Quality Standards and Inexpensive Drying Technology for Semi-Dried Jerky in Gialai Province: A Short Review

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Abstract:
The aims of this study were to: (1) review the quality standards for semi-dried jerky and (2) discuss common inexpensive drying methods as a preservation technique on nutrient contents of beef. A quality standard is a composite evaluation of factors that affect palatability of meat. These factors were materials, physicochemical evaluation, contaminated substances, bacteria, and parasites. Furthermore, the reviewed beef drying methods included natural drying, artificial drying and mixed mode solar drying. Results showed that solar greenhouse drying system is the optimal technique that could apply for semi-dried jerky in Gia Lai province. This study presents a brief overview of literature and legal resources related to food quality and inexpensive drying methods that would be suitable for semi-dried jerky in Gialai province.

Keywords: Drying technology, quality standards, semi-dried jerky, solar greenhouse drying

1. Introduction
Jerky is one of the typical intermediate-moisture foods that has been cut into strips and dried (dehydrated) to prevent spoilage [1]. Before dehydrating process, salt is usually added to prevent bacteria growth. Modern manufactured jerky is often marinated, prepared with a seasoned spice rub or liquid, or smoked with low heat (usually under 70°C). Store-bought jerky commonly includes sweeteners such as brown sugar [2].

The drying process is the oldest and widely used preservation methods of foods due to highly efficient and inexpensive. The shelf-life of meat and meat products were extended because of the reduction in water activity [3, 4]. The microbial load was reduced after the drying process and volumes and weights of the products were also lighter, which decrease storage and transportation costs [5].

Semi-dried jerky is a famous product in Gialai province because its properties from beef meat, specialty, featured spice... However, a major problem associate with this product is that we have no appropriate techniques of meat preservation that are suitable for Gialai. The meat is smoked and dried mainly by the village human who are mostly illiterate and have no scientific knowledge about its quality [6, 7]. Obviously, their products do not meet the quality standards. There is no information on the physical and nutritional features of drying of beef in Gialai. Furthermore,
selecting the correct drying method is an important step affecting the quality, time, and cost of dried food products. Therefore, the application and advances of different drying methods need to be considered.

This research is a part of a project that investigates the quality and develops a new solar dryer for semi-dried jerky in Gialai province.

This study reviewed (1) the present quality standards published by Vietnam Standards and Quality Institute (VSQI); (2) discuss some common drying methods that are suitable for semi-dried jerky. The considering methods were natural drying, artificial drying and mixed mode solar drying.

2. Quality Standards for Semi-Dried Jerky

2.1. Definitions

Beef standards and grading are terms that require some definition for accurate discussion as, together with classification, they are often used interchangeably in discussing beef appearance, cuts, estimated yield and eating quality. Classification is defined as a set of descriptive terms describing features of beef that are useful to those involved in the trading. Generally, this involves ranking beef in a hierarchy for the traits of interest. Depending upon the country marbling and lean color and/or texture have often been included other measurements of fatness (internal fat scores, rib) or muscling (eye muscle area, or carcass conformation). These parameters remain relevant and are in use today in most beef grading schemes [8]. Although the standard and quality grades for beef has been published by government in most countries in the world, related report on semi-dried jerky is limited. Vietnam standards are based on nationally uniform standards of quality developed by VSQI. VSQI published that the standards for fresh meat are following TCVN 7046:2009 [9]. Before treating with sun drying, beef was mixed with food additives such as salt, sugar, pepper, chili, lemongrass, monosodium glutamate. Therefore, TCVN 9668:2017 for corned beef has been reviewed [10]. Although semi-dried jerky in Gialai has been treated by natural sun drying method, the rest part is dominant (> 5%) which has not yet treated by sun drying. Therefore, TCVN 9668:2017 is not suitable for semi-dried jerky. Additionally, the product was stored in cool or frozen condition after drying and packaging. The product should be applied the standard for frozen meat. Thus, TCVN 7047:2009 for frozen meat was reviewed [11].

3. Standards Review for Semi-Dried Jerky

3.1. Materials

Fresh meat from the cattle has to approve by the competent veterinary inspection agency for use as food.

3.2. Sensory Evaluation

| Properties   | Requirements                                      |
|--------------|---------------------------------------------------|
| Visual observation | The meat surface is dry, clean, free from fur and impurity |
|              | Smooth shear                                      |
|              | Elasticity, no fingerprint when pressing           |
|              | The marrow adheres to the medullary tube (option)  |
| Color        | Product feature                                   |
| Smell        | Product feature, no funky smell                   |
| Flavor       | Product feature                                   |

*Table 1. Sensory Evaluation*

3.3. Physicochemical Evaluation

| Properties                          | Requirement |
|-------------------------------------|-------------|
| pH                                  | 5.5 – 6.2   |
| Qualitative reaction with hydro sulfua (H₂S) | Negative   |
| Ammonia content, (mg/100g)         | ≤ 35        |

*Table 2: Physicochemical Evaluation*

3.4. Contaminated substances

3.4.1. Heavy Metal Content

| Properties | Maximum (mg/kg) |
|------------|-----------------|
| Cadmi (Cd) | 0.05            |
| Lead (Pb)  | 0.1             |

*Table 3: Heavy Metal Content*
3.4.2. Hormone Residue

| Properties                               | Maximum (mg/kg) |
|------------------------------------------|-----------------|
| Dietylstylbestrol                        | 0.0             |
| Testosterol                              | 0.015           |
| Estadiol                                 | 0.0005          |
| Beta-agonist group (Salbutanol and Clenbutanol) | Disallow       |

*Table 4: Hormone Residue*

3.4.3. Veterinary Drug Residue and Pesticide Residue

Veterinary drug is following 24/2013/TT-BYT circular (Appendix A) while pesticide residue is according to the 50/2016/TT-BYT circular (Appendix B) [12, 13].

3.5. Bacteria

| Properties                             | Maximum (Colonies forming unit CFU/g) |
|----------------------------------------|--------------------------------------|
| **Aerobic bacteria**                   | **10^5**                             |
| *Coliform*                             | *10^2*                               |
| *E. coli*                              | *10^2*                               |
| *Staphylococcus aureus*                | *10^2*                               |
| *Clostridium perfringens*              | *10^2*                               |
| *Salmonella* *(in 25g product)*        | *Disallow*                           |

*Table 5: Bacteria*

3.6. Parasites

| Properties                               | Requirement  |
|------------------------------------------|--------------|
| Cysticercus csuitsae; Cysticercus bovis...| *Disallow*   |
| *Trichinella spiralis*                   |              |

*Table 6: Parasites*

3. Drying Technology

3.1. Definitions

Drying is the oldest method of preserving food. Drying is applied to reduce the water content of products. Reducing the water content of products is purpose to prolong the shelf-life of bio-origin by reducing the water activity. At low water content, growth of microorganisms, enzymatic reactions, and other deteriorative reactions are inhibited [14, 15]. Basically, drying can be divided into two types: natural drying and artificial drying. Natural drying takes place under the influence of sunlight and wind. There is no control over temperature, air flow and humidity in natural drying. Artificial drying is the method which can control the condition of drying process. Artificial drying includes the methods drying by heated air, direct contact with heated surface, and application of energy from a radiating microwave or dielectric source [15-20].

3.2. Natural Drying

3.2.1. Sun Drying:

Drying the food product under natural sunny conditions is called as sun drying. This drying process is no required energy. Hot days are desirable with high temperature (≥ 35°C) and low humidity. However, problems of contamination and intermittent drying are generally encountered with sun drying. For sun drying, vegetables and meats are not recommended. Microorganism in meats will grow due to high protein when heat and humidity cannot be controlled [21-25].
Advantages | Disadvantages
--- | ---
No energy is required | Slow drying process
Cheap, simple | Time taking
Friendly to the environment | Molding of food may occur due to slow drying
| Cannot carried out in dust, rainy weather
| Contaminations from the environment
| Product losses and contaminations by insects and birds
| Floor space requirements
| Inconsistent sensory quality

Table 7: Advantages and Disadvantages of Sun Drying

3.3. Solar Drying

Solar drying also uses the sun as the heat source. It uses designed structures to collect and enhance solar radiation. There are two types of solar dryer [26, 27]:

+ Direct solar dryer: expose the substance to be dehydrated to direct sunlight.

+ Indirect solar dryer: the sun shines upon a solar collector heating air which then moves upward through a stack of four to six trays loaded with produce. Indirect solar dryer is ideal for small scale due to low cost requirements and low throughput whereas the commercial drying requires high throughput.
Solar dryers consist of three main components: a drying chamber in which food is dried, a solar collector that heats the air, and airflow system. The drying chamber could protect the food from insects, dust, rain, and animals. The solar collector is made by a dark or black colored box with a transparent cover. The solar collector can heat the air temperature within 10 ~ 30°C above ambient temperature. The airflow system can be natural convection or forced convection with fans. The forced convection can reduce the drying time and increase drying efficiency [29, 30]. The advantages and disadvantages of solar drying method are shown in Table 8 [31].

| Advantages                                           | Disadvantages                                                   |
|------------------------------------------------------|-----------------------------------------------------------------|
| Drying is faster because inside the dryer it is      | UV radiation can damage food                                     |
| warmer than outside                                  |                                                                  |
| Less risk of spoilage                               | More complex and expensive than direct sun drying               |
| The product is protected against flies, pests, rain  | Hot and dry climates preferred                                   |
| and dust                                             |                                                                  |
| Labour saving                                        | Capacity per unit area of dryer is limited                      |
| The quality of the product is better in terms of     |                                                                  |
| nutrients, hygiene and colour                        |                                                                  |

Table 8: Advantages and Disadvantages of Solar Drying

4. Artificial Drying

4.1. Oven Drying

Air-oven drying is one of the most widely and commonly used methods. An oven is commonly combined the factors of heat, low humidity and air flow. The ovens should be thermally regulated to ± 0.5°C and have minimal temperature variations (≤ 3°C is better). The heat source is usually electric or infrared.

| Advantages                                           | Disadvantages                                                   |
|------------------------------------------------------|-----------------------------------------------------------------|
| Accommodates large number of samples                 | Variations of temperature due to particle size,                 |
|                                                     | sample weight, position in the oven                             |
| Large sample volumes possible                        | Difficult to remove all water                                   |
| High accuracy                                        | Loss of volatile substances during drying                       |
| Attain the desired temperature more rapidly          | Decomposition of sample (i.e., sugar)                           |

Table 9: Advantages and Disadvantages of Oven Drying

4.2. Freeze Drying

Freeze drying is a low temperature dehydration process that involves freezing the food, the reducing the pressure and adding heat to allow the frozen water in the food to sublimate. Freeze drying occurs in three phases.
Freeze phase: during the freeze phase, food is cooled below its triple point, the lowest temperature at which the solid, liquid and vapor phases of the food can coexist.

Primary drying phase (sublimation): during the primary drying phase, the pressure is lowered and heat is added to the food in order for the water to sublimate. The structure of food could be altered if too much heat is added. About 95% of the water is sublimated.

Secondary drying phase (adsorption): the final phase is secondary drying, during which the ionically-bound water molecules are removed. The temperature is raised higher than in the primary drying phase to break the bonds between food and water molecules.

Advantages | Disadvantages
--- | ---
Shelf-life extension | Spoilage organisms and pathogens resistant to the low temperature dehydration process can remain
Nutrients are retained and color is maintained | High cost
Easy storage | The product is prone to oxidation, due to high porosity and large surface area

Table 10: Advantages and Disadvantages of Freeze Drying

5. Mixed Mode Solar Drying

5.1. Passive Mode

The passive mode solar dryer is due to natural circulation. It is similar with indirect solar dryer. However, to minimize heat losses from the back of the solar collector, an insulation layer is installed at the bottom of the collector.

5.2. Active Mode

In this mode of mixed solar dryers, a blower or fan is installed to force the air into or out of the drying chamber. Solar dryer with green house is commonly used. Green house made from glass, plastic film, poly film or polycarbonate plate is often used as a collector. Heat air is forced to pass through the drying trays with an exhaust fan.
6. Conclusions

This paper discussed various types of drying methodologies. Among the advantages of a greenhouse dryer are simple structure, large load capacity and relatively good thermal performance. We concluded that greenhouse dryer is most suited for semi-dried jerky in Gialai province, Vietnam.

Furthermore, standardization is an important criterion for assessing the progress made by Vietnam in the integration process to the worldwide. Although the compliance with standards is not mandatory (the standards are not but rules, guidelines and characteristics for activities and their results), we hope that the products “in compliance” have the best quality while delivering to the consumers.

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## Appendix

| No. | Property                                      | ADI (µg/kg Bodyweight/Day) | Ingredients                                      | MRL (µg/kg) |
|-----|-----------------------------------------------|----------------------------|-------------------------------------------------|-------------|
| 1   | Albendazole (Anthelmintic)                    | 0-50                       | 2-aminosulfone metabolite                        | 100         |
| 2   | Amoxicillin (Antibacterial drug)              | 0-0.07                     | Amoxicillin                                     | 50          |
| 3   | Benzylpenicillin Procaine benzylpenicillin (Antibacterial drug) | 30                         | Benzylpenicillin                                | 50          |
| 4   | Ceftiofur (Antibacterial drug)                | 0-50                       | Desfuroylceftiofur                              | 1000        |
| 5   | Chlorotetracycline Oxytetracycline Tetracycline (Antibacterial drug) | 0-30                       | Main ingredients, individual ingredient and combined ingredient | 200        |
| 6   | Clenbuterol (Sympathomimetic drugs – adrenoceptor) | 0-0.004                   | Clenbuterol                                     | 0.2         |
| 7   | Closantel (Anthelmintic)                      | 0-30                       | Closantel                                       | 1000        |
| 8   | Colistin (Antibacterial drug)                 | 0-7                        | Total Colistin A and Colistin B                 | 150         |
| 9   | Cyfluthrin (Insecticide)                      | 0-20                       | Cyfluthrin                                      | 20          |
| 10  | Cyhalothrin (Insecticide)                     | 0-5                        | Cyhalothrin                                     | 20          |
| 11  | Cypermethrin Alpha-cypermethrin (Insecticide) | 0-20                       | Total cypermethrin residual                     | 50          |
| 12  | Danofloxacin (Antibacterial drug)             | 0-20                       | Danofloxacin                                    | 200         |
| 13  | Deltamethrin (Insecticide)                    | 0-10                       | Deltamethrin                                    | 30          |
| 14  | Dexamethasone (Glucocorticosteroid)           | 0-0.015                    | Dexamethasone                                   | 1           |
| 15  | Dihydrostreptomycin Streptomycin (Antibacterial drug) | 0-50                       | Sum of dihydrostreptomycin and streptomycin     | 600         |
| 16  | Diminazene (Drug treatment of blood parasites) | 0-100                      | Diminazene                                      | 500         |
| 17  | Doramectin (Anthelmintic)                     | 0-1                        | Doramectin                                      | 10          |
| 18  | Eprinomectin (Anthelmintic)                   | 0-10                       | Eprinomectin B1a                                | 100         |
| 19  | Febantel Fenbendazole Oxfendazole (Anthelmintic) | 0-7                        | Sum of fenbendazole, oxfendazole and oxfendazole sulphone | 100        |
| 20  | Fluazuron (Insecticide)                       | 0-40                       | Fluazuron                                       | 200         |
| 21  | Flumequine (Antibacterial drug)               | 0-30                       | Flumequine                                      | 500         |
| 22  | Gentamicin (Antibacterial drug)               | 0-20                       | Gentamicin                                      | 100         |
| 23  | Isometamidium (Drug treatment of blood parasites) | 0-100                      | Isometamidium                                   | 100         |
| 24  | Levamisole (Anthelmintic)                     | 0-6                        | Levamisole                                      | 10          |
| No. | Property                        | ADI (µg/kg Bodyweight/Day) | Ingredients       | MRL (µg/kg) |
|-----|---------------------------------|-----------------------------|-------------------|-------------|
| 25  | Monensin (Antibacterial drug)   | 0-10                        | Monensin          | 10          |
| 26  | Moxidectin (Anthelmintic)       | 0-2                         | Moxidectin        | 20          |
| 27  | Narasin (Antibacterial drug)    | 0-5                         | Narasin A         | 15          |
| 28  | Neomycin (Antibacterial drug)   | 0-60                        | Neomycin          | 500         |
| 29  | Pirlimycin (Antibacterial drug) | 0-8                         | Pirlimycin        | 100         |
| 30  | Ractopamine (Growth stimulant drugs) | 0-1                   | Ractopamine       | 10          |
| 31  | Spectinomycin (Antibacterial drug) | 0-40               | Spectinomycin     | 500         |
| 32  | Spiramycin (Antibacterial drug) | 0-50                        | Sum of spiramycin and neospiramycin | 200 |
| 33  | Thiambendazole (Anthelmintic)   | 0-100                       | Sum of thiambendazole and 5-hydroxythiambendazole | 100 |
| 34  | Tilmicosin (Antibacterial drug) | 0-40                        | Tilmicosin        | 100         |
| 35  | Trenbolone acetate (Growth stimulant drugs) | 0-0.02 | Beta-trenbolone | 2 |
| 36  | Triclabendazole (Anthelmintic)  | 0-3                         | Ketotriclabendazole | 250 |
| 37  | Tylosin (Antibacterial drug)    | 0-30                        | Tylosin A         | 100         |
| 38  | Zeranol (Growth stimulant drugs) | 0-0.5                      | Zeranol           | 2           |

Table 11: Maximum Veterinary Drug in Beef Meat