IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

A Study On The Effect Of Nacl 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 moisturecontent limit the utilization of carrot. The present study focused on the effect of different drying temperature that is 60℃,70℃and 80℃ on different thickness of carrot slices, in combination with pretreatment of NaCl (salt)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 alsoindicates that the moisture ratio of the blanched sample is lower than that of control sampleafter drying.

Keywords: Carrot slices, NaCl, Hot water, Blanching, Drying

1 GENERAL OVERVIEW OF CARROT PRODUCTION AND VALUEADDITION

1.1 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 riskof 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. Dueto the presence of terpenoids and polyacetylenes, it gives a characteristic flavor. The different colored root gives medicinal properties towards human health due to presence ofdifferent 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 orcooked. 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 imperator carrot; having a small shoulder with tapped tip, Nantes carrot havea blunt tip with medium length, large and medium length carrots are called Danvers, carrots have large shoulder with short height are called chastened (Kelley, 2012). The carrots are also varies upon taste ,color, size .They may taste lightly sweet or can taste earthy or bitter (John, 2010).When the vegetables are supplied abundantly, then there is a chances of spoilage of the vegetables, in order to avoid this preservation is the best methodto 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 vitaminslike B1,B2,β-carotene etc. The β-carotene helps to prevent cancer as it is the precursor ofvitamin A (Navazio, 2012). Drying is the most traditional method to preserve the food ,butblanching 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 micro-organisms (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 areawhere 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 (Goyal, 2014). 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 thefood is not dried in a particular time period, then there is a chance of spoilage in a large manner. 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, thewild 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 canter of thecontinent 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 routeestablished 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 between14 to 17th centuries. The white color 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 color. 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 (Zohaib, 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 developedin 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 *Daucus carota* mainly found in the high-altitude region of Europe, west Asia, northern Africa and local regions of tropical Africa (Sela, 2015).

1.3 VARITIES OF CARROT

There is a wide variety of carrots are cultivated all over the world. Each carrot hastheir own specific characteristics and morphology. Imperator 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 are the deep orange colour carrots with medium length, rounded body and pointed end. These are approximately about 6 to 7 inches long. These types of carrots are well known for their vibrant color, excellent taste and storage quality (Terrazas, 2017). Nantes carrots are cylindrical in shape with a bluntedtip. These carrots are almost colorless and often used in salad making and fresh eating (Thakre, 2018). Chantenay carrots are the bulky, short conical rooted carrots. It can be used in both raw and cooked form (Arunkumar, 2014). 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 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 carrot 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, juicemaking etc. (Dias, 2019). White carrots are the variety of carrots which are colorless still very sweet in taste. These are about 6 to 8 inches in length. These carrots have a mild andnatural taste and are typically sweeter than the orange carrots (Arunkumar, 2014).

1.4 NUTRITIONAL INFORMATION AND HEALTH BENEFITS

Nutritional value:

The nutritional value for 100 grams of two small to medium raw carrots (*Daucus carota*)are:

Table 1.1 Nutritional content of 100 grams of raw carrot

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

Carrots are good source of several vitamins, minerals, beta carotene, potassium, phylloquinone and especially biotin and vitamin B6.

Carrots are rich in multiple variety of vitamin, minerals and other beneficial things which provides multiple health benefits. Carrots are colorful 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 abilityto counteract the effect of free radicals (Sing D, 2020). 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). 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). 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 onthe 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 (Jafarl 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%), $NaHCO_3$ (0.1%), NaCl (1%), $CaCl_2$ (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 bio-materials, 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 determines the quality and shelf life 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 times 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 flowand the properties of that particular food product (Charles Nwajinka, 2016).

2.2.1 INFRARED ASSISTED HOT AIR DRYER

In the food industries infrared dryers are often used for various purposes such as drying of fruits, vegetables, spices etc. An infrared dryer is usually made of materials like ceramic. A control system is used to regulate various parameters of the drying process such as temperature. The infrared dryer was designed with IR lamp (250 W)/500 W, short and medium wavelength, UV-C lamp and 20 Kpa vacuum unit. The system should be switch on and temperature should be regulated before half an hour, when the desired temperature level attains we can keep our sample using a petri dish (A.Sayaslan, 2019). Hot air drying is most common drying method. Microwave drying is widely used by the researchers 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 researchers but due to its high price it can't be used widely. Freeze drying is a method where we can dry the product in low energy consumption with colour preservation but the drying time is relatively long and drying cost is high (Iswarya, 2015). Therefore, the infrared, 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).Infra-red 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 to1000μm (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℃, 70℃ and 80℃ 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 Bharadwaz, 2017).

Fig 2.1 Infrared assisted hot air dryer

ADVANTAGES OF INFRARED ASSISTED HOT AIR DRYER

Table 2.1 Advantages of infrared assisted hot air dryer (A.R.H. Rigit,2013)

Infrared assisted hot air dryer	Advantages
Process	It is a compact drying equipment Emitters of this dryer can beadjusted in length
Performance	Helps in fast solvent evaporation
Price	Investment cost for electricityis low For gas operated IR operationcost is low

3 OBJECTIVES

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 blanchingin 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. The objective of NaCl blanching of carrot slices before drying is to ensure product quality, safety, and shelf stability by inactivating enzymes, preserving color, reducing microbial load, and improving texture.

4 MATERIALS AND METHODS

4.1 LABORATORY EQUIPMENT

- The equipment used here was of standard quality;
- Petri dish
- Peeler
- Distilled water
- beaker
- Sodium chloride
- Tissue paper
- carrot
- steel container
- Plastic container
- Induction
- Knife
- Electronic weight

4.2 SAMPLE PREPARATION

Carrot (*Daucus carota*) were collected from local market of Paralakhemundi of Ganapati district, Odisha. Carrots were washed with fresh water in order to remove adhering soil, dust particles and peeled manually using stainless steel peeler. Then the peeled carrot cut into slices of 2mm and 4mm thickness and pretreated with NaCl for 2 minutes (2mm), 3minutes (4mm). After pre-treatment with NaCl solution the carrot sliceswere spread over the blotting paper to remove surface moisture for further dryingexperiment.

4.3 DRYING OF CARROT SLICES

The drying was conducted at 60°C initially, where the infrared dryer was run ideal for about 30 minutes to stabilize the desired temperature. Once the temperature gets stabilized 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 and placed again into the dryer for further drying. The drying process should be continued till the constant weight of the sample achieved. Sameprocedure was followed for the 70°C and 80°C. At the end of drying the samples were cooled at room temperature and ground to make carrot powder for further studies (Vaishali, Samsher, 2020).

Fig 4.1 Drying of carrot slices

4.4 DRYING CHARACTERISTIC ANALYSIS

4.4.1 MOISTURE CONTENT (WET BASE %)

The moisture content (wet base%) can be calculated by using equation 1(Abbas,2017).

$$moisture\ \ content\ (wet\ base\ \%) = \left(\frac{wet\ weight - dry\ weight}{dry\ weight}\right) \times 100 \qquad (1)$$

4.4.2 MOISTURE CONTENT (DRY BASE %)

The moisture content dry base was calculated by using equation (Akbarnejad,2017).

$$moisture\ content\ (dry\ base\ \%) = \left(\frac{wb}{100} \div \left(1 - \frac{wb}{100}\right)\right) \times 100 \qquad (2)$$

4.4.3 MOISTURE RATIO

Moisture ratio (MR) was calculated by using equation (3) (Bispo, 2015).

$$moisture\ ratio = \frac{initial\ dry\ base\ (\%)}{final\ dry\ base\ (\%)} \qquad (3)$$

4.4.4 DRY MATTER

Dry matter was calculated by using equation (Abbas, 2017).

$$dry\ matter = \frac{dry\ sample\ weight}{wet\ sample\ weight} \times 100 \qquad (4)$$

5 RESULTS AND DISCUSSION

5.1 ESTIMATION OF MOISTURE CONTENT DRY BASE AND DRYING TIME

The moisture content of blanched sample is typically lower as compare to control sample as shown in table1 and 2. The initial moisture content (dry base %) of 2mm control sample was 650 and 620.5542725 for NaCl blanched sample. After drying at 60°C the moisture content (dry base %) become 8.43 and 8.545034642 for control and blanched sample respectively. The time taken for drying was 180 minutes for both the sample. The initial moisture content (dry base %) of 4mm control sample was 335.3640416 and 334.7826087 for NaCl blanched sample. After drying at 60°C the moisture content(dry base %) become 8.469539376 and 7.826086957 for control sample and NaCl blanched sample respectively at 150 minutes as shown in the table 3 and 4. At 70°C the initial moisture content (dry base %) of 2mm control sample is 620 and 623.8095238 for NaCl blanched sample and it becomes 12 and 4.761904762 for control sample and NaCl blanched sample respectively at 180 minutes as shown in table 5 and 6. Similarly the initial moisture content (dry base%) of 4mm control and NaCl sample are same i.e. 334.7826087 and they become 4.347826087 and 6.280193237 for control sample and NaCl sample respectively as shown in table 7 and 8. Finally at 80°C the initial moisture content (dry base %) of 2mm control sample was 621.1538462 and 614.2857143 for NaCl blanched sample. It becomes 5.769230769 and 7.142857143 for control sample and NaCl blanchedsample respectively at 180 minutes as shown in table 9 and 10. Similarly the initial moisture (dry base %) content of the 4mm control sample and NaCl blanched sample are 335.4354354 and 334.7826087 respectively at 80°C and it becomes 7.207207207 and 5.590062112 at 240 minutes, as shown in the table 11 and 12.

Table 5.1 Moisture content and moisture ratio of 2mm control sample at temperature60°C

(60°C) 2mmcontrol	weight(g)	Moisture removed (g)	sture content(wb %)	Moisture content (db %)
0	12	0	86.166	650
30	6.4	5.6	74.062	285.542
60	3	9	44.666	80.722
90	2.3	9.7	27.826	38.554
120	2	10	17	20.481
150	1.9	10.1	12.631	14.457
180	1.8	10.2	7.777	8.433

Table 5.2 Moisture content and moisture ratio of 2mm NaCl blanched sample attemperature 60°C

Time(60°C) 2mm NaCl	'eight(g)	Moisture removed(g)	Moisture content (wb %)	ture content(db %)	Moisture ratio
0	31.2	0	86.121	620.554	1
30	23.7	7.5	81.729	447.344	0.720
60	17.8	13.4	75.674	311.085	0.501
90	10.6	20.6	59.150	144.803	0.233
120	8.3	22.9	47.831	91.685	0.147
150	7.4	23.8	41.486	70.900	0.114
180	6.1	25.1	29.016	40.877	0.065
210	5.8	25.4	25.344	33.949	0.054
240	5.3	25.9	18.301	22.401	0.036
270	4.8	26.4	9.791	10.854	0.017
300	4.7	26.5	7.872	8.545	0.013

Table 5.3 Moisture content and moisture ratio of 4mm control sample at temperature 60°C

Time(60°C) 4mm control	eight(g)	Moisture removed (g)	Moisture content (wb %)	ture content(db %)	oisture ratio
0	29.3	0	77.030	335.364	1
30	22.7	6.6	70.352	237.295	0.707
60	16.8	12.5	59.940	149.628	0.446
90	13.4	15.9	49.776	99.108	0.295
120	9.7	19.6	30.618	44.130	0.131
150	7.3	22	7.808	8.469	0.025

Table 5.4 Moisture content and moisture ratio of 4mm NaCl blanched sample attemperature 60°C

Time(60°C)4mm NaCl	eight(g)	Moisture removed (g)	Moisture content(wb %)	Moisture content(db %)	oistureratio
0	25	0	77	334.782	1
30	19	6	69.736	230.434	0.688
60	13	12	55.769	126.086	0.376
90	10.4	14.6	44.711	80.869	0.241
120	7.5	17.5	23.333	30.434	0.090
150	6.7	18.3	14.179	16.521	0.049
180	6.2	18.8	7.258	7.826	0.023

Table 5.5 Moisture content and moisture ratio of 2mm control sample at temperature 70°C

(70°C) 2mmControl	eight(g)	Moisture removed(g)	Moisture content (wb %)	ture content(db %)	oistureratio
0	4.5	0	86.111	620	1
30	2.5	2	75	300	0.483
60	1.8	2.7	65.277	188	0.303
90	1.5	3	58.333	140	0.225
120	1.2	3.3	47.916	92	0.148
150	1	3.5	37.5	60	0.096
180	0.7	3.8	10.714	12	0.019

Table 5.6 Moisture content and moisture ratio of 2mm NaCl blanched sample attemperature 70°C

Time(70°C)2mm NaCl	eight(g)	Moisture noved(g)	Moisture content(wb %)	Moisture content (db %)	oistureratio
0	7.6	0	86.184	623.809	1
30	2.6	5	59.615	147.619	0.236
60	1.4	6.2	25	33.333	0.053
90	1.2	6.4	12.5	14.285	0.022
120	1.1	6.5	4.545	4.761	0.007

Table 5.7 Moisture content and moisture ratio of 4mm control sample at temperature70°C

Time (70°C) 4mm control	Weight (g)	Moisture removed (g)	Moisture content (wb %)	Moisture content (db %)	Moisture ratio
0	5	0	77	334.782	1
30	4.5	0.5	74.444	291.304	0.870
60	3.6	1.4	68.055	213.043	0.636
90	2.9	2.1	60.344	152.173	0.454
120	2.4	2.6	52.083	108.695	0.324
150	1.9	3.1	39.473	65.217	0.194
180	1.5	3.5	23.333	30.434	0.090
210	1.4	3.6	17.857	21.739	0.064
240	1.2	3.8	4.166	4.347	0.012

Table 5.8 Moisture content and moisture ratio of 4mm NaCl blanched sample attemperature 70°C

Time(70°C)4 mm NaCl	Weig ht(g)	Moisture removed (g)	Moisture content (wb %)	Moisture content (db %)	oisture ratio
0	18	0	77	334.782	1
30	10.2	7.8	59.411	146.376	0.437
60	9.3	8.7	55.483	124.637	0.372
90	8.6	9.4	51.860	107.729	0.321
120	7.2	10.8	42.5	73.913	0.220
150	6.5	11.5	36.307	57.004	0.170
180	5.9	12.1	29.830	42.512	0.126
210	5.2	12.8	20.384	25.603	0.076
240	4.8	13.2	13.75	15.942	0.047
270	4.4	13.6	5.909	6.280	0.018

Table 5.9 Moisture content and moisture ratio of 2mm control sample at temperature80°C

Time (80°C)2mm Control	eight(g)	Moisture removed(g)	Moisture content (wb %)	Moisture content (db %)	Moisture ratio
0	15	0	86.133	621.153	1
30	8.4	6.6	75.238	303.846	0.489
60	3.9	11.1	46.666	87.5	0.140
90	2.4	12.6	13.333	15.384	0.024
120	2.3	12.7	9.565	10.576	0.017
150	2.2	12.8	5.454	5.769	0.009

Table 5.10 Moisture content and moisture ratio of 2mm NaCl blanched sample attemperature 80°C

80°C) 2mmNaCl	Veigt(g)	Moisture noved(g)	Moisture content (wb%)	moisture content(db%)	oistureratio
0	18	0	86	614.285	1
30	9.3	8.7	72.903	269.047	0.437
60	4.1	13.9	38.536	62.698	0.102
90	3.8	14.2	33.684	50.793	0.082
120	3.2	14.8	21.25	26.984	0.043
150	2.7	15.3	6.666	7.142	0.011

Table 5.11 Moisture content and moisture ratio of 4mm control sample at temperature80°C

Time(80°C) 4mm Control	eight(g)	Moisture removed (g)	Moisture content (wb%)	moisturecontent (db%)	Moisture ratio
0	14.5	0	77.034	335.435	1
30	7.1	7.4	53.098	113.213	0.337
60	5.7	8.8	41.578	71.171	0.212
90	4.82	9.68	30.912	44.744	0.133
120	3.79	10.71	12.137	13.813	0.041
150	3.57	10.93	6.722	7.207	0.021

Table 5.12 Moisture content and moisture ratio of 4mm NaCl blanched sample at 80°C

Time (80°C)4mm NaCl	Weight(g)	Moisture removed (g)	moisture content (wb%)	moisture content (db%)	Moisture ratio
0	14	0	77	334.782	1
30	9.2	4.8	65	185.714	0.554
60	8.46	5.54	61.938	162.732	0.486
90	6.25	7.75	48.48	94.099	0.281
120	5.95	8.05	45.882	84.782	0.253
150	4.67	9.33	31.049	45.031	0.134
180	4.2	9.8	23.333	30.434	0.090
210	3.5	10.5	8	8.695	0.025
240	3.4	10.6	5.294	5.590	0.016

5.1.1 GRAPHICAL REPRESENTATION OF MOISTURE CONTENT (DRY BASE %) WITH RESPCT TO TIME

The below graphs show the variation of moisture content (dry base %) with respectto time at different temperature (60°C, 70°C and 80°C).

The moisture content of blanched sample is typically lower as compare to control sampleas shown in table1 and 2. The initial moisture content (dry base %) of 2mm control samplewas 650 and 620.5542725 for NaCl blanched sample. After drying at 60°C the moisture content (dry base %) become 8.43 and 8.545034642 for control and blanched sample respectively. The time taken for drying was 180 minutes for both the sample as shown inthe below graph (Figure4).

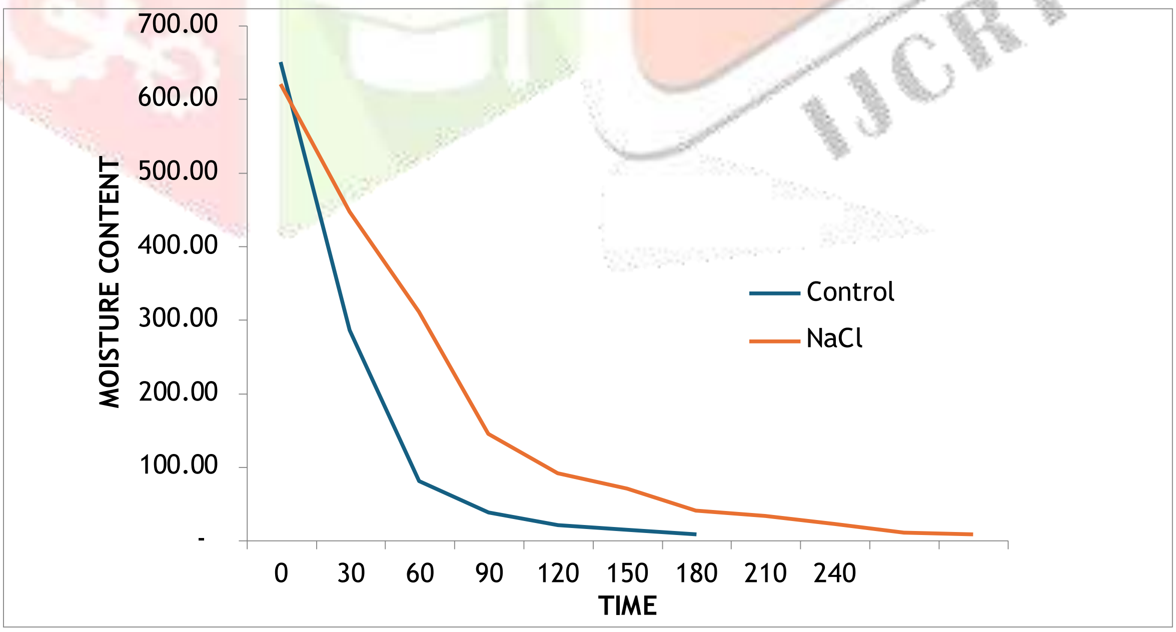

Fig 5.1 Comparison of moisture content of 2mm control and NaCl blanched sample versus time at temperature 60°C

The initial moisture content (dry base %) of 4mm control sample was 335.3640416 and 334.7826087 for NaCl blanched sample. After drying at 60°C the moisture content (dry base %) become 8.469539376 and 7.826086957 for control sample and NaCl blanched sample respectively at 150 minutes as shown in the below graph (Figure5).

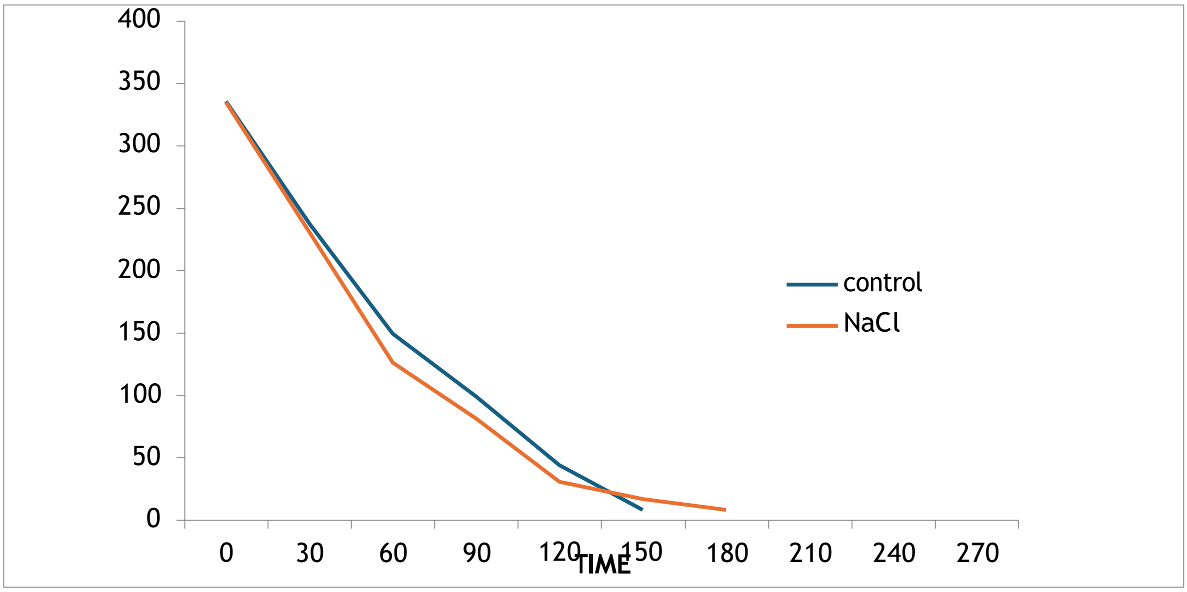

Fig 5.2 comparison of moisture content of 4mm control and NaCl blanched sample versus time at temperature 60°C

At 70°C the initial moisture content (dry base %) of 2mm control sample is 620 and 623.8095238 for NaCl blanched sample and it becomes 12 and 4.761904762 for control sample and NaCl blanched sample respectively at 180 minutes as shown in the below graph (Figure6).

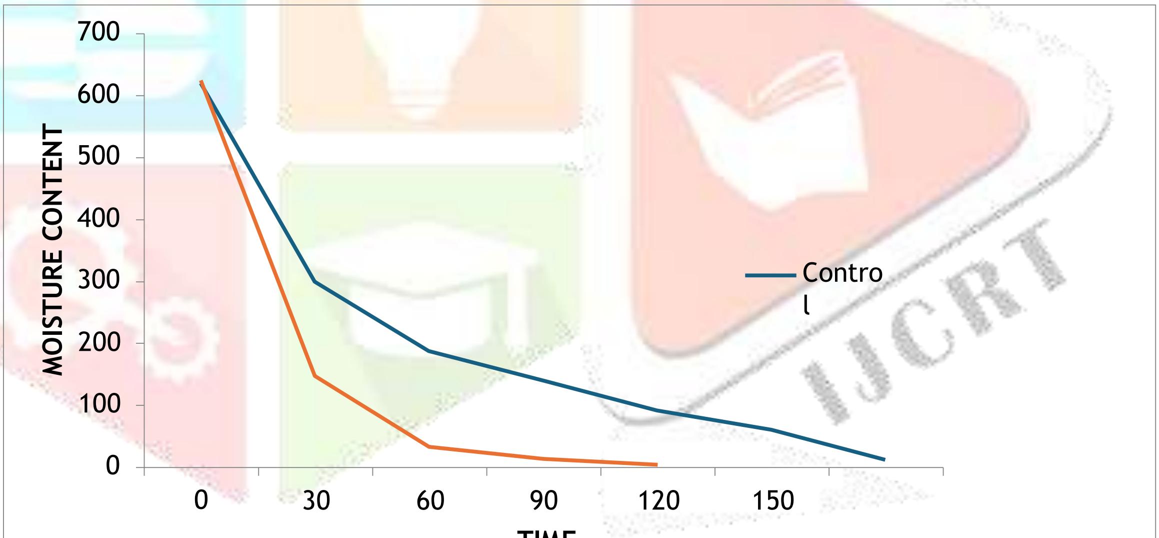

Fig 5.3 Comparison of moisture content of 2mm control and NaCl blanched sample versus time at temperature 70°C

The initial moisture content (dry base%) of 4mm control and NaCl sample are same i.e. 334.7826087 and they become 4.347826087 and 6.280193237 at 70°C for control sample and NaCl sample respectively as shown in the below graph.

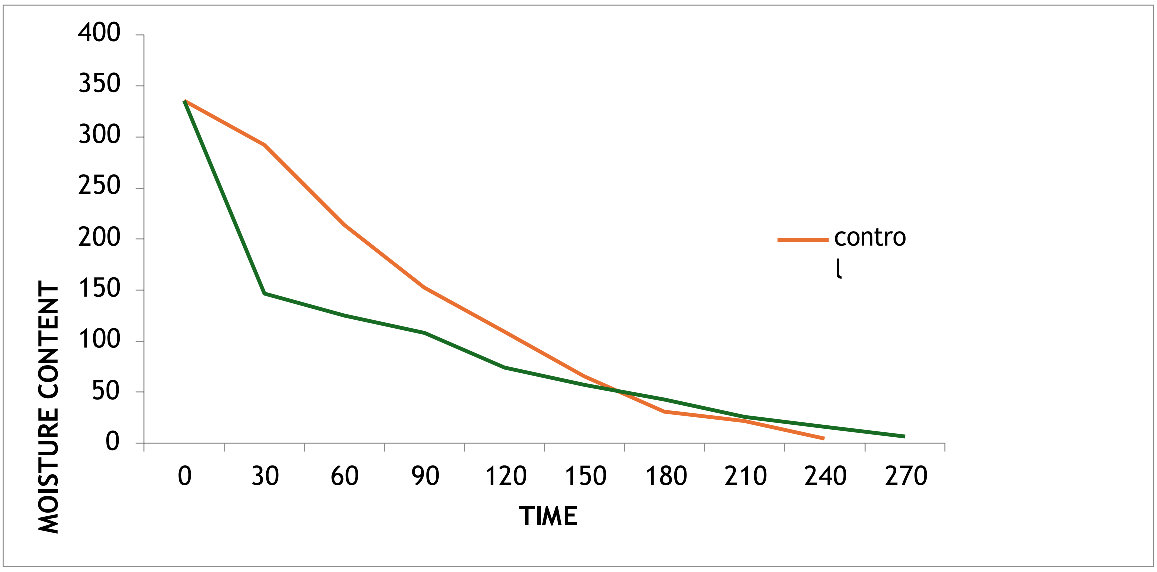

Fig 5.4 Comparison of moisture content of 4mm control and NaCl blanched sampleversus time at temperature 70°C

At 80°C the initial moisture content (dry base %) of 2mm control sample was 621.1538462 and 614.2857143 for NaCl blanched sample. It becomes 5.769230769 and7.142857143 for control sample and NaCl blanched sample respectively at 180 minutesas shown in the below graph (Figure8).

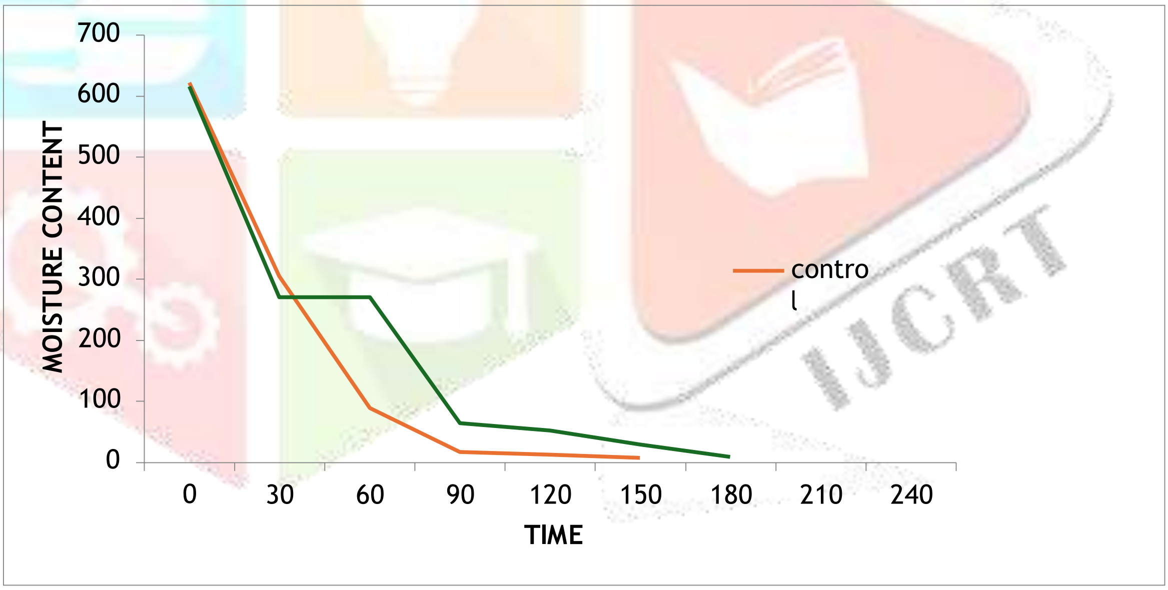

Fig 5.5 Comparison of moisture content of 2mm control and NaCl blanched sample versustime at temperature 80°C

The initial moisture (dry base %) content of the 4mm control sample and NaCl blanched sample are 335.4354354 and 334.7826087 respectively at 80°C and it becomes 7.207207207 and 5.590062112 at 240 minutes, as shown in the below graph (Figure9).

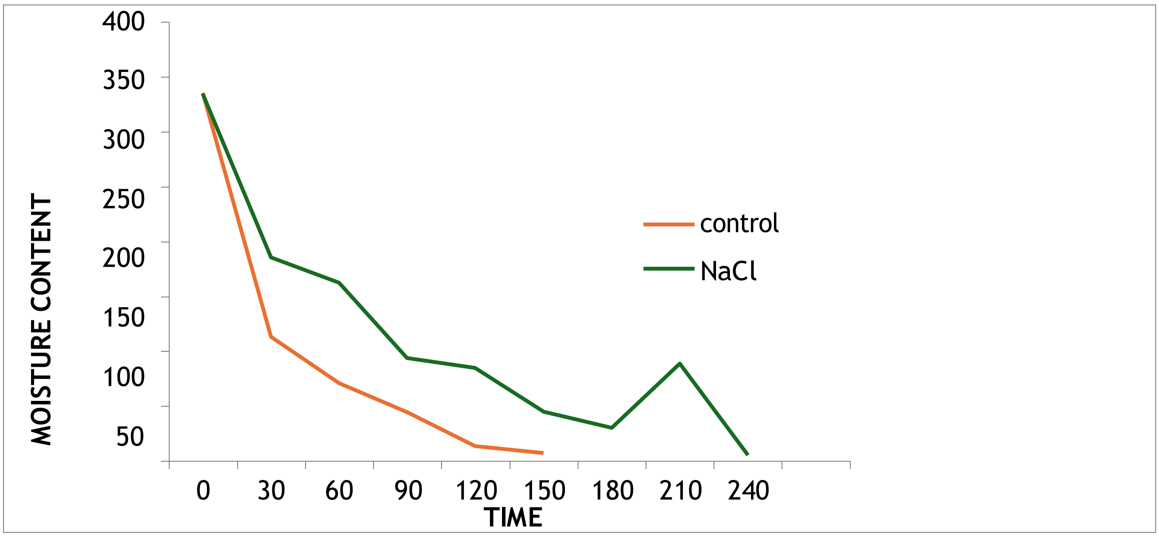

Fig 5.6 Comparison of moisture content of 4mm control and NaCl blanched sample versus time at temperature 80°C

5.2 ESTIMATION OF MOISTURE RATIO VERSUS TIME

The initial moisture ratio of 2mm control and NaCl sample was same i.e. 1. After drying it at 60°C the moisture ratio of control was 0.01 and NaCl blanched sample was 0.013770004 at 180 minutes as shown in the above table 3 and 4. The initial moisture ratio of both 4mm control and NaCl blanched sample was 1. After drying it at 60°C the moistureratio of control and NaCl blanched sample become 0.025254763 and 0.023376623 respectively at 150 minutes as shown I table 5 and 6. The initial moisture ratio of 2mm control and NaCl blanched sample are same i.e. 1. After drying at 70°C the moisture ratio becomes 0.019354839 and 0.007633588 for the control and NaCl blanched sample respectively at 180 minutes as shown in table7 and 8. Similarly the moisture ratio of 4mm control and NaCl sample are same i.e. 1. After drying at 70°C it becomes 0.012987013 and 0.018759019 for control and NaCl blanched sample respectively at time 240 minutes as shown in table9 and 10. At 80°C the moisture content of both 2mm control and NaCl blanched sample are 1 and it becomes 0.009287926 and 0.011627907 respectively for control and NaCl blanched sample at time 150 minutes as shown in table 11 and 12. Similarly the moisture ratio of 4mm control and NaCl blanched sample are 1 at 80°C and it becomes 0.021486124 and 0.016697588 for control and NaCl blanched sample at time150 minutes in the above table 13 and 14.

5.2.1 GRAPHICAL REPRESENTATION OF MOISTURE RATIO VERSUS TIME

The following graphs shows the variation in moisture ratio of 2mm and 4mm control and NaCl blanched sample with respect to time at different temperature (60°C, 70°C and 80°C).

The below graph showing that the initial moisture ratio of the 2mm control and NaCl blanched sample were 1. After drying the samples at 60°C the moisture ratio of the controlsample becomes 0.01 and NaCl blanched sample was 0.013770004 at 180 minutes.

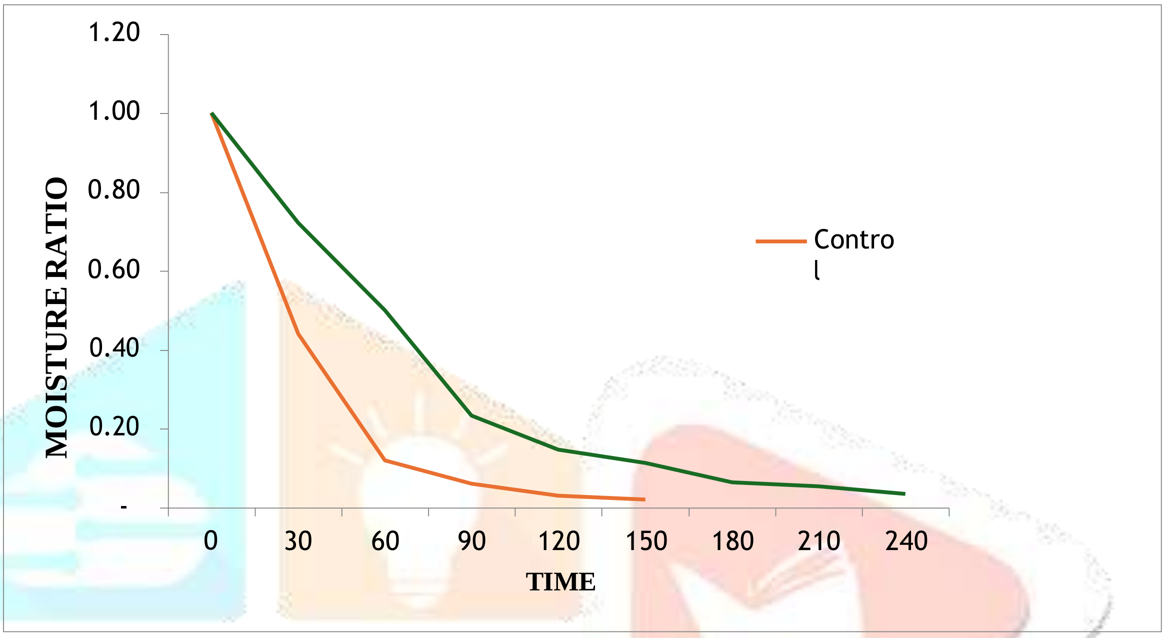

Fig 5.7 Moisture ratio of 2mm control and NaCl blanched sample versus time at temperature 60°C

The initial moisture ratio of 4mm control and NaCl blanched sample were1. After drying it at 60°C the moisture ratio of control and NaCl blanched sample become 0.025254763 and 0.023376623 respectively at 150 minutes as shown in the below graph (figure10).

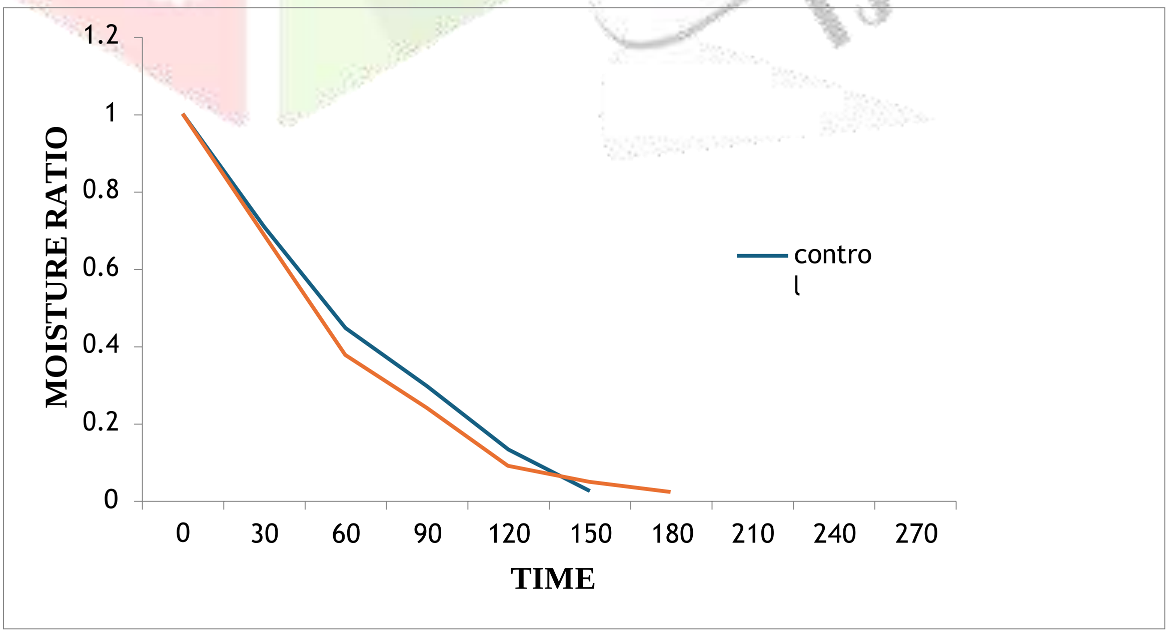

Fig 5.8 Moisture ratio of 4mm control and NaCl blanched sample versus time at temperature 60°C

The initial moisture ratio of 2mm control and NaCl blanched samples were1. . After drying at 70°C the moisture ratio becomes 0.019354839 and 0.007633588 for the control and NaCl blanched sample respectively at 180 minutes as shown in the below graph (Figure11).

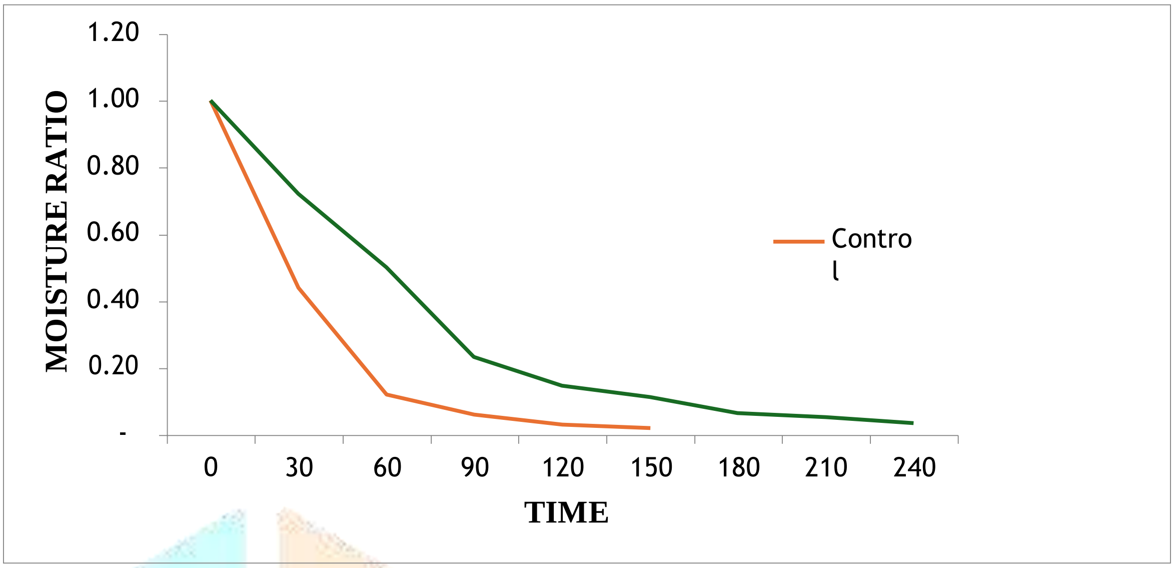

Fig 5.9 Moisture ratio of 2mm control and NaCl blanched sample versus time at temperature 70°C

The moisture ratio of 4mm control and NaCl sample were1. After drying at 70°C it becomes 0.012987013 and 0.018759019 for control and NaCl blanched sample respectively at time 240 minutes as shown in the below graph (Figure12).

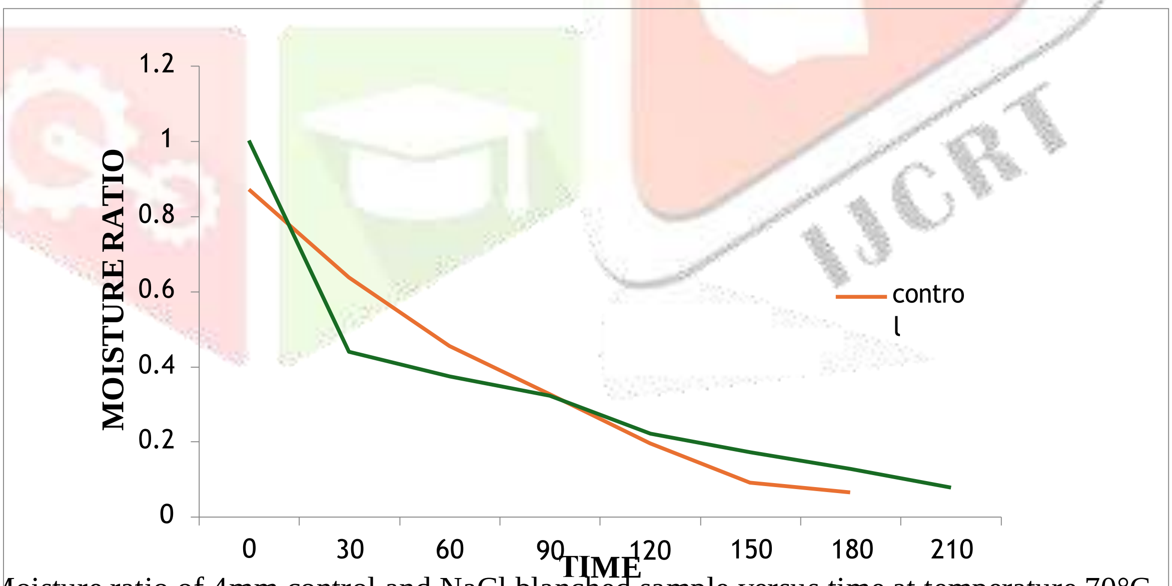

Fig 5.10 Moisture ratio of 4mm control and NaCl blanched sample versus time at temperature 70°C

The moisture ratio of 2mm control and NaCl blanched samples were 1 and it becomes 0.009287926 and 0.011627907 respectively for control and NaCl blanched sample afrter drying at 80°C at time 150 minutes as shown in the below graph (Figure13).

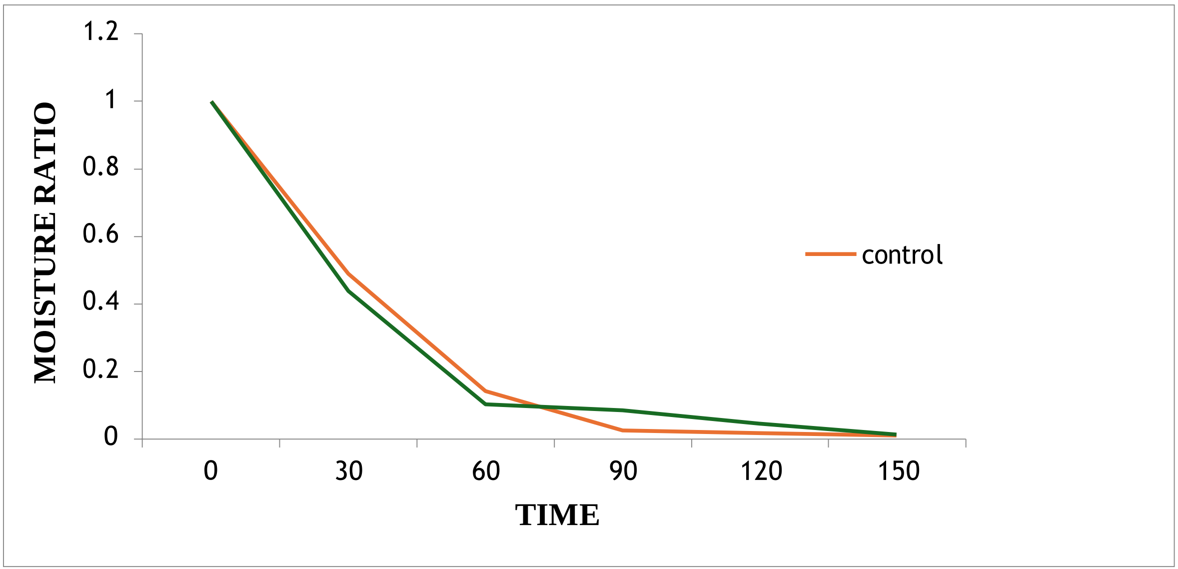

Fig 5.11 Moisture ratio of 2mm control and NaCl blanched sample versus time at temperature 80°C

The moisture ratio of 4mm control and NaCl blanched sample were 1. After drying at 80°C and it becomes 0.021486124 and 0.016697588 for control and NaCl blanched sample at time 150 minutes as shown in the below graph (Figure14).

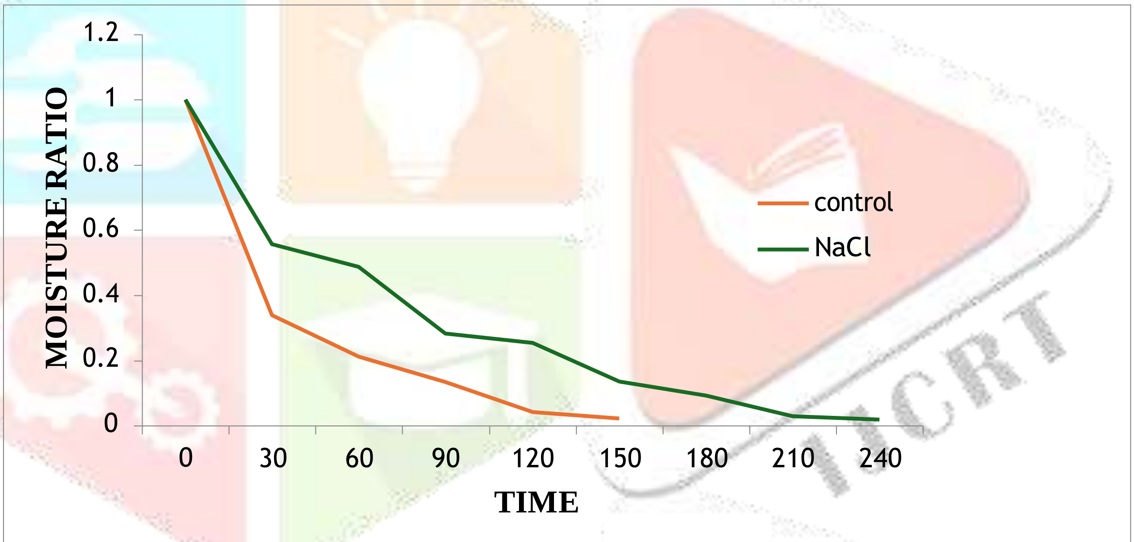

Fig 5.12 Moisture ratio of 4mm control and NaCl blanched sample versus time at temperature 80°C

6 CONCLUSION

Carrot are a very nourishing veggie. Farmers must sell their produce at a very lowprice during peak season since there are insufficient processing facilities. However, farmers will be able to obtain a fair price and be motivated to increase output if they can process their food in an efficient and cost-effective manner. Both large and small enterprises can employ mechanical and solar drying systems with various pretreatments. The properties of carrot drying using infrared drying are examined. When compared to other dryers, infrared drying proves to be an efficient way for drying carrots (Al- Amin,2015). The best temperature to dry carrots is discovered to be 80°C. Compared to traditional dryers, the Infrared Dryer facilitates faster weight loss (Gupta,2017). The drying rate drops as the moisture content drops. When compared to other drying methodsat every temperature, infrared assisted hot air drying has a higher drying rate (Motegaonkar,2024). 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 result from the above experiment indicates that with increase in thickness of the carrot slice the drying time to attain the equilibrium alsoincrease. The time taken for drying was more for NaCl blanched sample was more as compare to control. Blanching involves the immersing of food in boiling water, which canincrease its water current (Oliveira,2016). Therefore, the blanched sample may take longertime to dry. It also indicates that the moisture ratio of the NaCl 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 facilitates more efficient drying. As a result, blanched sample tends to have lower moisture content as compared to the untreated control sample after drying.

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