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The use of a very small business-scale oven to enhance quality of “ready–to-eat” Beef Jerky

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Abstract. The aim of this study was to enhance the quality of traditional ready-to-eat beef jerky using a very small business scale (VSB) oven “Rob-Han” 12 racks. The experiment was designed in a Completely Randomized Design consisted of 6 roasting treatments using a laboratory oven (15 min.) and using a Rob Han oven at 5 various times (0, 5, 10, 15, and 20 min.). The results showed that the use of the oven (Rob-Han) significantly affected the chemical qualities of beef jerky i.e. relative humidity, water activity, water content, and protein content. However, the treatments did not significantly affect the ash content of beef jerky. All of the heating time treatments in the oven (Rob-Han) were able to reduce total microbes 2 log cycles (into less than $1{,}0\text{x}10^3$ CFU/gram). Furthermore, coliform and fungi were undetected on agar media of all treatments, therefore they were safe for consumption. Based on the qualities and shelf-life parameters, the best treatment was the roasting for 20 minutes at 135 ^{o}C using the oven (Rob-Han) 12 rack, which resulted in beef jerky with a quality similar to that produced by roasting in the laboratory scale oven Memmert.

Keywords: laboratory-scale oven, small to medium-scale industrial oven, ready to eat beef jerky.

1. Introduction

Beef jerky (Jerky Ind.) is one of the preserved meat products, principally made from beef which is processed in a simple way using traditional equipment, but still highly acceptable among Indonesian society. Jerky is commonly processed from beef, meat is sliced into thin pieces marinated in a mix of spices which then dried up to 30 - 40% moisture [1]. Moreover, the United States Department of Agriculture (USDA) in the year 2004 has classified Jerky which is processed from beef meat by using heat into “ready to eat” meat products [2]. As highly nutritious products [3], low calorie and long shelf life, therefore Jerky is mentioned as one of the popular “ready to eat” food products in the USA which is mainly processed by many small scale industries [4] [5]

Like other foods, beef jerky which is manufactured traditionally by small industries using simple techniques with minimal household equipment offers some advantages such as easy technology, the low operational cost which then produce inexpensive foodstuffs. Unfortunately, that kind of traditional process is usually done by workers with limited knowledge of hygiene and sanitation. As mentioned by [6] that traditionally processed jerky including its drying technique is not enough to eliminate pathogenic microbial contamination.

On the other hand, [7] defined that control of microbial load in food products is very important in all meat-based processing industries [7]. [2] stated that oven drying (roasting) is one of the methods used for ensuring the safety of jerky for human consumption. Drying in an oven at a temperature of 163ºC for 10 minutes has been known to reduce the population of *Escherichia coli* and *Listeria monocytogenes* down to a very low level ($4{,}0 \text{ x } 10^2$ CFU/gram). [8] proved that the use of a laboratory-scale oven for roasting jerky offers wide possibilities of temperature adjustments ensuring microbial pathogen elimination. However, the laboratory-scale oven is not applicable for VSB industries because of the high price. On the other hand, it has been found that the use of a home-scale oven “Hock” did not give good products because of difficulties in controlling temperature and also it has low capacity. In addition, the technology transfer of the drying of jerky using a VSB-scale oven HOCK has resulted in products with short shelf life [8]

For those reasons, it is necessary to evaluate other types of the oven which can be used for processing jerky at a VSB-scale production. This research was conducted to assess the effectiveness of the VSB-scale oven Rob-Han 12 rack for processing "ready to eat" jerky. The microbial qualities of the jerky also were assessed as one of the considerations used for scaling up the process.

2. Materials and methods

2.1. Materials.

Materials used consisted of (1) the lean meat of Balinese Cattle from a Butcher House in Banyumulek West Lombok, West Nusa Tenggara, (2) media for microbial assessments (Plate Count Agar (PCA) for total microbial, Potatoes Dextrose Agar (PDA) for fungi, and Violet Red Bile Agar for coliform) purchased from Merck KGaA, Germany and coconut shell Liquid Smoke "Pro Awet" Grade 1 (purchased from Biochemistry laboratory of Faculty of Food Technology and Agroindustry-University of Mataram).

2.2. Methods.

Jerky was processed as the previous method of [8]. Meat is trimmed to remove fat, sliced into pieces of 10 cm x 5 cm then were frozen for 6 ± 0.08 hr to make it easy at the slicing step. Frozen meat pieces were thawed for 30 ± 5 minutes under running water while sliced using a meat slicer (Slicer/Shirman, Italy) at a thickness of 0.4 cm. The meat pieces were weighed 500 gr, mixed with a mix of traditional spicy then were soaked in a solution containing 2.5% (w/w) of liquid smoke for 3 hours at a room temperature before sun drying. After drying under sunlight for ±7 hr, raw dried jerky was then put in the oven set at 135°C for 15 min. Two kinds of ovens used were lab-scale oven (Memmert oven UNB 400, Germany) dan VSB-scale oven (Rob-Han) 12-rack at various roasting temperatures 0, 5, 10, 15, and 20 minutes [8].

The experiment was designed in a Completely Randomized Design (CRD) for chemical and microbiological analysis with three replicates of each treatment. Parameter measured including chemical qualities such as water content (Thermogravimetry), ash content (Thermogravimetry), and protein content (Kjeldahl method) [9], the relative humidity of the oven chamber (Digital Thermohygrometer), and water activity (Aw meter). Microbiological quality was estimated by bacterial enumeration according to the previous techniques [10], the pour plate method for determining total microbes and coliform, and the spread plate method for counting fungi. Natural liquid smoke used was prepared by the pyrolyzing process of coconut shells [11]. Data were analyzed using ANOVA (*analysis of variance*) at a 5% significant level. The values showed significant differences were further analyzed using Honest Significant Difference for chemical and microbial data [12].

3. Results and Discussions

Traditionally processed beef jerky was processed in an oven Rob-Han type 12 racks which have been used by VSB industries in Mataram West Nusa Tenggara for processing seaweed candy.

3.1. Chemical Quality

Like other drying equipment, the ability of a dehydrator oven is mainly affected by its ability to reduce the humidity level inside the chamber. Chemical analysis was conducted to measure Relative Humidity (RH) inside the oven Rob-Han during the process. The RH values, Aw, water content, protein content, ash content as shown in Table 1. Table 1 shows that the roasting treatments affected the relative humidity level inside the oven, water activity, water content, and protein content of the jerky. Principally, the water content of food is influenced by environmental humidity and affects the texture also the flavor of food. [2] stressed that humidity plays an important role in the drying process. The lower the humidity level inside an oven the faster the drying process. Table 1. Shows increased length of drying time-correlated inversely to relative humidity. Without heating, the humidity level reached 71% which is significantly higher than other treatments (10, 15 dan 20 min roasting time). Unfortunately, the relative humidity in the oven did not determine because it is not possible to put the RH meter inside.

Table 1. The relative humidity, water activity, water content, and of "ready to eat" beef jerky at a various roasting time.

Roasting time (minute)	Relative Humidity (RH) %	Aw	Water content (%)	Protein content (%)	Ash content (%)
15 (Memmert)	ND	0,77 [b]	22,92 [ab]	21,23 [b]	4,24[a]
0 (Rob-Han)	71[a]	0,887 [a]	32,147 [a]	24,33 [a]	3,85[a]
5 (Rob-Han)	58 [b]	0,863 [a]	29,59 [ab]	21,29 [b]	3,47[a]
10 (Rob-Han)	58 [b]	0,837 [ab]	24,65 [ab]	22,03 [b]	3,81[a]
15 (Rob-Han)	50 [c]	0,830 [ab]	25,93 [ab]	26,41 [a]	3,75[a]
20 (Rob-Han)	46 [d]	0,807 [ab]	21,69 [b]	24,85[a]	4,02[a]

[a] Mean value followed by the same letters in the same column is not significantly different at $P \geq 0.05$.

Table 1 shows that the humidity level of the oven correlated positively to the Aw value of jerky. The lower RH leads to the higher velocity of water vapor lost which leads to the lower Aw of jerky. However [13], suggested that during roasting in the oven is necessary to maintain the Aw value at 0.9 to ensure the elimination of the microbial pathogen. Results show that the higher the roasting temperature the lower the Aw value of the jerky although it was not statistically different. As stated that Aw plays an important role in determining the shelf life of food products as Aw supports the microorganism growth [14]. The results revealed that untreated jerky showed the highest Aw compare to the oven-roasted ones. On the other hand, it was found that the lower the Aw values the higher panelist acceptance. Refer to [1] that jerky with an Aw value less than 0.68 which will be accepted by the consumer and increased shelf life. However, roasting in the VSB- scale Rob-Han oven has not been able to reduce Aw of the jerky down to 0.70. Anyway, heating (roasting) time for 20 min at 135ºC produced jerky with longer shelf life compared to those roasted for less than 20 min at the same temperature.

The reduction of Aw values of jerky in line with the reduction of its water content. On the other hand, the reduction of Aw of food contributes to a degree of consumer freshness which leads to consumer acceptability and also shelf life [15]. According to the Indonesian National Standard Board [26] SNI 01-2908-1992, the water content of beef jerky maximal is 12%. However, the previous standard [16] SNI 01-2906-1990, stated that the water content of air jerky in between 15-25%. Water content is one of the factors that determine the shelf life of food, as water is good growth media for spoilage microorganisms. Principally, jerky has lower water content than other food products [15]. Therefore it has a relatively long shelf life. Generally drying either using an oven or sun-dried had produced jerky with water content about 21.69 - 32.147% (Table. 1). These values are still meet the standard of SNI 01-2906-1990 [16] and the Nutrition Board [25], i.e. 15 - 25%. During the drying process of traditional jerky, either in an oven or under sunlight, has successfully reduced the water content of jerky due to the transfer of heat from the oven into inside meat pieces. As stated by [17], that the longer the drying process the lower the water content of the material. The highest water content (26.41%) found in jerky dried for 15 min., although was not significantly different to those sample treated at 20 min.

Besides, protein content is also one of the important factors determining the quality of beef jerky. Results show that the protein content of traditional jerky was relatively stable. The protein content of beef jerky roasted in the Rob-Han oven for 15 minutes was 26.41%, which did not significantly different than treated for 20 minutes. Results revealed that the time of roasting had significantly affected the protein content of jerky. Generally, the lower the water in materials the higher content of soluble components. Results revealed that jerky produced by drying in the oven Rob-Han either for 15 or 20 min have produced jerky classified as grade II (minimal protein content of 25%, SNI 01-2908-1992). Table 1 also presents that the roasting treatments did not affect significantly the ash content of the samples. However, this fact might due to the natural properties of beef meat which is low in ash content resulted in undetectable changes.

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3.2. Microbial quality

High nutrition and water content of meat cause microorganisms to easily grow during [1]. The heating process might reduce the water content of food materials to a very low level which limits the growth of microbial spoilage. Table 2 shows that all heating treatments in the VSB-scale Rob-Han oven resulted from the microbial content of beef jerky were less than 1.0×10^3 CFU/gram, which is relatively similar to those processed in the Lab-scale oven Memmert for 15 minutes.

Table 2. The microbial load of ready to eat beef jerky at a various roasting time.

Time (min., oven)	Total Plate Count (CFU/gram)	Coliform (CFU/gram)	Fungi (CFU/gram)
15 (Memmert)	$<1.0 \times 10^3$	$<1.0 \times 10^1$	$<1.0 \times 10^2$
0	6.2×10^5	$<1.0 \times 10^1$	$<1.0 \times 10^2$
5 (Rob-Han)	$<1.0 \times 10^3$	$<1.0 \times 10^1$	$<1.0 \times 10^2$
10 (Rob-Han)	$<1.0 \times 10^3$	$<1.0 \times 10^1$	$<1.0 \times 10^2$
15 (Rob-Han)	$<1.0 \times 10^3$	$<1.0 \times 10^1$	$<1.0 \times 10^2$
20 (Rob-Han)	$<1.0 \times 10^3$	$<1.0 \times 10^1$	<1,. x 10^2

Values are the mean of three replicates.

Table 2 shows that all oven treated jerky bear a low level of coliform count less than $1.0\text{x}10^1$ CFU/gram and fungi load less than 1.0×10^2 CFU/gram. However, total microbes of untreated samples (0 min. roasting) show the highest microbial load i.e. 6.2×10^5 CFU/gram This proved that drying under sunlight without followed by roasting in an oven resulted in beef jerky with the microbial load still exceed the maximum limit stated by the Indonesian National Standard (SNI: 1.0×10^5 CFU/gram). Besides, the relative humidity of the oven chamber 71% and initial water content of about 0.887 of the samples might have caused a high microbial load. On the other hand, roasting using VCB scale oven reduced the microbial load of jerky as much as 2 log cycle. Although there were no significant differences showed among the time treatments but [1] had noted that increasing length of the roasting process caused in reducing Aw value which is in line with the declining of total microbial load. These undetectable differences might be caused by the small differences in the time applied in the experiments.

This high microbial load of unroasted jerky indicated that drying under sunlight only is not enough to eliminate microorganism contaminant of beef jerky. Conversely, the heating process using the oven either the Lab-scale or the Rob-Han could reduce microbial growth. This fact in line with that recommended by [18], stated that heating process in an oven is required to produce beef jerky free from microbial contamination as supported by [19] that fungi are mesophilic microorganisms which are sensitive to high temperatures.

In this research, all oven treated jerky Tests using a total plate count method showed no growth of coliform or mold. Rob-Han oven treatment showed a non-significant effect on the decrease in total coliform and total mold in ready-to-eat beef jerky due to coliform and mold growth on all treatments are equal / not detected. There were no coliform bacteria or mold found in the ready-to-eat beef jerky both in the pre-oven and after-oven treatments. This low microbial load of oven-heat treated jerky could be contributed by the hygienic and good sanitation process during research with might also a contribution of the liquid smoke added in the marinating solution [20] [21] [22] due to the presence of antimicrobial substances of the groups of phenols, carbonyls, and acids [11] [23]. Therefore, the combination of liquid smoke and spicy such as salt, sugar, and onion play an important role as a preservative which inhibits the growth of bacteria and fungi.

Jerky manufactured by small industries showed the same microbiological quality as that processed by [8] using an oven Memmert (Jerman) at the temperature of 135ºC for15 min The ready to eat jerky at all heat oven treatments have met the microbial quality standard stated in the Indonesian National standard SNI 01-2908-1992, with undetected growth of fungi. Based on the length of storage, jerky processed in the Rob-Han oven for 20 min showed the longest shelf life (34 days) at room temperature, although the heating at less than 20m min resulted in shorter shelf life (6 to 10 days). Therefore, refer to shelf life it is recommended to heat-oven jerky for at least 20 min. Besides that, all the spicy added jerky have been roasted to reduce initial microbial load combined with the high temperature of the oven which might able to inhibit fungi growth. Principally, the efficiency of the drying process is affected by several factors such as temperature, size of materials, and movement of hot air [24].

4. Conclusion

The use of the oven (Rob-Han) significantly affected the chemical qualities of beef jerky i.e. relative humidity, water activity, water content, and protein content. However, the treatments did not significantly affect the ash content of beef jerky. All of the heating time treatments in the oven were able to reduce total microbes 2 log cycles (into less than 1,0x10^3 CFU/gram). The process of roasting in the Ron-Han oven for 20 min is recommended for producing jerky with the same quality as that processed using the laboratory-scale oven Memmert which meet the criteria listed in the SNI 01-2906-1990 and Directorate of Nutrition and Health, Directorate Indonesian Health dan Directorate of Nutrition, Indonesian Department of Health.

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