RESEARCH ARTICLE

INVESTIGATION ON THE DRYING EFFECTS ON NUTRITIONAL ATTRIBUTES OF DRIED LAMB MEAT

Ata Manafzadeh*1 Zahra Emam-Djomeh2 Vajlheh Fadaei3

1 Department of Food Science & Technology, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran
2 Transfer Phenomena Laboratory (TPL), Department of Food Science, Technology and Engineering, Faculty of Agricultural Engineering and Technology, University College of Agriculture and Natural Resources, University of Tehran
3 Department of Food Science & Technology, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran

ARTICLE INFO

Article History:
Received 13th June, 2013
Received in revised form 25th June, 2013
Accepted 14th July, 2013
Published online 30th July, 2013

Key words:
Drying, lamb meat, microwave, vacuum, shelf life

ABSTRACT

This survey presents the effects of various process variables on quality characteristics of the dried lamb meat. Five methods such as hot air, microwave, vacuum and sun drying were applied to dry the lamb meat muscle (Longissimus dorsi). Microwave-hot air and microwave – vacuum techniques have also been used to process optimization. Process variables such as flow rate, micro wave power and pressure have been 3 and 2 levels, respectively. A symmetric analysis was used to evaluate the results. Protein content, water activity and microbial total count in dried samples were analyzed by various methods. The results showed best treatment was related to 300W – vacuum, also the worst treatment were related to the sun and hot air drying.

The results showed that microwave applying to drying have been reduced water activity and the lowest water activity level were related to 500 and 300 W, respectively. Highest level of water activity achieved in sun dried samples.

The results showed that protein contents did not change with microwave irradiation power and the protein contents were not affected significantly by increasing of microwave power, however vacuum protects proteins. The all of treatments were performed in a vacuum have similar protein content to raw meat. The highest protein loss was obtained in hot air and sun drying. Increasing of the air velocity increased firmness in all of the treatments. The most tightness of texture obtained in the sun dried samples and lowest value related to 300 W – Vacuum. All samples treated with microwave power of 500 W have negative microbial total count (fungal-bacterial) and highest contamination was related to samples dried by hot air and sun drying. All samples were negative for fungal growth and only sun dried samples were have a positive result for fungal tests.

INTRODUCTION

The most delicate meat is a lamb meat in Mediterranean countries and several south American, being consumed mainly as casserole dish either barbequed, roasted or grilled, but did not found numerous uses in processed forms. Thereby, drying is not a customary way to consume of lamb meats. It had an adverse effect on the quality and appearance of the resulted product. Lamb meat have a higher content of protein quality compared to several other meats, also is a good source of several vitamins for example (thiamin, riboflavin, niacin, B6 and B12) and minerals including phosphorous, iron and etc. Whereas lamb meat has a higher ratio of PUFA/SFA, it helps to improve human health through reducing blood cholesterol level. (1)

Meat, due to its nutrient composition, and especially lamb meat, with higher pH as compared to pork and beef can be composed substrate growth due to spoilage in bacteria resulted to spoilage can be derived from Pseudomonads, Moraxella, Acinetobacter, Enterobacteriaceae, Br. Thermophilica, Aeromonas (7) as well as pathogens including: Salmonella, Staphylococcus aureus, Listeria monocytogenes, Cl. perfringens and E. coliO157:H7. (2)

Yeasts including Candida, Torulopsis and mols including Rhizopus, Sporotrichum, Fusarium, Monilia and Aspergillus may also be found in fresh meat microflora. (2)

Dehydration is a basic process in the dry processing. The important objective in food drying is the removal of water from a foodstuff to the point that deteriorating chemical reactions and microbial spoilage are greatly minimized. (3) Darkening is a deficiency happens in the dried food surface. It is important to customers buying behavior. (4)

To now a different methods have been used to dry fruits and vegetables, between this methods Hot-air drying is the most used. However, this method can be result in an unpleasant taste
and color deterioration and reduce the nutritional composition of the food product that was important to the point of customers view. (5, 6, 7)

It can cause shrinkage and lower water absorbance capacity resulted a moving of the internal solutes to surface in the high temperature and long time. (8, 9, 10)

Also, heat transfer limited in the drying falling rate to the inner part of foods that have a low thermal conductivity in during of conventional heating. (8) To eliminated of these problems and control quality losses and reaching the better thermal processing, as resulted uses of microwave powers in drying can be useful for prevent of these problems. Microwave drying have a higher race in drying and uniformity to conventional hot air drying, also it is effective to upper of the efficiency in energy consumption. (11)

In the microwave processes, energy can be absorb with dielectric molecules which causes the oscillation of water molecules and produce a friction producing heat in the surrounding environment when water molecules be rearranged in a line in the impact of changing electrical field direction. (12, 13)

The many of drying techniques use to prevent hot air drying disadvantages which occurs. Such as two-stage drying that used it superheated steam and hot air, it combines advantages any of two drying techniques. (14) This drying method is an airless drying uses high temperature steam to transport heat, in this way, high-temperature superheated steam causes to increase effective diffusion coefficients of the products elevated drying rates. (15, 16, 17) The use of vacuum or lower pressures in the drying environment reduce boiling point resulted can be useful for prevent of quality losses. Thus, microwave drying can improve with vacuum applying. (18, 19)

This technique resulted to produce dehydrated with better texture, color and flavor (20). Also demonstrated that use of microwave and vacuum drying can be useful to conserve the product quality of dried such as color the conventional drying. Also physical and biochemical properties better conserve in dehydrated foodstuffs, for instance, microwave vacuum drying is effective way to the inhabit damages to food nutrients which are sensitive to the heat and oxygen, for example ascorbic acid and etc. (3)

**MATERIALS AND METHODS**

**Sample Preparation**

Fresh lamb meat (Longissimus dorsi) purchased from a local market in Tehran, Iran. Quality of meats controlled visually for freshness, color and any lack of look. They were brought to the laboratory in the ice package, meats has been kept in 4°C environment for 48hrs before sample preparing. The meats was trimmed to remove excess fat as per USDA (1996)’s recommendation to prevent fat being rancid in the drying process. After deboning with using a sharp knife were cut to square pieces in uniform size with the dimensions (15mm x 50mm x 50mm) all experiments were run in triplicates. (21)

For salting, dry method used, the all dimensions of meat pieces salted with NaCl powder amount 2% w/w and stayed for 5 min into glass dish until not seen any NaCl crystals in the surface of meat samples (21)

**Sun Drying**

The meat cuts exposed to sun light, the sun heats up the meat samples and also the surrounding air. The applied action caused water evaporated from the meats. Drying with sun was conducted until a moisture content of 0. 2 kg/kg dry matter was reached.

**Water Content**

The initial moisture content of sample was determined by the method of drying at temperature of 130°C described by Gerasimov and Antonova (1979) and observed as % 72± 3kg dry matter. Water content was measured using a hot air drier at 100°C until a constant weight was achieved (AOAC, 1991) (22)

**Hot-Air Drying**

Meat cuts were dried in a pilot plant hot-air drier (tray dryer, Armfield, Hampshire, England). The drying was operated at air velocities of (0-5-10m/s) parallel to the drying surface of the slices at 75°C dry bulb temperature.

The operation mode was controlled using a computer connected to the dryer (figure 1). To obtain the drying curves, moisture loss was recorded with a digital balance (Cobos, Homburg, Germany) at 5-min intervals beginning 30 min after the start of drying until 30 min before end of drying, after which point it was measured every 10 min. Hot-air drying was conducted until subjected moisture content was reached.

**Vacuum Drying**

Vacuum conditions were maintained using a vacuum pump and monitored with a manometer. Two steel plates heated by electric resistance provided the thermal energy. An automatic regulator controlled the temperature of the plates. The experimental procedure consisted of putting food samples on the hot plate, closing the door of the chamber and putting the chamber under a vacuum. Meat samples were from the dryer at set intervals and their weights determined using an analytical balance with accuracy to 0. 001 g. The temperature of the plate was set at 55°C and the pressure of the chamber at 75 kPa.

**Hot-Air MicrowaveAssisted Drying**

Hot-air drying was conducted as previously described until moisture content of 0.3 kg/kg dry matter was reached. Initial observation revealed the using of higher moisture content produced a lower quality product and higher risk to spoilage; thus, samples with a low moisture content of 0.3 kg/kg were used. After this point, to obtain uniform moisture distribution in the samples, they were placed in a hermetically sealed container for 30 min. Next, the samples were transferred system for the microwave treatment in 50-300-550 W, respectively.

Samples were placed at the center of the grid in the microwave stand. The use of air velocity was necessary to remove of vapor from drying reach to faster rate of drying in the samples and to reduce the level of microwave power on the magnetron. (10)
**Vacuum - Microwave Assisted Drying**

In this method instead of air velocity, vacuum used to remove of vapor from drying environment and reach to lower temperature of boiling point of water that caused decrease quality damage in the products. Also faster rate of drying in the samples and to reduce the level of microwave power on the magnetron can be reachable. (10) After the microwave treatment, all of the samples had the same moisture content. Approximately recorded moisture content was near 0.2 kg/kg.

**Drying equipment**

Drying experiments were conducted using a modified domestic microwave oven (900 W) as illustrated in Fig. 1.

![Microwave assisted vacuum or hot-air dryer](image)

This device was designed to dry samples while the temperature and velocity of air and microwave power were controlled. Microwave power can be adjusted in domestic ovens by controlling operation time, but this approach does not yield sufficient power control accuracy. Accordingly, power was adjusted as directed by the manufacturer (in increments of 150 W) and moreover, a time controller was installed to achieve smaller stepwise power changes. Therefore, resulting output power could be adjusted by increments of 50 W.

The drying chamber consisted of callous net inserted on the Pyrex duct of 20 cm height which was positioned inside the microwave oven.

This configuration was necessary to ensure careful adjustment of air velocity around the samples and prevent the exposure of moisture to the internal parts of the microwave oven which could lead to power loss and electrical hazards.

An external duct made of stainless steel was connected to an 8 kW electric heater to heat the air to the desired drying temperature which was controlled by a PID temperature controller. Air velocity was controlled by a fan speed controller. For all experiments, air velocity was maintained at a constant value of 0 and 5 or 10 m/s inside the cavity noted to technique used. It could be noted that cubed meats was inserted at triple air velocity.

Only 50, 300 and 550 W power levels were used in this study. Experiments to determine the kinetics of the vacuum and convective microwave drying process were performed in triplicates and their averages used to qualify the optimized technique.

The operational parameters (76-760mmHg), microwave power (50-300-550W), air velocity (0-5-10 m/s). Relative humidity of ambient was kept by means of a laboratory air conditioner.

**Water Activity**

Water activity, which is the critical parameter used to assure the product safety was Aqua lab water activity meter (Model H 500, Novasina Inc., Switzerland). The dried sample was crushed into small pieces and placed in water activity measurement cup and the readings were noted. (AOAC, 1990)(23)

**Microbial analysis**

The aerobic bacteria count was determined by 5 g samples that had been aseptically removed from dryer. Samples were homogenized for 1 min at room temperature in 45 ml of sterilized 0.9% NaCl saline using a Stomacher 80 Lab-blender (Seward, London, UK). Serial 10 fold dilutions were prepared in 0.9% NaCl saline solution, and 0.1 ml samples of each dilution were spread on the plates. The aerobic bacteria count was determined on Plate Count Agar (Difco, Spark, MD) after incubation for 48 h (24), and yeasts and mold count was determined on DRBC (Merck)after incubation at 20 - 25 C for 5 day. Each analysis was carried out two times in triplicate. (25)

**Protein content**

Protein content was measured by determination of total nitrogen in meat samples (Kjeldahl methods) with AOAC, 1974 official methods. (26)

**Statistical Analyses**

Experiments were conducted in triplicate and an analysis of variance results was carried out using MINITAB software version 16. The means obtained from each set were compared using the Duncan’s multiple range test based on a completely randomized design (confidence level of 0.05).

**RESULT AND DISCUSSION**

**Water activity**

The results reached from aw measurements by the instrumental methods presented in Fig. 2.

![Fig.2. the effects of drying methods on the water activity values of dried lamb meats](image)

The most value of it obtained in sun dried and lowest value related to vacuum assisted microwave dried samples in 300w and hot air microwave assisted samples in 550w.
According to follow diagram increasing of microwave power has decreased aw values and air velocity increasing was not affected the most of samples likely related to limited effect of air velocity increasing to the surface of samples and had not volumetric effect against microwave power increasing.

The microwave power increasing because of the dielectric molecules and volumetric evaporation helped to more easily exit of water molecules with the change of protein structures caused to more release of water molecules in these structures. Also the variant levels of case hardening that occurred especially in 550w can be other reason for these results.

Generally, the effect of microwaves power increasing in the inner protein structures conquets to cooling function of air velocity rising and vacuum applying.

In the vacuum dried samples, influence of microwave power increasing from 50 to 300w was decreased it but from 300 to 550w had was increased.

Because the conductive heat drying dominate to microwave irradiation effects in vacuum assisted microwave drying in 50w, inner protein structure changes were low and more thick layers formed in surface in 550w that cause to spacious changes in the protein structures, aw values decreased.

Whereas vacuum assisted dried samples in the 300w, had a better and unified form of vapor exit and low changes of protein structures. Otherwise moderated condition of drying to utilize microwave advantage as well as lesser diameter of thick layers in the surface was helped to easier exit of vapor during rehydration time and reached to lowest aw value in finally.

**Protein contents**

The results of protein measurement tests presented in Fig. 3, demonstrated vacuum dried samples not had protein losses considerably. These samples in the point of protein amount very similar to fresh meats. Whereas, lowers values related to the sun and hot air dried samples. Also results presented losses decreased and power increasing from 300w to 550w had a little effect in decrease of protein. Thereby could be resulted their effects in prevent of protein losses considerably and significant.

Although air velocity increasing not had affected it in blanks or hot air dried meats, but observed air velocity increasing in hot air microwave assisted drying method from zero to 5 m/s on surface as cooling caused decrease of protein losses. But their decrease from 5m/s to 10 m/s not had a significantly effect. Probably these results related to over effect of air velocity increasing in the rise of evaporation speed on the surface of samples resulted effects and surface overheating.

**Microbial tests**

- **Bacteria counts**

The microbial test after 4 month from preparing applied for evaluation of samples health. This results offered in Fig. 4. The observations exhibited microwave assisted methods had a very little number of counts for bacteria that grew in the culture media. Meanwhile vacuum applied by the pressure gradiants made in the surface and probably all of samples volume caused micro organism cell wall destructed or punched. This condition as well as very high temperatures made in small bubbles burst during of microwave drying could be violent lethal agent for these organisms.

**Fungi counts**

According to Fig. 5. all of samples except sun dried samples in the point of mold and yeast count numbers had a zero values. These results could be reasonable by low aw obtained in samples.

Almost all of samples dried in microwave espescially higher power of vacuum conditions had a zero value for bacteria count. These culture results was reached after few month stored according to low aw obtained offten in the range of (0.49- 0.65) could be reseaneable scientifically.
during of drying, conditions approached to direct that micro organisms died or missed capability of grows.

CONCLUSION

Generally, results presented drying methods that we offered could be a useful for prevent of meat spoilage without nutritional compositions losses (protein contents). The use of vacuum assisted microwave drying in 300w could had a more of microwave drying methods as well as all of vacuum drying methods, for example: prevent outer layers overheating, decrease of water activity in samples and etc. Also this method caused shelf life of dried increased with direct of conditions to unbearable for the micro survive or subsequently grows of it, prevented later problems in storage and consumption.

References