Malaysian Journal of Applied Sciences 2017, **Vol 2(1)**: 11-18

eISSN 0127-9246 (Online)

Malaysian Journal of Applied Sciences

ORIGINAL ARTICLE

Effects of Different Drying Methods and Hydrocolloids on Quality Properties of Semi-dried Catfish Jerky

Ishamri Ismail, Nur Husna Mohd Fauzi, Mastura Zahidi Baki, and Ho Lee Hoon

Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, Besut 22200, Terengganu, Malaysia

*Corresponding author: ishamriismail@unisza.edu.my

Received: 12/06/2016, Accepted: 12/08/2016

Abstract

This study was carried out to evaluate the effects of different drying methods (sun drying, cabinet drying and convection oven) and hydrocolloids (carrageenan and alginate) on physicochemical properties of semi-dried catfish jerky. The concentration of hydrocolloids used was 1% and 2%. Samples without the addition of hydrocolloid served as the control group. The water activity of semi-dried catfish jerky decreased with the addition of hydrocolloids. For colour properties, lightness (L*) value of semi-dried catfish jerky increased with the increased concentration of hydrocolloids. The addition of 2% alginate (2%A) and 2% carrageenan (2%C) showed higher lightness (L*) than the controlled group for all drying methods, except for sun drying with carrageenan. Both carrageenan and alginate added into semi-dried catfish jerky increased the processing yields. The addition of 2% carrageenan (2%C) and 1% alginate (1%A) improved the product yields for all drying methods. This paper argues that the application of cabinet dryer gives better shelf stability due to the lower range of water activity than other drying methods while preserving colour quality and product yields.

Keywords: Carrageenan; alginate; catfish; jerky; drying.

Introduction

Jerky has a shelf-stable property, needs no refrigeration during commercial distribution due to its low water activity. The growing consumer demand for convenient and nutritious food products has led to increasing sales of ready-to-eat snack food in many countries (Yang et al., 2009). According to Li et al. (2014), jerky is an important part of snack food with the characteristics of low moisture content, endurable storage, small size, and convenience for transportation. Jerky is a very convenient food product and suitable to be consumed by backpackers and others who do not have access to refrigeration (FSIS, 2013). Traditionally, jerky is made from beef and pork. However, the growing consumers demand for various types of food products in different texture and flavour, jerky is now made from poultry and fish meats (Konieczny et al., 2007).

Intermediate moisture (IM) meat products such as jerky can be preserved by salting and drying to reduce water activity. Drying is the world's oldest and most common method of food preservation in the production of meat and meat products (Lim et al., 2012). Drying lowers water activity by controlling the moisture content and relative humidity of meat thereby inhibiting the growth of microorganisms. Different microorganisms would grow since water activity varies depending on the products (Ku et al., 2013). After drying, the IM meat product reaches water activity of 0.6-0.9 equivalent to a relative humidity (RH) of 60-90% at ambient temperature (Chang et al., 1996). There is various type of drying methods in making jerkies, such as natural drying and hot air drying. Hot air drying that uses circulated heated air is effective to eliminate moisture quickly, then jerky acquire microbial safety and economy of time (Kim et al., 2014). In regards to colour and texture, time and temperature control is very crucial in jerky preparation. If meat is over-dried, whole muscle jerky products may be too dry or brittle, and may have the undesirable colour (Miller et al., 1996) and resulted in a lower yield.

In order to achieve a desirable texture and stability of jerky, various texture modifying ingredients, additives, antioxidants, and humectants are used. In this study, hydrocolloid of carrageenan (a mixture of iota and kappa carrageenan) and sodium alginate are used in the preparation of catfish jerky. Carrageenan is a linear anionic sulfated polymer of galactose and anhydrogalactose, which is extracted from red seaweeds; three main carrageenan fractions are kappa (thermoreversible brittle gel formation), iota (thermoreversible elastic gel formation) and lambda (thickener, non-gelling). They are widely used in the food industries such as canned meat, reduced fat products (frankfurters) for its gelling characteristic, thickening and water binding properties (Candogan and Kolsarici, 2003a, 2003b; Bixler and Porse, 2010).

Alginate is the salt of alginic acid and a gum-like derivate from seaweed Macrocystis pyrifera and it is applied as a gelling agent or thickener. In the presence of calcium ions, alginate forms a heat stable gel that “cold-sets” at refrigeration or room temperatures. In the poultry meat industry, it is used for binding small meat particles and also to enhance texture (Keeton, 2001; Barbut, 2002). Alginates can also be used for the production of meat replacers whereby a little amount of meat is combined with a high amount of water plus flavours and colorants to yield a gelled alginate matrix that can be subsequently used as a raw material for a variety of low-value meat products (Petracci and Bianchi, 2012). Finally, some applications of alginate preparations allow to produce stable cold fat emulsions (i.e. with chicken skin) to be used for including a stable form of fat/skin in product formulations such as chicken nuggets or sausages (Petracci and Bianchi, 2012). Therefore, the objective of this study was to investigate effects of various drying methods on the physicochemical quality of semi-dried catfish jerky and to determine whether hydrocolloids treatment can be effectively utilized during jerky processing..

Materials and Methods

Raw Materials and Curing Solution Preparation

Freshwater catfish (Clarias marcrocephalus, mincemeat moisture contents 75.15 ± 0.11%, protein contents 74.58 ± 0.12%, fat contents 29.36 ± 0.41%, ash contents 4.27 ± 0.01%, water activity 0.99 ± 0.00, and pH 6.95 ± 0.02) was purchased from a local market in Besut, Terengganu, Malaysia. Catfish was placed in an ice box and transported to the laboratory for further processing. Catfish was gutted and trimmed of visible fat and ground through a 2-mm grinder plate (Rheninghaus, Eve/All-12, Torino, Italy). The composition (%, w/w) of the curing solution was based on the method of Han et al. (2011) with some modification. The ingredients used as described in Table 1. Additionally, each hydrocolloid was added in the formulation with the following amount: (i) 1% carrageenan (labeled as 1%C); (ii) 2% carrageenan (labeled as 2%C); (iii) 1% alginate (labeled as 1%A); (iv) 2% alginate (labeled as 2%A); and without hydrocolloid added was used as a control. The carrageenan was prepared with 50% kappa and 50% iota fractions of food grade quality (Sim Company Sdn. Bhd., Penang, Malaysia) and was diluted in hot water (70°C) prior to add into the formulation.

While alginate powder (Sim Company Sdn. Bhd., Penang, Malaysia) was added directly into the formulation.

Table 1. Curing solution formula for semi-dried catfish jerky

Ingredients	Formulation (% in batch)
Water	22%
Soy sauce	5%
Sorbitol (70%)	5.8%
Lemon juice	1%
Smoke flavour	0.5%
Salt	0.6%
Sugar	1.8%
Black pepper powder	0.18%
Ginger powder	0.09%
Garlic powder	0.18%
Onion powder	0.18%
Soup stock powder	0.09%
Sodium tripolyphosphate	0.1%

Preparation of Jerky

The preparation of jerky was based on Han et al. (2011) with a slight modification. The ground catfish was mixed with the curing solution and hydrocolloid by a hand mixer for 4 minutes. Cured meat was stuffed into a moulder to form strip shape with 8 cm length and 2 mm thick. Each group of semi-dried catfish jerky samples was subjected to undergo three different drying methods. For sun drying, the sample was dried directly in the sun at a temperature of 32-33°C for 12-15 hours until a 0.70-0.75 water activity is achieved. For cabinet drying and convection oven, samples were dried continuously at a different time and temperature for 180 min at 55°C, for 180 min at 65°C, and for 60 min at 75°C.

Water Activity

The semi-dried catfish jerky samples were chopped into a small size and spread evenly into Retronic cup. Water activity of the sample was measured using dew point water activity meter (AQUA LAB, 4TE). The calibration was made using distilled water.

Colour

The colour of surface semi-dried catfish jerky was measured by the lightness (L*), redness (a*), and yellowness (b*) using Chromameter (Model CR-400, Konika Minota Co. Ltd., Japan), with measurements standardized with respect to a white calibration plate.

Processing Yield

Processing yields were determined by calculating the weight differences of jerky before and after drying (Han et al., 2011) as follows:

$$\text{Processing yields}\,(\%) = \frac{\text{jerky weight after drying}\,(g)}{\text{cured meat weight before drying}\,(g)} \times 100$$

Statistical Analysis

The analyses were run in triplicate. The results were expressed as mean value ± standard deviation. The sample physicochemical characteristics were compared using one-way Analysis of Variance (ANOVA) and a Duncan test for multiple mean comparisons. The interaction between drying methods, hydrocolloids and concentration were carried by two-way MANOVA. Data were processed using SPSS version 17.0. The level of significance was 95%, i.e., $p<0.05$.

Results and Discussion

The results of water activity, colour, and processing yields are presented in Table 2. Generally, the water activity of semi-dried food should be ranged 0.60-0.90 so that are considered to be relatively safe food against microorganisms (Ku et al., 2013). In this study, the water activity of semi-dried catfish jerky samples was ranged from 0.62-0.71, 0.58-0.64, and 0.58-0.70 according to the drying methods of sun drying, cabinet drying and convection oven, respectively. The cabinet drying method showed the lower value in water activity than other drying methods and the water activity of catfish jerky decreased by 1% and 2% of hydrocolloids added ($p<0.05$), except for sun drying 1%C and 2%C. This is similar to the result by Ku et al. (2013) who observed that water activity of restructured jerky decreased as additives added into the formulations. According to FSIS (2014) in order to achieve a shelf-stable product, a water activity critical limit should be 0.85 or lower for products stored in an aerobic or oxygen containing environment. For products stored in an anaerobic environment or vacuum packaged the water activity critical limit can be 0.91 or lower. The water activity obtained in the present study was under the recommended values.

Colour is a major factor in consumer purchase decisions because it is presumed to be an indicator of meat quality (Brewer et al., 2002). Colour values of semi-dried catfish jerky with hydrocolloids added show brighter colour than the control (Table 2). The increased value of lightness (L*) in this study was similar to the finding by Lamkey (2010) and Demirci et al. (2014) in which the product incorporating with hydrocolloids give brighter colour. In this study, the highest lightness was shown by sample added with 2% alginate (2%A). The lightness of semi-dried catfish jerky samples was differed significantly ($p<0.05$) between drying methods. The findings obtained by Lim et al. (2012) showed that hot air-dried beef jerky have a lower lightness than sun-dried, 33.01 and 37.24, respectively. Raw material, temperature and time, and ingredients used (addition of nitrite) all these could influence the variation in colour properties. Redness (a*) values of semi-dried catfish jerky seemed to be improved with carrageenan added for both cabinet drying and a convection oven. For yellowness (b*), the b* values tended to be increased after addition of hydrocolloids. Numerous studies have reported that the colour of restructured jerky is typically dependent on light, oxygen, temperature, and process and packaging conditions and the colour based upon drying duration is influenced by the moisture content of the products (Acton and Dick, 1977; Chasco et al., 1996; García-Esteban et al., 2004; Mancini and Hunt, 2005; Rubio et al., 2008; Cava et al., 2009).

The process yields of semi-dried catfish jerky samples ranged between 31.12–34.70% (sun drying), 32.01–34.95% (cabinet drying), and 30.76–39.22% (convection oven). The catfish jerky containing hydrocolloids had higher yields than the control for all drying methods ($p<0.05$), except for cabinet drying 2%A treatment. Han et al. (2011) reported similar results with the processing yields of semi-dried chicken jerky containing humectants. The addition of additives for example, chicken feet gelatin and wheat fiber (Kim et al., 2012) and glutinous rice flour, potato starch, soybean and acorn powder (Ku et al., 2013) to meat products increased the processing yields. These additives were improved water holding capacity and fat binding properties. According to Demirci et al. (2014) the cooking loss of the high-fat control (no hydrocolloid added) was higher than the hydrocolloid added meatball samples, due to the high loss of fat and moisture during cooking. Nevertheless, the processing yield of

Table 2. Comparison on water activity, colour, and processing yield of semi-dried catfish jerky prepared using different drying method and hydrocolloids

Drying Method	Treatment	Water activity	Colour			Processing yield (%)
			L*	a*	b*	
Sun drying	Control	0.69 ± 0.00^{bB}	28.36 ± 0.61^{aB}	3.23 ± 0.10^{dB}	8.30 ± 0.97^{aA}	31.12 ± 1.26^{aA}
	1%C	0.70 ± 0.01^{bB}	27.56 ± 0.18^{aA}	3.16 ± 0.05^{cdB}	8.06 ± 0.28^{aA}	33.48 ± 0.62^{bcAB}
	2%C	0.71 ± 0.01^{bC}	28.12 ± 0.58^{aA}	2.81 ± 0.05^{bcA}	7.99 ± 0.40^{aA}	34.70 ± 0.07^{dA}
	1%A	0.63 ± 0.01^{aC}	34.18 ± 0.60^{bA}	2.45 ± 0.38^{abA}	10.66 ± 0.51^{bA}	33.16 ± 0.08^{abA}
	2%A	0.62 ± 0.01^{aB}	37.82 ± 1.00^{cB}	2.18 ± 0.21^{aB}	12.13 ± 0.83^{cA}	34.46 ± 0.10^{cdB}
Cabinet drying	Control	0.64 ± 0.00^{cA}	27.08 ± 0.48^{aA}	3.66 ± 0.25^{bB}	7.89 ± 0.10^{aA}	32.48 ± 0.50^{aA}
	1%C	0.59 ± 0.01^{aA}	36.32 ± 0.55^{cC}	5.68 ± 0.62^{cC}	13.31 ± 0.30^{cC}	34.51 ± 0.76^{bcB}
	2%C	0.62 ± 0.00^{bA}	37.75 ± 0.13^{dC}	3.73 ± 0.21^{bB}	13.60 ± 0.25^{cC}	34.95 ± 0.16^{cB}
	1%A	0.60 ± 0.01^{aB}	33.28 ± 0.47^{bA}	3.31 ± 0.29^{abB}	10.11 ± 0.66^{bA}	33.73 ± 0.53^{bA}
	2%A	0.58 ± 0.02^{aA}	39.80 ± 0.37^{dC}	2.71 ± 0.14^{aC}	13.60 ± 0.56^{cB}	32.01 ± 0.71^{aA}
Convection oven	Control	0.70 ± 0.01^{eC}	26.13 ± 0.76^{aA}	2.22 ± 0.49^{bA}	7.75 ± 0.61^{aA}	30.76 ± 1.13^{aA}
	1%C	0.59 ± 0.00^{bA}	33.55 ± 0.53^{bB}	2.44 ± 0.20^{bA}	11.18 ± 0.65^{cB}	33.05 ± 0.05^{abA}
	2%C	0.66 ± 0.00^{dB}	34.48 ± 0.33^{cB}	2.59 ± 0.44^{bA}	11.28 ± 0.14^{cB}	35.87 ± 0.05^{bcC}
	1%A	0.58 ± 0.01^{aA}	33.33 ± 0.30^{bA}	2.17 ± 0.24^{abA}	9.62 ± 0.78^{bA}	39.22 ± 4.34^{cB}
	2%A	0.63 ± 0.00^{cB}	33.52 ± 0.37^{bA}	1.63 ± 0.31^{aA}	9.92 ± 0.35^{bA}	32.78 ± 0.07^{abA}

All values are mean±SD.
$^{a-e}$ Means in the same column with different letters are significantly different ($p<0.05$).
$^{A-C}$ Means with different superscript within drying method differ significantly ($p<0.05$).

the samples increased with the hydrocolloids added. Overall, the highest and the lowest processing yield of the semi-dried catfish jerky in the present study was obtained from the convection oven which using the formulation of 1% alginate (1%A) and without hydocolloid-added (control), respectively.

Overall, based on the result presented in Table 3, there was a statistically significant interaction effect between drying methods, hydrocolloid (alginate and carrageenan) and concentration (0,1% and 2%) on the combined dependent variables, $F (6, 56) = 5.226$, $p = 0.000$; Wilks' $\lambda = 0.411$.

Table 3. Two-way MANOVA for the semi-dried catfish jerky prepared using different drying method and hydrocolloids

Effect	Wilks' λ-value	F	Hypothesis df	Error df	P-value
Drying	0.023	51.674	6.000	56.000	0.000
Hydrocolloid	0.081	105.206	3.000	28.000	0.000
Concentration	0.169	45.991	3.000	28.000	0.000
drying * hydrocolloid	0.059	28.993	6.000	56.000	0.000
drying * concentration	0.105	19.419	6.000	56.000	0.000
hydrocolloid * concentration	0.250	28.060	3.000	28.000	0.000
drying * hydrocolloid * concentration	0.411	5.226	6.000	56.000	0.000

df: Degree of freedom

Conclusion

As a conclusion, the use of hydrocolloids enhanced the quality properties of semi-dried catfish jerky. The results of this study showed that both carrageenan and alginate could reduce water activity of semi-dried catfish jerky, improve lightness and processing yields. Application of cabinet dryer gives better shelf stability due to the lower range of water activity than other drying methods without compromising colour quality and product yields..

Acknowledgments

The authors would like to acknowledge with gratitude the support given by Universiti Sultan Zainal Abidin (UniSZA) for our research in this area and the aid of a research grant from Dana Penyelidikan Universiti (DPU) UniSZA/2015/DPU/25.

References

Acton, J. C., & Dick, R. L. (1977). Cured color development during fermented sausage processing. *Journal of Food Science, 42*(4), 895-897.

Barbut, S. (2002). Poultry products processing. An industry guide: Poultry products-formulations and gelation. (pp. 467-511): CRC Press, New York.

Bixler, H. J., & Porse, H. (2010). A decade of change in the seaweed hydrocolloids industry. *Journal of Applied Phycology, 23*(3), 321-335.

Brewer, M. S., Jensen, J., Sosnicki, A. A., Fields, B., Wilson, E., & McKeith, F. K. (2002). The effect of pig genetics on palatability, color and physical characteristics of fresh pork loin chops. *Meat Science, 61*(3), 249-256.

Candogan, K., & Kolsarici, N. (2003a). The effects of carrageenan and pectin on some quality characteristics of low-fat beef frankfurters. *Meat Science, 64*(2), 199-206.

Candogan, K., & Kolsarici, N. (2003b). Storage stability of low-fat beef frankfurters formulated with carrageenan or carrageenan with pectin. *Meat Science, 64*(2), 207-214.

Cava, R., Ladero, L., González, S., Carrasco, A., & Ramírez, M. R. (2009). Effect of pressure and holding time on colour, protein and lipid oxidation of sliced dry-cured Iberian ham and loin during refrigerated storage. *Innovative Food Science & Emerging Technologies, 10*(1), 76-81.

Chang, S. F., Huang, T. C., & Pearson, A. M. (1996). Control of the dehydration process in production of intermediate-moisture meat products: A review. In L. T. Steve (Ed.). *Advances in Food and Nutrition Research* (Vol. 39, pp. 71-161): Academic Press.

Chasco, J., Lizaso, G., & Beriain, M. J. (1996). Cured colour development during sausage processing. *Meat Science, 44*(3), 203-211.

Demirci, Z. O., Yılmaz, I., & Demirci, A. Ş. (2014). Effects of xanthan, guar, carrageenan and locust bean gum addition on physical, chemical and sensory properties of meatballs. *Journal of Food Science and Technology, 51*(5), 936-942.

FSIS. (2013). Jerky and food safety. Retrieved 20 July 2015 http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/meat-preparation/jerky-and-food-safety/ct_index

FSIS. (2014). FSIS compliance guideline for meat and poultry jerky produced by small and very small establishments. Retrieved 20 August 2015 http://www.fsis.usda.gov/wps/wcm/connect/5fd4a01d-a381-4134-8b91-99617e56a90a/Compliance-Guideline-Jerky-2014.pdf?MOD=AJPERES

García-Esteban, M., Ansorena, D., & Astiasarán, I. (2004). Comparison of modified atmosphere packaging and vacuum packaging for long period storage of dry-cured ham: effects on colour, texture and microbiological quality. *Meat Science, 67*(1), 57-63.

Han, D. J., Choi, J. H., Choi, Y. S., Kim, H. Y., Kim, S. Y., Kim, H. W., Chung, H. K., & Kim, C. J. (2011). Effects of konjac, isolated soy protein, and egg albumin on quality properties of semi-dried chicken jerky. *Korean Journal Food Science Animal Resources, 31*, 183-190.

Keeton, J. T. (2001). Formed and emulsion products. In A. R. Sams (Ed.). *Poultry meat processing* (pp. 195-226): CRC Press, Boca Ranton, Florida, USA.

Kim, H. Y., Kim, K. J., Lee, J. W., Kim, G. W., & Kim, C. J. (2012). Effects of chicken feet gelatin and wheat fiber levels on quality properties of semi-dried chicken jerky. *Korean Journal Food Science Animal, 32*, 732-739.

Konieczny, P., Stangierski, J., & Kijowski, J. (2007). Physical and chemical characteristics and acceptability of home style beef jerky. *Meat Science, 76*(2), 253-257.

Ku, S. K., Park, J. D., Lee, N. H., Kim, H. J., & Kim, Y. B. (2013). Physicochemical and sensory properties of restructured jerky with four additives. *Korean Journal Food Science Animal, 33*, 572-580.

Lamkey, J. W. (2010). Hydrocolloids in Food Processing. Hydrocolloids in Muscle Foods (pp. 35-49): Wiley-Blackwell.

Li, M., Wang, H., Zhao, G., Qiao, M., Li, M., Sun, L., Gao, X., & Zhang, J. (2014). Determining the drying degree and quality of chicken jerky by LF-NMR. *Journal of Food Engineering, 139*, 43-49.

Lim, D.-G., Lee, S.-S., Seo, K.-S., & Nam, K. C. (2012). Effects of different drying methods on quality traits of hanwoo beef jerky from low-valued cuts during storage. *Korean Journal Food Science Animal, 32*(5), 531-539.

Mancini, R. A., & Hunt, M. C. (2005). Current research in meat color. *Meat Science, 71*(1), 100-121.

Miller, M. F., Davis, G. W., Ramsey, C. B., & Irizarry, H. (1996). Aw theory and application to food. In L. B. Rockland & L. R. Beuchat (Eds.). (pp. 295-328): Marcel Dekker, New York, USA.

Petracci, M., & Bianchi, M. (2012). *Functional ingredients for poultry meat products.* Paper presented at the XXIV World's Poultry Congress, Savador, Bahia, Brazil, 5 - 9 August.

Rubio, B., Martínez, B., García-Cachán, M. D., Rovira, J., & Jaime, I. (2008). Effect of the packaging method and the storage time on lipid oxidation and colour stability on dry fermented sausage salchichón manufactured with raw material with a high level of mono and polyunsaturated fatty acids. *Meat Science, 80*(4), 1182-1187.

Yang, H.-S., Hwang, Y.-H., Joo, S.-T., & Park, G.-B. (2009). The physicochemical and microbiological characteristics of pork jerky in comparison to beef jerky. *Meat Science, 82*(3), 289-294.

How to cite this paper:
Ismail, I., Fauzi, N.H.M., Baki, M.Z. & Hoon, H.L. (2017). Effects of different drying methods and hydrocolloids on quality properties of semi-dried catfish jerky. *Malaysian Journal of Applied Sciences, 2*(1), 11-18.