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Changes in the Physicochemical Properties, Microstructure and Sensory Characteristics of Shark Dendeng Using Different Drying Methods

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ABSTRACT

The aim of the study was to identify physico-chemical properties, SEM (Scanning Electron Microscopy) and sensory characteristics of dendeng made from shark flesh (*Chiloscyllium* sp.). Three drying methods were used in this study and they were sun drying, oven drying and oven vacuum drying. Before drying, the slices with dimension of 4 cm×12 cm×3 mm were soaked in a mixture of sugar (20%), salt (1%), tamarind (4%), coriander (1.5%), galangal root (2.5%), ginger (0.5%), garlic (1.0%) and onion (1.0%) for 12 h. The drying was carried out until the moisture content reached 23-25%. Proximate analysis showed there were no significant differences among these samples but had significant influence ($p < 0.05$) on the color. The lightness value for vacuum drying was 32.19 followed by oven drying (29.97) and sun drying (28.92). There were no significant differences in mineral values except for sodium (Na). SEM photograph shows that different drying methods affect the compactness of the tissue structure. Sensory evaluation result indicated that all samples were moderately acceptable but there were no significant difference among the samples. However, shark dendeng using oven drying was most preferred.

Key words: Fish drying, shark fish, dendeng, chemical composition, sensory evaluation

INTRODUCTION

Fish provides a good source of high quality protein and also contains many vitamins and minerals. It is an extremely perishable food. Quality losses can occur very rapidly after catch (Zakhia, 2002). Processing was carried out with the aim of either to supply distant markets or to produce a range of products with different flavors and textures. Of all food preservation methods, that of drying food had received the most widespread and enthusiastic publicity in recent years. Actually, drying is one of the oldest methods of food processing and preservation. Compared with other methods, drying is quite simple. Dried products have been considered as one of the safest food groups for humans because their manufacture involves hurdles to microbial survival or growth (Calicioglu *et al.*, 2002).

Sharks are a valuable resource. Sharks are commonly termed fish, even though they are only distantly related to the classical (bony) fish (Schubring, 2007). There are numerous species of fish caught annually throughout the world but they are not all necessarily commercially important

(Yapar *et al.*, 2006). However, from the economic and nutritional standpoints, it is essential to utilize the entire catch for human consumption.

The amount of catches in Malaysia is continuing to increase every year from 2500 ton in 1950 to 27948 ton in 2003 (Lack and Sant, 2006). Fishermen in Malaysia do not specifically target sharks for capture, but normally catch them as bycatch, with the more important targeted bony species. Once caught however, the sharks are not discarded, but are brought back whole to the port where the meat is sold for a low price and the fins sold at a much higher price due to their higher demand. The smaller species of sharks are generally used as sources of fresh, chilled, or frozen meat, while the larger sharks provide fins and hides. But, shark product preservation including drying is still limited (Ali *et al.*, 1999).

Fish dendeng is a type of preserved fish product traditionally made in Indonesia by adding sugar, salt and spices to thinly sliced fish flesh which were then dried. It can be dried using sun drying or using dryer (mechanic). This is a dried product like Biltong in South Africa, Beef Jerky in North America, Carne de sol in South America, Charqui in Brazil, Lup cheong, Isusou gan, Nyoursou gan, Sou song in China and Pemmican in North America (Leistner, 1987). Sun drying does not allow very much control over drying times and it also exposes the dendeng to attack by insects and allows contamination by sand and dirt. Such techniques are totally dependent upon the weather conditions (Fellows and Hampton, 1992). Another way of drying is by using dryer (mechanic). Oven drying is the simplest way to dry dendeng because it needs almost no special equipment. It is also faster than sun drying or using a food dryer. But oven drying can be used only on a small scale (Troftgruben and Keith, 1984).

Several studies have been carried out to examine the psychochemical properties of fish dendeng (Nasran, 1993; Arifudin, 1993; Peranginangin, 1993; Buckle *et al.*, 1988). The aim of this study was to evaluate the physicochemical, microstructure and sensory characteristics of shark dendeng using different drying methods.

MATERIALS AND METHODS

Preparation of shark flesh: This study was carried out over the period end of 2007 to middle 2009. Fresh shark was purchased from the local fish market at Bayan Baru, Pulau Pinang, Northern Part of Malaysia. The samples were transported to the Fish and Meat Processing Laboratory of Food Technology Programme, Universiti Sains Malaysia in ice box. Immediately on reaching the lab, the fishes were thoroughly washed and sliced (dimension of 4 cm width×12 cm length×3 mm of thickness) manually. Fish flesh was then washed until it was free from blood, placed in plastic box and kept in freezer at -18°C until used (2 days).

Ingredients for spice marinade: All spice ingredients such as red sugar (20%), salt (1%), tamarind (4%), coriander (1.5%), galangal root (2.5%), ginger (0.5%), garlic (1.0%) and onion (1.0%) were obtained from a local supermarket. The percentage calculated from weight of flesh. All ingredients were in fresh form except for coriander and salt which were in powdered form.

Preparation of dendeng: Processing of dendeng was carried out using the method of Nasran (1993) with slight modifications. Shark flesh was immersed in salt solution (5%) for 10 min and drained for about 15 min or until there was minimum water dripping from the flesh. The flesh was then soaked in spice marinade for 12 h at chilling temperature (4°C). The spice marinade was made by mixing all ingredients using blender with water added ratio of 1:1 (w/v) from weight of flesh.

The flesh was then pressed on both sides between wires to keep the surface smooth and then dried by hanging them inside dryers. Dendeng was dried using three different methods namely; sun drying, oven drying (AFOS MINI KILN, HULL, ENGLAND) at temperature 60°C and oven vacuum drying (Model 1450D, SHEL LAB, DENMARK) at temperature 60°C until the moisture content was about 23-25%. Dendeng was placed in sealed polyethylene bags and kept in chiller at 4°C before they were analyzed.

Proximate analysis: The proximate composition such as moisture content, protein, fat and ash were determined according to AOAC (1990) standard method. The moisture content was determined by drying the dendeng in a hot air oven at 100-105°C for 4 h or until a constant weight was obtained. Protein content was calculated by converting the nitrogen content (%N x 6.25) as determined by Kjeldahl's method (AOAC, 1990). Fat was determined using Soxhlet Extraction Method utilizing petroleum ether at 40-60°C. Ash content was determined by heating the samples in the furnace at 550°C until the white colour of samples, while carbohydrate content was determined by difference.

Mineral analysis: Mineral content were determined by atomic absorption spectrophotometer (Flame Perkin Elmer 3110) method. The minerals in the samples were brought into solution by wet digestion using 6 mL HNO₃ (65%) and 1 mL H₂O₂ (30%). The elements, Na, Ca, Mg, Zn, K, Fe, Cu, were measured by AAS (Flame Perkin Elmer 3110, US). Phosphorus (P) was determined by Vanado- Molybdate colorimetric method (Pearson *et al.*, 1981) using a spectrophotometer UV-160A (Shimadzu UV 160 A, Japan). The results were expressed as absorbance at 450 nm. Standard curves were used for the determination of the elements.

Colour measurement: The surface color of shark dendeng was measured using the Minolta Spectrophotometer (Model CM-3500d; Osaka, Japan). The equipment was calibrated using calibration box and white calibration tile. Samples were cut into 2×2 cm rectangle and placed in the colorimeter. The color reading includes lightness (L*), redness (a*) and yellowness (b*) using the spectramagic software version 2.11, 1998. L* defines lightness, a* denotes the red/green value and b* the yellow/blue value. The L* axis has the following boundaries: L* = 100 (white or total reflection) and L* = 0 (black or total absorption). Along the a* axis, a color measurement movement in the -a direction depicts a shift toward green; +a movement depicts a shift toward red. Along the b* axis, -b movement represent a shift towards blue; +b shows a shift towards yellow. Twenty five measurements were taken from each sample.

Scanning electron microscopy examination: Shark dendeng were cut into 1x1 cm rectangle and placed in Petri Dish, then cover with aluminum foil. Make the small hole in the cover to allow the air circulation. The samples were kept in freezer (-20°C) for 24 h then frozen samples were freeze dried (LABCONCO, US). Samples were then attached on the SEM stub using a double-sided cellophane tape. The surface of the samples was coated with + 30 nm thickness of gold (Sputter Coater POLARON SC515). The area was view and micrograph using Leo Supra 50 VP Field Emission SEM apparatus Model Carl-Ziess SMT, Oberkochen (Germany) at an accelerating voltage of 5.00 kV.

Sensory evaluation: Dendeng used for sensory analysis were fried using electric fryer (Model FFA 3001; ANVIL, South Africa) in cooking oil (Saji palm oil, Malaysia) at 160°C, cooled at room

temperature and then cut into 2×2 cm rectangle. Sensory evaluation was determined according to Abdullah (2000). Panels of 30 students of Food Technology Division, Universiti Sains Malaysia participated in the study. A 7-points hedonic scale method (7: Like very much and 1: Dislike very much) was used to evaluate the colour, odour, taste, bite-texture and overall acceptability.

Statistical analysis: All analyses were carried out in triplicate. Statistical analysis was carried out using Analysis of variance and significant differences among means was determined by the Duncan's Multiple Range test using SPSS version 11.05 was used to determine significant among means. A value of $p < 0.05$ was used to indicate significant difference.

RESULTS

Proximate composition: The proximate content of shark dendeng is shown in Table 1, there was no significant differences ($p < 0.05$) for proximate analysis between the samples. The different drying methods did not affect the proximate composition of shark dendeng.

Mineral content: Table 2 shows the composition of minerals, there was no significant difference ($p < 0.05$) noted in minerals except for sodium. The results showed the highest sodium recorded for sun drying followed by vacuum drying and oven drying. Other minerals did not show significant differences since they were present in only small amounts in the spices. The mineral (element) contents of the samples analyzed showed that shark dendeng are rich in sodium, calcium, magnesium, phosphorus, potassium (macro-nutrients) and had lower quantities of iron, zinc and copper (micro-nutrients).

Color properties: Instrumental color values are based on the reflectance of light at specific wavelengths from the shark dendeng surface. Most of the material changes occurring during fish processing are associated with color changes. Changes in the color of dendeng are shown in Table 3, there were significant differences ($p < 0.05$) in colour (L^* , a^* and b^*) of samples. It was observed that different drying methods affected the lightness, redness and yellowness. Statistical analysis showed that the maximum value for color (lightness, redness and yellowness) obtained in vacuum drying followed by oven drying while minimum value was observed in sun drying. The lightness sample recorded for vacuum drying was 32.19 followed with oven drying 29.97 and sun drying 28.92.

Table 1: Proximate composition of shark dendeng

Sample	Moisture	Protein*	Fat*	Ash*	Carbohydrate*
Sun drying	24.82±0.05 ^a	63.38±2.21 ^a	1.25±0.67 ^a	6.20±0.03 ^a	29.17±2.14 ^a
Oven drying	24.57±0.15 ^a	64.78±6.31 ^a	1.32±0.55 ^a	6.21±0.06 ^a	27.81±2.82 ^a
Vacuum drying	24.70±0.25 ^a	63.62±3.51 ^a	1.52±0.36 ^a	6.07±0.14 ^a	28.80±3.23 ^a

Means within a column with the same letter are not significantly different ($p < 0.05$); *Determinations were based on dry weight

Table 2: Mineral contents of shark dendeng (mg/100 g)

Methods	Na	Ca	Mg	Zn	P	K	Fe	Cu
Sun drying	2265.55±0.74 ^c	34.80±1.54 ^a	155.89±4.18 ^a	30.80±0.21 ^a	60.50±0.65 ^a	310.04±0.71 ^a	310.04±0.71 ^a	0.45±0.04 ^a
Oven drying	2257.72±0.41 ^a	34.87±0.58 ^a	157.39±0.71 ^a	31.25±0.70 ^a	60.56±0.12 ^a	311.31±0.66 ^a	4.01±0.86 ^a	4.01±0.86 ^a
Vacuum drying	2259.95±1.09 ^b	35.94±0.70 ^a	156.83±0.48 ^a	31.52±0.37 ^a	60.61±0.07 ^a	311.39±2.73 ^a	4.26±0.32 ^a	0.48±0.04 ^a

Means within a column with the same letter are not significantly different ($p < 0.05$).

Scanning electron microscopy examination: SEM was used to examine the effects of different drying methods on the structure of shark dendeng. The micrographs of the deep tissue are shown in Fig. 1a-d. The micrographs indicate shark dendeng using oven and vacuum drying more decrease in compactness of the tissue structure compare with dendeng using sun drying.

Sensory evaluation: The results of the sensory evaluation of samples are given in Table 4, there was no significant difference ($p < 0.05$) noted on the color, odor, taste, texture-bite and overall acceptability of shark dendeng. The panelist failed to detect any differences in the sensory attributes of shark dendeng. However dendeng using oven drying method gave a higher score among the samples.

Table 3: Color properties of shark dendeng

Methods	Lightness (L*)	Redness (a*)	Yellowness (b*)
Sun drying	28.92±0.23 ^a	3.06±0.08 ^a	8.14±0.08 ^a
Oven drying	29.97±0.13 ^b	5.23±0.08 ^b	11.42±0.15 ^b
Vacuum drying	32.19±0.11 ^c	5.43±0.13 ^c	12.74±0.13 ^c

Means within a column with the same letter are not significantly different ($p < 0.05$)

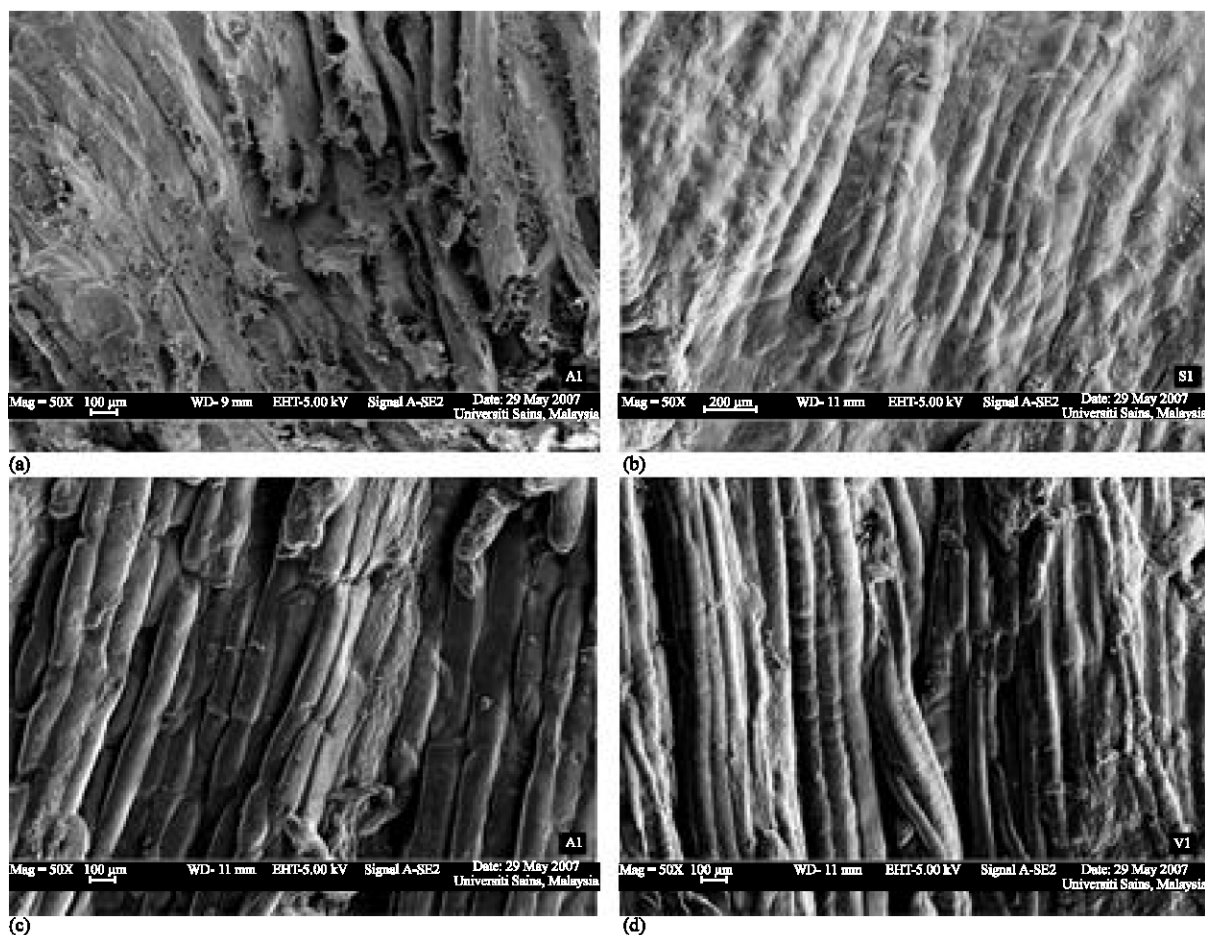


Fig. 1: SEM micrograph (50x) of the deep tissue of fresh shark, sun drying dendeng, oven drying dendeng, vacuum drying dendeng (a-d, respectively)

Table 4: Mean sensory scores of shark dendeng (n = 30)

Methods	Colour	Odour	Taste,	Texture-bite	Overall acceptance
Sun drying	5.33±0.76 ^a	5.30±1.32 ^a	5.03±1.38 ^a	5.23±0.94 ^a	5.13±1.17 ^a
Oven drying	5.07±0.87 ^a	5.80±0.71 ^a	5.17±0.46 ^a	5.33±0.55 ^a	5.57±0.50 ^a
Vacuum drying	5.03±1.33 ^a	5.23±0.87 ^a	5.20±0.85 ^a	5.23±0.77 ^a	5.33±0.99 ^a

Means values within the same column are not significantly different (p<0.05)

DISCUSSION

Proximate composition: Proximate composition of fresh shark flesh consists of 78.96% moisture, 19.39% protein, 0.66% fat, 0.56 ash and 0.43% carbohydrate. According to their chemical composition sharks can be seen as high in protein and low in fat. The low fat content makes it suitable to be processed. The dendeng in this study was higher in moisture and fat content than those reported by Nasran (1993). Nasran (1993) reported that the moisture and fat content of shark fish which were dried using sun drying were 23.8 and 0.87%, respectively. The variations of the fat content of shark dendeng are also affected by the production seasons. Buckle *et al.* (1988) reported that the proximate content of fish dendeng were 32.4-35.4% moisture, 3.0-3.8% fat, 33.4-36.9% protein, 3.0-3.8% ash. Moradi *et al.* (2009) reported the fat content of pre-fried breaded fillets was 8.80 and 8.84% at 57.70 and 57.33% moisture content for samples pre-fried in sunflower oil and palm olein, respectively. The lipid oxidation and protein denaturation resulted in a decrease in nutritive value. As the amount of lipid increased the amount of water falls in almost linear proportion (Aitken and Connell, 1979).

Mineral content: There was no significant difference (p<0.05) noted in minerals except for sodium. The samples were probably not homogeneous due to the uneven absorption of minerals and spices; the minerals and spices settled at the bottom of the container; therefore samples at the bottom might absorb more minerals and spices and since sodium was present in a relatively high amount, the location of the samples significantly affect the sodium content. Minerals have been reported to show significant variations among fish species (Lal, 1995). The Na content of shark dendeng ranging from 2257.72 to 2265.55 mg 100 g⁻¹. This value is higher than emu jerky reported by Pegg *et al.* (2006). According to Gokoglu *et al.* (2004), the Na content of cooked rainbow trout ranged from 335.54-607 mg kg⁻¹. Several studies have indicated that the concentration of trace minerals in fish is influenced by a number of factors such as seasonal and biological differences (species, size, dark/white muscle, age, sex and sexual maturity), food source and environment (water chemistry, salinity, temperature and contaminants) (Badsha and Sainsby, 1978; Farmer *et al.*, 1970; Lal, 1995).

Mineral components such as sodium, potassium, magnesium, calcium, iron, phosphorus and iodine are important for human nutrition (Erkan and Ozkan, 2007). The main functions of essential minerals include skeletal structure, maintenance of colloidal system and regulation of acid-base equilibrium. Minerals also constitute important components of hormones, enzymes and enzyme activator (Belitz *et al.*, 2001).

Color properties: The temperature of sun drying was around 27-29°C at the time of drying dendeng and this makes the color of dendeng lighter than oven drying (60°C) and vacuum drying (60°C). The color of cured meat products is extremely critical component mainly because of its influence on consumer preference (Moretti *et al.*, 2009). Oven dried foods usually are darker, more

brittle and less flavorful than foods dried by a dehydrator. The differences in the accumulated water loss and uptake of NaCl in both split fish and fillets could probably be explained by the unrestrained rigor contractions occurring during salting. Such contractions may have reduced the light transparency through highly overlapped actin and myosin filaments (Lauritzsen *et al.*, 2004). According to Konieczny *et al.* (2007), the range of L*, a* and b* value of beef jerky at various drying time is 30.66-33.44, 7.82-13.42 and 4.10-4.76 respectively. Brennan (2006) concluded that when the food pieces are rehydrated, their color and texture may be significantly inferior to those of the fresh material.

It is difficult to measure the color of heterogeneous products (Louka *et al.*, 2004). The color attributes of dendeng were influenced by brown sugars, tamarind, coriander and roots of galangal which were used in the formulation. Drying also was responsible for a severe deterioration in the quality of food and especially fish, particularly with respect to their color. Although the maillard reaction is an obvious candidate to explain the yellow-brown color after processing, the low amounts of reducing sugar particularly at the beginning of processing makes this hypothesis less convincing (Louka *et al.*, 2004). In some places (Hong Kong) the dark color and rancid odor of cured fish is a sign of quality (Bligh *et al.*, 1988). The maillard reaction, in combination with oxypolymerisation of unsaturated fish oils, was responsible for darkening, toughening and the unpalatable, bitter flavor associated with lengthy drying process and storage of dehydrated fish (Cutting, 1962).

Scanning electron microscopy examination: SEM photograph shows that different drying methods affect the compactness of the tissue structure. The fibers become more disrupted. Shark dendeng using sun drying had a compact, coherent structure with hardly any spaces between the fibers. Decreased protein solubility indicates some damage to the proteins in the dried product and this is further echoed in the dehydration behavior of the dried fish.

Sensory evaluation: Descriptive analysis is one of the most useful tests for sensory profiling and uses trained panels to detect and rate the intensities of sensory attributes in a product (Chambers and Wolf, 1996; Grosso *et al.*, 2008). The average score of sensory evaluation is more to the score of 5 which means that Shark dendeng is accepted by panelist. Bligh *et al.* (1988) concluded the major effect of lipid degradation is development of aesthetically unappealing odors and flavors while the effect of oxidative rancidity on nutritive quality of fish, especially in terms of protein availability, is debatable. Different methods of heating can undoubtedly give rise to differences in odors and flavors; in particular, commercial heat sterilization produces an overall character unlike that produced by other forms of heating. This sensory evaluation constituted subjective measuring characteristic of products (Abdullah, 2000).

CONCLUSION

Results indicate that the shark dendeng analyzed was high in protein and mineral content. The results also demonstrated that different drying methods affect color but not for proximate composition, mineral content and sensory analysis. Overall, it can be concluded that oven drying is the most suitable method for drying shark dendeng.

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