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RESEARCH PAPER

# Studies on dehydration of legume based sweet product Puran by radio frequency heating technology

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**SUMMARY :** This research was carried out to explore the instant mix of puran prepared by Bengal gram and sugar in proportion of 40:60. Puran was prepared by traditional method of preparation. Among the dehydration methods radio frequency dehydration assisted with hot air gave acceptable quality of final powdered Puran product. It also had good colour after dehydration. Reconstituted easily with less amount of water than microwave dried. It is necessary to study storage life of dehydrated puran. It is also recommended that packaging of powdered puran should be under vacuum.

**Key Words :** Dehydration, Radio frequency dryer

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The preparation of food is a skilled job. In ancient times, the number of persons used to involve preparing food. But life styles of person are steadily shifted to fast food, and, therefore, the convenience food have achieved important place in modern days. Among the various convenience foods, ready mixes have its own importance.

In view of above these aspects, attempts are made to prepare instant dehydrated puran mix. Puran is a traditional and popular food item of Maharashtra, Gujarat, Madhya Pradesh and adjoining areas. It is a legume based sweet product and, therefore, economical source of protein, vitamins, minerals and calories that are essential in human nutrition. Puran provides a large amount of energy; since it contains around 50 per cent sugar.

The instant convenience food has the greatest advantage of reduction in preparation time and also easy preparation. This decrease in cooking time increases the convenience in its use in today's fast life style.

The project was designed to prepare dehydrated puran by combining different parts of Dal and sugar. After this the sensory evaluation of all the different proportion of mixes are done and also reconstitution of dehydrated puran. The sensory evaluation makes us to select the best in taste among the various combinations.

This product is made available in semisolid form. An attempt will be made to make this product in the most convenient form.

Bengal gram is called chickpea or gram *(Cicer aritinum* L.) in South Asia and Garbanzo bean in most of the developed world. Bengal gram is a major pulse crop in India, widely grown for centuries and accounts for nearly 40 per cent of the total pulse production. India is the major growing country of the world, accounting for 61.65 per cent of the total world area under Bengal gram and 68.13 per cent of the total world production. Bengal gram is widely appreciated as health food. It is a protein-rich supplement to cereal-based diets, especially to the poor in developing countries, where people are

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vegetarians or cannot afford animal protein. It offers the most practical means of eradicating protein malnutrition among vegetarian children and nursing mothers. It has a very important role in human diet in our country. Bengal gram is a valuable anti-diabetic food.

**Fundamentals of dehydration:**

Drying is one of the widely used methods of food preservation. It consists in removal of water to a final concentration, which assures microbial stability of the product and minimizes chemical and physical changes of the material during storage. In most drying processes water is removed by convective evaporation, and heat is supplied by hot air. Food dehydration is still one of the most relevant and challenging unit operations in food processing, although the art of food preservation through the partial removal of water content. Dehydration or drying of food is complex phenomenon involving momentum, heat and mass transfer, physical properties of food, air and water vapour mixture, and micro and macrostructure of the food. There are many possible drying mechanisms, but those that control the drying of particle product depend on its structure and the drying parameters-drying conditions, moisture content, dimensions, surface transfer rate, and equilibrium moisture content. These mechanisms fall into three classes

- Evaporation from a free surface,
- Flow as a liquid in capillaries, and
- Diffusion as a liquid or a vapour.

The most important reasons for the popularity of dried products are longer shelf-life, product diversity as well as substantial volume reduction. This could be expanded further with improvements in product quality and process applications. The application of dryers in developing countries, reduce losses and significantly improve the quality of the dried product when compared to the traditional means of drying such as open sun drying. The first mechanism follows the laws for heat and mass transfer for a moist object. The second mechanism becomes difficult to distinguish from diffusion when one sets the surface tension potential to be proportional to the logarithm of the moisture potential (or water activity). The third set of mechanisms follows Fick's second law of diffusion, which is analogous to Fourier's law of heat transfer when the appropriate driving force is used.

All solid materials have certain equilibrium moisture content when in contact with air at particular temperature and humidity. The material will tend to lose or gain moisture over a period of time to attain this equilibrium value. The equilibrium moisture content curve depends on the environment temperature for a particular material.

In conventional drying the heating medium, generally air, comes into direct contact with the solid. Various ovens, rotary, fluidized bed, spray, and flash dryer are typical examples. In conduction drying, the heating medium is separated from the solid by a hot conducting surface. Examples are drum, cone, and through dryers. In radiation dryer, the heat is transmitted as radiant energy. Some dryer also use microwave energy to dry food material at atmospheric pressure or at vacuum. Dehydration takes place in three stages

– Constant rate period: During this period (section AB) drying takes place by evaporation of moisture from a saturated surface.

– First falling rate period: The moisture content at the end of the constant rate period, is the "critical moisture content". At this point the surface of the solid is no longer saturated, and the rate of drying decreases with the decrease in moisture content. The surface moisture film has evaporated fully, and with the further decrease in moisture content, the drying rate is controlled by the rate of moisture movement through the solid.

– Second falling rate period: The drying rate is largely independent of the condition outside the solid. The moisture transfer may be by any combination of liquid diffusion, capillary movement, and vapour diffusion.

**Radio frequency dryer:**

*What is radio frequency :*

Radio frequency (RF) energy and microwave energy are both dielectric heating technologies, where high-frequency electromagnetic radiation generates heat to dry moisture in nonmetallic materials. RF waves are longer than microwaves, enabling them to penetrate larger objects better than microwave energy.

Material to be dried is placed in a high-frequency electric field created between a set of parallel plates or bars. Water molecules in the material are heated until they become steam. Air circulating through the drying chamber removes the steam and prevents condensation. Radio frequency (RF) drying has been successfully used in the textile and furniture industries for over 30 years and its use has progressively grown in other industries such as food processing and paper manufacturing.

Electromagnetic fields at radio frequencies can produce a heating effect in some non-conductive or dielectric materials. Radio frequency or dielectric heating has been in use for over fifty years, and has become an important technique in many industrial processes. The alignment of molecules of the dielectric materials changes rapidly at the radio frequency field. Since heat is defined as a motion of molecules, increasing the molecular motion generates heat. The electromagnetic energy heats the desired material directly without affecting the surrounding structure or the air within it. The entire material of product is heated uniformly without being dependent on the thermal conductivity of the material dielectric heating is fast, uniform, energy efficient and clean. Water is very receptive to dielectric heating; radio frequency dryers are ideal for a most of drying application. A wide range of materials including food, natural and synthetic textiles, papers, plastics, agro and pharmaceutical products can be processed using RF dryers.

**Principle of operation:**

In a radio frequency drying system the RF generator crates an alternating electric field between two electrodes. The material to be dried is conveyed between the electrodes where the alternating energy causes polar molecules in the water to continuously re-orient them to face opposite poles much like the way magnets would move in an alternating magnetic field. The friction of this movement causes the water in the material to rapidly heat throughout its entire mass (Fig. 1). The frequency, the square of the applied voltage, dimensions of the product and the dielectric loss factor of the material determine the amount of heat generated in the product, which is essentially a measure of the ease with which the material can be heated by this method. Because water is far more receptive than other materials usually found in glass or ceramics, the water is preferentially heated and evaporated. The reduction in loss factor as the material dries out provides a valuable safeguard against overheating. This method of drying, therefore, is ideal for application where uniformity of product dryness is an important requirement.

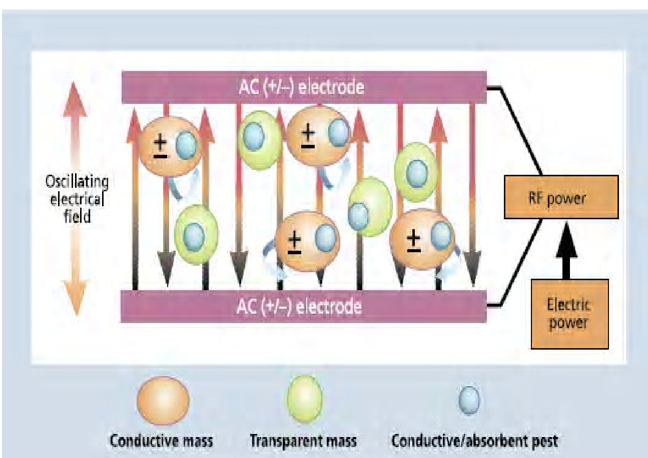



**Fig. 1 :**

The more difficult an item is to dry with convection heating, the more likely it is to be a good candidate for RF drying. Materials with poor heat transfer characteristics, such as ceramics and glass fibers, have traditionally been problem materials when it comes to heating and drying. Radio frequency heats all parts of the products mass simultaneously and evaporates the water in situ at relatively low temperature usually not exceeding 180$^0$F. Since water moves through the product in the form of a gas rather than by capillary action, migration of solids is avoided. Warping, surface discoloration, and cracking associated with conventional drying methods are also avoided.

**The benefits of RF drying:**

*Precise control of moisture content and uniformity:*

Radio frequency drying increases product. Yield because of the uniform level of dryness throughout the product. The moisture-leveling phenomenon of RF drying likewise occurs within each item being dried.

*Reduction of surface cracking:*

RF drying eliminates cracking caused by the stresses of uneven shrinkage in drying. This is achieved by the RF dryer's even heating throughout the product maintaining moisture uniformity from the center to the surface during the drying process. Other factors may contribute to surface cracking; however, the control of moisture uniformity achieved by RF drying has by far been the most significant in solving such problems.

*Energy saving:*

The efficiency of convection dryer drops significantly as lower moisture levels are reached and the dried product surface becomes a greater thermal insulator. At this point, but with more moisture to be removed, the RF dryer provides an energy efficient means of achieving the desired moisture objectives. Typically, one kilowatt of RF energy will evaporate 1kg of water per hour.

*Savings in plant space:*

Since heating begins instantaneously throughout the product, the dwell time in an RF dryer is far less than in a conventional dryer.

**Fluidized bed dryer:**

It is possible to conduct drying by passing hot air through the food materials. As the velocity of the air passing through increases, a situation eventually reaches where the pressure drop across the bed balances the weight of the bed. At greater velocity the bed expands, particle becomes suspended in the air, and the bed is said to be fluidized. Fluidizing is a very effective way of maximizing the surface area of drying within a relatively small total space. The major limitation of fluidized bed drying is the limited range of particle size. Fluidized bed can be carried out as a batch or continuous drying process.

Fluidized bed dryers have long been used in the chemical industry for such products as fertilizers and waste materials. The food industry employs the fluidized bed principles for drying as well as for freezing. The theory and practice of fluidized bed drying are well established. Heated air is blown through an orifice plate into a bed of grain at a rate sufficiently high to cause fluidization with vigorous mixing of the grain kernels. As the grain kernels dry, they lose weight and tend to float toward the product discharge. A proper combination of air velocity and grain kernel size is critical for successful operation of a fluidized bed dryer. It generally accepted that fluidized-bed dryers are best suited for products, which lose moisture primarily during the constant rate period (Nonverbal and Moss, 1971) cereal grains, however, dry at a falling rate. The range of particle sizes is another important criterion. If the ratio of the largest to the smallest diameter exceeds 8, the coarse particles tend to settle out while the smallest particles are immediately carried to the dust arrestor (Kearns, 1974). This would be unacceptable in a commercial grain dryer. Fluidized bed drying is one of the most important drying techniques employed in food processing (Potter, 1987).

**Advantages of a fluidized-bed drying:**

The excellent contact and thus high heat transfer rates between the kernels and the surrounding drying air,

– The ability to closely control the kernel temperature,
– The uniformity of grain drying,
– The high thermal efficiency, and
– The relatively low initial cost.

**Disadvantages of a fluidized-bed drying:**

– The need for a very efficient dust arrestor system,
– The requirement for a relatively uniform grain kernel size,
– The high power demand,
– The difference in fluidized air velocities for different grains.

**Microwave drying:**

Microwave refers to the electromagnetic waves in the frequency range of 300 to 300,000 mega hertz. Once microwave energy is absorbed, polar molecules and ions inside the food will rotate or collide according to the alternating electromagnetic field and heat is subsequently generated for drying. The use of microwave oven provides a convenient way to thaw, cook and reheat foods. However, the safety of the microwave food has on and off aroused some public interest. This study revived the basic principle of microwave drying, the associated potential food hazard and the health risk if any, posed to consumer as a result of consumption of microwave food. Our study of available evidences suggested that the use of microwave cooking results in food with safety and nutrient quality similar to those dehydrated by another process.

**Principle of microwave drying:**

Microwaves refer to the electromagnetic waves in the frequency range of 300 to 300,000 mega hertz (MHz) (million cycles per second). Electromagnetic waves are waves of electrical and magnetic energy moving together through space. They include gamma rays, X-rays, ultraviolet radiation, visible light, infrared radiation, microwave and the less energetic radio waves. Microwave can pass through materials like glass, paper, plastic and ceramic, and be absorbed by food and water, but they are reflected by metals.

Microwaves have many applications. They are used to detect speeding cars, send telephone, radio and television communications and treat muscle soreness, dry and cure plywood, cure rubber and resins, raise bread and doughnuts, as well as cook potato chips. However, its application in frequency (Hz) microwave oven is most commonly used by consumers.

**Heating process:**

Generally speaking, the alternating electromagnetic field generated inside the microwave oven would lead to excitation, rotation/collision of polar molecule and ions inside the food. This molecule friction would generate heat subsequently lead to temperature rise. The two major mechanisms namely dipolar and ionic interaction, explain how heat generated inside food.

**Dipolar interaction:**

Once microwave energy is absorbed, polar molecule such as water molecule inside the food will rotate according to the alternating electromagnetic field. The water molecule is a 'dipole' with one positively charged end and one negatively charged end. Similar to the action of magnet, these 'dipole' will orient themselves when they are subject to electromagnetic field. The rotation of water molecule would generate heat for drying.

**Ionic interaction:**

In addition to the dipole water molecule, ionic compounds, (*i.e.* dissolved salts) in food can also be accelerated by the electromagnetic field and collided with other molecule to produce heat. Hence, the composition of a food will affect how it will be heated up inside the microwave oven. Food with higher moisture content will be heated up faster because of the dipolar interaction. As the concentration of ions (e.g. dissolved salts increase, the rate of heating also increase because of the ionic interaction with microwave. Even though oil molecule are much less polar than water molecule and non- ionic, food produce with high oil content has a heat of oil is about less than half that of water.

**Differences between RF and conventional heating:**

Conventional heating (*i.e.* conduction, convection, radiant) has a heat source on the outside and relies on transferring the heat to the surface of the material and then conducting the heat to the middle of the material. Radio frequency heating is different; it heats at the molecular level so it heats from within the material and heats the middle as well as the surface.

A conventionally dried product is hot and dry on the outside and cold and wet on the inside. Unfortunately, this is not efficient because the dry outer layer acts as an insulating barrier and reduces the conduction heat transfer to the middle of the product. This dry outer layer can cause quality problems, such as surface cracking, a skin on coatings and uneven solids dispersion through wicking of sizing and additives from the middle to the surface.

With radio frequency drying, the heating is from within so there is no hot, dry outer layer. The product is heated throughout so the water in the middle will be heated and will move to the surface. In general, because of the heat losses at the surface, radio frequency dried products are hot and dry on the inside and cooler and wetter on the outside. The combination of two technologies, using the RF heating to heat the inside and move the water to the surface where conventional methods are effective at removing it, offers some great potential benefits.

## EXPERIMENTAL METHODS

**Raw materials:**

Puran poli is a legume based sweet product prepared from Bengal gram dal, sugar, salt and spices. The raw material required for preparation of Puran was evaluated for its physiochemical characteristics and its nutritive value.

Raw materials are required for preparations of Puran are:

Bengal gram, sugar, salt, spices

These raw materials are analysed for its proximate composition by standard methods.

**Chemicals and glass wares:**

In the present investigation analytical grade chemicals from Himedia, Emerck, and BDH and Glass wares from Borosil were used.

**Methods for proximate analysis:**

*Moisture content:*

About 5g of sample was weighed accurately on the balance, then it was spread uniformly into a Petri dish and put in a hot oven at 105±1°C for 6h.After drying; the covered dish was transferred to the dessicator and weighed soon after it reached the room temperature. The procedure was repeated till constant weight of dried matter was obtained. The loss in moisture was recorded as the moisture content.

$$\%\text{Moisture} = \frac{\text{Wt.of sample before drying} - \text{Wt. after drying}}{[\text{Wt. of sample}]} \times 100$$

**Fat content :**

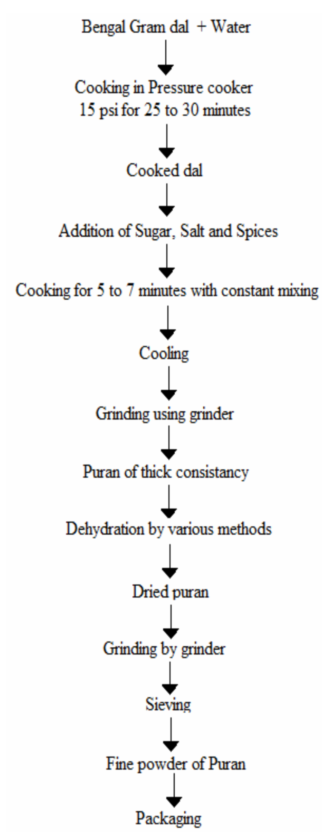
The sample was transferred to a thimble paper and the top of the thimble was plugged with cotton. The thimble was next placed in the fat extraction chamber of the Soxhlet apparatus. A previously weighed flask was filled with solvent e.g. hexane and was attached to the extraction chamber. The condenser was attached to the assembly. Extraction was carried out at proper temperature for 5hrs.The excess hexane was recovered by boiling it further. Then the flask was dried and the weight was recorded.

[Wt.of flask after extraction-Wt. of f ace at 550°C until light grey ash resulted. Ashing was done for 5h.The crucible was then cooled in a dessicator and weighed after it reached the room temperature. The difference in the weight of crucible gave the ash content.

$$\%\text{Ash} = \frac{(\text{Difference in weight})}{(\text{Wt. of sample})} \times 100$$

**Protein content :**

Protein in the sample was determined by estimating the percentage nitrogen by Kjeldahl's method and further calculating the protein content. The sample was digested with conc.$H_2SO_4$ in presence of catalyst and oxidizing agent. The organic nitrogen compounds are thereby converted to ammonium sulphates. The digested mixture was made strongly alkaline. Ammonia was distilled off and collected in dilute acids and was determined volumetrically.



Exactly 1-2 g of defatted sample was weighed in the Kjeldahl's flask.10g $K_2SO_4$ and 0.5g $CuSO_4$ was added followed by 20ml conc. $H_2SO_4$ that raises the boiling point of mixture and ensures complete reaction. The flask was gently heated on a digestion stand in inclined position until frothing ceased and then it was boiled strongly until the liquid was clear.2-3 glass beads were added to avoid bumping during boiling. Along with experimental digestion, the blank determination was done by digesting 0.5g of soluble starch instead of sample in exactly similar manner and diluted to 250ml in volumetric flask. About 20ml of the diluted sample was taken in the semi-micro-distillation unit followed by rapid addition of 10ml of 50 per centNaOH.The stopcock was closed and steam distillation was allowed to proceed for about 20min.The tip of the delivery tube was dipped in a flask containing known volume of 0.1N $H_2SO_4$ .The same procedure was repeated for blank. The unutilized $H_2SO_4$ was then titrated with 0.05N NaOH.

The percentage nitrogen was calculated as:

$$\% N_2 = \frac{1.4 \times N \times (V_1 - V_2)}{W}$$

where,

N = Normality of NaOH

$V_1$ = Titration reading for blank

$V_2$ = Titration reading for experimental

W = Weight of sample

Protein% = 6.24 x $N_2$

**Method of preparation of instant puran mix:**

Bengal gram dal was first cleaned; extraneous matter was removed and washed with water and made foreign matter free. It was then added into equal amount of water and cooked in a pressure cooker for 20 - 25 minutes at 15 PSI. To the cooked dal, when still hot, well proportion of sugar is added. All the things are mixed well and boiled in a pan for 5 minutes and cooled and grinded using mixer-grinder. The Puran was then dried by various dehydration methods.

After drying 2 - 3.5 per cent the dried Puran is grinded in grinder and then sieved through an 80 mesh sieve. To this powder 250 g (cardamom: nutmeg: cloves: 7: 2: 1) added and blended uniformly to obtain Puran mix.

In order to make this product popular, our aim was to prepare the Puran powder which will be called as 'Instant Puran'. This instant Puran can be easily reconstituted by adding definite amount of cold water. Unfortunately there is no published reports and work on preparation and standardization of instant Puran. The present project work tried to standardized and prepare a powdered Puran that can be reconstituted quickly.

Puran poli is a traditional sweet prepared from Bengal gram dal which is cooked under pressure and then mixed with sugar while cooking. To this spices and salt was added. It was then followed by making a uniform fine batter. This batter is then packed in sheet of wheat flour dough and and gave a shape of chapati. The chapati was then cooked on iron pan with the addition of ghee or vanaspati fat. This is very critical process and needs skilled worker.

Prepared puran was dehydrated by different methods of drying like $60^0$ C hot air drying assisted with radio frequency dehydration at room temperature(HA+RFD), $60^0$ C hot air drying assisted with fluidized bed drying at $60^0$ C (HA+FBD) and $60^0$ C hot air drying assisted with microwave drying (HA+MWD).

## EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussions have been presented under following sub heads:

**Proximate analysis of bengal gram:**

Analyzed bengal gram had moisture content of 9.8 per cent. Other nutrients like protein, carbohydrates contents are 17.10 per cent and 61.20 per cent, respectively. Fat content of Bengal gram was estimated that 5.30 per cent.

**Proportion of Puran 40:60 (Dal: Sugar):**

Fig. 1 A represents dehydration curve for hot air drying at $60^0$ C assisted with RF dehydration. Its first part shows that hot air drying at $60^0$ C for 120 min which reduced the initial moisture content 52 per cent to 49 per cent. Then sample were shifted to RFD for 300 min gave final moisture content 6 per cent from 49 per cent initial moisture content. Curve for second part shows decline position than first part because moisture removal from Puran was very fast in second part of RF dehydration than first part of hot air drying at $60^0$ C. Total time required for dehydration of Puran was 420 min gave 6 per cent final moisture content. Minimum exposure of RF to the Puran tended to drying of Puran by hot air at $60^0$ C. RF dryer had more efficiency of removal of water than hot air. Final dehydrated Puran powder had good appearance and golden yellow colour.

Fig. 1B represents dehydration curve for hot air drying at $60^0$ C assisted with FBD dehydration. Its first part shows hot air drying at $60^0$ C which reduced the initial moisture content 52 per cent to 49 per cent within 120 minutes. Then sample were shifted to FBD at $60^0$ C for 240 min gave final moisture content 8 per cent. Curve for second part showed steadily decline condition than first part because moisture removal from Puran was very fast in second part of FBD dehydration than first part of hot air drying at $60^0$ C. Total time required for dehydration of Puran was 360 min gave 8 per cent final moisture content. Final dehydrated Puran powder had good appearance and golden yellow colour (Table 1).

Fig. 1C represents dehydration curve for MWD assisted with hot air drying at $60^0$ C. Curve for first part showed that steadily decline condition than hot air drying at $60^0$ C which

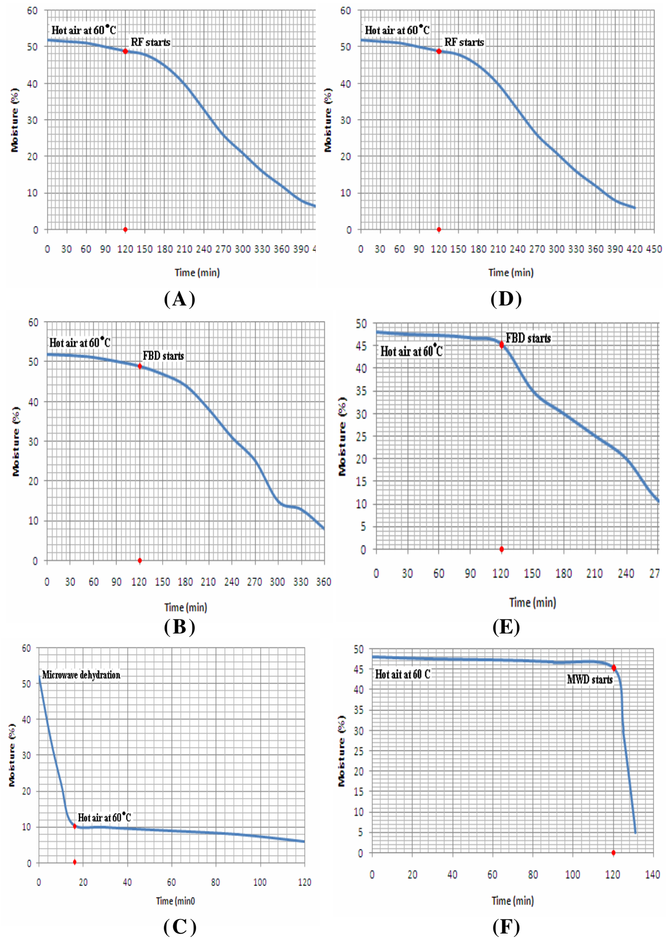



**Fig. 1 : Dehydration curve for Puran prepared by different proportion.**

reduced the initial moisture content 11 per cent to 6 per cent within 15 minutes because moisture removal from Puran was very fast in first part of MWD. Total time required for dehydration of Puran was 30 min gave 6 per cent final moisture content. Final dehydrated Puran had some cooked flavour and caramelised colour which is unacceptable as consumer point of view.

Fig. 1 D shows that dehydration by hot air drying at $60^0$ C + RF dehydration at RT for total time 330 min resulted in reduction of moisture content up to 6 per cent from initial moisture content 48 per cent. Initial moisture was removed by hot air drying at $60^0$ C for 120 min. Then it was shifted to radio frequency dehydration at room temperature for 210 min which reduced moisture content up to 65 per cent from 45.4 per cent. Drying curve showed some variation during RF dehydration. Final product was having golden yellow colour.

Fig. 1 E shows dehydration curve for hot air drying at $60^0$ C assisted with FB dehydration at $60^0$ C. Moisture removal was very slow during first part of dehydration at $60^0$ C gave near about straight line. In first part moisture was reduced from 48 per cent to 45.4 per cent in 120 min. Fluidised bed dehydration helped to reduce moisture level up to 8 per cent within 180 min (Table 2). There was declined curve during second part indicated that fast removal of moisture from sample. For total dehydration it took 300 min. Final product had good colour and flavour.

Fig. F shows that dehydration curve for hot air drying at $60^0$ C + MW dehydration. In first part hot air drying at $60^0$ C for 120 min. First part of figure shows near about straight line indicated very less removal of moisture from the sample. In Second part, there was more decline position indicated that very fast removal of moisture content from 45.4 per cent to 5

**Table 1: Dehydration parameter for Puran 40:60 by different drying combination**

| Sr. No. | Parameters | HA+RF | HA+FBD | MWD+HA |
|---|---|---|---|---|
| 1. | Initial moisture content of Puran | 52% | 52% | 52% |
| 2. | Hot air temperature | $60^0$C | $60^0$ C | $60^0$ C |
| 3. | Hot air time | 2 hr | 2 hr | 2 hr |
| 4. | Dehydration parameter | RF current | Air temp. | Microwave |
| | | 0.5 to0.6 A | $60^0$C | at 900 power |
| | | RF time 5hrs | FBD time 4 hrs | MWD time 15 min |
| 5. | Final moisture content | 6% | 8% | 6% |

**Table 2 : Dehydration parameters for Puran 45:55 by different drying combination**

| Sr. No. | Parameters | HA+RF | HA+FBD | HA+MWD |
|---|---|---|---|---|
| 1. | Initial moisture content of Puran | 48% | 48% | 48% |
| 2. | Hot air temperature | $60^0$ C | $60^0$ C | $60^0$ C |
| 3. | Hot air time | 2 hr | 2 hr | 2 hr |
| 4. | Dehydration parameter | RF current | Air temp. | Microwave |
| | | 0.5 to0.6 A | $60^0$ C | at 900 power |
| | | RF time 3.30 hrs | FBD time 3 hrs | MWD time 11 min |
| 5. | Final moisture content | 6% | 8% | 5% |

**Table 3 : Reconstitution of Puran 40:60 (Dal: Sugar) by using water**

| Reconstitution of Puran 40:60 | | | | | |
|---|---|---|---|---|---|
| Sr. No. | Puran | Initial sample weight | Weight after reconstitution | Amount of water required | Time given for reconstitution |
| 1. | HA+RFD | 25 g | 34.2 g | 10 ml | 15 min |
| 2. | HA+FBD | 25 g | 34.4 g | 10 ml | 15 min |
| 3. | MAW+HA | 25 g | 34.0 g | 11 ml | 15min |

**Table 4 : Reconstitution of Puran 45:55 (Dal: Sugar) by using water**

| Reconstitution of Puran 45:55 | | | | | |
|---|---|---|---|---|---|
| Sr. No. | Puran | Initial sample weight | Weight after reconstitution | Amount of water required | Time given for reconstitution |
| 1. | HA+RFD | 25 g | 35.7 g | 11 ml | 15 min |
| 2. | HA+FBD | 25 g | 35.6 g | 11 ml | 15 min |
| 3. | HA+MWD | 25 g | 36.9 g | 12 ml | 15 min |

per cent within 11 min. Total time required for dehydration of sample was 131 min. In microwave dehydration time required was very less as compared to other method but there was chances of cooked flavour and browning of final product which is not acceptable as consumer point of view.

## Reconstitution of Puran by using water:

*Reconstitution of Puran 40:60 (Dal: Sugar) by using water:*

Table 3 shows reconstitution properties of Puran 40:60 by using water. Same weight of sample 25 g was taken for reconstitution. It took near about 10-11 ml of water for reconstitution in 15 min. Sample dehydrated by hot air at $60^0$ C assisted with RF and MW dehydration took same amount of water *i.e.* 10ml for reconstitution of 25 g of sample but sample dehydrated by MW dehydration assisted with hot air at $60^0$ C took more water as compared to sample dehydrated by hot air at $60^0$ C assisted with RF and FB dehydration. So it indicated that near about 40-44 ml of water will be required for reconstitution of 100 g of sample which gives same and acceptable level of consistency, flavour after reconstitution within 10-15 min.

*Reconstitution of Puran 45:55 (Dal: Sugar) by using water:*

Table 4 shows reconstitution properties of puran 45:55. Same weight of sample 25 g was taken for reconstitution. Water was used for reconstitution of sample. Samples were dehydrated by hot air at $60^0$ C assisted with RF dehydration at RT, hot air at $60^0$C assisted with FB dehydration and hot air at $60^0$C assisted with MW dehydration reconstituted in near about 11ml,11ml and 12 ml of water, respectively in 15 min. In both the proportion sample dehydrated by hot air at $60^0$C assisted with MW dehydration took more water for reconstitution as compared to remaining two methods.

## Yield of dehydrated Puran 40:60 :

Table 5 shows the yield of dehydrated Puran 40:60. Sample were dehydrated by hot air at $60^0$C assisted with RF dehydration at RT, hot air at $60^0$C assisted with FB dehydration at $60^0$C and MW dehydration assisted with hot air at $60^0$C gave 56.72 per cent, 58.28 per cent and 65.04 per cent yield, respectively. Yield of dehydrated sample was more in case of MWD+HA as compared to HA+ RFD and HA+FBD. But final appearance and reconstitution properties of sample was good in case of HA+RF dehydration than samples from HA+FBD and MWD+HA.

**Table 5 : Yield of dehydrated Puran 40:60**

| Sr. No. | Puran | Initial weight | Final weight | Yield of powdered Puran |
|---|---|---|---|---|
| 1. | HA+RFD | 460 g | 260.9 g | 56.72% |
| 2. | HA+FBD | 460 g | 268.1 g | 58.28% |
| 3. | MWD+HA | 460 g | 299.2 g | 65.04% |

## Yield of dehydrated Puran 45:55 :

Table 6 shows the yield of dehydrated Puran 45:55. Sample were dehydrated by hot air at $60^0$ C assisted with RF dehydration at RT, hot air at $60^0$ C assisted with FB dehydration at $60^0$ C and hot air at $60^0$ C assisted with MW dehydration gave 60.80 per cent, 59.45 per cent and 61.70 per cent yield, respectively. Yield ranged from 59 per cent to 61 per cent which is important for final product.

**Table 6 : Yield of dehydrated Puran 45:55**

| Sr. No. | Puran | Initial weight | Final weight | Yield of powdered Puran |
|---|---|---|---|---|
| 1. | HA+RFD | 400 g | 243.2 g | 60.80% |
| 2. | HA+FBD | 400 g | 237.8 g | 59.45% |
| 3. | HA+MWD | 400 g | 246.8 g | 61.70% |

## Sensory evaluation of Puran :

Sensory evaluation was carried out at department of Food Technology, Laxminarayan Institute of Technology, R.T.M.N.U. Nagpur. Following sensory evaluation chart is average nine

**Table 7 : Average value of sensory evaluation of Puran by nine point hedonic scale**

| Sensory evaluation of Puran | | | | | | |
|---|---|---|---|---|---|---|
| Average nine point hedonic scale evaluation | | | | | | |
| Attributes | Sample A | Sample B | Sample C | Sample D | Sample E | Sample F |
| Appearance | 7.6 | 7.4 | 5.8 | 7.4 | 7.6 | 7.2 |
| Texture | 7.2 | 7 | 5.6 | 6.2 | 6.8 | 7.2 |
| Flavour | 6.6 | 6.6 | 5.2 | 5.4 | 6.6 | 6.8 |
| Taste | 6.4 | 6.4 | 5.2 | 5.2 | 6.6 | 6.8 |
| After taste | 6.2 | 6.4 | 4.8 | 5.6 | 6.2 | 6.8 |
| Overall acceptability | 6.6 | 6.4 | 5 | 5.4 | 6.7 | 6.8 |
| Sensory evaluation: | | | | | | |
| Like extremely | | | | | 9 | |
| Like very much. | | | | | 8 | |
| Like moderately | | | | | 7 | |
| Like slightly | | | | | 6 | |
| Neither like nor dislike. | | | | | 5 | |
| Dislike slightly. | | | | | 4 | |
| Dislike moderately. | | | | | 3 | |
| Dislike very much. | | | | | 2 | |
| Dislike extremely | | | | | 1 | |

(45:55=A:HA+RFD,B:HA+FBD,C:HA+MWD and 40:60=D:HA+RFD,E:HA+FBD,F:MWD+HA)

point hedonic scale evaluation of Puran of different combination.

Dehydrated puran was reconstituted by using water and analyzed for different attributes like appearance, texture, flavour, taste, after taste and overall acceptability. Reconstituted puran had same appearance and texture. Colour of puran dehydrated by microwave drying was slightly caramelized and was hard dough among all samples. Puran prepared by 40:60 proportion had more overall acceptability as compared to 45:55 proportion. Sweetness remained in puran 40:60 proportion after reconstitution so this proportion of dal and sugar was best for preparation of puran by traditional method. Puran (45:55) dehydrated by hot air assisted with RF gave good overall acceptability but with less sweetness. For better sweetness 40:60 proportion was preferred and dehydration by RF assisted with hot air. Reconstituted samples liked moderately.

**Texture analysis of reconstituted samples:**

Table 8 shows the firmness in term of force in grams. Puran dehydrated by hot air at $60^0$ C assisted with RF at RT, fluidised bed dehydration at $60^0$ C and microwave dehydration gave firmness in terms of force 42216.203g, 49162.971g and 58683.883g, respectively.

Table 9 shows the firmness in term of force in grams. Puran dehydrated by hot air at $60^0$ C assisted with RF at RT, fluidised bed dehydration at $60^0$ C and microwave dehydration gave firmness in terms of force 18268.944g, 41213.153g and 41341.855g, respectively.

**Table 8 : Results for firmness of puran prepared by 40:60 proportion**

| Samples | Firmness force (g) | Work of shear gsec area F-T 1:2 |
|---|---|---|
| HA+RFD | 42216.203 | 48498.01 |
| HA+FBD | 49162.971 | 61980.496 |
| HA+MWD | 58689.883 | 81494.243 |
| Average | 38969.824 | 48753.793 |
| S.D. | 20017.98 | 28881.125 |
| C.V. | 51.368 | 59.239 |

**Table 9 : Results for firmness of puran prepared by 40:60 proportion**

| Samples | Firmness force (g) | Work of shear gsec area F-T 1:2 |
|---|---|---|
| HA+RFD | 18268.944 | 19538.862 |
| HA+FBD | 41213.153 | 42695.406 |
| HA+MWD | 41341.855 | 46097.101 |
| Average | 33607.984 | 36110.456 |
| S.D. | 10846.486 | 11799.892 |
| C.V. | 32.273 | 32.677 |

It can be concluded that Puran dehydrated by RF technology exerted less force to probe. It indicated that firmness was more in RF dehydrated puran than other methods. Firmness plays important role during the rolling of puran polis. It is easier to get firmness in puran by proper reconstitution.

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