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EFFECT OF SUN DRYING ON THE COMPOSITION AND SHELF LIFE OF GOAT MEAT (*Capra aegagrus hircus*)

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Abstract

An experiment was conducted in the laboratory of the Department of Food Engineering and Technology and in the roof of Academic building - 2 of Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from August, 2009 to February, 2010 to evaluate the effect of sun drying on the composition and shelf life of goat meat. Goat meat was dried into three different thicknesses as 0.5 cm (S_1), 0.75 cm (S_2), and 1.0 cm (S_3) for five weeks and compositional analysis were done at an interval of one week. Then the dried meats were packaged in polyethylene pack and examined quality and shelf life. The experiment was laid out in the Completely Randomized Design (CRD). Sun drying was done at average 32^{0}C temperature and at average of 85 % relative humidity. The results showed that sun drying increased ($p < 0.05$) the dry matter and protein contents of the dried samples compared to the fresh samples, also fat, carbohydrates and minerals were significantly ($p < 0.05$) higher in dried sample. The results were attributed to the various changes that occurred during the drying process. Sun drying of meat samples could be adopted under the hot humid tropical environment providing under hygienic condition.

Key words: Meat, sun-drying, moisture, nutritive value, meat quality, shelf life

Introduction

Meat was referred to as the flesh of animal used as food. It is the part of the muscle of the domesticated or other designated animals that are consumed. It includes the muscles that are found in the skeleton, tongue, diaphragm, heart or esophagus with or without the accompanying and overlying fat. Portions of bones, skins, nerve and blood vessels that normally accompany muscles are included as meat parts. Meat does not include the muscles found on the lips, snout or ears (Janus, 1999).

In terms of global meat production over the next decade, there will be an increase from the current annual production of 267 million tons in 2006 to nearly 320 million tons by 2016. Almost exclusively, developing countries will account for the increase in production of over 50 million tons. This enormous target will be equivalent to the levels of overall meat production in the developing world in the

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mid -1980s and place an immense challenge on the livestock production systems in developing countries (Gunter Heinz and Peter Hautzinger, 2007).

Meat is a highly valued food product for human consumption because it is a good source of all essential amino acids and a major source of B-complex vitamins and minerals. Its distinctive flavor makes it one of the most preferred foods. However, the intrinsic properties of fresh meat including relatively high water activity, slightly acidic pH and the availability of carbohydrate (glycogen) and proteins make it a good substrate for microbial growth and consequently it is a highly perishable commodity. Therefore, the shelf life of meat products is limited by enzymatic and microbiological spoilage.

To extend the shelf life of meat and meat products, traditional preservation methods using sun drying and salting techniques have been used. Many developing countries are still preparing traditional dried products for human consumption (Campbell-Platt 1987). In spite of the numerous benefits of dietary meat, it is highly perishable due to its high moisture and protein contents which can be utilized by micro-organisms (Hotchkiss and Potter, 1995). The principle of meat preservation is concerned, mainly with preventing or delaying microbial spoilage, autolysis avoidance of weight loss and any changes in taste or texture (Macrae et al. 1997). Dried products produced by different processes remain of interest since they do not require refrigeration during distribution and storage. Drying techniques mostly rely on extending the keeping properties of the meat by reducing the water activity (Scott 1953, 1957).

Preservation methods include use of low temperature, high temperature, reduction of water activity and use of chemicals among the many preservation methods, dehydration or drying is probably one of the earliest and most effective method developed (Hotchkiss and Potter, 1995). The sun drying method is known to have certain disadvantages, such as exposure to contamination from sources such as dirt, wind, rain, insects, rodents and birds. Quality deficiencies, such as changes in color, off-flavors, foreign contaminating substances such as dirt and sand and even high surface microbial contamination may occur.

Sun drying is a common phenomenon in developing countries. The nutritive value and taste of dried meat is slightly varied with its thickness. This work was therefore designed to evaluate the effects of sun drying on nutrition and sensory quality with different thickness for better adoption by the people in these areas. Goat meat was chosen for religious point of view.

Materials and Methods

Experimental site

The study was conducted in the laboratory of the Department of Food Engineering and Technology and in the roof of Academic building - 2 of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, during August 2009 to February 2010.

Materials

The goat meat was collected from the local market. The equipments for drying and chemical analysis were taken from laboratories.

Fresh goat meat sample

⇩

Cleaning of meat

⇩

Cutting into strips

⇩

Preparation of drying bed

⇩

Sun drying (at about 32 ^{0}C for several weeks)

⇩

Collection of dried meat

⇩

Packaging of dried meat

Figure 1. Flow chart for meat drying

Chemical Analysis

The raw and dried meat samples were analyzed for their moisture, ash, protein and fat. All the determinations were done in triplicate and the results were expressed as mean value.

Determination of moisture content

Moisture content was determined by adopting AOAC (2000) method.

Procedure

First of all, weight of empty previously dried (1 hour at 100^{0}C) crucible with cover was taken and sample was placed on it. Then the crucible was placed in an air oven (thermostatically controlled) and dried at temperature of 100^{0}C to 105^{0}C for 24 hours. After drying, the crucible was removed from the oven and cooled in desiccator. It was then weighed with cover glass. The crucible was again placed in the oven and dried for 30 minutes, taken out of the drier, cooled in a desiccator and weighed. Drying, cooling and weighing were repeated until the two consecutive weights were the same. From these weights the percentage of moisture was calculated by the following equation:

$$\% \text{ Moisture} = \frac{\textit{Loss of Weight}}{\textit{Weight of Sample}} \times 100$$

This procedure was followed for determining moisture of different raw and dried Chevon.

Determination of ash content

Ash content of foodstuff represents inorganic residue remaining after destruction of organic matter. Total ash content was determined by AOAC (2000) method.

Procedure

2 gram sample was taken in a dry, clean porcelain dishes and weighed accurately. Hot air oven method was applied to remove the moisture. Then the sample was burned using an electric heater. This was done to avoid the loss of sample in the Muffle furnace at higher temperature of 550^{0}C and ignited until light gray ash resulted. The sample was then cooled in a desiccator and weighed. The ash content of all the samples was calculated by the following equation:

$$\% \text{ Ash} = \frac{\text{Weight of Recedue}}{\text{Weight of Sample}} \times 100$$

Determination of crude fat

Ether soluble material in a food is extracted from an oven dried sample using a Soxhlet extraction apparatus. The ether is evaporated and the residue weighed. The ether extract or crude fat of a food represents, besides the true fat (triglycerides), other materials such as phospholipids, sterols, essential oils, fat soluble pigments, etc., extractable with ether. Water soluble materials are not extracted since the sample has been thoroughly dried prior to extraction with anhydrous ether or petroleum ether.

Procedure

The sample remaining after moisture determination was transferred to a thimble and plugged the top of the thimble with a wad of fat free cotton. The thimble was dropped into a fat extraction tube of a Soxhlet apparatus. The bottom of extraction tube was attached to a Soxhlet flask. Approximately 75 ml or more of anhydrous ether was poured through the sample in the tube into the flask. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hours or longer on water bath at 70^0C to 80^0C. At the end of the extraction period, the thimble from the apparatus was removed and distilled off most of the petroleum ether by allowing it or collected in Soxhlet tube. The petroleum ether was poured off when the tube was nearly full. When the petroleum ether had reached small volume, it was poured into a small, dry beaked through a small funnel containing plug cotton. The flask was raised and filtered thoroughly using ether. The ether was evaporated on steam bath at low temperature and was then dried at 100^0C for 1 hour, cooled and weighed. The percentage of crude fat was then calculated as follows:

$$\% \text{ Crude Fat} = \frac{\text{Weight of Ether Soluble Material}}{\text{Weight of Sample}} \times 100$$

Determination of crude protein content

Nitrogen content is estimated by the Kjeldahl method which is based on the determination of the amount of reduced nitrogen present in the sample. The various nitrogenous compounds are converted into ammonium sulphate by boiling with conc. H_2SO_4. The ammonium sulphate formed is decomposed with an alkali (NaOH) and the ammonia liberated is absorbed in excess of neutral boric acid solution and then titrated with standard acid.

Digestion

About 2 gm sample was taken in 250 ml of Kjeldahl flask. About 25 ml of concentrated H_2SO_4 and 2 gm of digestion mixture was added to the flask. The flask was placed in an inclined position on the stand in the digestion chamber and digested. The contents of the Kjeldahl flask was heated over a low flame in the digestion chamber, and the flask was rotated for several times, until the solution becomes clear (bluish color). After digestion the flask was cooled carefully and added slowly 30 to 40 ml of water in 5 ml portion with mixed made the volume 100 ml with distilled water. A blank digestion was carried out without the sample and makes the digest to 100 ml.

Distillation

5ml of aliquot was taken for distillation in a distillation flask. 10 ml Boric acid solution in 10-15 ml of ammonia free water and 2 drops of mixed indicator were taken in a 100 ml conical flask. The distillation apparatus was connected up with the delivery tube dipping below the boric acid solution in the conical flask. To the distillation flask, about 40 ml of 40% NaOH was added solution and distilled of the ammonia into the boric acid solution. The boric acid was changed from bluish purple to bluish green.

Titration

The micro burette was filled with 0.01 N HCl to the zero mark. The content of conical flask was titrated against standard 0.01 N HCl until the blue color disappears. The blank distillation was carried out and titrated.

Calculation

$$\% \text{ Nitrogen} = \frac{(\text{Sample Titre} - \text{Blank Titre}) \times \text{Normality of HCl} \times 14 \times \text{Volume made up of the Digest} \times 100}{\text{Aliquot of the Digest Taken} \times \text{Weight of the Sample Taken} \times 1000}$$

% Protein = %Nitrogen × Protein Factor

% Protein = %Nitrogen × 6.25

[Protein factor for meat is 6.25]

Sensory Evaluation

Sensory quality is of great importance to both the processor and consumer to the processor, since it attracts consumers; to the consumer, since it satisfies his aesthetic and gustatory sense. Sensory quality is combination of different senses of perception coming into play in choosing and eating a food. The consumer's acceptability of dried chevon (goat meat) was evaluated by a Panel Test. The Hedonic rating test was used to determine this acceptability. Hedonic rating relates to pleasurable or unpleasurable experiences. The hedonic rating test is used to measure the consumer acceptability of food products.

The panelists were untrained and selected randomly from the teachers and students of the faculty of Agro- Industrial and Food Process Engineering, of Hajee Mohammad Danesh Science and Technology University, Dinajpur. Three samples were served to the panelists at one session and were asked to assign appropriate score for appearance, color, aroma, texture, taste and overall acceptability of dried chevon.

The scale was arranged such that:

9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4= Dislike slightly, 3 = Dislike moderately, 2= Dislike very much, 1 = Dislike extremely.

Storage studies

The dried chevon were packed by polyethylene film and stored at room temperature. The different parameters of assessing the deterioration of the products were observed at a regular interval of one month up to two months and at an interval of two months for the next four months. The color, aroma, texture and visual fungal growth etc. were observed up to the whole storage period.

Statistical analysis

The recorded and calculated data were statistically analyzed using a MSTAT-C Statistical Computer Package Programme in accordance with the principles of Completely Randomized Design (Gomez and Gomez, 1984), Duncun's Multiple Range Test (DMRT) was performed to compare variations among treatments.

Results and Discussion

Effect of sun drying on meat sample with 0.5 cm thickness

The moisture content of raw meat was 63.86%, and dry matter in finally dried product was 92.47%, such result is slightly varies with the findings of (M.S. Rahman et al, 2005). Protein percentage of dried meat was 67.84%. Table 1 shows the composition at various drying stage and figure 1 shows regression and correlation values of the meat components.

Table 1: Composition of meat sample with 0.5 cm thickness (in percentage)

Drying Stage	Moisture	Protein	Fat	Ash	Carbohydrate	Dry Matter
S_1W_1	63.86	21.82	12.07	1	1.25	36.14
S_1W_2	16.9	61.11	19.07	1.3	1.62	83.1
S_1W_3	12.65	63.97	20.29	1.42	1.67	87.35
S_1W_4	7.97	67.65	20.9	1.63	1.85	92.03
S_1W_5	7.54	67.84	21.02	1.69	1.91	92.46
S_1W_6	7.53	67.84	21.03	1.69	1.91	92.47

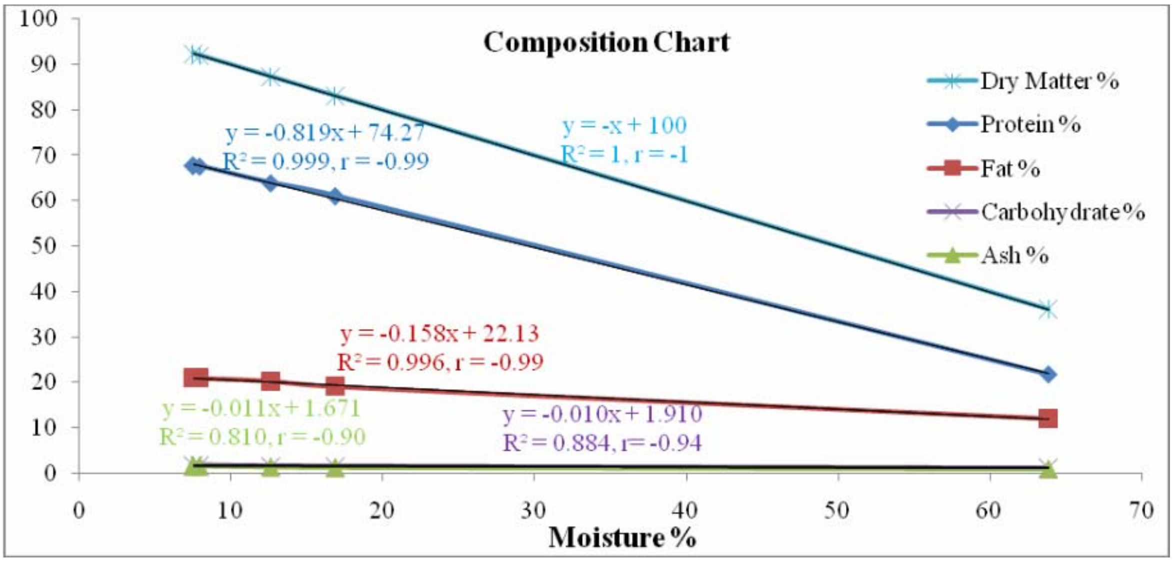

Figure 2. Effect of Drying on Chevon for sample 1

Table 2. Mean sensory scores of chevon

Drying Stage	Color	Texture	Aroma	Appearance	Overall Acceptability
S_1W_1	7.2^a	7.3^a	7.3^a	7.3^a	7.2^a
S_1W_2	6.2^b	5.6^b	5.9^c	6.3^{cd}	5.5^b
S_1W_3	5.6^c	5.6^b	5.8^c	5.7^e	5.6^b
S_1W_4	5.7^c	5.8^b	5.9^c	5.8^{de}	5.8^b
S_1W_5	6.8^a	6.9^a	6.7^b	6.7^{bc}	6.9^a
S_1W_6	7.1^a	7.0^a	7.4^a	7.0^{ab}	7.4^a
LSD	0.4741	0.5221	0.4098	0.5095	0.5087
CV	8.18%	9.11%	7.01%	8.75%	8.82%

In a column, figures having similar superscript(s) do not differ significantly where as figures bearing dissimilar superscript(s) differ ($p < 0.05$) significantly (as per DMRT).

Effect of sun drying on meat sample with 0.75 cm thickness

From table 2, it is clear that the dry matter and protein percentage in the dried product is 92.48% and 67.89% respectively which is higher than other two samples. The percentage of ash and carbohydrate is slightly lower in this sample.

Table 3. Composition of meat sample with 0.75 cm thickness (in percentage)

Drying Stage	Moisture	Protein	Fat	Ash	Carbohydrate	Dry Matter
S_2W_1	63.87	21.81	12.08	0.99	1.25	36.13
S_2W_2	16.99	61.02	19.01	1.31	1.67	83.01
S_2W_3	12.62	63.95	20.26	1.46	1.71	87.38
S_2W_4	7.99	67.68	20.85	1.65	1.83	92.01
S_2W_5	7.53	67.88	21.02	1.68	1.89	92.47
S_2W_6	7.52	67.89	21.01	1.7	1.88	92.48

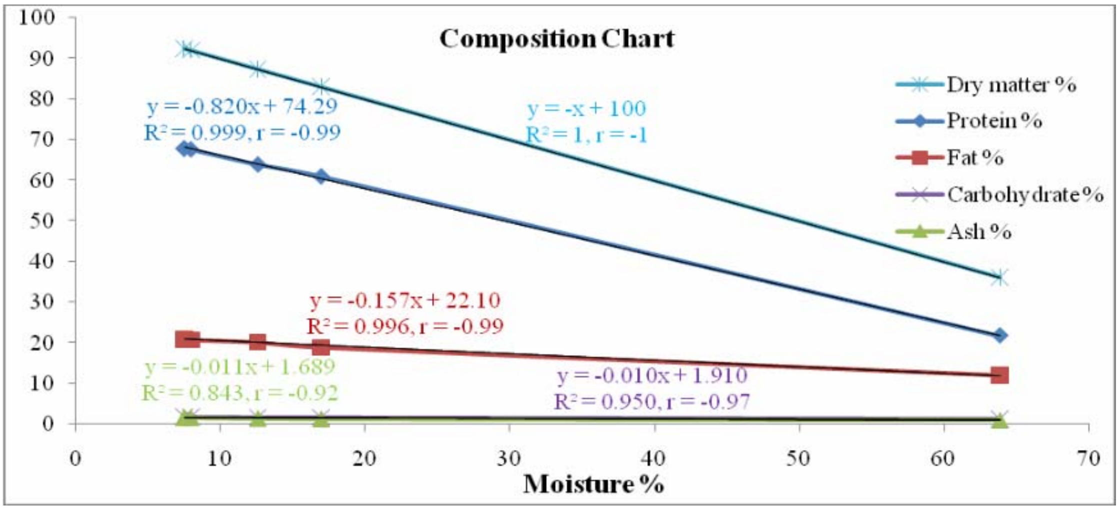

Figure 3. Effect of Drying on Chevon for sample 2

Table 4: Mean sensory scores of chevon

Drying Stage	Color	Texture	Aroma	Appearance	Overall Acceptability
S_2W_1	7.4^a	7.5^a	7.5^a	7.5^a	7.4^a
S_2W_2	6.5^b	6.1^b	6.2^b	6.6^b	6.1^b
S_2W_3	6.2^b	6.2^b	6.3^b	6.3^b	6.2^b
S_2W_4	6.2^b	6.2^b	6.3^b	6.2^b	6.3^b
S_2W_5	7.2^a	7.2^a	7.1^a	7.1^a	7.3^a
S_2W_6	7.2^a	7.2^a	7.5^a	7.1^a	7.5^a
LSD	0.3625	0.4557	0.4495	0.4206	0.4654
CV	5.93%	7.48%	7.95%	6.86%	7.59%

In a column, figures having similar superscript(s) do not differ significantly where as figures bearing dissimilar superscript(s) differ ($p < 0.05$) significantly (as per DMRT).

Effect of sun drying on meat sample with 1 cm thickness

This sample bears an ideal level of nutrient content after drying. The percentage of all nutrient increases gradually due to successive loss of moisture from the sample. Table 3 shows the composition of meat sample and figure 3 describes the regression and correlation values.

Table 5. Composition of meat sample with 1.0 cm thickness (in percentage)

Drying Stage	Moisture	Protein	Fat	Ash	Carbohydrate	Dry Matter
S_3W_1	63.88	21.82	12.06	1.01	1.23	36.12
S_3W_2	16.92	61.08	19.05	1.31	1.64	83.08
S_3W_3	12.67	63.94	20.27	1.46	1.66	87.33
S_3W_4	7.98	67.62	20.9	1.65	1.85	92.02
S_3W_5	7.55	67.83	21.02	1.68	1.92	92.45
S_3W_6	7.54	67.84	21.02	1.67	1.93	92.46

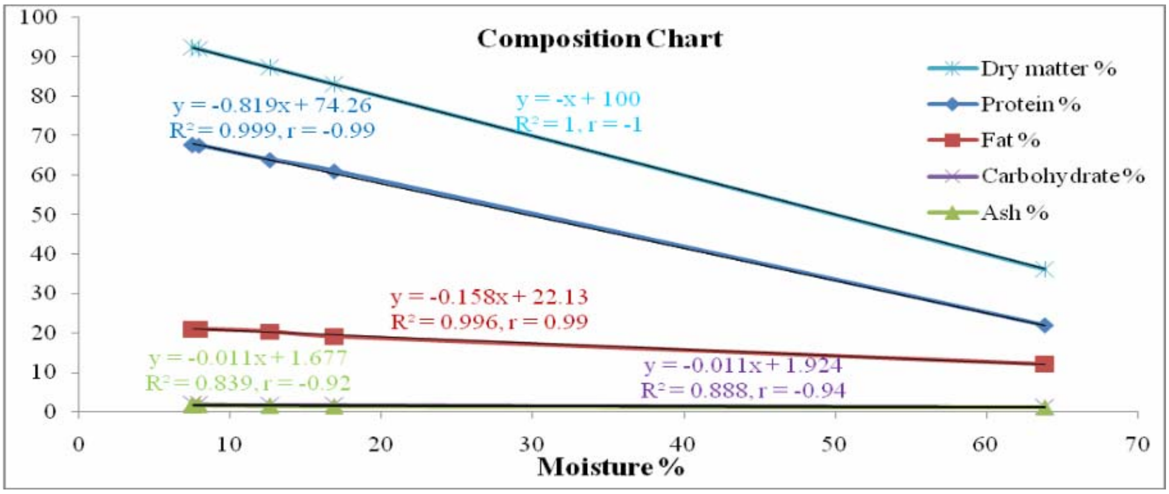

Figure 4. Effect of Drying on Chevon for sample 3

Table 6. Mean sensory scores of chevon

Drying Stage	Color	Texture	Aroma	Appearance	Overall Acceptability
S_3W_1	7.6^a	7.7^a	7.6^a	7.7^a	7.6^a
S_3W_2	6.6^b	6.3^c	6.6^b	6.7^c	6.4^b
S_3W_3	6.7^b	6.4^c	6.7^b	6.7^c	6.7^b
S_3W_4	6.4^b	6.4^c	6.7^b	6.3^c	6.7^b
S_3W_5	7.4^a	7.2^b	7.3^a	7.3^{ab}	7.5^a
S_3W_6	7.3^a	7.2^b	7.6^a	7.2^b	7.9^a
LSD	0.4348	0.4706	0.4329	0.4310	0.5560
CV	6.89%	7.60%	6.79%	6.85%	8.65%

In a column, figures having similar superscript(s) do not differ significantly where as figures bearing dissimilar superscript(s) differ ($p < 0.05$) significantly (as per DMRT).

Drying Rate

The drying rate was very fast in the first week and gradually decreases in span of time. After third week drying the rate of moisture removal was very slow.

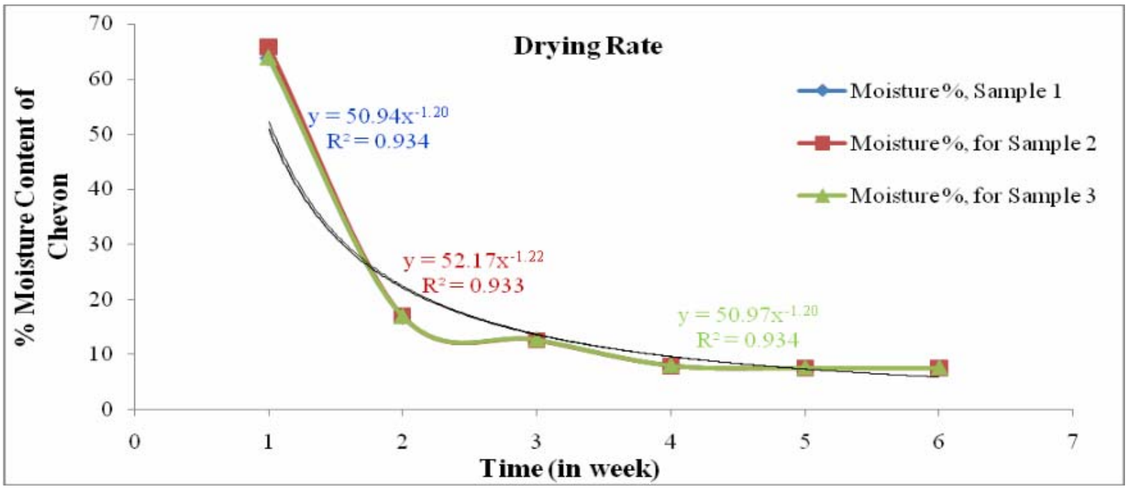

Figure 5: Drying Rate

Shelf life study

Three different samples of dried goat meat were used for storage studies at room temperature (20-25^{0}C) for four months. The effect of storage time on physical properties such as color, flavor and texture of the dried goat meat were studied. The dried meat was packaged in polyethylene packs. All the processed samples of dried goat meat were in good condition up to four months of storage. From the shelf life study it is evident that the durability of the product was very high and will be safe for six months to one year.

Sensory quality

A two-way analysis of variance (ANOVA) was carried out to determine the difference between the products at 5% level of significance. The results showed that the products were significantly different. Duncan's Multiple Range Test (DMRT) was carried out for color, texture, aroma, appearance and overall acceptability and results revealed that there was significant ($p < 0.05$) difference in acceptability among all the samples. The sample 3 after 5th week drying was highly acceptable securing mark 7.9 out of 9.

Meteorological Information

The meteorological information in terms of average dry bulb temperature of air ^{0}C and relative humidity is given below

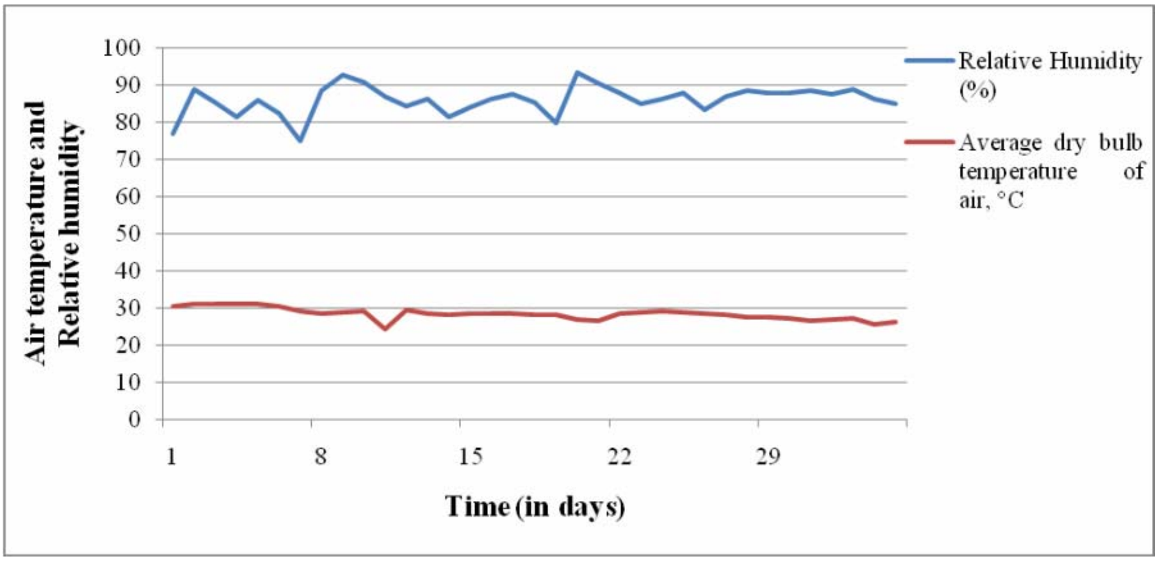

Figure 6. Trend of average air temperature and relative humidity

Summary and Conclusion

The composition of raw meat were 65.34% moisture,20.14% protein, 13.06% fat, 1.12% carbohydrate, 1.01% ash and energy 554 kcal/100 gm. The composition of dried meat were 7.6% moisture, 67.2% protein, 21.1% fat, 1.83% carbohydrate, and 1.67% ash which is highly different. The chemical analysis showed that moisture content was highly reduced in all the samples. The protein percentage of the dried meat was highly increased after drying. But the percentage of fat slightly increased and was relatively lower than protein percentage.

The chemical analysis also showed that ash and carbohydrate percentage increased very slightly in the dried meat. Duncan's Multiple Range Test (DMRT) showed that there was significant ($p > 0.05$) difference among all the samples and raw meat has greater appearance but lower acceptability than the dried meat. The sample 3, after 5th week drying was highly acceptable securing mark 7.9 out of 9. The sun dried samples had higher functional properties, nutritional level and greater acceptability compared to the raw meat. So meat pieces with 1 cm thickness are recommended for drying under hygienic condition.

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