlled forced air oven (Gallenkamp, England) operating at 105°C for 3 h. The difference in weight before and after drying was used to calculate the per cent moisture content. Crude fat determination was done using the Soxhlet extraction apparatus to thoroughly extract crude fat from 4 g of sample using petroleum ether (boiling point 40 to 60°C), in the Soxhlet method of fat determination.

The weight of fat divided by weight of sample was used to compute for the percent crude fat content. Crude protein (% N × 6.25) was determined by the Kjeldahl method using a 1.0 g sample. Ash was determined by incinerating 5.0 g of sample at 550°C overnight in a muffle furnace (Gallenkamp, England), and the weight before and after ashing used in calculating the per cent ash content.

Total carbohydrate was obtained by subtracting the percent amounts of moisture, fat, ash, and protein from 100%. The energy value of each sample was determined by multiplying the percent composition of carbohydrate, fat, and protein by their corresponding Atwater values of 17, 37, and 17, respectively (James, 1995).

Microbiological analysis

One gram of each milled sample was weighed into a separate test tube containing 10 ml of sterile 0.1% peptone solution. The mixture was shaken and allowed to settle and the supernatant filtered using No. 1 Whatman filter paper (Whatman Intl. Ltd., Maidstone, England). The filtrate was used to prepare serial dilutions of 10^{-2}, 10^{-4}, and 10^{-6}.

For aerobic bacteria count, the spread-plate method was used. For each diluent, 0.1 ml was aseptically pipetted onto pre - poured, solidified plate count agar (PCA) plates and the inoculum spread with a sterile, bent glass rod. Plates were incubated at 37°C for 48 h in a Gallenkamp incubator. Plates with colonies between 30 and 300 were counted (Gallenkamp colony counter) and expressed as colony forming units per gram (cfu/g).

For moulds determination, 0.1 ml of the diluents was inoculated onto sterile potato dextrose agar (PDA) (BDH) using surface plating technique. Plates were then incubated at 25°C in a Gallenkamp incubator for five days. Colonies formed were counted using a Gallenkamp colony counter and counts expressed as cfu/g of snail meat. The mean number of bacteria and moulds obtained for each determination was converted to natural logarithm and used for the statistical analysis.

Sensory evaluation

Dried snail meat from the three samples was separately used to prepare vegetable soup, referred to as 'Light soup' using equal quantities of ingredients. Twelve panellists, who regularly eat snails, were selected and trained for the sensory evaluation. The degree of preference for colour, flavour, and taste was determined using the Kruskal Wallis ranking test.

Statistical analysis

The data obtained from the proximate determinations and energy calculation were subjected to statistical analysis using one-way analysis of variance (ANOVA) to test significant variations ($p < 0.05$) among mean values obtained. Where significant differences existed, Duncan's least significance difference (LSD) test was applied to indicate where the differences occurred. The statistical package used was SPSS 17.0 (SPSS Inc. Chicago, IL, USA). The Kruskal Wallis test was used to establish whether there were significant differences ($p < 0.05$) in the various sensory attributes (colour, flavour, and taste) of the three snail samples.

The microbiological data were analysed using the general linear model for repeated measures design in Minitab v15.1™ (Minitab Inc., State College, PA, USA). The between-group effect on the response variable (microbial population) was the drying methods and the within-group effect was the weeks of storage. The moisture content of the samples was used as a covariate. All factors were treated as fixed.

The moisture content was used as a response variable to compare how microbial numbers are affected by moisture absorption during storage. The least square means were separated using the Tukey's pair-wise comparison method when the analysis of variance test was significant ($p < 0.05$).

RESULTS AND DISCUSSION

Proximate analysis

Table 1 shows mean values obtained for the proximate analysis and energy calculation on dry matter basis. The mean moisture contents of the solar, tray, and traditional hot air/smoke-dried (smoke-dried for short) samples at the end of drying were 7.24, 6.56, and 3.24%, respectively. There was no significant difference ($p < 0.05$) between the moisture content of the solar and tray dried samples. However, there were significant differences ($p > 0.05$) between the solar and smoke-dried samples, as well as the tray and smoke-dried samples.

The solar-dried sample attained the final moisture content after five days as the maximum achievable

Table 1. Proximate and energy values of dried farm-reared Giant African snail (*Achatina achatina*) meat.

Sample	Crude protein (%)	Crude fat (%)	Ash (%)	Carbohydrate (%)	Energy (kJ/100 g)
Smoke-dried	89.92±0.49[a]	4.76±0.13[a]	3.84±0.30[a]	1.48±0.06[c]	1729.92±8.09[a]
Tray -dried	88.78±0.11[b]	4. 26±0.19[b]	3.45±0.19[a]	3.51±0.13[b]	1726.55±6.36[a]
Solar-dried	80.91±0.12[c]	4.72±0.15[a,b]	3.18±0.09[a]	11.19±0.12[a]	1740.34±2.12[a]

Mean values with different superscripts ([a, b, c]) in a column are statistically different ($p < 0.05$).

temperature (50°C) in the tent solar dryer was relatively lower than the tray and smoke-dried samples (75 - 80°C), which took six hours to dry. The tray dryer took one hour to build up temperature to 80°C, explaining why there was a difference in the moisture content of the tray and smoke-dried samples.

The protein content formed a higher percentage of dried snails compared with the other nutritional components. This was the case because snail meat is basically muscle and with the moisture removal, the protein content in the muscle was more evident. The mean values obtained for the three samples were statistically different ($p < 0.05$), with the smoke-dried sample having the highest average value and the solar-dried sample having the least average value. The relatively low protein value of the solar-dried sample, compared to the smoked and tray-dried samples, may be attributed to the putrefaction the solar-dried sample underwent.

Putrefaction leads to the production of ammonia and pyruvate (Girard, 1992). The ammonia released and the conversion of amino acids to pyruvate led to loss of nitrogen, which is the element quantitatively determined in the Kjeldahl method of protein determination (Nielson, 1994). Thus, a reduction in the nitrogen content invariably led to a reduction in the protein content of the sample. This possibly may account for the relatively lower value obtained for the solar-dried sample as compared to the tray and smoke-dried samples.

Crude protein values obtained in this work were relatively higher compared to results reported by other workers (Oduro et al., 2002; Watson, 1971). There were no significant differences ($p > 0.05$) in the mean values of crude fat between the solar and tray-dried samples, as well as between the solar and smoke-dried samples. The value obtained for the tray-dried sample was lower and significantly different ($p < 0.05$) from the smoke-dried sample. The observed difference may be due to the slight melting away of fat from the tray-dried sample as a result of direct contact with the metal tray which transfers heat more efficiently than air. The values obtained were within the range (4.11 to 5.06%) reported by Oduro et al. (2002), but were appreciably high compared to Gernadi (1951) and Mead (1961).

For ash, there were no significant differences ($p > 0.05$) in the mean values obtained for the three samples. Relatively, the smoke-dried sample had the highest ash value, followed by the tray and solar-dried samples in that order. Values obtained in this work compared favourably with those reported by Gernadi (1951) and Mead (1961).

There were significant differences ($p < 0.05$) in the mean values obtained for total carbohydrate in the three samples. The solar-dried sample had the highest percentage of carbohydrate followed by the tray and smoke-dried samples in this order. Browning, due to the Maillard reaction, may have accounted for the relatively low values of carbohydrate in the smoke-dried and tray-dried samples, as they underwent browning during drying. The reducing sugars that participate in the Maillard reaction could be transformed into various compounds and therefore lost in the process (Martins et al., 2001; Wong et al., 2009).

Browning was extensive in the smoke-dried sample than the tray-dried sample and that may explain why the smoke-dried sample had relatively lower carbohydrate value than the tray-dried one. Browning did not take place in the solar-dried samples, and thus the carbohydrate content may not have been affected, accounting for the relatively high value. Apart from the solar-dried sample, the values were relatively low compared to that reported by Oduro et al. (2002) (6.87 to 7.8 9%).

The energy value of the smoke-dried sample had the highest value and was significantly different ($p < 0.05$) from the solar and tray-dried samples. There was however, no significant difference ($p > 0.05$) in the energy levels of the tray and solar-dried samples. The energy levels of the three samples were quite high compared to that reported by Oduro et al. (2002) (390.92 to 435.97 kJ/100 g).

Microbiological analysis

Statistical analysis of microbial population using the general linear model for a repeated measure approach indicated that, all means adjusted for moisture content between - group (smoke - dried, solar-dried and tray - dried) and within - group (weeks 0, 6, 12 and 30) were significantly different ($p < 0.0001$) (Figures 2 and 3).

If the difference in value between any two points within or between groups is less than the least significant difference (LSD), then there is no significant difference between those points. Alternatively, where error bars overlap (between-group or within-group), it implies no

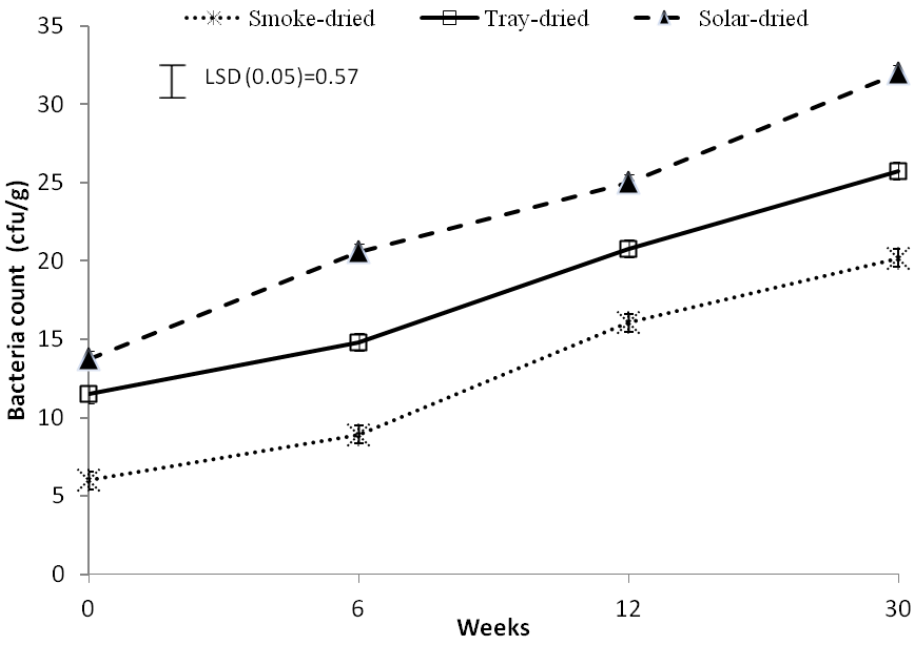

Figure 2. Bacteria population, as cfu/g, of dried farm-reared Giant African snail (*Achatina achatina*) meat.

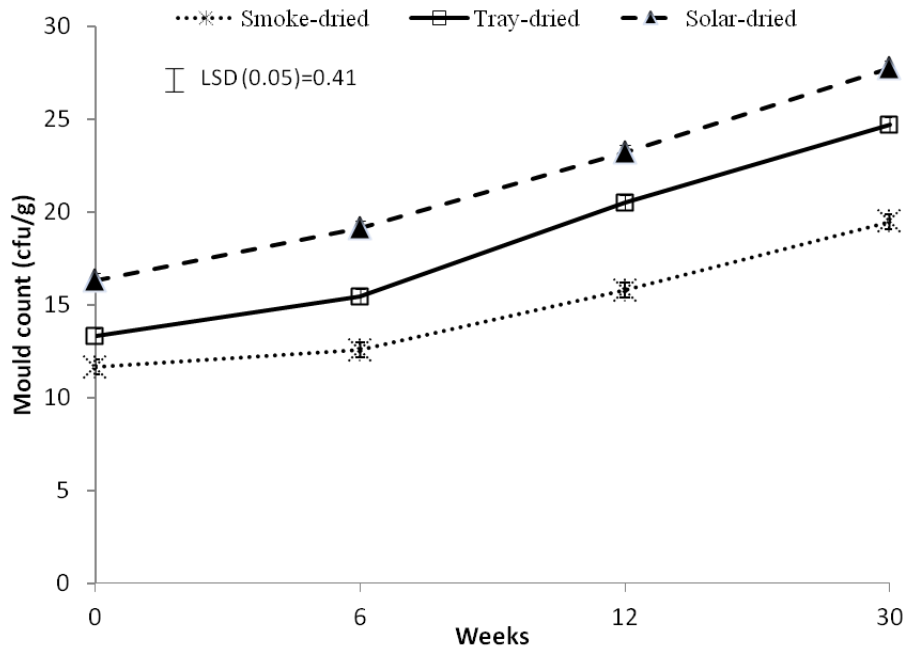

Figure 3. Mould population, as cfu/g, of dried farm-reared Giant African snail (*Achatina achatina*) meat.

significant difference ($p > 0.05$).

The smoke-dried sample had relatively least number of both bacteria and moulds at each stage determined. This was followed by the tray and solar-dried samples in that order. It could be seen from Figures 2 and 3 that, increases in microbial population were higher for the solar and tray-dried samples than in the smoke-dried one. As the moisture content of the samples increased during storage (Figure 4), there was a corresponding increase in microbial population for all the three samples.

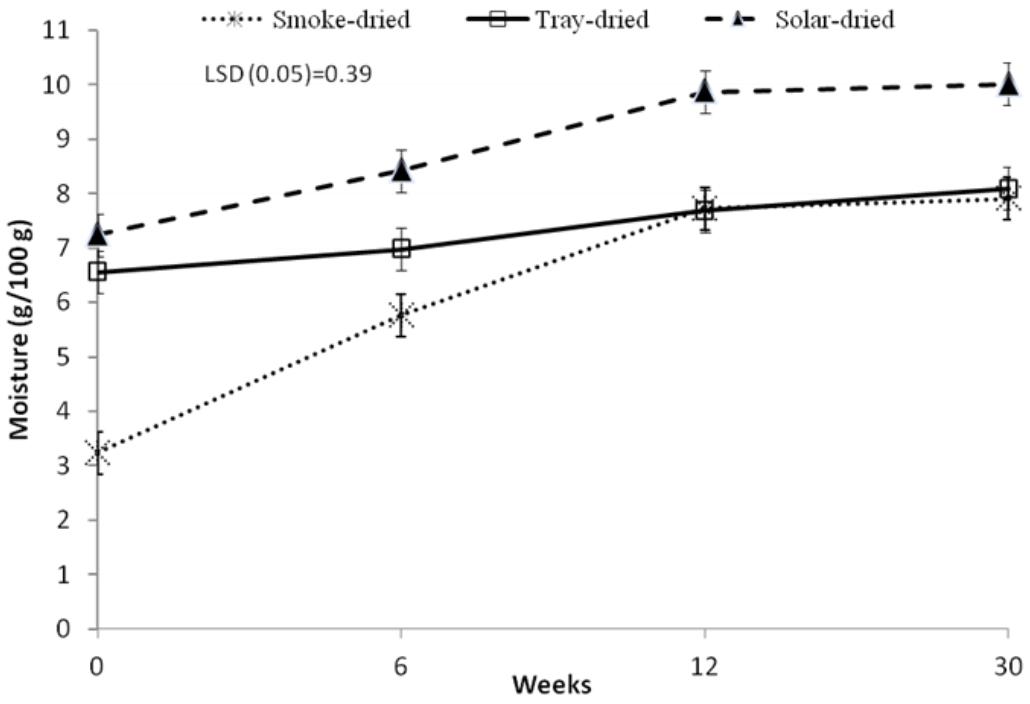

Figure 4. Moisture, as g/100g, uptake of dried farm-reared Giant African snails (*Achatina achatina*) during storage period, expressed in weeks.

The smoke-dried sample rapidly absorbed moisture and by weeks 12 and 30, there were no significant differences in the moisture content of the smoke and tray-dried samples. However, the increases in levels of bacteria and moulds were least in the smoke-dried sample as compared to the tray and solar-dried samples. Smoke contains over 400 substances (methanal, ethanal, alcohols, ethanoic acid, methanoic acid, furfuraldehyde, phenols, etc), some of which are antimicrobial in nature (Arvanitoyannis and Kotsanopoulos, 2011; Goulas and Kontominas, 2005; Horner, 1997). The combined effect of heat (75 to 80°C) and the antimicrobial substances in smoke may be responsible for the relatively low population of bacteria and mould in the smoke-dried sample, just after drying and throughout the storage period.

In the tray drying method, it was only heat that reduced the microbial population, without additional antimicrobial property. This may explain why the tray-dried sample had relatively higher values for both bacteria and moulds compared to that of the smoke-dried sample.

The initial high moisture content (80%), conducive temperature within the tent during the night (30°C), the nutritious nature of the snail meat, and the relatively long drying period, promoted microbial growth which resulted in it acquiring the noticeable putrid odour.

Moulds are generally more resistant to adverse conditions, especially low water activity, than bacteria (Girard, 1992; Wilson, 1981). This may explain the higher population of moulds than bacteria after the drying process and throughout the storage period.

Sensory evaluation

Using the Kruskal Wallis test, the sample with the least mean rank score for a sensory attribute, means that it was the most preferred. From Table 2, the tray-dried sample was the most preferred sample in terms of flavour and appearance, followed by the smoke-dried and solar-dried samples in that order. The solar-dried sample was the most preferred in terms of taste. This was closely followed by the smoke-dried sample and the least preferred was the tray-dried sample.

The solar drying method did not change the colour of the snail meat and therefore there was no improvement in its appearance. In the smoke and tray drying procedures, the drying temperature was high enough to cause Maillard browning. However, smoke particles deposited on the smoke-dried sample ameliorated its attractive colour as compared to the tray-dried sample. This may have influenced panellists' decision to choose the tray-dried sample over the smoke-dried one, in terms of appearance.

The putrid odour of the solar-dried sample, due to proteolysis, may have led to it being least ranked in terms of flavour. The smoke-dried sample had a reduced snail aroma due to compounds (carbonyls, lactones, etc.) in

Table 2. Kruskal Wallis sensory ranking test results for dried farm-reared Giant African snails (*Achatina achatina*).

Attribute	Product	Mean rank scores
Flavour	Smoke-dried	17.50
	Tray-dried	14.50
	Solar-dried	23.50
	Asymptotic significance	0.08
Appearance	Smoke-dried	16.50
	Tray-dried	14.50
	Solar-dried	24.50
	Asymptotic significance	0.03
Taste	Smoke-dried	16.08
	Tray-dried	24.13
	Solar-dried	15.29
	Asymptotic significance	0.07

Mean rank score of sample with lowest value for each attribute was most preferred.

Table 3. Cost and Operational comparison parameters of drying methods for snail meat.

Drying equipment	Capacity (m^2)	Acquisition cost* ($)	Ancillary equipment	Energy source	Expertise and supervision	Maintenance
Smoke-dryer	5.0	450	Thermo-couple	Fire-wood	A little training is required. Requires attention	Occasional application of clay suspension on stove
Tray-dryer	0.8	7000	Electricity to site, electrical switchgear, cabling and starters, back-up generator	Electricity	Personnel should be well trained. Requires constant attention	Heating coils and switchgears ought to be changed periodically
Tent -solar dryer	2.2	530	nil	The sun	A little training. Minimum supervision required.	Plastic film should be changed after 6-8 months

*2010.

smoke that may possibly have modified the original flavour (Daun, 1979; Arvanitoyannis and Kotsanopoulos, 2011). Panellists therefore ranked the tray-dried sample better over the smoke-dried one in terms of flavour.

For taste, the solar-dried sample was ranked first followed closely by the smoke-dried sample and lastly by the tray-dried sample. Endogenous meat enzymes as well as microbial enzymes are capable of causing enzymatic and oxidative changes under favourable conditions in the solar-dried snail meat leading to the formation of molecules that can modify its taste (Girard, 1992). These enzymatic processes may have contributed to the improvement in taste of the solar-dried sample making panellists rank it highest. This was absent in the tray and smoke-dried samples. However, smoke generally tends to enhance the flavour of foods. The presence of certain phenolic compounds such as guaiacol, 4-methylguaiacol, and syringol in smoke play an important role in the characteristic flavour of smoked products (Arvanitoyannis and Kotsanopoulos, 2011; Ihekoronye et al., 1985).

Other constituents of smoke such as 1, 2-cyclopentadione and 2-butenolide possess a caramel odour whereas furfural, 5-methylfurfural, 2-acetofuran, and acetophenone exhibit a pleasant sugary and flowery aroma (Daun, 1979). The presence of these compounds may have possibly improved the taste of the smoked-dried sample, accounting for it being ranked higher over the tray-dried sample.

Cost and operational comparison

The cost and operational comparison of the three drying methods are shown in Table 3. The “Tech dryer” acquisition cost was the least but had the highest

capacity, whilst the tray dryer was the most expensive, but with least capacity. The tray dryer required the most ancillary equipment and devices, whilst the “Tech dryer” required only a thermocouple, but the solar dryer required no ancillary equipment. The unpredictability of the weather especially when snails are in abundance (rainy season), can have effect on the rate of drying and invariably affect the consistency of dried snail meat quality.

The source of energy for the “Tech dryer” was firewood, which is easily accessible and may come at no or very low cost in forest areas where snails abound. The use of firewood has environmental concerns though. The tray dryer was powered by electricity, which is relatively expensive but a cleaner form of energy.

In terms of personnel expertise and attention, the tray dryer requires well-trained personnel who must pay constant attention during the drying process. For the “Tech dryer”, the operative requires training only in reading the thermometer and the general operation of the “Tech dryer”. The “Tech dryer” also requires constant attention, at least in the early stages of the drying process. The solar dryer requires the least level of training and attention.

Therefore, the tray dryer is the most expensive to use in terms of hiring an operative, training, and operating the dryers. This was followed by the “Tech” and solar dryers in that order. For maintenance of the dryers, it is required that the transparent plastic film of the solar dryer be changed after six to eight months as the film becomes brittle and usually tears as a result of exposure to sunlight.

The film must also be changed when the structural integrity of the film is accidentally severed to ensure effective drying and protection from rain and pests. Periodic painting of the wooden frame must be undertaken to prevent termite attack and decay.

For the “Tech dryer”, there must be periodic application of a thick clay suspension on the inside and outside of the stove compartment. The maintenance of the tray dryer centres around the heating coils, integral fans, thermostat, and switches. These component parts must be periodically assessed to determine their efficiency.

Conclusion

From the evaluation of the sensory characteristics, proximate and energy analysis, and microbiological stability of dried snail samples obtained after solar, tray, and traditional hot air/smoke drying, it could be concluded that, the traditional hot air/smoke drying method, using the modified “Chorkor smoker” (Tech dryer), was relatively the best method for drying the meat of the Giant African snail. In addition, comparing the three dryers in terms of cost of acquisition as against capacity, and other operational requirements, the “Tech dryer” was relatively better. Moreover, the “Tech” dryer can easily be constructed and operated everywhere with minimum training.

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REFERENCES

Ademolu KO, Idowu AB, Mafiana CF, Osinowo OA (2004). Performance, proximate and mineral analyses of African giant land snail (*Archachatina marginata*) fed different nitrogen sources. Afr. J. Biotechnol. 3:412-417.

Ahmed M, Raut SK (2008). Changes in proximate constituents and the fate of aestivating *Achatina fulica* Bowdich. Proc. Nat. Acad. Sci. India., Sec. B 78:343-350.

Akinnusi O (1998). A practical approach to backyard snail farming. Niger. J. Anim. Prod. 25(2):193-197.

AOAC (1999). Official Methods of Analysis Method. AOAC International, Gaithersburg, MD, USA.

Appiah M, Blay D, Damnyag L, Dwomoh FK, Pappinen A, Luukkanen O (2009). Dependence on forest resources and tropical deforestation in Ghana. Environ. Dev. Sustain. 11:471-487.

Arvanitoyannis IS, Kotsanopoulos V (2011). Smoking of Fish and Seafood: History, Methods and Effects on Physical, Nutritional and Microbiological Properties. Food Bioprocess Technol. DOI: 10.1007/s11947-011-0690-8.

Asibey EOA (1986). Wildlife and Food Security. FAO Forestry Department, Rome 14:18-21.

Beckett WH (1964). Akokoaso – A Survey of a Gold Coast Village: Monograph of snails Anthropology. 10 London School of Economics, pp. 9-14.

Cobbinah JR (1993). Snail farming in West Africa; A Practical Guide, Technical Centre for Agricultural and Rural Co-operation (CTA). Sayee Publishing Company, United Kingdom, pp. 18–20.

Daun H (1979). Interaction of wood smoke components and foods. Food Technol. 33:85-90.

Fagbuaro O, Oso JA, Edward JB, Ogunleye RF (2006). Nutritional status of four species of giant land snails in Nigeria. J. Zhejiang Univ. Sci. 7(9):686-689.

Gernadi GA (1951). A preliminary report on the biology, ecology and control of the Giant African Snail (*Achatina fulica* Fer.). Philippine J. Agric. 14(4):337-347.

Girard JP (1992). Technology of Meat and Meat Products. Ellis Horwood Ltd., England pp. 94-198.

Goulas AE, Kontominas MG (2005). Effect of salting and smoking method on the keeping quality of chub mackerel (*Scomber japonicus*): Biochemical and sensory attributes. Food Chem. 93: 511-520.

Hadfield MG (1986). Extinction in Hawaiian *Achatinelline* snails. Malacologia 27:67-81.

Horner WFA (1997). Preservation of fish by curing (drying, salting and smoking). In: Fish Processing Technology (2nd edn), Hall GM (ed), Blackie Academic & Professional (Chapman and Hall), London pp. 32-72.

Ihekoronye AI, Ngoddy PO (1985). Integrated Food Science and Technology for the Tropics. Macmillan Publishers pp. 155-160.

James CS (1995). Analytical Chemistry of Foods. Blackie Academic and Professional, Glasgow, U.K pp. 64-65.

Martins SIFS, Jongen WMF, Van Boekel MAJS (2001). A review of Maillard reaction in food and implications to kinetic modeling. Trends Food Sci. Technol. 11:364-373.

Mead AR (1961). The Giant African Snail: A problem in economic malacology. The University of Chicago Press, pp. 146-171.

Nielson SS (1994). Introduction to chemical analysis of foods. Chapman and Hall, New York, pp. 184-186.
Oduro W, Ellis WO, Oduro I, Tetteh D (2002). Meat Yield and Quality of Selected Snail Species in Ghana. J. Ghana Sci. Assoc. 4(2):24-30.
Rahman S, Raut, SK (2010). Factors Inducing Aestivation of the Giant African Land Snail *Achatina fulica* Bowdich (Gastropoda: *Achatinidae*) Proc. Zool. Soc. 63(1):45–52.
Thiengo SC, Faraco FA, Salgado NC, Robert H, Cowie RH, Fernandez MA (2007). Rapid spread of an invasive snail in South America: the giant African snail, *Achatina fulica*, in Brasil. Biol. Invasions 9:693-702.
Watson JD (1971). The nutritive value of some Ghanaian foodstuffs Ghana J. Agric. Sci. 4:95-111.
Wilson MJ (2007). Terrestrial mollusc pests (2007). In: Lacey LA, Kaya HK (Eds), Field Manual of Techniques in Invertebrate Pathology; Application and Evaluation of Pathogens for Control of Insects and other Invertebrate Pests. Springer, AA Dordrecht. The Netherlands, pp. 751-765.
Wilson NRP (1981). Meat and Meat Products. Applied Science Publishers, London, pp. 81-108.
Wong BT, Day L, McNaughton D, Augustin MA (2009). The Effect of Maillard Conjugation of Deamidated Wheat Proteins with Low Molecular Weight Carbohydrates on the Secondary Structure of the Protein. Food Biophys. 4:1-12.