



A Study On The Effect Of Kms Blanching On The Drying Characteristics Of Carrot (*Daucus Carota*) Slices

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Abstract: Carrot is the most important vegetable grown throughout the world, as it is a very good source of β - carotene, α -carotene. The post-harvest losses because of having high moisture content limit the utilization of carrot. The present study focused on the effect of different drying temperature that is 60°C, 70°C and 80°C on different thickness of carrot slices, in combination with pretreatment of KMS (potassium metabisulphite) The result from the experiment indicate that with increase in thickness of the carrot slices the drying time to attain the equilibrium also increases. The time taken for drying was more for blanched sample as compare to the control sample, as blanching involves the immersing of food in boiling water, which can increase its water content. Therefore, the blanched sample take longer time to dry. It also indicates that the moisture ratio of the blanched sample is lower than that of control sample after drying.

Index Terms - Carrot slices, KMS, Blanching, Hot water, Drying

Introduction

Carrot (*Daucus carota*) belongs to the Apiceae family. It is a commonly grown vegetable which was originated around northwest India in Asia. As carrots are fresh root vegetables they grown as annual vegetables. About 2000 to 3000 years ago carrots were cultivated for medicinal purpose. Carrots are cultivated and produced for various uses both in fresh and processed form. As carrots are fresh root vegetables they grown as annual vegetable (Prasad, 2021). Carrots are the fleshy edible roots which are rich and cheap sources of dietary fibers, beta carotene, vitamin C, vitamin K, potassium and non-nutritive bioactive phytochemicals. Except carrot carotenoid pigments are not usually present among root vegetables. Increased consumption of fruits and vegetables decreases the risk of various diseases like cancer (Bansal,

2016). Red carrots are generally a source of lycopene which is an effective anti-cancerous carotenoid (Prasad, 2021). Carrot as a temperate crop usually cultivated in India during winter season. These are rich in phytonutrients, vitamins and minerals and rank seventh among fruits and vegetables in overall contribution to nutrient. New carrot derived products found to have increased consumption rate in recent years

(Bansal, 2016). Carrots are root vegetables known for their vibrant orange color, though they can also be found in other colors like purple and white. They are rich in beta-carotene, which is converted into vitamin A in the body, promoting good vision and overall eye health.

Carrots are also a good source of fiber, vitamins, and minerals. They can be enjoyed raw, cooked, juiced, or incorporated into various dishes such as salads, soups, and stir-fries. Additionally, carrot tops (the greens) are edible and can be used in salads or as a garnish (Hossain, 2015).

Carrots are rich in carotene, ascorbic acid and contain more moisture, fat, carbohydrate, sugar and fiber. Due to the presence of terpenoids and polyacetylenes, it gives a characteristic flavor. The different colored root gives medicinal properties towards human health due to

presence of different pigments. The pigments present in carrot helps to develop macular pigment which is essential for functioning of eye (Anon, 2014). Carrots can be eaten either raw or cooked. Some value-added products also made from carrot are wine, soup, jam etc.

Carotenoids and dietary fibers found rich amount in carrot. The carrot shows anti-oxidant and anti-cancer activity. Carrots can be used commercially by converting it into nutritionally rich product like juice, dried powder etc. (Dubey and S.K, 2015). The β carotene present in cake helps as a supplement in cake. Different types of carrot have been found that is emperor carrot; having a small shoulder with tapered

tip, Nantes carrot have a blunt tip with medium length, large and medium length carrots are called Danvers, carrots have large shoulder with short height are called chastered (Kelley, 2012). The carrots are also varying upon size. They may taste lightly sweet or can taste earthy or bitter (John, 2010). When the vegetables are supplied abundantly, then there is a chance of spoilage of the vegetables, in order to avoid this

preservation is the best method to store food for a long time by increasing their shelf life and available them in the off-season period (Sharma

and Dubey, 2017). Carrot is highly nutritious as it contains vitamins like B1, B2, β carotene etc. The β -carotene helps to prevent cancer as it is the precursor of vitamin A (Navazio, 2012). Drying is the most traditional method to preserve the food, but blanching is done before drying in

order to inactivate all the enzymes which may lead to deterioration of the food. In the process of dehydration, the products are dried and no moisture is present inside the food, the moisture is totally removed in order to control the growth of microorganisms (Singh and

S.K, 2013). In some area sun drying is used in a popular method as it is the most budget friendly way. The carrots are spread in a large area where they are exposed to sunlight and the dehydration process occur, it may lead to change in color, texture, taste due to the direct exposure

of sunlight (Wang, 2015). But the disadvantages of this process are sun drying is a climate dependent process, we cannot undergo the process in cloudy weather. It also depends on air velocity, humidity, etc. If the food is not dried in a particular time period, then there is a chance of

spoilage in a large manner (Goyal, 2014). As the demand of the growing population is increasing day by day on conventional food, different air dryers are used to dry the food as the dryer helps in uniform drying method. In the driers the food products are exposed to hot air with

desired amount of temperature and velocity, which result in moisture migration from the surface of food.

As the uniform amount of hot air is blown, the products are dried uniformly, the drying time may varies depending upon the type(species), size and thickness of the food (Radhika and Satyanarayana, 2011).

1.2 ORIGIN, DISTRIBUTION AND PRODUCTION OF CARROT

The wild carrot is considered as the ancestor of domestic carrot (*Daucus carota*). Both the wild carrot and the domestic carrot

co-exist in this present world. Generally, the wild carrots are domestic to the area of Asia and some parts of Europe (Dahham, 2015).

Approximately about 10000 years ago the carrots seeds were found for medicinal purpose. The carrots were generally originated in

Himalayas and Hindu Kush centre of the continent and it moved both in the direction of Silk Road. The Silk Road was established during the period of Hans Dynasty of China and it was generally a network of trade route established for the commercial purpose

(Shebaby, 2014). Generally, it is considered that the purple rooted carrot (a variety of carrot) was found at the meeting area of

Himalayas and Hindu Kush mountains in the region of Afghanistan. It was domesticated in Afghanistan and the nearby regions of India, Pakistan, Russia, Iran and Anatolia (Shebaby, 2015). The carrot is assumed to be originated from the purple rooted carrots with anthocyanins as well as the yellow rooted mutant which

lacks anthocyanins. These forms of carrots were spread to the East and West regions of Asia around 10th or 11th century. Later it spread to Arab occupied Spain around 12th century, China in 13th century, Northwest Europe by the 14th century and England by the early 15th century. The purple rooted carrot along with the yellow mutant form spread to the Mediterranean region and the western part of Europe in 11 to 14th centuries and to China, India and Japan in between 14 to 17th centuries. The white colour carrot was first found in the 14th century (Shebaby, 2017). The orange root carrots were found in the area of Spain and Germany by 15th or 16th century and soon became the famous colour. It is found that these carrots were sweeter as compare to the purple and yellow one and they did not stain the utensils and food items (Zgheib, 2014). All these characteristics made it famous than other varieties of carrots. Before 16th century the carrots are generally purple rooted and yellow rooted. The purple rooted carrots are rich in anthocyanin and because of this reason the yellow carrots were preferred because they did not release any anthocyanin during cooking process. In the late 15th century the Dutch people developed a deep orange variety of carrot which became popular in the 16th century and also considered as the ancestor of the carrot we know (modern cultivated carrots) (Daaboul, 2018). Different varieties of carrots were developed in different region of the globe. In 10 to 11th centuries the purple rooted and the yellow carrots were appeared in the area of Syria, North Africa and Spain. By 12 to 14th centuries there is a wide variety of carrots like purple, yellow red, white was found in the region of Italy, China, France, Germany, the Netherlands and England. Later in between 15 to 17th century red, yellow, purple, orange and white carrots were appeared in some parts of England, Northern Europe and Japan, North America. *Daucus* consist of about 20 species which are found in the area of Mediterranean region. The wild carrot mainly found in the high-altitude region of Europe, west Asia, northern Africa and local regions of tropical Africa (Sela, 2015).

1.3 VARIETIES OF CARROT

There is a wide variety of carrots are cultivated all over the world. Each carrot has had their own specific characteristics and morphology. Some of the different variety of carrots are given below: **Imperator:** These are the long root carrots approximately about 10 inches in length. The imperator carrot contains high sugar in it and these are very good in look and taste. These are very good for freshly eating and often preferred in salad items (Arunkumar, 2014). **Danvers:** These are the deep orange colour carrots with medium length, rounded body and pointed end. These are approximately about 6 to 7 inches long. This type of carrots is well known for their vibrant colour, excellent taste and storage quality (Terrazas, 2017). **Nantes:** These carrots are cylindrical in shape with a blunted tip. These carrots are almost colourless and often used in salad making and fresh eating. (Thakre, 2018) **Chantenay:** Chantenay carrots are the bulky, short conical rooted carrots. It can be used in both raw and cooked form (Arunkumar, 2014). **Rainbow carrots:** Generally, carrots are orange in colour but the carrots which are cultivated earliest in Afghanistan were purple, red or yellow in colour later the Dutch people created the orange variety of carrot in about 17th century (Dias, 2019). **Purple carrots:** These are the variety of carrots which contains antioxidant i.e anthocyanin. It provides a spicy flavor and often used in making soup, salad, snacks and juices (Thakre, 2018) **Yellow carrots:** It is the variety of carrot which is the hybrid of both orange and yellow varieties of carrots. It does not contain anthocyanin and basically prefer for cooking, juice making etc. (Dias, 2019). **White carrot:** These are the variety of carrots which are colourless still very sweet in taste. These are about 6 to 8 inches in length. These carrots have a mild and natural taste and are typically sweeter than the orange carrots (Arunkumar, 2014).

1.4 NUTRITIONAL INFORMATION AND HEALTH BENEFITS

Nutritional value: The following table showing the nutritional value of 100 gm of carrot.

Water	88%
Calories	41
Protein	0.9grams
Carbs	9.6 grams
Sugar	4.7grams
Fiber	2.8 grams
Fat	0.2 grams

Table 1.1: Nutritional value of carrot

Carrots are rich in multiple variety of vitamin, minerals and other beneficial things which provides multiple health benefits like: Source of antioxidants: Carrots are colourful vegetables rich in high number of antioxidants. Antioxidants are found in the form of vitamins, carotenoid and polyphenol. Orange carrots are rich in carotenoids which a powerful antioxidant and it have the ability to counteract the effect of free radicals (Singh D, 2020). Immune-booster and Anticarcinogen: Carrot contains the antioxidant carotenoid which have a strong ability to reduce free radicals and ultimately helps in reducing the chance of cancer in the body. It was proven to reduce cancers like breast cancer, lung cancer etc. It is rich in vitamins like vitamin C, B, K which helps in boosting the immune system (B. Cotes, 2018). Provides protection against sun damage: Carrot contains many derma-friendly ingredients, one of the most important ingredients is beta-carotene which is converted into vitamin A inside the body and provides protection against the harmful damage from sun rays and helps in tissue rejuvenation (S. Varanasi, 2018). Management of dental health: Carrot contains a variety of nutrients that provides protection against various damage causing bacteria and prevents tooth decay (Y. Zou and A. Jiang, 2016).

1.5 PROCESSING AND VALUE ADDITION

Value addition of carrots involves transforming raw carrots into processed or value-added products that offer higher market value, convenience, and versatility. Some examples of value-added products made from carrots are carrot soup, carrot salad, carrot puree, carrot juice, carrot chips, carrot powder, carrot jam or chutney, carrot cake or muffins etc. (Praanjal, 2023). By adding value to carrots through processing and creating these value-added products, producers can cater to diverse consumer preferences, extend the shelf life of carrots, and increase their profitability in the market (Tushir, 2017).

2. POST HARVEST MANAGEMENT OF CARROTS BY DRYING METHOD

Post-harvest management of carrots by drying involves several steps to ensure the quality, safety, and shelf stability of the dried product. There are several methods for drying carrots, including air drying, sun drying, oven drying, and using food dehydrators. Each method requires proper ventilation, consistent temperature control, and adequate airflow to ensure even drying and prevent spoilage (Shafiq, 2018).

2.1 PRE-TREATMENT (BLANCHING) BEFORE DRYING

Blanching involves briefly immersing the prepared carrots in boiling water, followed by rapid cooling in ice water. Blanching helps to stop enzymatic activity, remove any surface contaminants and preserve color. The blanching time may vary depending on the size and thickness of the carrot pieces (Iqbal, 2018). It is a widely used method used in fruits and vegetable processing companies prior to freezing, canning, drying and other suitable processing techniques (Felipe Richter Reis, 2023). It is a pre- heat treatment before drying, freezing or canning usually conducted to modify texture and to inactivate the deleterious enzymes (Eun-Ho Lee, 2021). In order to avoid deterioration in texture, flavor, color and nutrient. Blanching is of various types i.e water blanching, steam blanching (Rana Muhammad Adil, 2019) in-can

and vacuum steam blanching. The most common blancher type is water blancher, with screw/belt conveyor, where the water is heated up to

100°C and depending on product the goods are either immersed with it. It results in increased leaching of minerals and nutrients such as vitamins and produces effluents with large biological oxygen demand (Felipe Richter Reis, 2023). In steam blancher food grade steam is

diffused in to closed chambers and forced with fans to increase heat transfer. It reduces high temperature, gradient between the surface and center of goods that are blanched. It is more energy efficient and produces lower biological oxygen demand and hydraulic loads than water

blanching (Fellows, 2019). Can-blanching done for canned foods which helps to remove inter-cellular gases from plant tissue, it also assists

the formation of partial vacuum in the head space. Vacuum steam blanching is an innovative steam blanching method where the air and water

vapor are expelled by the vacuum pump to facilitate steam deep penetration in the materials to improve blanching efficiency and uniformity

(M.A. Karim, 2021). Previously it was studied that vacuum steam blanching could soften texture and reduce the drying time of carrot but mechanism was not clear (Lei Gao, 2021) but currently it is clear that the vacuum steam blanching soften texture and enhances drying rate of carrot via micro-ultrastructure modification, here it comes for understanding and controlling the blanching triggered texture formation and

drying enhancement (Jafar and Hosseini, 2017). In the pre-treatment of carrot, white particles are formed in the secondary phloem (Lee Kim and Han, 2018). Blanching treatment also done chemically by using potassium metabisulphite (0.1%), NaHCO₃ (0.1%), NaCl (1%), CaCl₂

(0.5%), in water at 100°C for 180 seconds and steam blanching for 300 seconds, it has better retention of ascorbic acid (Navneet Kaur, 2018).

The blanching treatment reduces the total phenolic compound, so that it prevents enzymatic browning reaction and also improve the supply of protein and soluble fibers (Wallaf Costa Vimercati, 2021).

Microwave blanching is a heat treatment given to biomaterials, which has the advantage of volumetric heating, lower nutrient loss and high-quality end product (Xiao, 2017). The influence of blanching on frozen products of carrot determine the quality and shelflife of product during storage.

2.2 DRYING RATE
Drying is a most preferable and ancient method of food preservation. Various drying techniques are there, but we have to choose the

proper method in order to increase the shelf life of the product, by decreasing their moisture content (N. Naemeka and R. Nwakuba, 2023). It is the most expensive and time consume process in post-harvest operation. It is the process of removing moisture in a product up to certain

threshold value in order to decrease water activity to reduce physical damage by reducing microbiological activity. Drying rate refers to the speed at which moisture is removed from a substance during drying, it can be influenced by several factors like temperature, humidity, air flow and the properties of that particular food product (Charles Nwajinka, 2016).

2.2.1 INFRARED ASSISTED HOT AIR DRYER

In the food industry, infra-red assisted hot air dryer is often utilized for various purpose such as drying of fruits, vegetables and,

spices etc. (A. Sayaslan, 2019). Hot air drying is most common drying method. Microwave drying is widely used by the researcher because

of its high drying velocity, relatively low energy consumption etc, but if microwave dryer is used continuously then there is a high chance of the product to be deteriorated. The vacuum drying also used by the researcher but due to its high price it cannot be used widely. Freeze

drying is a method where we can dry the product in low energy consumption with color preservation but the drying time is relatively long and drying cost is high (Ishwarya, 2015). Therefore, the infrared assisted hot air dryer, microwave infrared dryer becomes very popular.

(Geranpour and Jafari, 2020). Infra-red radiation is a form of electromagnetic wave radiation from a heat source. The electromagnetic wave does not require any medium, it directly propagate in vacuum. A control system is used to regulate various parameter of the drying process

such as temperature. The infra-red dryer was design with 250w/500w lamp. The system should be switch on before half an hour, when the desired temperature level attains we can keep our sample using a petri dish (A. Sayaslan, 2019). The infra-red energy absorbed by the different layers of molecule and which prevents the energy loss and maintain the original quality of product (Pawar and Pratape, 2017). Infrared drying can be successfully applied to carrot, potato, yam. Heat sensitive food products should be avoided. (Barzegar, zare and stroshine, 2019). The experiment is done examining the efficient drying procedure with the help of infrared radiation This paper helps us to know about that how infrared was made up, in which principle it works, it may result to enhanced drying efficiency or not whether it decreases drying time and it helps to improve the quality of dried product in terms of sensory aspects (B.A. Eke, 2013). The experiment helps us to provide a basic in order to identify suitable drying methods and modes to enhance efficiency and product quality. The infrared part of electromagnetic spectrum falls between microwave and visible regions. The wavelength of infrared wave is from 0.75 to 1000 μ m (P. Gbaha, 2017). The infrared assisted hot air dryer was designed to undergo drying experiments to retain the moisture content of a food product. Here we dried our sample at temperature 60°C, 70°C and 80°C to gain the equilibrium moisture content. In infrared assisted hot air dryer, the infrared penetrates in to the surface of the food and helps to remove the moisture content (H. Atalay, 2019). Infrared dryers are often considered effective because they use infrared radiation to penetrate the object being dried, heating it from the inside out. This can result in faster drying times and more even drying compared to traditional dryers, which rely on convection or hot air (S. Dhanushkodi, 2014). Additionally, infrared dryers can be more energy efficient and gentler on delicate materials, making them a preferred choice in industries such as textile manufacturing and food processing, so the infrared dryer is considered as best among all dryers (Kaustav Bharadwaj, 2017).



Fig 1.1: Infra-red assisted hot air dryer

The infra-red assisted hot dryer is a compact drying equipment. The emmitors of this dryer can be adjust in length. It helps in fast evaporation of the product; the investment cost of the electricity is also low. For gas operated infrared assisted hot air dryer operation cost is low (A.R.H. Rigit, 2013).

3.OBJECTIVE

We are choosing drying over frying because drying is a healthier option, as here oil is not required. Dried foods have longer shelf life than the fried foods. The fried foods can not be stored for longer time period, as it may lead to nutrient loss due to high heat and oil exposure.

Drying is a budget friendly method. Before drying we undergo blanching in order to remove the surface dirt and micro-organism. It increases the shelf life period of the food, by deactivating the enzyme which may cause deterioration of color, flavor and texture. It also helps to preserve the quality of vegetables and

preserve the nutritional content. We are basically performing this experiment in order to study the effect of kms blanching on samples of carrots of different thickness on passing through the infrared assisted hot air dryer. The Major objectives of the Project were 1. To evaluate the effect of KMS blanching on the drying rate of carrot slices:

- This objective will involve comparing the drying times of KMS blanched and unblanched carrot slices

under controlled conditions.

- The drying rate will be measured by monitoring the weight loss of the slices over time.

2. To optimize the KMS blanching conditions for drying carrot slices:

- This objective will involve investigating the effect of different KMS blanching parameters, such as

temperature and time, and on the drying characteristics and quality of dried carrot slices.

- The optimal blanching conditions will be identified based on the results obtained from the

experiments.

4.MATERIALS AND METHODS

4.1 LABORATORY EQUIPMENT

The equipment used here was of standard quality;

- 1.Petri dish
- 2.Peeler
- 3.Distilled water
- 4.beaker
5. Potassium meta bisulphite
- 6.Tissue paper
- 7.carrot
8. steel container
9. Plastic container
- 10.Induction
- 11.Knife
12. Electronic weight machine

4.2 SAMPLE PREPARATION

Carrot (*Daucus carota*) were collected from local market of paralakhemundi, dist. gajapati, Odisha and transported to lab of

centurion university of technology and management, paralakhemundi. Carrot were washed with fresh water in order to remove adhering soil, dust particles and peeled manually using stain less steel peeler. The carrot is now cutted in to 2mm and 4mm thickness .5 gm of KMS was taken per 100ml of water and the solution was prepared.2mm thick carrot are pretreated in KMS solution for 1 minute, and 4mm thick carrot blanched in kms for 2 minutes. After pretreatment slice were spread over the blotting paper to remove surface moisture for drying experiment. Another control sample was made for 2mm and 4mm thick carrot slice, which undergo bone dry for 24 hours.

4.3 DRYING OF CARROT SLICE

The drying was conducted at 60°C initially, where the infra-red dryer was run idle for about 30 minutes to stabilize the temperature. Once the temperature gets stabilize a known mass of carrot slice were kept using petri dish in the drying chamber. Then at pre-determined time interval of 30 minutes, sample were quickly taken out and weighted using electronic balance weigh machine and placed again in to the dryer

for further drying. The drying process should be continued till the constant weight of the sample achieved. Same procedure was followed for 70°C and 80°C . The control sample kept for bone dry should be taken out after 24 hour and weight should be measured. At the end of the drying the sample were cooled at room temperature and ground to make carrot flour for further studies (Vaishali and Samsher, 2010).



Fig 4.1: Drying of carrot slices

4.4 DRYING CHARACTERISTICS ANALYSIS

4.4.1 Dry matter =Initially ,7.2 gm of 2mm and 10 gm of 4mm sample was taken. After 24 hour the final weight of 2mm sample was 1gm and 4mm sample was 8. 4gm.The dry matter can be calculated by using equation 1 (Abbas, 2017).

$$\frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100 \quad (1)$$

initial weight

4.4.2 Bone dry ="Bone dry" is an expression used to describe something as completely dry, often emphasizing that there is absolutely no moisture left. It's like saying something is as dry as bones, which are naturally devoid of moisture. "Bone dry" is a term often used to describe the complete absence of moisture in a substance, typically referring to wood or other organic materials. To calculate bone dry weight, you would need to remove all moisture from the material through drying methods, such as oven drying, and then weigh the dried material. The percentage of moisture content can be calculated by comparing the weight before and after drying. It should be calculated by using equation 2 (Horn, 2016).

$$\text{Bone dry} = 100 - \text{dry matter} \quad (2)$$

4.4.3 Moisture content (wet base%) Moisture content wet basis refers to the amount of moisture present in a substance as a percentage of the total wet weight of the substance, it was calculated by using equation 3 (Abbas, 2017).

$$\frac{\text{moisture content (wet base\%)} = \text{sample weight} - (\text{bone dry} \times \text{sample weight})}{\text{sample weight}} \times 100 \quad (3)$$

sample weight

4.4.4 Moisture content (dry base%)

Moisture content (dry base%) was calculated by using equation 4 (Akbarnejad, 2017).

$$\text{moisture content (dry base\%)} = (w^b \div (1 - w^b)) \times 100 \quad (4)$$

100 100

4.4.5 Moisture ratio

Moisture ratio can be calculated by using equation 5 (Bispo, 2015).

$$\text{moisture ratio} = \frac{\text{initial dry base (\%)}}{\text{final dry base (\%)}} \quad (5)$$

5. RESULT AND DISCUSSION

5.1 ESTIMATION OF DRY MATTER

Initially, 7.2 gm of 2mm and 10 gm of 4mm sample was taken. After 24 hour the final weight of 2mm sample was 1gm and 4mm sample was

8.4gm. The dry matter can be calculated by using equation 1. The dry matter of 2mm sample was 86.11%, the dry matter of 4mm sample

77%.

5.2 ESTIMATION OF MOISTURE CONTENT (DRY BASE%) WITH DRYING TIME:

The moisture content of blanched sample is typically lower as compare to control sample as shown in table. The initial moisture

content (dry base%) of 2mm control sample was 650 and 631.7073 for kms blanched sample. After drying at 60°C the moisture content db%

become 8.43 and 7.317 for control and blanched sample respectively. The time taken for drying was 180 minutes for both the sample (Table no 5.1 and 5.2). The initial moisture content db% for 4mm control is 335.364 and for kms blanched solution is 334.782. After drying at 60°C the final moisture content db% becomes 8.4695 and

7.8904 for control and kms blanched respectively. The drying time varies between 180 minutes to 240 minute, here blanched sample take more time to dry than the control sample (shown in table 5.3 and 5.4).

The initial moisture content db% of 2mm control was 620 and KMS blanched sample was 620, but after drying at 70°C the final moisture content db% was 12 and 0.108 for control and blanched sample respectively. The drying time varies from 90 to 180 minutes, here the control sample took more time to dry (shown in table 5.5 and 5.6).

The moisture content of db% of 4mm control sample was 334.782 and for kms blanched 334.782609 initially. After drying at 70°C the final moisture content of control and blanched sample become 4.347 and 6.5217 respectively. The drying time varies from 210 to 240 minute, here the control sample take more time to dry then blanched sample (shown in table 5.7 and 5.8). The moisture content db% of 2mm was 621.1583 and 609.090909 for control and kms blanched respectively. After drying at 80°C the moisture content db% becomes 5.769 and

5.4545454 for control and kms blanched respectively. The drying time varies from 150 to 180 minute, here blanched sample took more time to dry than the control sample (shown in table 5.9 and 5.10). The moisture content db% for 4mm control sample was 335.43544 and KMS

blanched sample was 334.968017 initially. After drying it under 80°C the final moisture content db% becomes 7.2072072 and 6.6098081 for control and KMS blanched sample respectively. The drying time varies from 150 to 180 minutes, here the blanched sample took more time to dry (shown in table 5.11 and 5.12).

Table 5.1: Moisture content (dry base%) and moisture ratio of 2mm control sample at 60°C.

Time (60 °C) 2mm control	Weight (g)	Moisture removed (g)	Moisture content (wb%)	Moisture Content (db%)	Moisture ratio
0	12	0	86.17	650.00	1.00
30	6.4	5.6	74.06	285.54	0.44
60	3	9	44.67	80.72	0.12
90	2.3	9.7	27.83	38.55	0.06
120	2	10	17.00	20.48	0.03
150	1.9	10.1	12.63	14.46	0.02
180	1.8	10.2	7.78	8.43	0.01

Table 5.2: Moisture content (dry base%) and moisture ratio of 2mm KMS blanched sample at 60°C.

Time (60°C) 4mm control	weight(g)	Moisture removed (g)	Moisture content (wb%)	Moisture content (db%)	Moisture ratio
0	30	0	86.333	631.70731	1
30	25	5	83.667	509.75609	0.8069
60	18	12	77.222	339.02439	0.5366
90	12.4	17.6	66.9354	202.43902	0.3204
120	7.3	22.7	43.8356	78.048780	0.1235
150	5.1	24.9	19.6078	24.390243	0.0386
180	4.4	25.6	6.81818	7.3170731	0.0115

Table 5.3: Moisture content (dry base%) and moisture ratio of 4mm control sample at 60°C.

Time (60°C) 4mm Moisture control (db%)	Weight(g)	Moisture removed (g)	Moisture content(wb%)	moisture content	ratio
0	29.3	0	77.03071672	335.3640	1
30	22.7	6.6	70.35242291	237.2956	0.7075
60	16.8	12.5	59.94047619	149.6285	0.4461
90	13.4	15.9	49.7761194	99.1084	0.2955

120 9.7 19.6 30.6185567 44.1307 0.1315 150 7.3 22 7.808219178 8.46953 0.0255

Table 5.4: Moisture content (dry base%) and moisture ratio of 4mm KMS blanched sample at 60°C.

Time (60°C) 4mm KMS	Weight(g)	Moisture removed (g)	Moisture content(wb%)	moisture content (db%)	Moisture ratio
0	27	0	77	334.7826	1
30	20	7	68.95	222.0611	0.663299
60	15	12	58.6	141.5458	0.422799
90	11.6	15.4	46.46551724	86.7954	0.259259
120	8.4	18.6	26.07142857	35.2657	0.105339
150	7.9	19.1	21.39240506	27.2141	0.081289
180	7.4	19.6	16.08108108	19.1626	0.057239
210	6.8	20.2	8.676470588	9.50080	0.028379
240	6.7	20.3	7.313432836	7.89049	0.023569

Table 5.5: Moisture content (dry base%) and moisture ratio of 2mm control sample at 70°C.

Time (Control) 70°C,2mm	Weight(g)	Moisture removed (g)	Moisture content (wb%)	moisture content (db%)	Moisture ratio
0	4.5	0	86.1111	620	1
30	2.5	2	75	300	0.48387
60	1.8	2.7	65.2778	188	0.30322
90	1.5	3	58.3333	140	0.22580
120	1.2	3.3	47.9166	92	0.14838
150	1	3.5	37.58	60	0.09677
180	0.7	3.8	10.7142	12	0.01935

Table 5.6: Moisture content (dry base%) and moisture ratio of 2mm KMS blanched sample at 70°C

Time (KMS) 70°C,2mm	Weight(g)	Moisture removed (g)	Moisture content(wb%)	moisture content (db%)	Moisture ratio
0	8	0	86.125	620.7207207	1
30	3.2	4.8	65.3125	188.2882883	0.30333
60	2.2	5.8	49.54545455	98.1981982	0.15820
90	1.2	6.8	7.5	8.108108108	0.01306

Table 5.7: Moisture content (dry base%) and moisture ratio of 4mm control sample at 70°C.

Time(control)	Weight(g)	Moisture removed (g)	Moisture content (wb%)	moisture content (db%)	Moisture ratio
70°C,4mm	g	(g)	(wb%)	(db%)	
0	5	0	77	334.7826087	1
30	4.5	0.5	74.444444	291.3043478	0.87012
60	3.6	1.4	68.055555	213.0434783	0.63636
90	2.9	2.1	60.344827	152.173913	0.45454
120	2.6	2.6	52.083333	108.6956522	0.32467
150	1.9	3.1	39.473684	65.2173913	0.19480
180	1.5	3.5	23.333333	30.43478261	0.09090
210	1.4	3.6	17.857142	21.73913043	0.06493
240	1.2	3.8	4.1666667	4.347826087	0.01298

Table 5.8: Moisture content (dry base%) and moisture ratio of 4mm kms blanched sample at 70°C.

Time (KMS)	Weight(g)	Moisture content (wb%)	Moisture content (db%)	Moisture removed (g)	Moisture ratio	70°C,4mm	ht(g)	removed (g)
0	20	0	77	334.782608	1			
30	14	6	67.142857	114	204.347826	0.610389	60	13.3
60	11.9	8.1	61.34453782	158.695652	0.474025	120	9.3	10.7
90	10.2	17.3913	0.305194					
150	6.7	13.3	31.34328358	45.6521739	0.136363			
180	5.2	14.8	11.53846154	13.0434782	0.038961			
210	4.9	15.1	6.12244898	6.52173913	0.019480			

Table 5.9: Moisture content (dry base%) and moisture ratio of 4mm control sample at 80°C.

Time(control)	Weight(g)	Moisture removed (g)	Moisture content (wb%)	moisture content (db%)	Moisture ratio
80°C,4mm	g	(g)	content(wb%)	(db%)	ratio
0	14.5	0	77.03448276	335.4354354	1
30	7.1	7.4	53.09859155	113.2132132	
60	5.7	8.8	41.57894737	71.17117117	
90	4.82	9.68	30.91286307	44.74474474	
120	3.79	10.71	12.13720317	13.81381381	
150	3.57	10.93	6.722689076	7.207207207	

Table 5.10: Moisture content (dry base%) and moisture ratio of 4mm KMS blanched sample at 80°C.

Time (KMS)80°C,4mm	Weight(g)	Moisture removed (g)	Moisture content (wb%)	moisture content (db%)	Moisture ratio
0	20.4	0	77.00980392	334.9680171	1
30	12.6	7.8	62.77777778	168.6567164	0.50350
60	10.7	9.7	56.1682243	128.1449893	0.38255
90	8.2	12.2	42.80487805	74.84008529	0.22342

120	6.1	14.3	23.1147541	30.06396588	0.08975
150	5.5	14.9	14.72727273	17.27078891	0.05155
180	5	15.4	6.2	6.609808102	0.01973

Table 5.11: Moisture content (dry base%) and moisture ratio of 2mm control sample at 80°C.

Time(control) 80°C,2mm	Weight(g)	Moisture removed (g)	Moisture content (wb%)	Moisture content (db%)	Moisture ratio
0	15	0	86.133333	621.1538462	1
30	8.4	6.6	75.238095	303.8461538	0.48916
60	3.9	11.1	46.666666	87.5	0.14086
90	2.4	12.6	13.333333	15.38461538	0.02476
120	2.3	12.7	9.5652173	10.57692308	0.01702
150	2.2	12.8	5.4545454	5.769230769	0.00928

Table 5.12: Moisture content (dry base%) and moisture ratio of 2mm KMS blanched sample at 80°C.

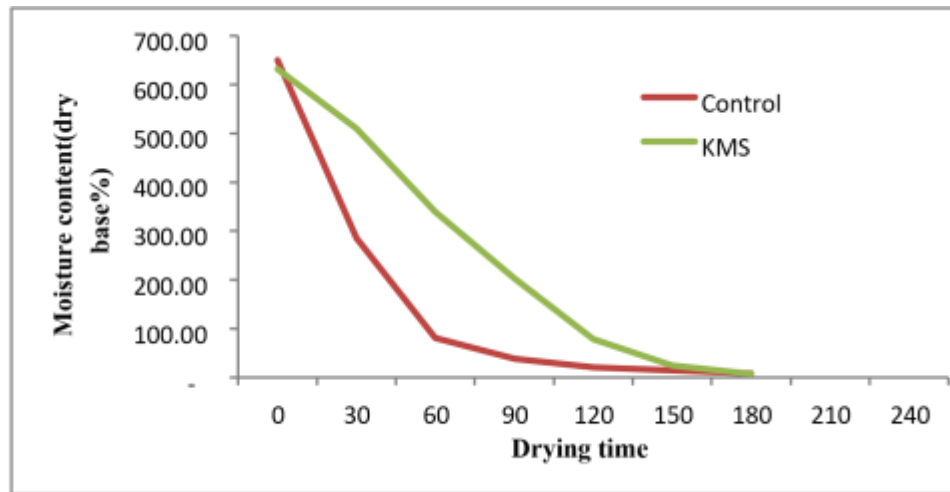
Time (KMS)	Weight(g)	Moisture removed (g)	Moisture content(wb%)	Moisture content (db%)	Moisture ratio
0	19.5	0	85.8974359	609.0909091	1
30	10.7	8.8	74.29906542	289.0909091	0.474626
60	4	15.5	31.25	45.45454545	0.074626
90	3.8	15.7	27.63157895	38.18181818	0.062686
120	3.5	16	21.42857143	27.27272727	0.044776
150	3.1	16.4	11.29032258	12.72727273	0.020895
180	2.9	16.6	5.454545455	0.008955	

5.2.1 GRAPHICAL REPRESENTATION OF MOISTURE CONTENT (DRY BASE%) VS DRYING TIME OF CONTROL AND KMS BLANCHED SAMPLE AT DIFFERENT TEMPERATURE

The following graph shows the variation of moisture content (dry base%) with drying temperature at 60°C, 70°C, and 80°C of control and blanched sample. It was observed that sample pre-treated with KMS takes more time to dry than the control sample. The moisture content of blanched sample is typically lower as compare to control sample as shown in table. The initial moisture content (dry base%) of 2mm control sample was 650 and 631.7073 for KMS blanched sample. After drying at 60°C the moisture content db.% become 8.43 and 7.317 for control and blanched sample respectively. The time taken for drying was 180 minutes for both the sample shown in figure 5.1.

Fig 5.1: Comparison of experimental moisture content (dry base %) with time of 2mm control and KMS blanched carrot sample at 60°C.

The initial moisture content db% for 4mm control is 335.364 and for KMS blanched solution is 334.782. After drying at 60 °C the final moisture content db % becomes 8.4695 and 7.8904 for



control and kms blanched respectively. The drying time varies between 180 minutes to 240 minute, here blanched sample take more time to dry than the control sample, shown in figure 5.2

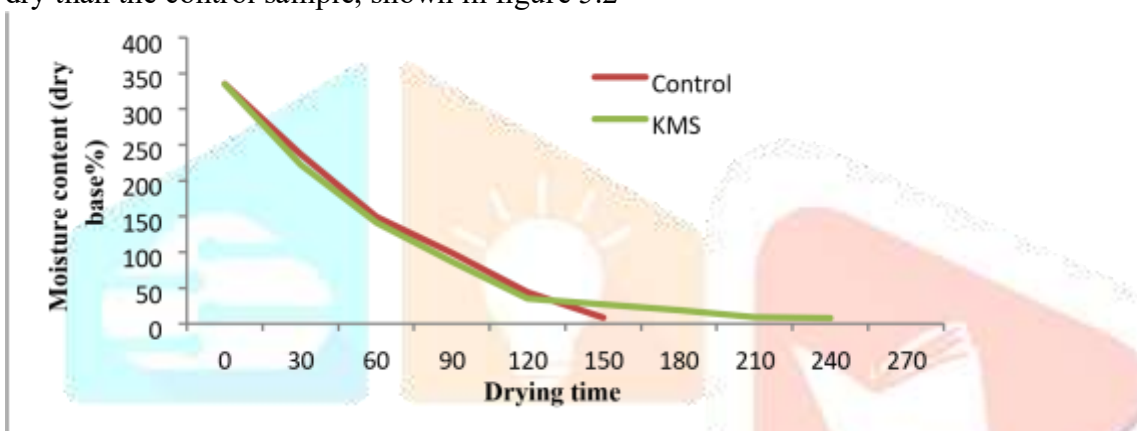


Fig 5.2: Comparison of experimental moisture content (dry base %) with time of 4mm control and KMS blanched carrot sample at 60°C.

The initial moisture content db% of 2mm control was 620 and kms blanched sample was 620, but after drying at 70°C the final moisture content db% was 12 and 0.108 for control and blanched sample respectively. The drying time varies from 90 to 180 minutes, here the control sample took more time to dry shown in figure 5.3.

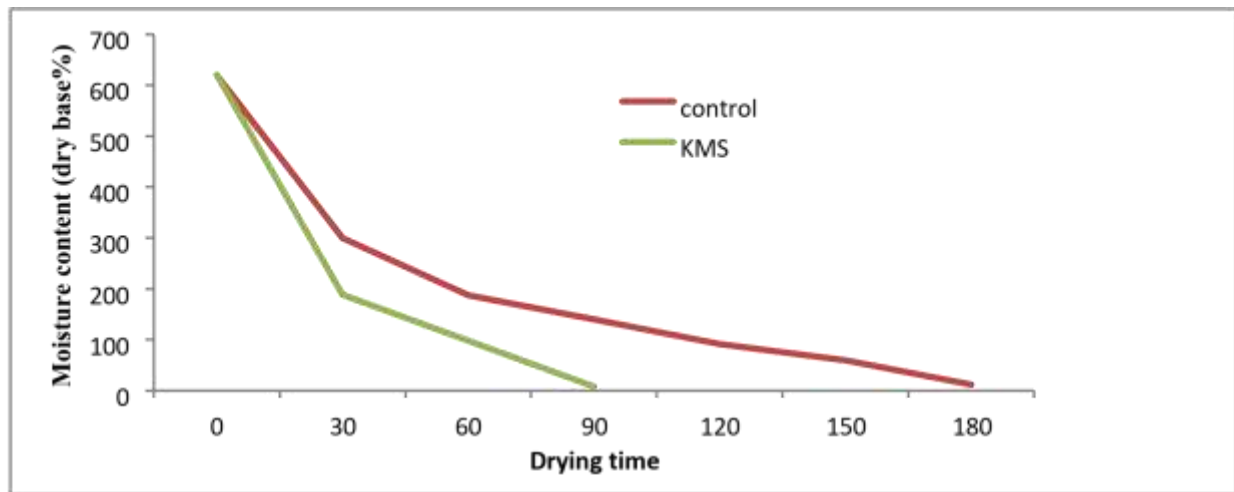


Fig 5.3: Comparison of experimental moisture content (dry base %) with time of 2mm control and KMS blanched carrot sample at 70°C.

The moisture content of db% of 4mm control sample was 334.782 and for KMS blanched 334.782609 initially. After drying at 70°C the final moisture content of control and blanched sample become 4.347 and 6.5217 respectively. The drying time varies from 210 to 240 minute, here the control sample take more time to dry then blanched sample shown in figure 5.4.

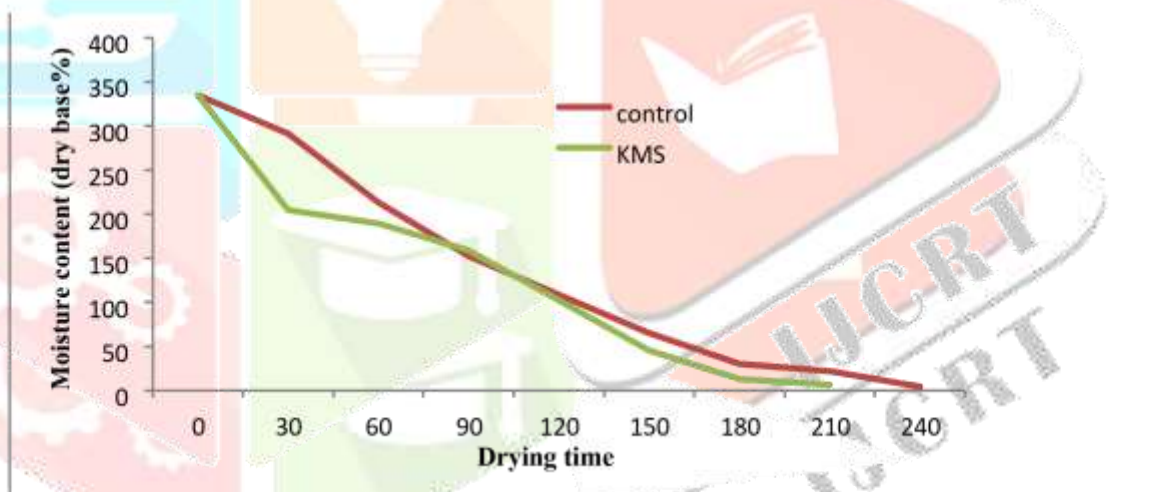
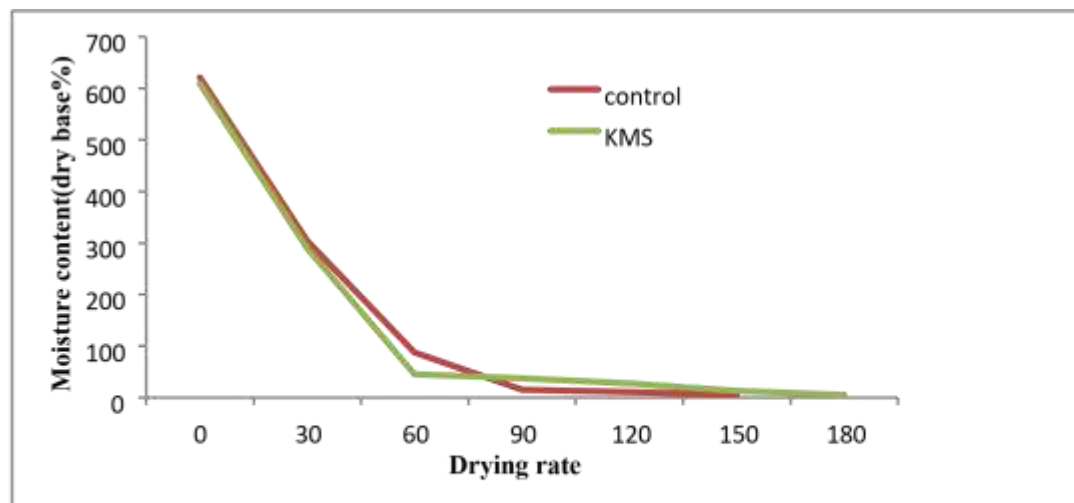


Fig 5.4: Comparison of experimental moisture content (dry base %) with time of 4mm control and KMS blanched carrot sample at 70°C.

The moisture content db% of 2mm was 621.1583 and 609.090909 for control and KMS blanched respectively. After



drying at 80°C the moisture content db% becomes 5.769 and 5.4545454 for control and kms blanched respectively. The drying time varies from 150 to 180 minute, here blanched sample took more time to dry than the control sample.

Fig 5.5: Comparison of experimental moisture content (dry base %) with time of 2mm control and KMS blanched carrot sample at 80°C.

The moisture content dB% for 4mm control sample was 335.43544 and kms blanched sample was 334.968017 initially. After drying it under 80°C the final moisture content db% becomes 7.2072072 and 6.6098081 for control and kms blanched sample respectively. The drying time varies from 150 to 180 minutes, here the blanched sample took more time to dry shown in figure 5.6.

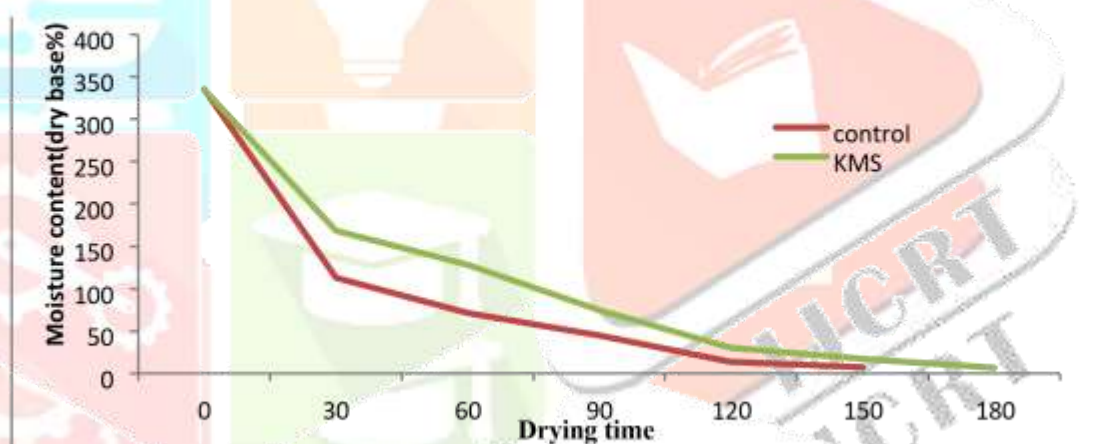


Fig 5.6: Comparison of experimental moisture content (dry base %) with time of 4mm control and KMS blanched carrot sample at 80°C.

5.3 ESTIMATION OF MOISTURE RATIO WITH DRYING TIME

The initial moisture ratio of all the control sample and all the blanched sample was 1. After drying at 60°C the moisture ratio of 2mm sample became 0.01 for control and 0.01158 for KMS blanched sample, the drying time of both control and blanched sample was same (shown in table 5.1 and 5.2). After drying at 60°C the moisture ratio of 4mm sample became 0.02525 for control and 0.023569 for KMS blanched sample, the blanched sample took more time to dry than the control sample (shown in table 5.3 and 5.4).

After drying the 2mm sample at 70°C the moisture ratio of control sample and blanched sample became 0.01935 and

0.01306 respectively, the control sample took more time to dry than the blanched sample (shown in table 5.5 and

5.6). Similarly, the 4mm thick control and kms blanched sample become

0.012987 and 0.019480519 respectively after drying at 70°C, here the control sample took more time to dry than the blanched sample (shown in table 5.7 and 5.8). The 2mm control and kms blanched sample become 0.0092879 and 0.008955224 respectively after drying at 80°C, here the blanched sample took more time to dry than the control sample (shown in table 5.9 and 5.10).

Similarly, the 4mm control and kms blanched sample become 0.0214 and 0.01973 respectively, here the blanched sample took more time to dry than the blanched sample (shown in table 5.11 and 5.12).

5.3.1. GRAPHICAL REPRESENTATION OF MOISTURE RATIO VS DRYING TIME OF KMS BLANCHED AND CONTROL SAMPLE AT DIFFERENT TEMPERATURE

The following graph shows the variation of moisture ratio with drying temperature at 60°C, 70°C, and 80°C of control and blanched sample. The initial moisture ratio of all the control sample and all the blanched sample was 1.

After drying at 60°C the moisture ratio of 2mm sample became 0.01 for control and 0.01158 for KMS blanched sample, the drying time of both control and blanched sample was same shown in figure 5.7.

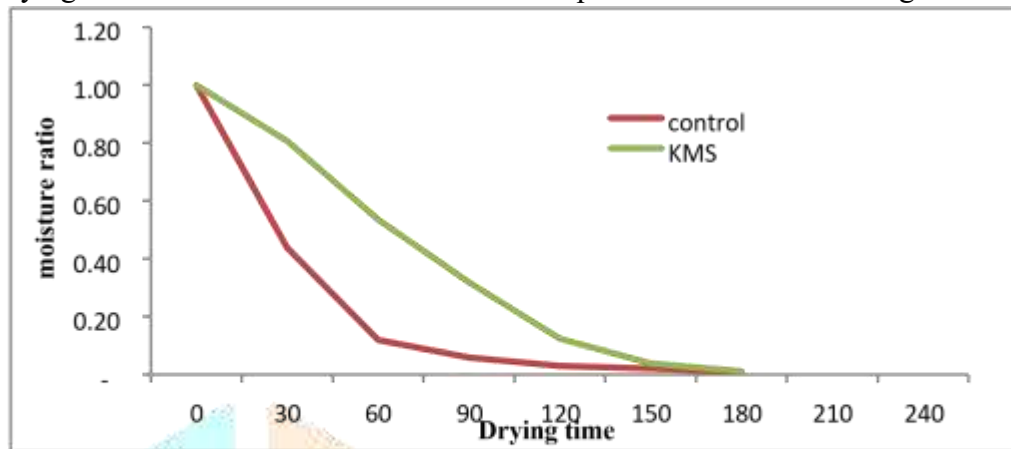


Fig 5.7: Comparison of experimental moisture ratio with time of 2mm control and kms blanched carrot sample at 60°C.

After drying at 60°C the moisture ratio of 4mm sample became 0.02525 for control and 0.023569 for KMS blanched sample, the blanched sample took more time to dry than the control sample shown in figure 5.8.

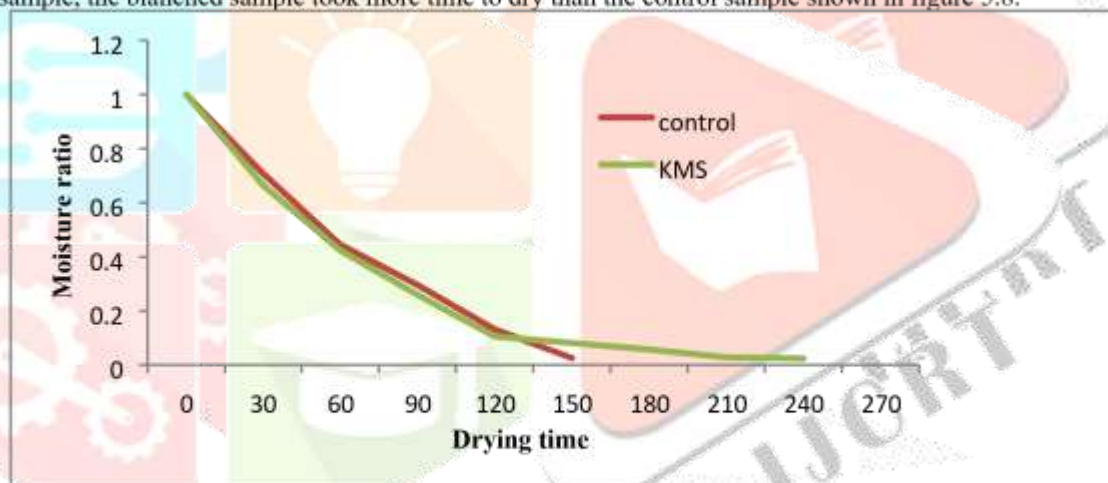


Fig 5.8: Comparison of experimental moisture ratio with time of 4mm control and KMS blanched carrot sample at 60°C.

After drying the 2mm sample at 70°C the moisture ratio of control sample and blanched sample became 0.01935 and 0.01306 respectively, the control sample took more time to dry than the blanched sample shown in figure 5.9.

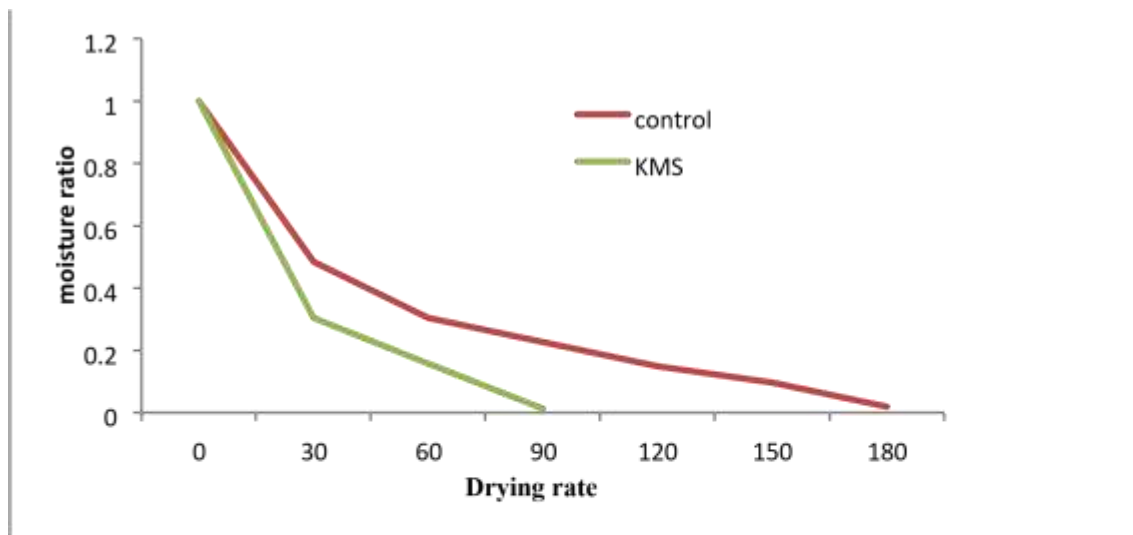


Fig 5.9: Comparison of

experimental moisture ratio with time of 2mm control and KMS blanched carrot sample at 70°C.

Similarly, the 4mm thick control and kms blanched sample become 0.012987 and 0.019480519 respectively after drying at 70°C, here the control sample took more time to dry than the blanched sample shown in figure 5.10.

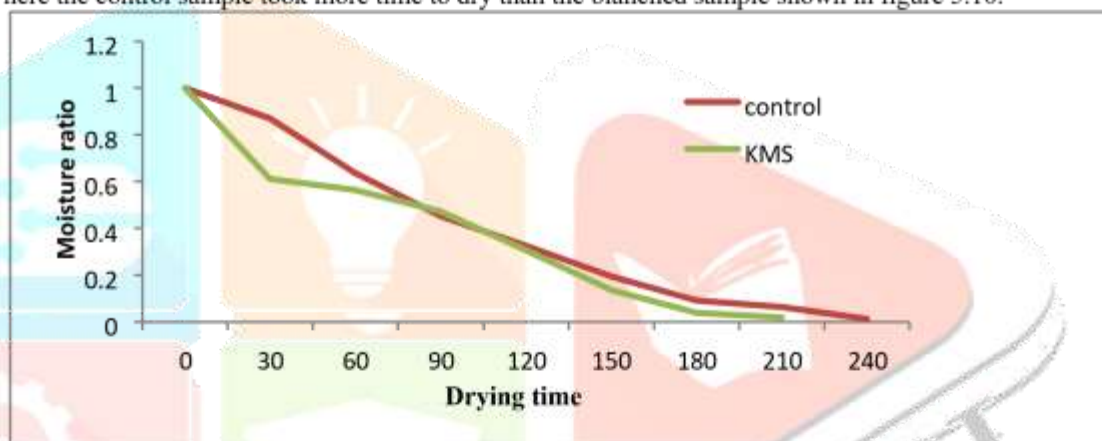


Fig 5.10: Comparison of experimental moisture ratio with time of 4mm control and KMS blanched carrot sample at 70°C.

The 2mm control and kms blanched sample become 0.0092879 and 0.008955224 respectively after drying at 80°C, here the blanched sample took more time to dry than the control sample shown in figure 14.

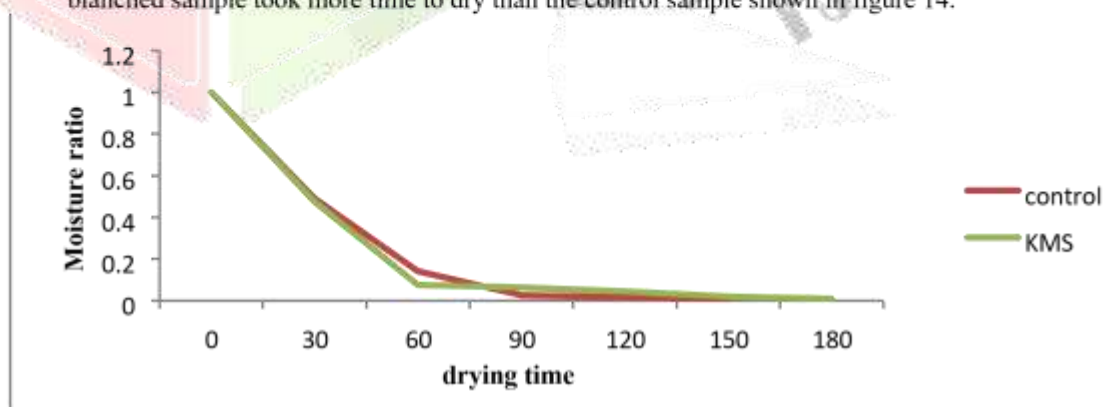


Fig 5.11: Comparison of experimental moisture ratio with time of 2mm control and KMS blanched carrot sample at 80°C.

Similarly, the 4mm control and kms blanched sample become 0.0214 and 0.01973 respectively, here the blanched sample took more time to dry than the blanched sample shown in figure 5.12.

1.2

1

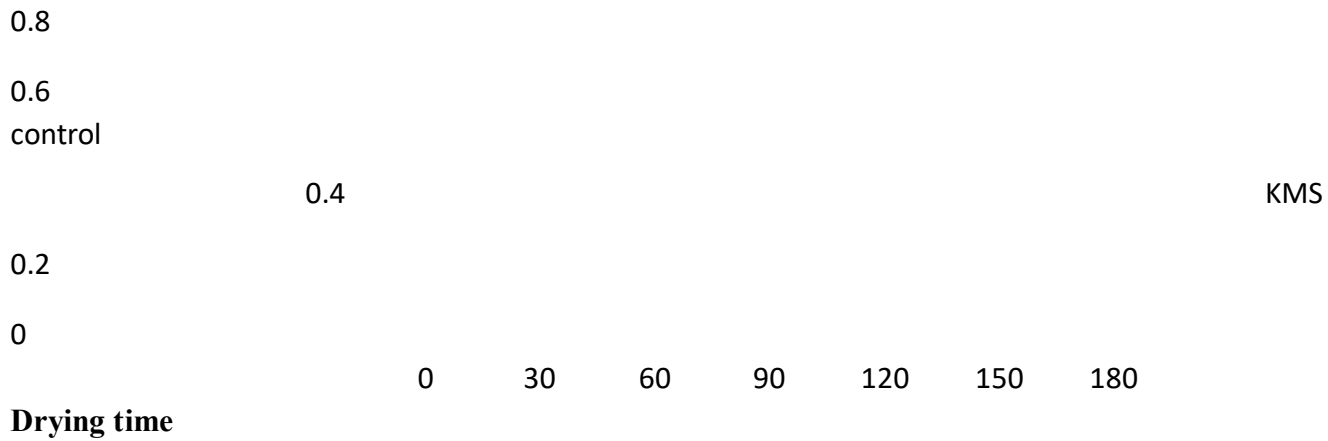


Fig 5.12: Comparison of experimental moisture ratio with time of 4mm control and KMS blanched carrot sample at 80°C.

Carrot slices were pretreated with brine solution, KMS solution, KMS plus blanching, blanching and control. It was observed that sample pretreated with brine solution took higher drying time to achieve the final moisture content as compared to other pretreated samples. The KMS treated slices were achieved higher value of drying rate and brine treated slices were achieved

lowest drying rate. It was observed that potato slices did not have any constant rate period and the entire drying took place in falling rate period. This shows that diffusion is dominant physical mechanism governing moisture movement in the samples. It

was also observed that drying rate was higher in the initial period of drying and subsequently reduced with decrease in moisture content. The drying rate of carrot slices dipped in brine solution was slower than blanched samples due to the presence of salt in solution which inhibits the rate of water transfer from carrot slices (Abbas, 2017).

6. CONCLUSION

In this research work the comparative study was done for different thickness (2mm and 4mm) of carrot slices which is dried under the infrared dryer at temperature 60°C, 70°C and 80°C. The moisture content (dry base) and moisture ratio decreases with increase in time. The result from the experiment indicate that with increase in thickness of the carrot slices the drying time to attain the equilibrium also increases (Al-Amin, 2015). The time taken for drying was more for blanched sample as compare to the control sample, as blanching involves the immersing of food in boiling water, which can increase its water content. Therefore, the blanched sample take longer time to dry (Naimish Gupta, 2017). It also indicates that the moisture ratio of the blanched sample is lower than that of control sample after drying. Blanching is often used as a pre-treatment step before drying to remove surface moisture and deactivate enzymes which facilitate more efficient drying (Oliveira, 2016). As a result, blanched sample tends to have lower moisture content compared to untreated control sample after drying. So that, the food items which undergo blanched before drying has relatively longer shelf life than the untreated food products (Motegaonkar, 2024).

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