Comparative Study of Bajra and Jowar Drying In Tray Dryer, Hot Air Oven and Tappered Fluidised Bed

Shaik Shakeera[1], Bhasker Vellanki [2]

[1] M. Tech, Food Technology, Department of Food Technology ,University College of Technology,   Osmania University, Hyderabad, Telangana, India
[2] Assistant Professor, Food Technology, Department of Food Technology, University College of Technology, Osmania University Hyderabad, Telangana, India

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ABSTRACT: Physico-chemical analysis & Drying properties of Jowar,Bajra are studied under Tray dryer, Hot air oven and Tappered Fluidised Bed. The grains are purchased from the local market in Telangana and soaked in water overnight and placed in desiccators to increase their moisture content.Physical parameters of the grains such as Length(mm), Breadth(mm), l/b ratio, Moisture(%), Density(g/ml), Bulk density(g/ml), Porosity(%),Ash,Protein, Fat,CrudeFiber and Minerals were investigated before and after Drying at 60^0c.Bajra had the highest thousand grain weight, thousand grain volume, swelling capacity.Coming to Jowar kernels are larger than the other millets.Sun drying, the most common method of drying of grains which has several disadvantages with respect to the quality of the product and it is also time consuming. The study is done to find out the best possible alternative methods in terms of quality and efficiency among three drying methods-Tappered Fluidised Bed, Hot Air Oven and Tray drying.As Drying is essentially a process of simultaneous Heat and Mass transfer and it also differs from evaporation, which yields concentrated liquid products. The main purpose of drying is to extend the shelf-life of foods by reducing their in-water activity. In this work, the drying of Bajra and Jowar using Tray dryer, Hot Air Oven and Tappered Fluidised Bed at 60ºC was carried out.The drying performance of Tappered Fluidized Bed drier has been studied by analyzing moisture content of the sample during drying operation.Results revealed that Tappered Fluidized Bed drier is better when compared to Tray drier and Hot Air Oven drying. The time taken for drying in Hot Air Oven is twice the time of Tray dryer and in Tappered Fluidised Bed is lessthan other drying methods and it is better even in terms of efficiency and quality.Among three dryers Tappered Fluidised Bed is better for drying of Grains in large quantity.

I.   INTRODUCTION
1.1 Pearl millet (Pennisetum glaucum) is a warm season crop, planted in early summer when soils have warmed up. Pearl millet is a summer annual crop in Kharif season.Temperature required is 20^0c to 30^0c .In India it reaches the stage of 50% flowering in about 60 to 70 days from planting. The crop is primarily cross pollinated and it takes a flower about 30 days to develop into a mature seed. Pearl millet appears to have relatively fast root development, sending extensive roots both laterally and downward into the soil profile to take advantage of available moisture and nutrients. In general, pearl millet fits the same areas of adaptation as sorghum, except that it is somewhat more drought tolerant, and has a little earlier maturity. The best stage to harvest pearl millet is when the plants reach physiological maturity determined by the black spot at the bottom of the grain in the hilary region. current recommendations are that the grain be stored at a maximum moisture of 12–13%. Pearl millet is a rich source of energy (361 Kcal/100g)

1.2 Jowar (Sorghum bicolor L. Moench) is one of the most important cereal crops in the world and is one of the four major food grains of our country. Jowar is an annual plant belonging to family Gramineae. Height of the plant varies from 0.5 to over 4.0 metres.The inflorescence of sorghum is a panicle, which is commonly known as heads. Grain is usually partially covered by glumes. The seed is rounded, pointed at the base. The colour of the grain is white, pink, yellow or brownish-yellow. It is a staple food for millions of poor rural people in Asian and African countries. Besides being a major source of staple food for human beings, it also serves as an important source of fodder, animal feed and industrial raw material.

Jowar is grown in semi-arid climate where other crops don't stand well. The crop can withstand in drought condition. Sorghum is about 70% starch, so is a good energy source. Jowar is used in different ways as human food, fodder, poultry feed, cattle feed and industrial raw materials.

1.3 Drying or dehydration of fruits and vegetables is an age old method to prevent the products. Removal of water (70-90%) present in the fresh commodity results in reduction in the water activity and ultimately resistance against most of the deteriorative agents.The terms drying refers to the removal of moisture from a substance. The word dehydration usually compiles the use of controlled conditions of heating, with the forced circulation of air and vacuum or any other artificial drying methods.

Why drying?
Water acts as the main source for micro- organisms which deteriorates the quality of grains by which reduces the keeping quality of grains.
Reduction in weight, size and volume of the grains. Hence bulk transportation becomes easier and cheaper.
Long time storage of grain without deterioration.
Farmers to have better quality product.
Facilitate further processing. Example: grain drying for flour.
Continuous supply of product throughout the year

Types of drying methods
Conventional: Sun drying, Hot air drying
Modern: Freeze drying, Vacuum drying, Spray drying, Osmotic dehydration etc.
Innovative: Microwave drying, Pulse electric field, Ultra sound.

Abid et al and others (2003) performed an experimental and theoretical analysis on the mechanism of heat and mass transfer during the drying of corn kernels in a Tray dryer. They found that the humidity and velocity of the gas and the external conditions, such as the humidity, had only a small effect on the rate of drying. Hamdullahpur and others (2008) experimentally investigated the drying of wheat. They found that the inlet air temperature had an important effect on the magnitude of the drying rate, while the gas velocity and bed hold-up did not show significant contributions to the drying rate.Koloini and Farkas (1973) worked on fundamental understanding of the behaviour of tappered fluidised beds and their applications. Some of the previous investigations include studies on pressure drop of fixed and fluidized beds in tapered vessels ,flow regimes,

incipient condition of fluidization,voidage distribution and bed expansion and particle mixing. Watanoet al.(1998) experimentally studied the drying of wet granules in an agitating fluidized bed type dryer that has a tapered fluidized bed with an agitator blade turning on a central axis installed at the bottom of the cylindrical vessel to impart a tumbling and circulating motion to the granules. The effects of the conditions on the properties of the granules such as the mass media diameter, yield, shape and density of the granules were investigated under various air temperatures, air velocities and agitator rotational speeds. The relationships between the operating conditions and the drying rates were also examined.

II. MATERIALS AND METHODS:
In accordance with the objectives of the study, experiments on drying of Bajra and Jowar were conducted using different drying techniques. Using the data, the drying behavior of Bajra and Jowar viz. temperature and time taken were studied.

2.1 Materials:
Raw Material: Bajra and Jowar were procured from local market in Hyderabad and are checked for the quality and sorted out depending in its quality.
Equipment: Electronic balance, Vernier calliper,Screw guage Tray dryer, Hot air Oven, Tappered Fluidised Bed, Desiccator, Muffle furnace, Soxhlet apparatus, Kjeldhal apparatus, Atomic Absorption Spectroscopy

2.2 Methods:
2.2.1 Preparation of Bajra and Jowarfor drying: The mean moisture content of the Bajra and Jowar are recorded as 11.06(w.b.) and 9.00(w.b.) To increase the moisture content they are soaked in 150ml and are allowed to drain all the water and then placed in desiccators overnight and nextday they are taken for drying in different types of dryers.
Moisture content can be expressed in two ways, dry or wet basis. The equations are given below:
Moisture percentage by wet basis = (Mass of water/Mass of sample) ×100
Moisture percentage by dry basis = (Mass of water/Mass of dry solid) ×100

2.2.2 Methods for Drying: In this study Bajra and Jowar were subjected to three different drying techniques (Tappered Fluidised bed drying, Tray drying and Hot air oven drying) at a temperature of 60°C to obtain the best possible quality dried

product. The driers were preheated to corresponding temperature before the drying process.

a. Tray drying: The dryer was pre-heated to required temperature and then the samples of 20g each were spread in thin layers on the trays. Once the drying process started, the weights of the sample were collected at every 20 min until a constant weight was reached. The process was done by taking sample of 20g at a temperature of 60°C.

b. Hot air Oven drying: It is electrically operated equipment used to dry heat sterilize samples at temperature between 50°C to 300°C which requires exposure time up to 2 hours depending upon the temperature employed The Oven was pre-heated to required temperature and then the samples in petriplate dishes were placed in oven. The weights of the sample were collected at every 20 min until a constant weight was reached. The process was done by taking sample of 20g at a temperature of 60°C.

c. Tappered Fluidised Bed: A weighed amount of material was charged to the bed and air of 60^0c is passed through it for about ten minutes till the system was stable. The initial stagnant bed height was recorded. Then the velocity of the air was increased incrementally allowing sufficient time to reach a steady state. The rotameter and manometer readings were noted. When the minimum fluidization was attained, the expanded static bed height was also measured. The dried material is taken out after the process is over and is weighed until a constant weight was reached. The process was done by taking samples of 50g at a temperature of 60°C.

2.3Grain Size:
To characterize the grain used in this study, the length, breadth and diameter was considered as the size criterion measured by Vernier callipers and screwguage
These were measured with the help of screw gauge having least count of 0.01 millimeter.
L= HSR + (PSR X LC) mm
Where,
HSR = Head scale reading of the screw gauge
PSR = Pitch scale reading of the screw gauge
LC = Least count of the screw gauge
The length and breadth ratio were also found for the suitable grains.
L/B ratio= (Length/ Breadth)

2.4 Bulk Density:
It is estimated as the ratio of mass to volume for each sample
It is determined by filling a measuring cylinder with the sample for a fixed volume
Bulk density = weight/volume (gm/ml).

2.5 Density:
By definition, all matter has mass and occupies volume. The density of a substance is the ratio of its mass to its volume. At constant temperature and pressure, the density of a substance is constant.

$$\rho = \frac{m}{V}$$

2.6 Porosity:
Porosity indicates the extent of intracellular spaces or gaps in between the grains. Porosity is expressed as
Porosity= (Density – Bulk Density)/Density

2.7 Determination Of Ash Content:
Apparatus:
a)Porcelain crucibles.
b)Muffle furnace, capable of maintaining a temperature of 625±25°C ensure enough oxygen is admitted to the furnace chamber to complete removal of the carbonaceous material.
c)Desiccators.
Procedure:
About 5gms of sample was weighed accurately in to a porcelain crucible as Fig 23. This is transferred into a muffle furnace set at 550°C and left for about 3hrs.About this time it had turned into white ash. The crucible and its content were cooled at room temperature in desiccators and weighed.
The percentage of ash calculated

$$\% \text{ ash content} = \frac{\text{weight of ash}}{\text{Original weight of sample} \times 100}$$

2.8 Estimation Of Protein Content :
The principle of method involves the estimation of total nitrogen content in food and conversion of nitrogen to protein assuming that all nitrogen in food is present as protein and using a conversion factor based on the percentage of nitrogen in food.
Conversion factor F=100/% of nitrogen

Procedure:
Weigh 1gm of sample and place in digestion tube of instrument and add 25ml of

conc.sulphuric acid. Then add 10gm of catalyst mixture. Adjust the temperature to 370ºC and keep for digestion for 4-6 hrs, that is till the solution becomes blue in colour. Remove the tube from the digestion then cool the samples. Place 25ml of standard 0.1N boric acid solution or 0.1N sulphuric acid in the titration receiver flask(250ml conical flask) and place it in the distillation unit. Attach the tube containing digested sample to the distillation unit and press the start button to effect the metered addition of 40% sodium hydroxide solution and to initiate the steam distillation when the receiver platform falls and the distillation stops. Remove the flask and add 5 drops of methyl red indicator solution and titrate with 0.1N HCl solution to yellow colour end point if boric acid is used or 0.1N NaOH if 0.1N sulphuric acid is used and indicator is phenopthalein, carry out a blank determination.

% of Nitrogen = (sample titre value – blank) x N of HCl x 14 x 100/(weight of sample x1000)

Protein % = nitrogen% x conversion factor

2.9 Estimation Of Total Dietary Fibre Content: About 2-5gm of moisture and fat free sample are weighed into a 500ml beaker and 200ml of boiling 0.255N(1.25% w/v) sulphuric acid is added. The mixture is boiled for 30 min keeping the volume constant by adding water at frequent intervals (glass rod inserted in the beaker helps in smooth boiling). At the end of this period the mixture is filtered through a muslin cloth and the residue is washed with hot water till free from acid. The material is then transferred to the same beaker and 200ml of boiling 0.313N(1.25% w/v) sodium hydroxide solution is added.After boiling for 30 min (keeping the volume constant as before). This mixture is filtered through a muslin cloth(Fig 25). The residue is washed with hot water till free from alkali, followed by washing with some alcohol and ether. Then it is transferred to a crucible, dried overnight at 80-100 ºC and weighed   (We). The crucible is heated in muffle furnace at   600ºC for 2-3 hrs, cooled and weighed again (Wa). The difference in the weights represents the weight of crude fibre.

Crude fiber(gm/100gm of sample) = [100-(moisture+fat)][weight of fibre]/weight of the sample

Where weight of fibre = We-Wa

2.10 ESTIMATION OF FAT CONTENT:
Chemical used: Petroleum ether 40-60
Apparatus:
a)soxhlet apparatus
b)250 ml beakers

c) Filter paper
d) Hot plate

Procedure: Fat content is determined using Soxhlet extraction method. This is based on the continuous extraction of the food with a non polar organic solvents such as petroleum ether for about 16hrs. A known weight of food is placed in a porous thimble and the extracting solvent is poured in a dried weighed distillation flask. The solvent then mixes with the food, dissolves out the fat and eventually siphons back into the original distillation flask. The process is repeated continuously for a period of 16hrs, after which it is assumed that all the fat has been extracted from the food and is now present in the solution in the distillation flask. Removal of solvent leaves the fat as a residue. The flask is weighed and the increase in the weight of flask is taken as the weight of fat present in original food.Here the dry sample 5-10gm is weighed accurately and placed in a thimble and plugged with cotton. Then thimble is placed in a Soxhlet's apparatus(Fig 26) and extract with anhydrous ether/petroleum ether for about 16hrs. The ether extracted is filtered into a weighed conical flask. The flask containing ether extract is washed 4-5 times with small quantities of ether and washings are also transferred. The ether is then removed by evaporation and the flask with the residue dried in an oven at 80-100ºC, then cooled in a desiccators and weighed.

Fat content (%) = (weight of ether extract) x100/ weight of sample

Calculations:

$$\%Fat\ content = \frac{weight\ of\ fat\ extract \times 100}{Weight\ of\ sample\ taken}$$

2.11 Atomic Absorption Spectroscopy: The samples were analyzed using atomic absorption spectrophotometer (AAS) model afor determination of minerals at different wavelengths. The method used was by direct aspiration of sample digest, using air acetylene flame.Atomic Absorption Spectrometry (AAS) is a technique for measuring quantities of chemical elements present in environmental samples by measuring the absorbed radiation by the chemical element of interest. This is done by reading the spectra produced when the sample is excited by radiation. The atoms absorb ultraviolet or visible light and make transitions to higher energy levels. Atomic absorption methods measure the amount of energy in the form of photons of light that are absorbed by the sample. A detector measures the wavelengths of light transmitted by the sample, and compares them to the wavelengths which originally passed through the sample. A signal processor then integrates the

changes in wavelength absorbed, which appear in the readout as peaks of energy absorption at discrete wavelengths. The energy required for an electron to leave an atom is known as ionization energy and is specific to each chemical element. When an electron moves from one energy level to another within the atom, a photon is emitted with energy E. Atoms of an element emit a characteristic spectral line. Every atom has its own distinct pattern of wavelengths at which it will absorb energy, due to the unique configuration of electrons in its outer shell. This enables the qualitative analysis of a sample. The concentration is calculated based on the Beer-Lambert law. Absorbance is directly proportional to the concentration of the analyte absorbed for the existing set of conditions. The concentration is usually determined from a calibration curve, obtained using standards of known concentration. However, applying the Beer-Lambert law directly in AAS is difficult due to: variations in atomization efficiency from the sample matrix, non-uniformity of concentration and path length of analyte atoms (in graphite furnace AA). The chemical methods used are based on matter interactions, i.e. chemical reactions. For a long period of time these methods were essentially empirical, involving, in most cases, great experimental skills. In analytical chemistry, AAS is a technique used mostly for determining the concentration of a particular metal element within a sample. AAS can be used to analyze the concentration of over 62 different metals in a solution.Although AAS dates to the nineteenth century, the modern form of this technique was largely developed during the 1950s by Alan Walsh and a team of Australian chemists working at the CSIRO (Commonwealth Science and Industry Research Organization) Division of Chemical Physics in Melbourne, Australia. Typically, the technique makes use of a flame to atomize the sample, but other atomizers, such as a graphite furnace, are also used.

Three steps are involved in turning a liquid sample into an atomic gas:

1. Desolvation– the liquid solvent is evaporated, and the dry sample remains;
2. Vaporization – the solid sample vaporizes to a gas; and
3. Volatilization – the compounds that compose the sample are broken into free atoms.

To measure how much of a given element is present in a sample, one must first establish a basis for comparison using known quantities of that element to produce a calibration curve. To generate this curve, a specific wavelength is selected, and the detector is set to measure only the energy transmitted at that wavelength. As the concentration of the target atom in the sample increases, the absorption will also increase proportionally. A series of samples containing known concentrations of the compound of interest are analyzed, and the corresponding absorbance, which is the inverse percentage of light transmitted, is recorded. The measured absorption at each concentration is then plotted, so that a straight line can then be drawn between the resulting points. From this line, the concentration of the substance under investigation is extrapolated from the substance's absorbance. The use of special light sources and the selection of specific wavelengths allow for the quantitative determination of individual components in a multi element mixture.

III. RESULTS AND DISCUSSIONS

3.1 Physico-Chemical Parameters Of Jowar And Bajra

| S.NO.	PHYSICAL PARAMETERS	JOWAR				BAJRA			
		BEFORE DRYING	TAPPERED FLUIDISED BED	TRAY DRIER	HOT AIR OVEN	BEFORE DRYING	TAPPERED FLUIDISED BED	TRAY DRIER	HOT AIR OVEN
1	MOISTURE PERCENT (%)	16.05	4.98	6.60	7.53	19.60	6.09	6.40	7.60
2	LENGTH (mm)	4.21	4.21	4.20	4.10	2.28	2.20	2.38	2.31
3	BREADTH (mm)	4.16	4.19	4.22	4.30	-	-	-	-
4	L/B RATIO	1.012	1.004	0.99	0.953	-	-	-	-
5	DENSITY(g/ml)	1.28	1.45	1.35	1.31	1.19	1.28	1.25	1.25
6	BULK DENSITY (g/ml)	0.83	0.98	0.85	0.88	0.80	0.84	0.79	0.79
7	POROSITY (%)	35.15	40.09	38.80	36.82	32.26	37.90	38.83	39.12
8	FAT(%)	2.08	1.90	1.56	1.50	6	5.90	5.45	4.49
9	ASH(%)	1.42	1.39	1.39	1.79	7.2	7.19	7.09	7.14
10	FIBER(%)	1.89	1.87	1.87	1.86	1.67	1.66	1.65	1.65
11	PROTEIN(%)	12.09	11.87	10.4	9.08	11.34	11.17	11.09	11.12
12	CALCIUM(mg)	23	20	22	24	38	34	36	32
12	IRON(mg)	5	4.72	4.34	4.67	7.89	7.43	7.09	6.76
14	PHOSPHOROUS (mg)	200	187	180	168	280	271	210	190

DRYING TEMPERATURE= 60^0 C
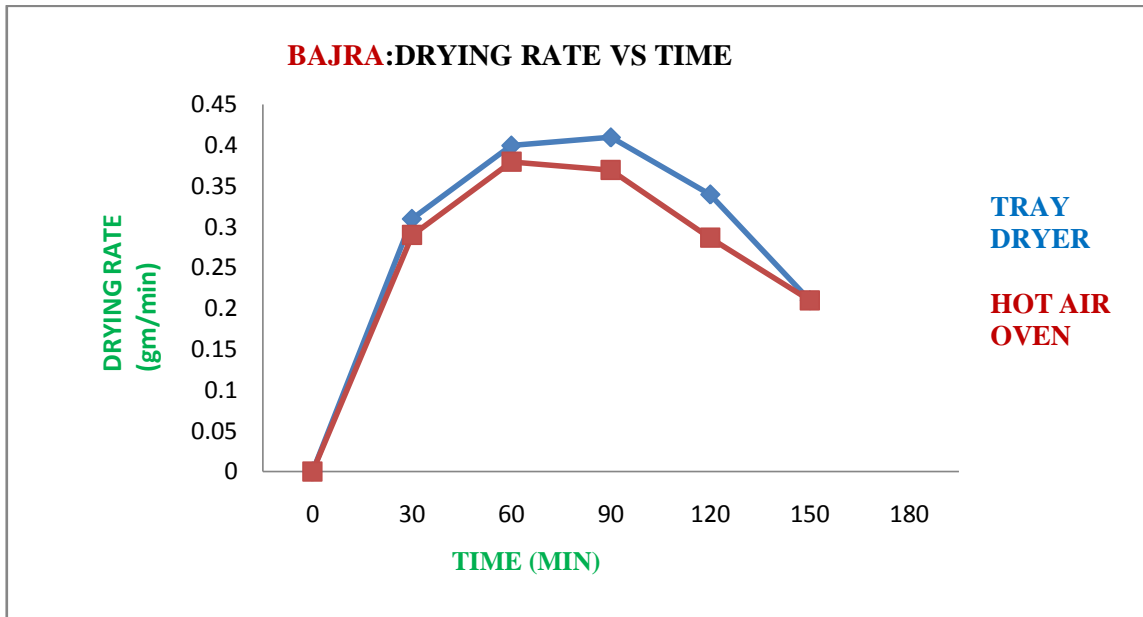
3.2 Graphs:
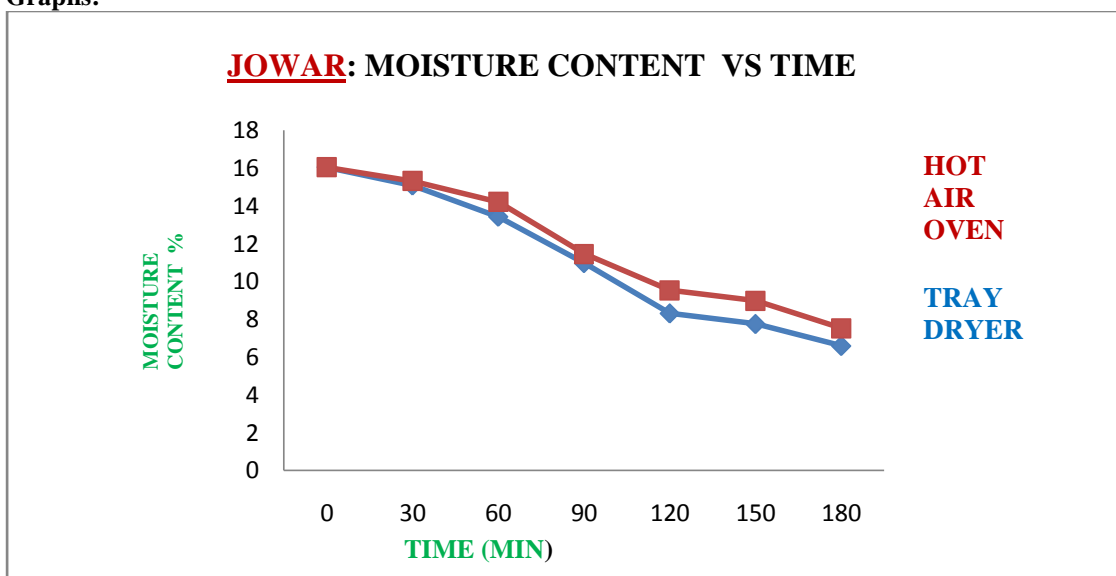
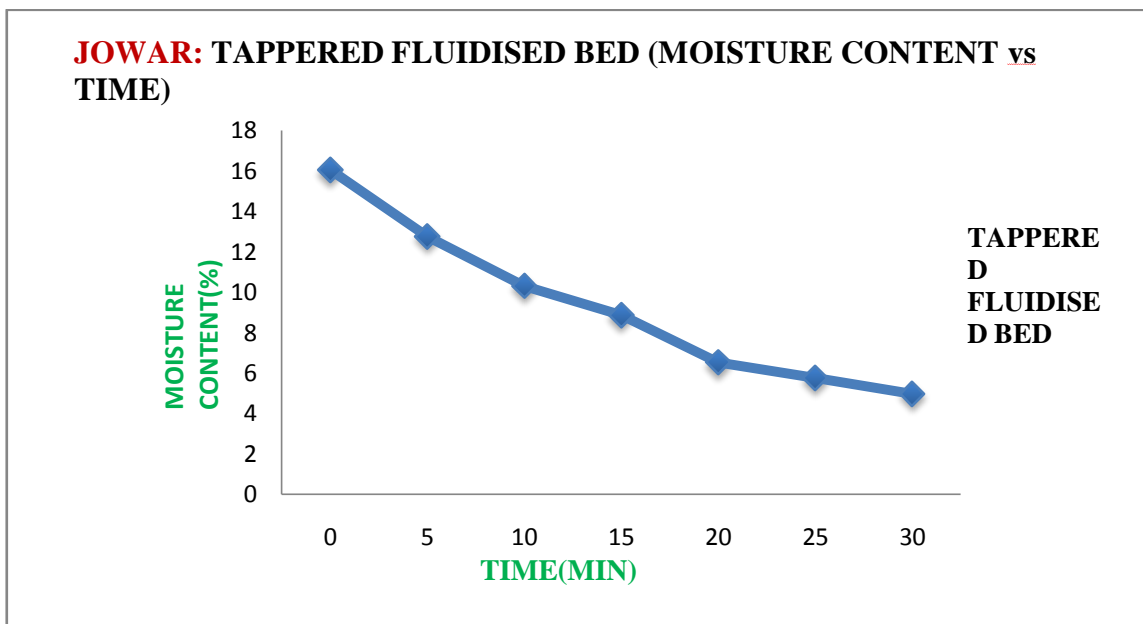**GRAPH NO 1:EFFECT OF TEMPERATURE ON MOISTURE CONTENT FOR JOWAR**
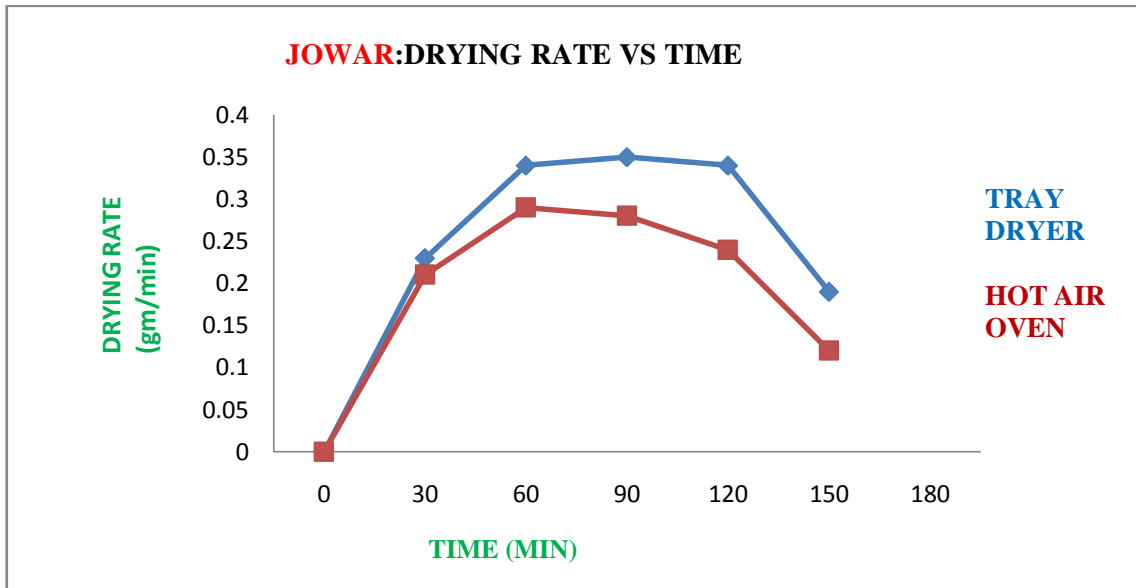
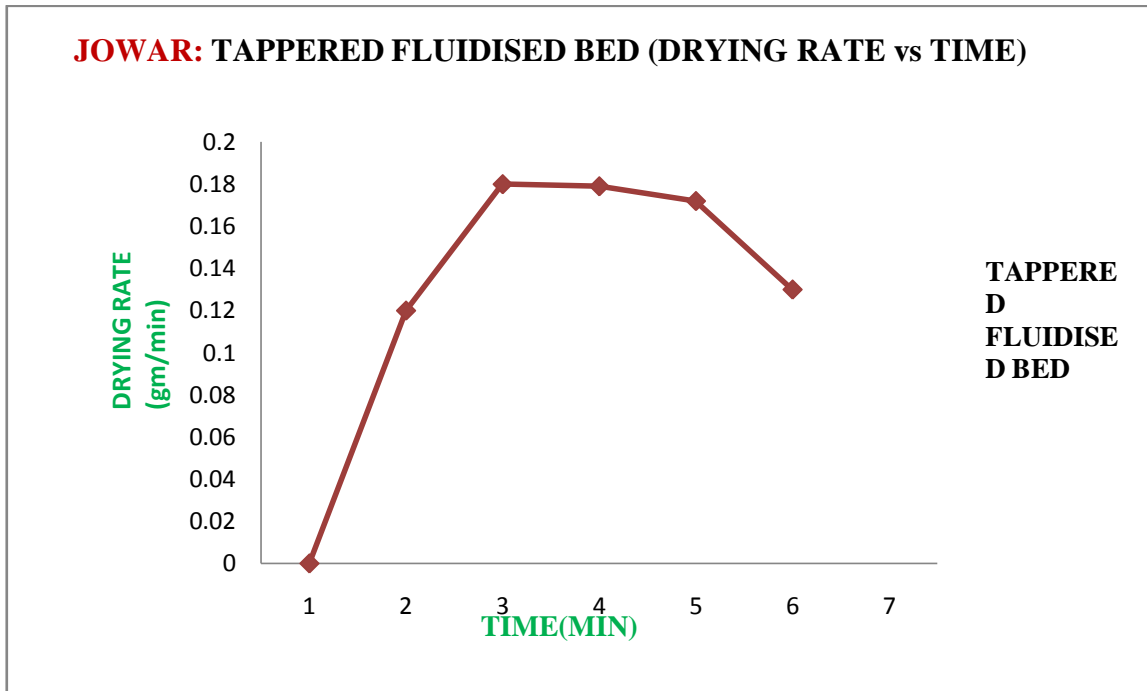**GRAPH NO 2: EFFECT OF TEMPERATURE ON DRYING RATE FOR JOWAR**
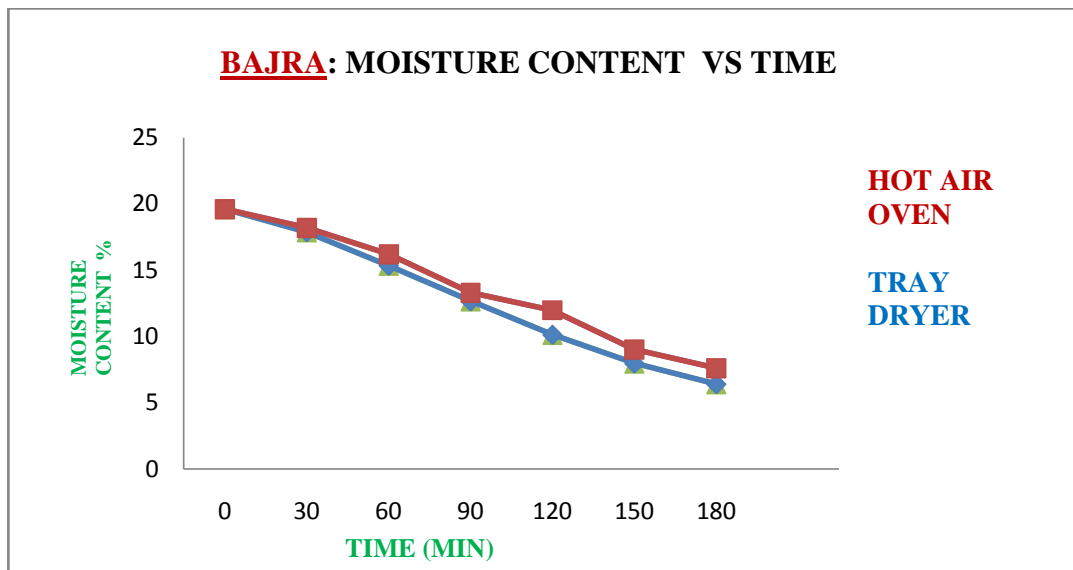
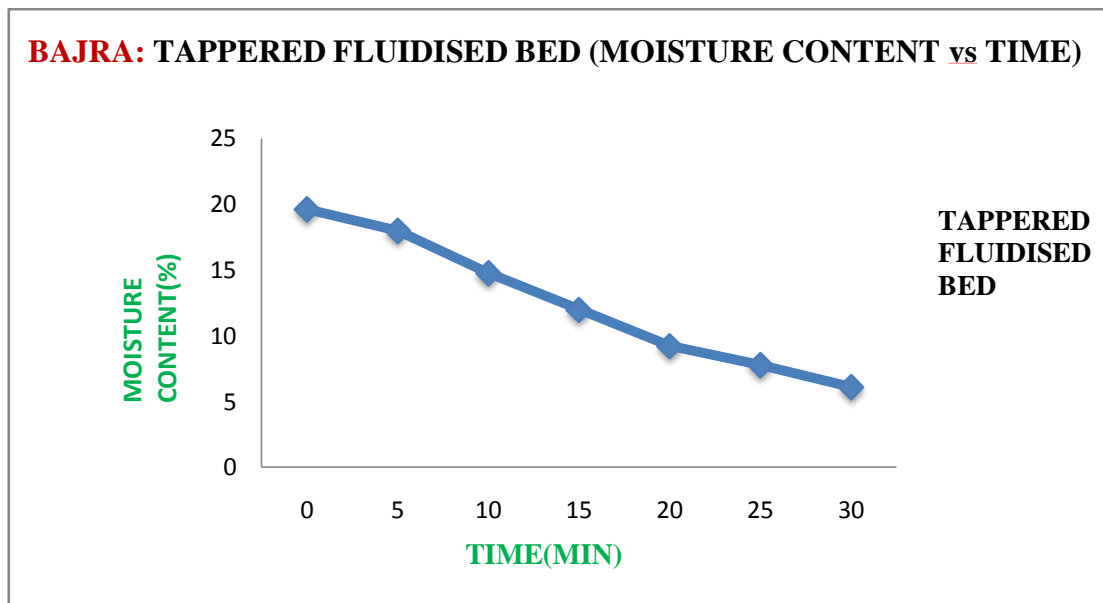**GRAPH NO:3 EFFECT OF TEMPERATURE ON MOISTURE CONTENT FOR BAJRA**

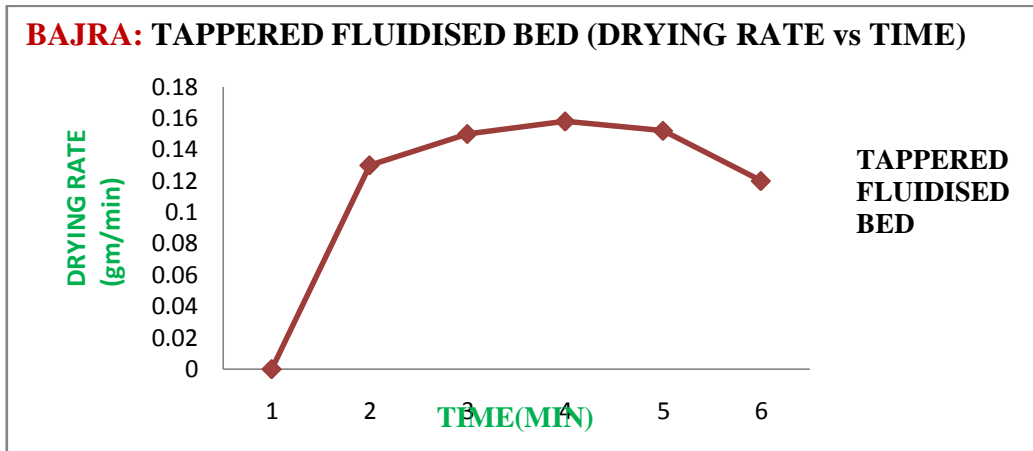**GRAPH NO 4: EFFECT OF TEMPERATURE ON DRYING RATE FOR BAJRA**

**GRAPH NO 5: EFFECT OF TEMPERATURE ON MOISTURE CONTENT FOR JOWAR**

JOWAR: TAPPERED FLUIDISED BED (DRYING RATE vs TIME)

GRAPH NO 6: EFFECT OF TEMPERATURE ON DRYING RATE FOR JOWAR

BAJRA: TAPPERED FLUIDISED BED (MOISTURE CONTENT vs TIME)

GRAPH NO 7:EFFECT OF TEMPERATURE ON MOISTURE CONTENT FOR BAJRA

BAJRA: TAPPERED FLUIDISED BED (DRYING RATE vs TIME)

GRAPH NO 8: EFFECT OF TEMPERATURE ON DRYING RATE FOR BAJRA

JOWAR PHYSICAL PROPERTIES
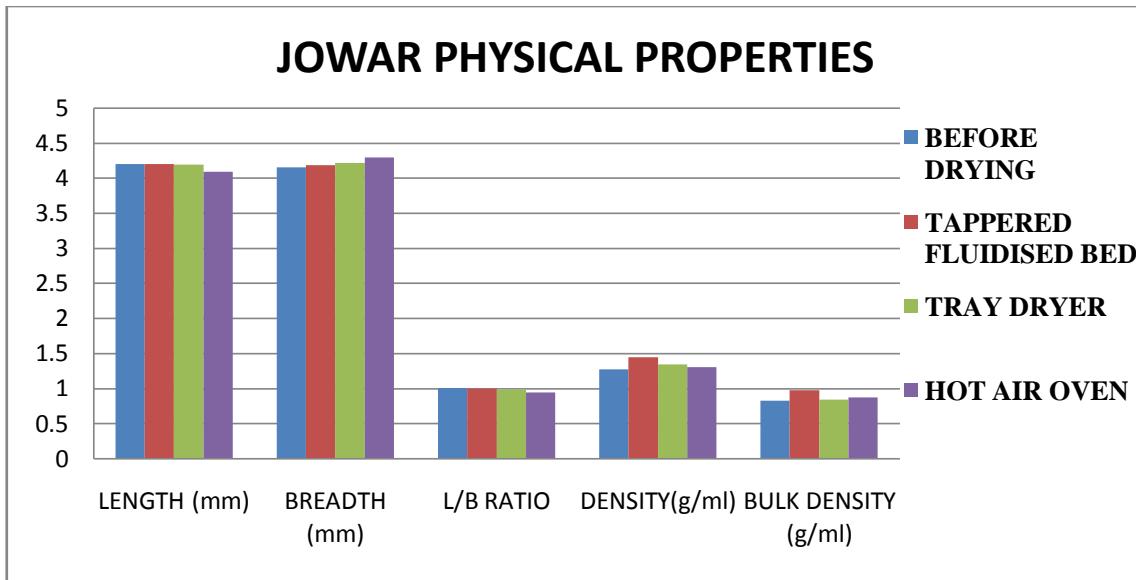
GRAPH NO 9: JOWAR –COMPARISION OF PHYSICAL PROPERTIES IN DIFFERENT DRYERS

JOWAR CHEMICAL PROPERTIES
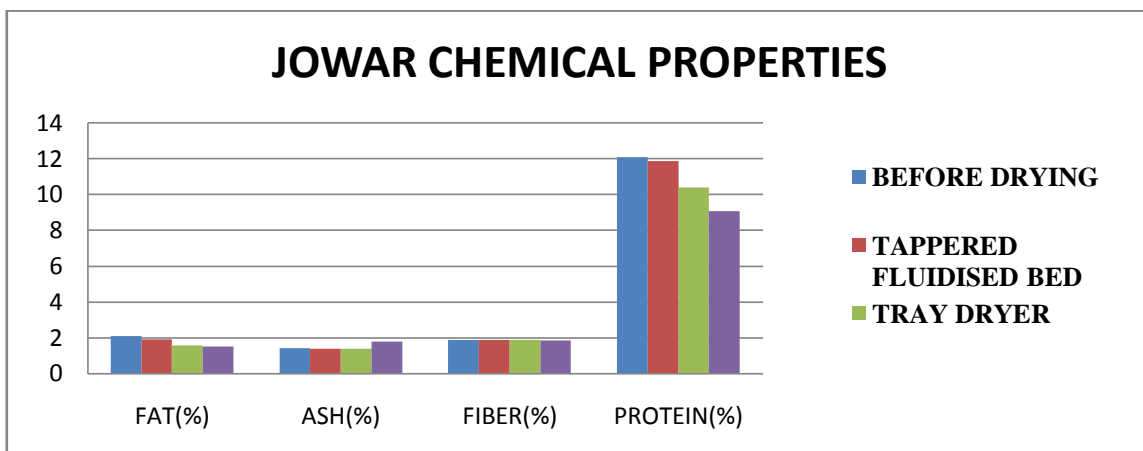
GRAPH NO 10: JOWAR –COMPARISION OF CHEMICAL PROPERTIES IN DIFFERENT DRYERS

JOWAR-MINERAL CONTENT
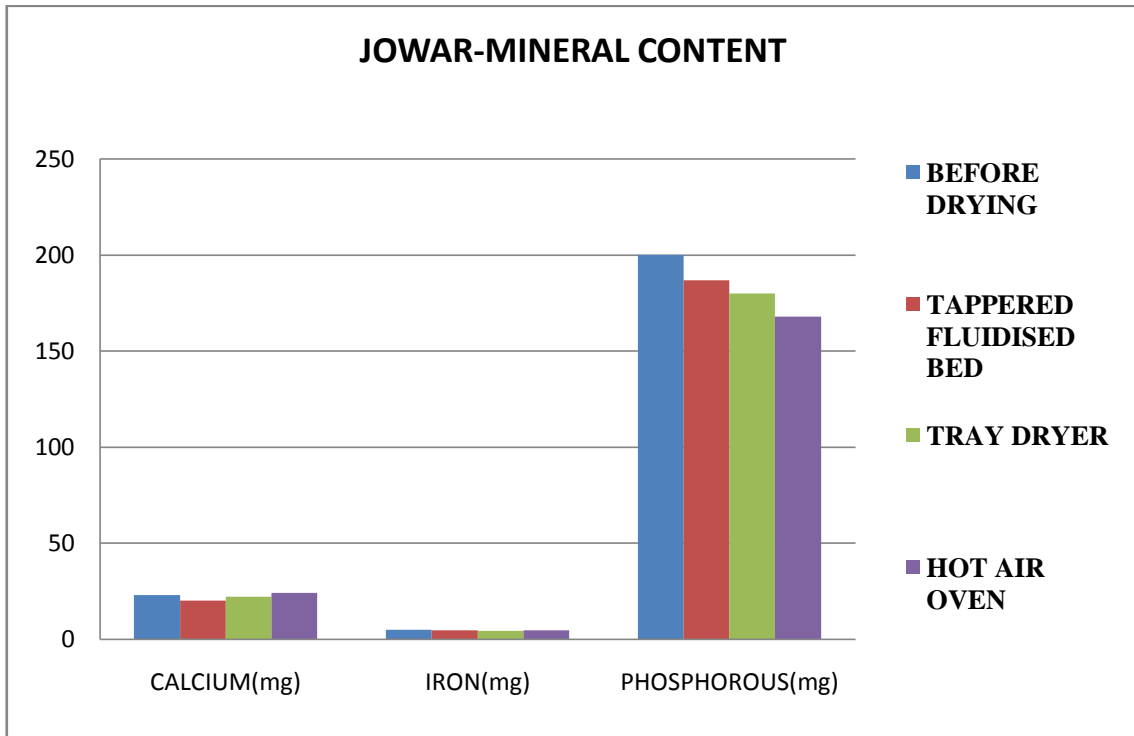
GRAPH NO 11: JOWAR –COMPARISION OF MINERAL CONTENT IN DIFFERENT DRYERS

BAJRA-MINERAL CONTENT

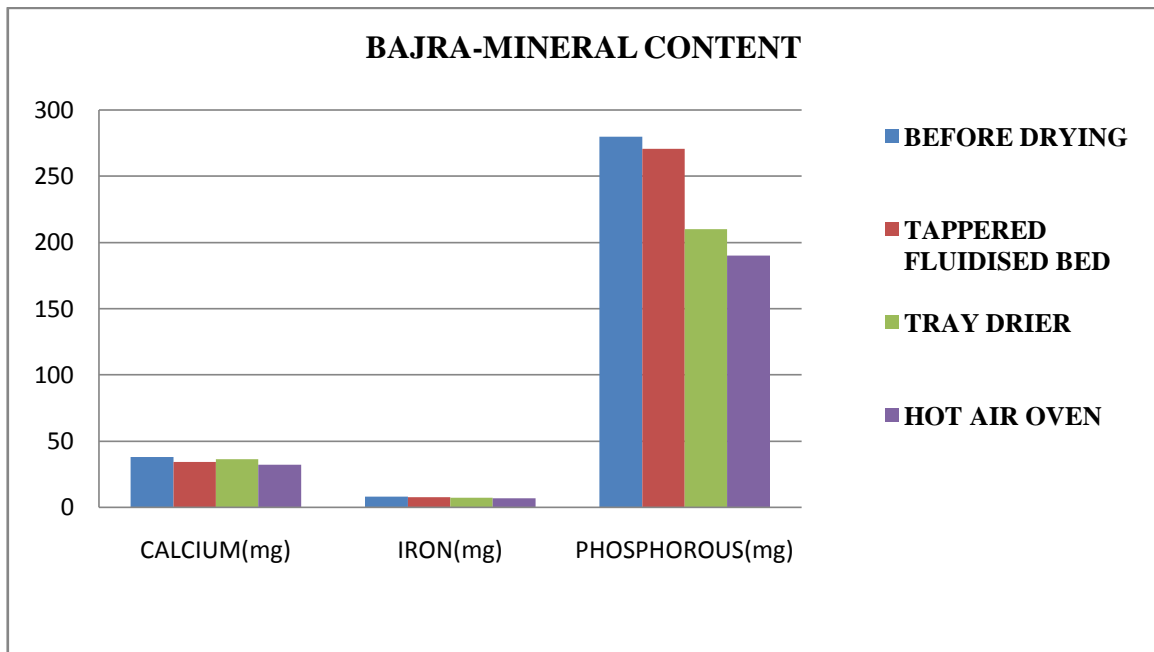GRAPH NO 12: BAJRA–COMPARISION OF MINERAL CONTENT IN DIFFERENT DRYERS
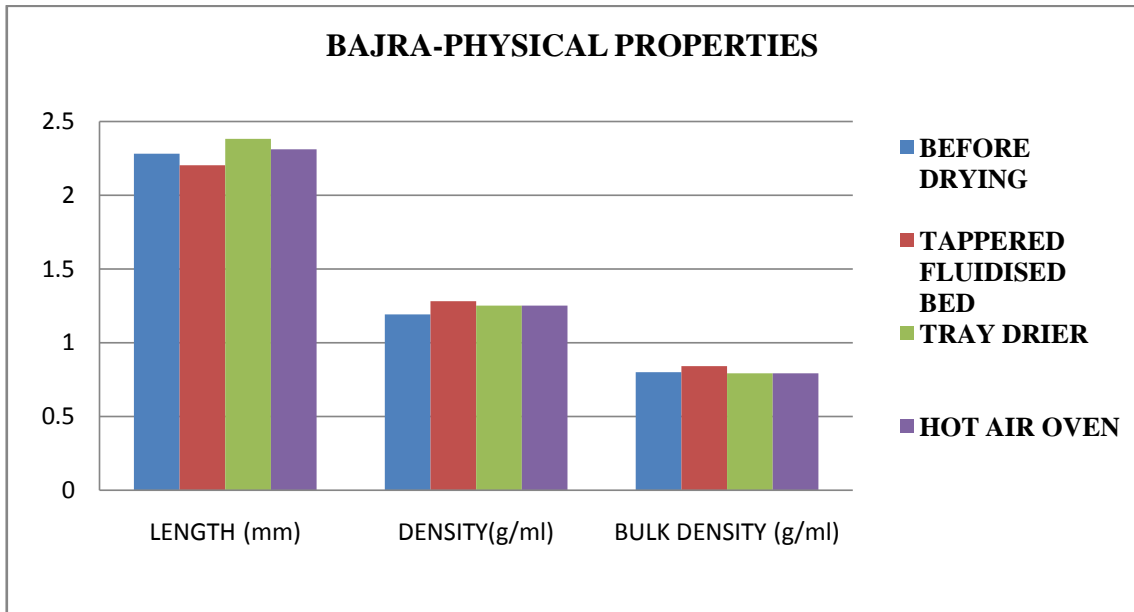
GRAPH NO 13: BAJRA –COMPARISION OF PHYSICAL PROPERTIES IN DIFFERENT DRYERS

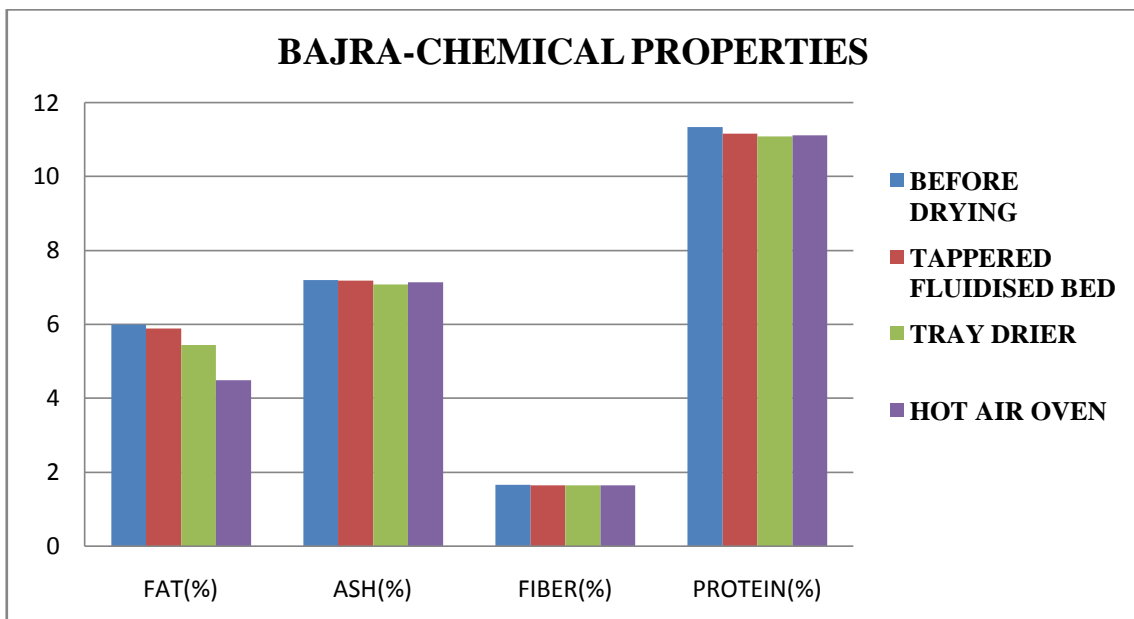**GRAPH NO 14: BAJRA –COMPARISION OF CHEMICAL PROPERTIES IN DIFFERENT DRYERS**

IV. CONCLUSION

It can be concluded that the Tappered Fluidised Bed drying method at 60°C was the best method for drying Jowar and Bajra. The drying performance of Tappered Fluidized Bed drier has been studied by analyzing moisture content of the sample during drying operation.The advantages of Tray drying over Hot air oven are clear and it is one of the better promising alternative method of drying. Finally it can also be suggested that the observed data can be suitably used for the industrial drying purpose with a suitable scale-up factor with an optimum drying process.Results revealed that Tappered Fluidized Bed drier is better when compared to Tray drier and Hot Air Oven drying.The time taken for drying in Tappered Fluidised Bed is lessthan other drying methods and it is better even in terms of efficiency and quality.Among three dryers Tappered Fluidised Bed is better for drying of Grains in large quantity.

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