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Optimization Of Process Parameters for Tray Dried Broccoli Powder for The Development of Protein Rich Pizza Base

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ABSTRACT

Researchers have shown that broccoli benefits are growing tremendously due to its awareness among the people. People who are concerned about their health are moving forward to change their food habits. Even if the new products that are evolving into the market are suddenly dropped out due to the various health defects in human life. The optimization studies is the first and foremost analysis for the raw material because the processed product shows different characteristics while processing. In this paper work detailing the optimization of the process in the tray drying the broccoli powder at the two different temperatures namely 60℃ and 70℃ for the development of protein rich pizza base. The broccoli optimization studies are done with the working principle of the analysis and calculation are made with respect to the values. The dryer analysis are carried out to interpret the efficiency of three types of dryers: tray drier, cabinet –tray drier and microwave dryer. As a result of analysis and interpretation the broccoli powder which is dried at 60℃ gives the best results over the combination with the millet powder. Development of the product with the optimized parameters are giving the diet supplement with processed food like pizza.

INTRODUCTION:

Broccoli, botanically known as *Brassica oleraceaL.var .italica*belongs to the family Brassicaceae and genus Brassica. Broccoli florets are rich in nutrients like high protein, low fat, dietary fibre, vitamins, minerals and antioxidants. These florets play a vital role in curing various diseases including diabetes and cancer. This vegetable is gaining importance among people as they move towards a healthy lifestyle. Now-a-days doctors are also recommending the inclusion of this nutrition rich vegetable in the diet. Drying is one of the preservation methods where the water and the moisture content of the vegetable is removed by passing hot air at certain temperatures to decrease the biological and microbial deterioration. Drying also makes it easier for the storage and the transportation of the product. Optimization of drying temperature for the florets is important as they help in determining the temperature at which the nutritional values of the vegetable can be utilised completely. This research paper mainly deals with the optimization of the drying temperature of the broccoli florets using a tray dryer at two different temperature ranges, 60°C and 70°C and further analysis of powder and the nutritional properties of the final dried product.

MATERIALS AND METHODS:

Tray dryer was used for the drying purpose which is the most efficient way for drying the broccoli florets. Drying is the process of removing excess amounts of water or moisture from the samples to increase the shelf life of the final product.

SAMPLE PREPARATION:

The broccoli florets were purchased from the local market and the samples were cut into pieces and blanched at 100°C for 5-10 minutes to inactivate the enzymes and it also helps in reducing the drying time. The blanched sample was then drained to remove the excess water and cooled to room temperature. The florets are then minced into a fine paste, this step is done for efficient drying of the sample and to obtain a fine powder as the final product.

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DRYING:

The drying experiment was done using a laboratory scale Tray dryer. The minced sample was spread in two square shaped trays in equal quantities. One tray was used to determine the drying curve of the sample and the other tray was used for the analysis of the broccoli for its moisture content. The sample kept for drying was checked for its weight every 30 minutes until it reached a constant weight. The moisture content analysis was done for the samples simultaneously using a hot air oven at a temperature range of 105°C and the weight of the broccoli sample was taken every 60 minutes until a constant weight was reached. This drying experiment was conducted at two different temperature ranges of 60°C and 70°C separately. A graph showing the comparison of drying time and weight of the sample and another graph representing the drying time and the moisture content of the samples were plotted separately for both the temperature ranges and were interpreted. A drying experiment was conducted separately for 60°C where three samples each of 3g were taken at each interval and the same process is carried out for this experiment and a graph is plotted from the average of the values obtained.

FOXTAIL MILLET PROPERTIES:

The foxtail millet is majorly cultivated in Asia and other regions. From the sangam period, foxtail millet has been consumed as staple food for its taste and health benefits. Research studies have shown the physicochemical and functional properties of the foxtail millet like protein, fibre, mineral, moisture, bulk density. The bar graph shows the production rate of the foxtail millet during the year 2022.

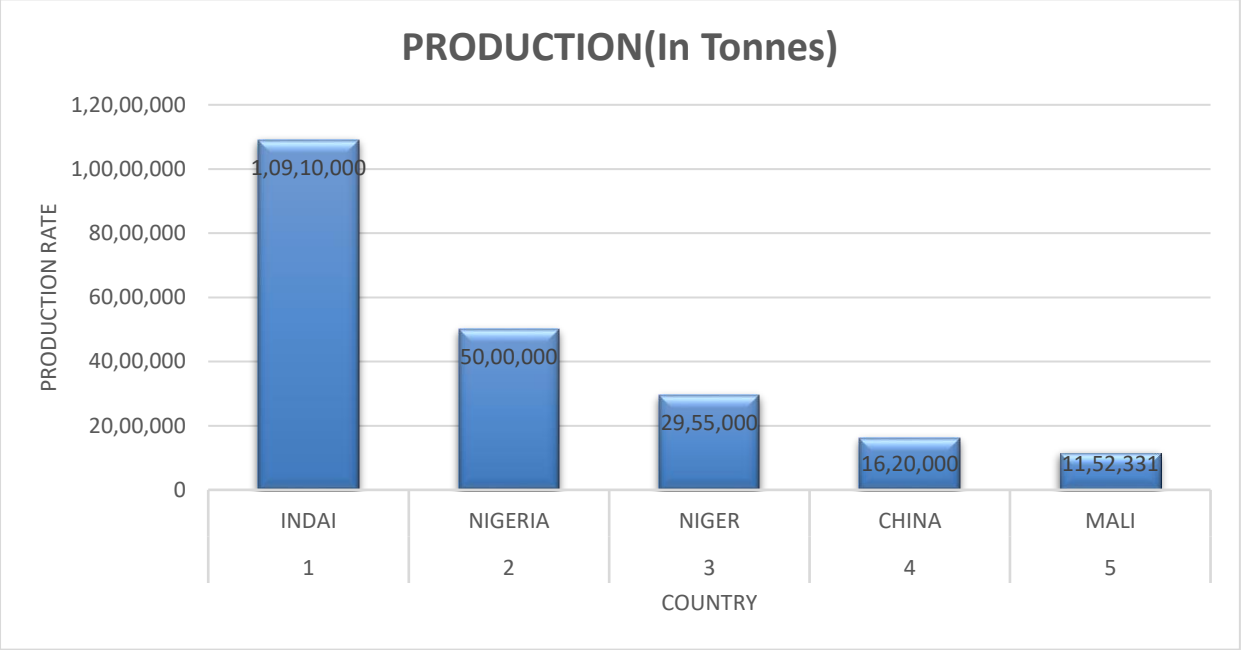

Fig – Production rate of foxtail millet in the year 2022, (source- article- leading millet producing country in the world, world atlas)

PROPERTIES OF FOXTAIL MILLET:

The properties of the foxtail millet are[9],

S.No	PROPERTIES	RESULTS
1	Protein	12.3g
2	Fibre	8g
3	Mineral	3.3g
4	Moisture	10-45%
5	Bulk density	500-540 kg m^{-3}

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6	Fat	4.3g
7	Energy	351kcal

ANALYSIS FOR BROCCOLI AND ITS POWDER:

After the drying process, fine powder is obtained by grinding the dried sample using the food processor. Certain analyses are conducted to analyse the powder properties and to determine the best suitable temperature range for the dried broccoli powder to incorporate it into the pizza base. The raw material optimization studies are the major key factor for the product development. Here so developing the new product with the incorporation of broccoli with the foxtail millet.

MOISTURE CONTENT:

The samples dried using both the temperatures (60°C and 70°C) were taken for the moisture content analysis. This experiment is done using the Hot air oven by oven dry method. 3g of samples were measured and taken in a petri dish and is placed at a temperature of 105°C. The weight of the sample is constantly measured at a time interval of 60 minutes until it reaches a constant weight. Formula for calculating the moisture percentage is:

Moisture content = $W_1 – W_2/ W_1$

Where,

W_1 = Initial weight of the sample

W_2 = Final weight of the sample

WATER ACTIVITY:

The water activity for the dried products obtained as a result of drying at 60°C and 70°C were analysed, this will help in interpreting the shelf life of the final product. Laboratory scale water activity meter were used for this purpose. Two samples each of 5g were measured and analysed for its water activity for each temperature and the results are tabulated as shown in the fig.

BULK DENSITY:

Bulk density ($_b$) is the mass of the solid particles occupied in a particular space including the voids. Analysing the bulk density of the powder will help in determining the amount of space occupied by the powder in different equipment. Broccoli powder dried at 60℃ and 70℃ were analysed for its bulk density. 5g of samples, blanched and dried at two different temperatures were taken in a beaker separately. The weight of both the beaker and the sample is taken as the total weight. Bulk density ($_b$) can be calculated using the following formula:

Bulk density ($_b$) = Mass / bulk volume

TAPPED DENSITY:

Tapped density ($_t$) is the total volume of the sample occupied after it has been tapped for several times. Sample of 5g dried at both the temperatures (i.e., 60℃ and 70℃) were taken in a beaker separately. The total weight was calculated to be the weight of the beaker and the sample. The beaker is tapped about 30-50 times for the powder to fill the voids. The final weight was measured and was used for the calculation. The tapped density ($_t$) can be found using the following formula:

Tapped density ($_t$) = Mass / tapped volume

WATER SOLUBILITY INDEX:

Water solubility index (WSI) is the amount of powder that is dissolved in the total volume of the water. For the analysis, 2g of the samples blanched and dried at 60°C and 70℃ were taken separately in conical flasks. The samples are

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then dissolved in 40ml of distilled water. Conical flasks containing the dissolved samples are then kept in the centrifuge at 3000rpm for 10 min. The supernatant obtained after centrifuging is then taken in a petri dish. Petri dish containing the supernatant is then dried in a hot air oven at a temperature range of 105℃ for over 6-7 hours until it is completely dried. The weight of the dry solids obtained after drying is measured and is used for the final calculation. The water solubility index is calculated from the following formula:

Water solubility index (WSI) = weight of the dry solids / weight of the dry sample × 100

WATER ABSORPTION CAPACITY:

Water absorption capacity (WAC) is the amount of water a powder can absorb when mixed with the solvent. The powder settled after the centrifuging process conducted for the water solubility index (WSI) is used for this analysis. The weight of the sediment powder is measured along with the centrifuge tube. During the final calculation the weight of the centrifuge tube can be eliminated. The Water absorption capacity (WAC) is determined using the formula:

Water absorption capacity (WAC) = weight of the wet sediment / (weight of the dry sample) – (weight of the dry solids)

pH:

The pH of the powder samples were analysed using a standard pH meter. 3g of the powder samples dried at two different temperatures were first dissolved in 20ml of distilled water separately. After calibrating the pH meter using distilled water, the samples were kept to check their pH.

TITRATABLE ACIDITY:

The acids that are dominant in the broccoli powder are Oxalic acid and malic acid. So after titration, the results were interpreted for both oxalic acid and malic acid. 3g of each sample were dissolved in the distilled water separately and it is kept in the orbital shaker for 10 minutes. The supernatant obtained is taken in a conical flask. 2-3 drops of phenolphthalein indicator is added to the conical flasks containing the samples. The solution is then titrated against 0.1N sodium hydroxide (NaOH). The formula to calculate the percentage of both the acids are:

Titratable acidity = volume of NaOH × 100 × molecular weight / weight of the sample

Molecular weight of oxalic acid = 0.0045

Molecular weight of Malic acid = 0.0067

COLOUR:

Colour analysis for the dried powder is done using the Hunter colour lab. Three variables namely L, a, b were used for the measurement, where L value represents the lightness, a value represents the redness and the greenness, and the b value shows the yellowness and blueness. To calibrate the instrument a standard white and a black tile was used. The colour of the raw broccoli and the final powder was measured. The values obtained are used to calculate the total colour difference formula

Total colour difference = $\sqrt{(L_0-L)^2 +(a_0-a)^2 + (b_0-b)^2}$

Where L_0 signifies the lightness of the broccoli before drying and L lightness after drying. a_0 shows the value of redness or greenness before drying and a redness or greenness after drying. b_0 represents the yellowness or blueness before drying and b yellowness or blueness after drying.

FLOWABILITY:

Flowability of the powder samples can be found from the values obtained from the bulk density and tapped density by using the formula

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Flowability = Tapped density – bulk density / tapped density × 100

TOTAL MINERAL CONTENT:

Analysis of Ash content helps in determining the amount of minerals present in the given powder sample. There are two types of ashing, one is dry ashing and the other type is called wet ashing. Dry ashing procedure has been followed here for the powder analysis. 5g of samples were taken in a crucible and it is kept in the muffle furnace at a temperature of 550℃ for 6 hours. During dry ashing, the organic matter gets oxidized due to the ignition in the furnace and the left inorganic matter of the samples is used for the calculation. The weight of the crucible along with the sample after the ash analysis is measured and are used for the calculation.

Ash content = W1– W2 / W1× 100

Where,

W1 = initial weight of the powdered sample

W2 = final weight of the powdered sample

ACID INSOLUBLE ASH:

The ash obtained as a result of dry ashing is used for this analysis. 25ml of 5N Hydrochloric acid (Hcl) is added to the crucible containing the ash, mixed using a glass rod and kept undisturbed for 5 minutes. The sample is then kept in the water bath for 10 minutes and cooled to room temperature. The solution is then filtered using Whatman filter paper. The filter paper containing the residue is again kept in the muffle furnace for 30 minutes and then weighed. 25ml of Hydrochloric acid is filtered through a blank filter paper and is kept in the muffle furnace along with the samples, and the measured final weight is used for the calculation.

Acid insoluble ash = ($W_1 – W_2$) / W

Where,

W_1 = weight (in grams) of the crucible containing the acid insoluble ash.

W_2 = weight (in grams) of the empty crucible.

W = weight of the sample.

PROTEIN:

The final powder product is analysed for its protein content using the Kjeldahl method. In this method, the amount of nitrogen consumed after titration is used for the calculation as proteins contain amino acids in which nitrogen is the main element. This process includes three steps: digestion, distillation and titration. Sample of 0.3g is taken along with the catalyst sodium sulphate and copper sulphate, to this sulphuric acid is added which increases the boiling point, this process is carried out in the digester. The distillation process is then carried out in the analyser. NaOH is passed into the solution. Boric acid of 25ml and methyl red is taken in a conical flask and is kept in the receiving end where the ammonia gas from the solution condenses into a liquid and settles in the conical flask. The obtained solution is then titrated against Hcl, the titre value obtained, gives the amount of nitrogen consumed during the process.

Protein percentage is calculated using the following formula:

= (Titre value-blank) × 0.1N × 1.4 ×6.25 / sample weight

FAT:

Fat analysis of the food sample is important as they contribute to the functional and nutritive value of the product. Analysis of fat is done using the soxhlet apparatus. 2g of the powder sample is measured. The weight of the thimble is taken before the analysis. The weighted sample is then placed in the thimble. Petroleum ether used as a solvent, is poured into the thimble containing the samples. During the process the solvent gets evaporated and the fat gets deposited in the

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thimble. By measuring the final weight of the thimble, the fat content present in the sample can be calculated using the following formula

Fat content = (W2-W1)/W

Where

W2 = final weight of the thimble

W1 = initial weight of the thimble

W = weight of the sample

FIBRE:

The defatted sample obtained from the fat analysis is used for the fibre analysis. Fibre analyser (Fibrotron) is used for this purpose. Sample is taken in the fibre cloth and placed in the analyser. It is washed with alkali (NaOH) and acid solution (Sulfuric acid) . The sample is then placed in the hot air oven at 100°C for 3 hours and then it is placed in the muffle furnace for 5 hours at a temperature of 550°C. The final weight of the sample is measured and calculated using the following formula

Percentage of fibre = W1 - W2 / W * 100

Where,

W1 = initial weight of the sample

W2 = final weight of the sample

W = weight of the sample

RESULTS AND DISCUSSION:

Effect of drying time and temperature on the weight of the sample:

Drying time and temperature has a great influence on the weight, colour, appearance and texture of the sample. The initial weight of the sample which is dried at 60℃ was 167g which decreased with time and attained a constant weight of 12.5g after five hours of drying, whereas, the samples dried at 70℃ had an initial weight of 378g and attained a constant weight of 2.5g after drying it for five hours and thirty minutes. With increase in the drying time there was a decrease in the weight of the sample and the graph for the values obtained are shown in the fig.

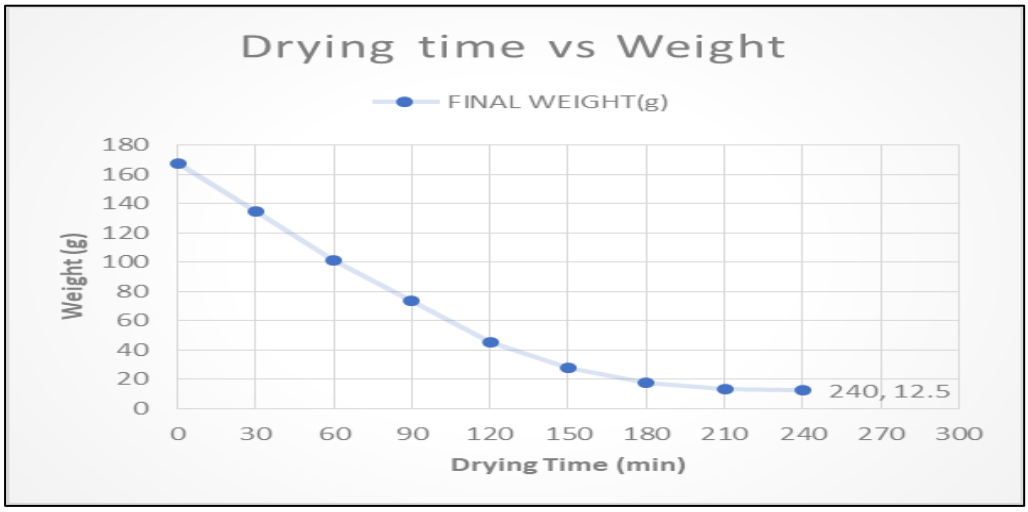

Fig. Drying time vs. weight of the sample dried at 60℃

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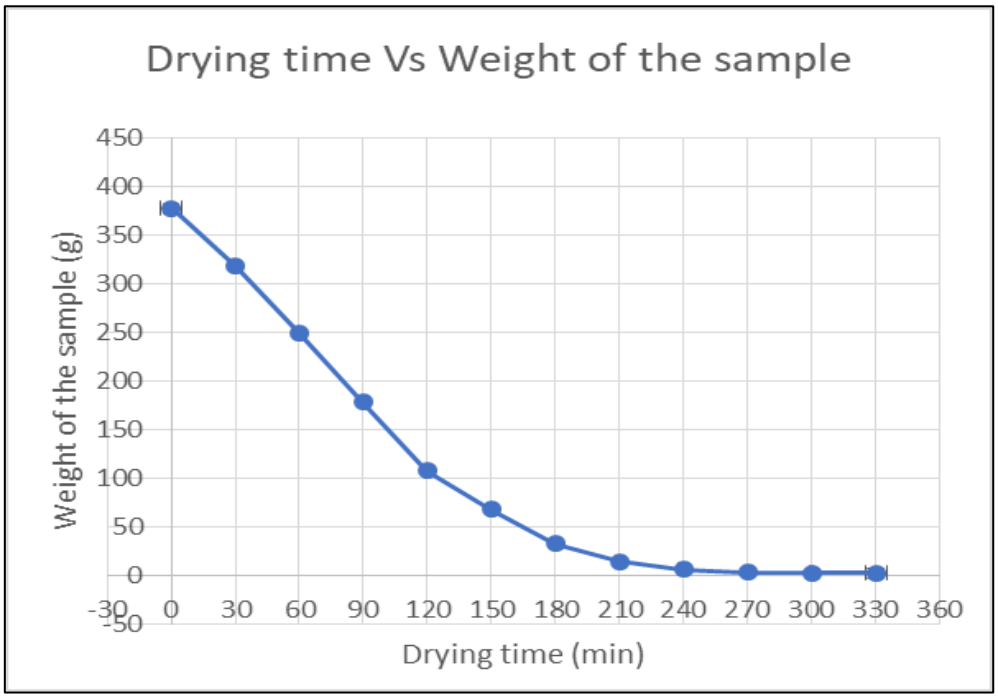

Fig. Drying time vs. weight of the samples dried at 70℃

Effect of drying time on the moisture content:

The moisture content of the broccoli was analysed to check the effect of drying time on the sample. Initially the moisture content of the broccoli was around 83% - 85%. For every thirty minute interval 3g samples were taken from the tray dryer and kept in the hot air oven for this analysis and the weight of the samples were measured every one hour until constant weight is attained. For the samples dried at 60℃, the final moisture content was 9.5% and for the samples dried at 70℃ the moisture content was 40%.The values obtained from the analysis are plotted in the graph shown in fig. The graph represents the decrease of the moisture content of the samples with increase in the drying time.

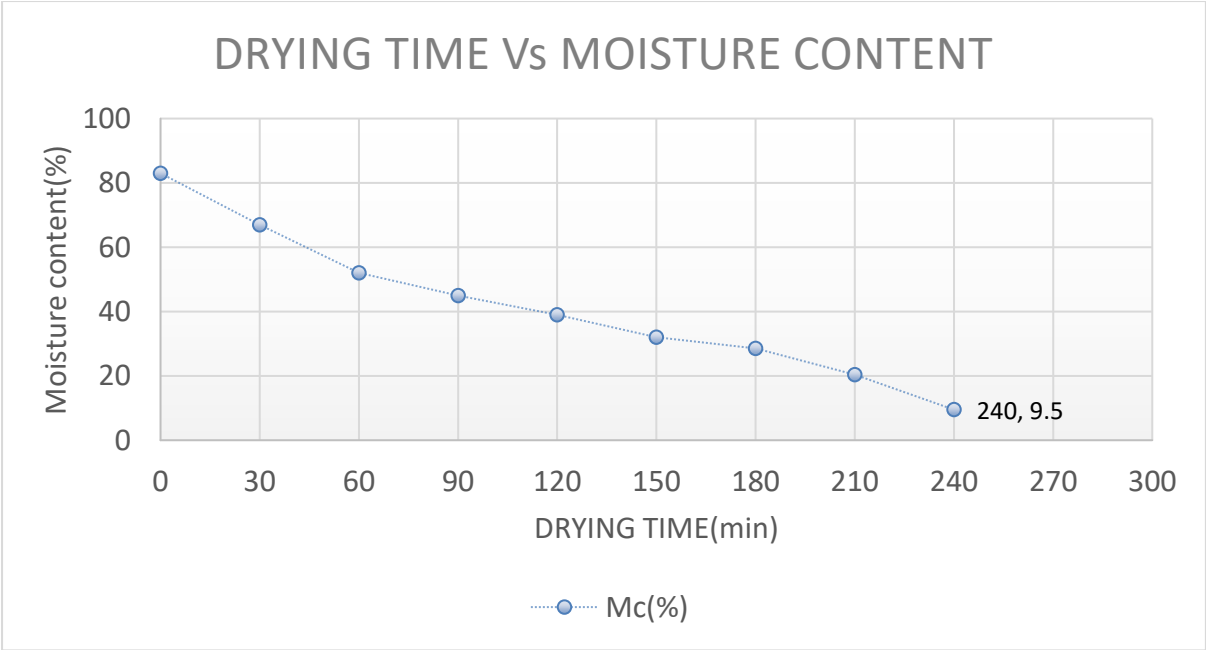

Fig. Drying time vs. moisture content of the sample dried at 60℃

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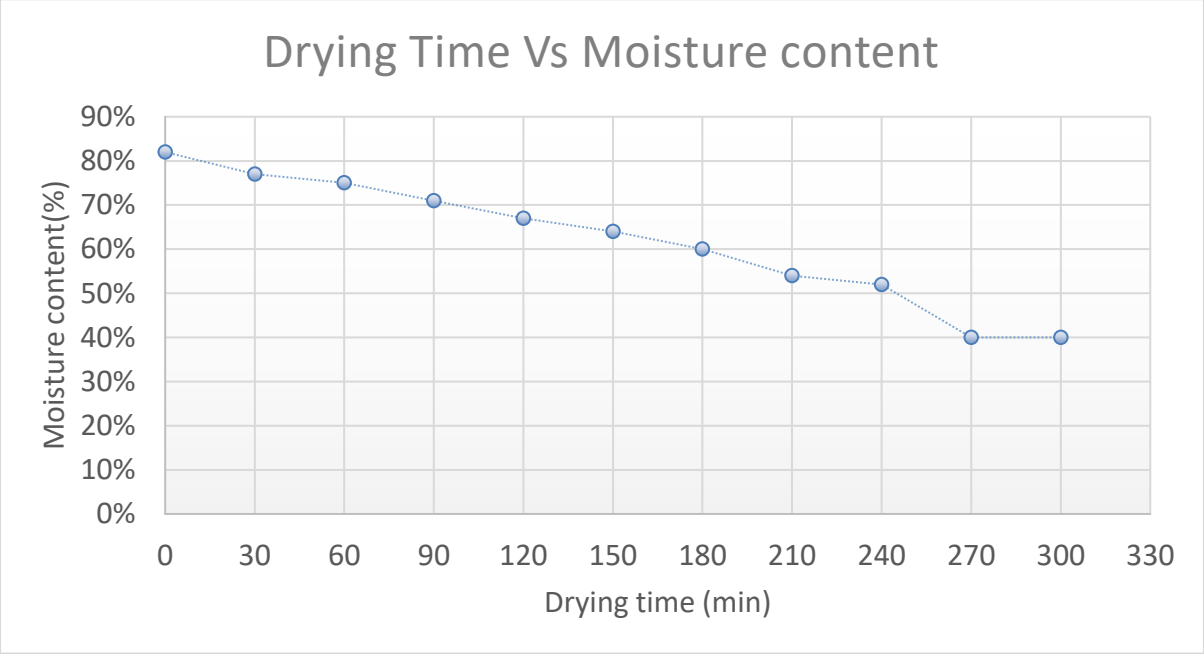

Fig. Drying vs. moisture content of the sample dried at 70℃

Moisture content Analysis for the broccoli powder:

The final dried broccoli was grinded and the obtained powder was analysed for its moisture percentage using the oven drying method. Moisture content analysis helps to study the shelf life of the product as moisture is one of the important parameters that is responsible for the microbial deterioration in the food samples. The weight of the samples were measured every one hour, using the formula the moisture content percentage is calculated. Moisture content of the powder dried at 60℃ is 11% and the moisture content of the powder dried at 70℃ is 7%. Comparing the moisture content of both the samples, the powder dried at 60℃ was less which results in the increase of shelf life.

Water activity:

The water activity of the powdered samples were measured using the water activity meter. Two values were taken for each sample dried at both temperatures. The resulting values are given in the table shown below. The powder samples dried at 70℃ were found to have values slightly less than the powder samples dried at 60℃.

For sample dried at 60℃	**For sample dried at 70℃**
0.499 at 32.5℃	0.305 at 33.4℃

Changes in the bulk density and tapped density after drying:

There was no significant changes in the bulk density and tapped density of the powders dried at both the temperatures. The values of bulk density were 0.65868g/ml and 0.60888/ml and the tapped density values were 0.819875g/ml and 0.759425g/ml for the powders dried at 60℃ and 70℃ respectively.

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Water absorption capacity and water solubility index for the dried powder:

Water absorption capacity (WAC) is the amount of moisture absorbed by the powder. The value obtained for the powder dried at 60℃ is 6.3350 which is slightly greater than the Water absorption capacity value 5.3975, the powder sample dried at 70℃. Water solubility index (WSI) indicates the solubility of the sample. Water solubility index (WSI) of the sample dried at 60℃ is 30.14, comparatively greater than the solubility index value of the sample dried at 70℃ which is 29.58.

Effects of drying on the pH and acidity of the samples:

After drying, the broccoli is powdered and is analysed for its pH and acidity levels. pH and acidity analysis are important for a food product as they are the key factors which determine the quality, microbial activity and also the shelf life of the product. The pH of the powder sample dried at 60℃ was 5.64 and the pH of the sample dried at 70℃ was 6.29. Both the samples are slightly acidic, when comparing both the values, the pH of 60℃ is less. The titratable acidity is calculated for both oxalic acid and malic acid as they are the dominant acids in the broccoli. Oxalic acid levels were 0.252% and 0.3752% and the Malic acid levels were 0.171% and 0.2546% for the powder dried at 60℃ and 70℃ respectively.

Colour:

Colour plays an important role in the consumer acceptability of the product. Due to the heat treatment there will be changes in the colour of the powder samples. The values of l, a, b of the hunter colour lab acquired for the broccoli samples before and after Drying are used for calculating the total colour difference. The resulting values show that the samples dried at 60℃ have less colour difference when compared to the sample dried at 70℃. By calculating the Total color difference using the formula. The values inferred are 13.7180 for powder dried at 60℃ and 15.2705 for 70 ℃.

Total mineral and acid insoluble mineral content:

Analysis of Ash content gives the amount of inorganic minerals such as calcium, sodium and potassium present in the powdered samples. Once the crucible attains the room temperature after the dry ashing, the weight of the leftover Ash along with the crucible is measured. The values obtained are given in the table shown below,

S.No	For sample dried at 60℃	For sample dried at 70℃
1	93.07%	92.68%

For Acid insoluble ash, which is present in the sample for 60℃ is 34.40% and for 70℃ is 36.33%.

Protein:

The protein was determined by the three processes: digestion, distillation and titration. The amount of Nitrogen absorbed is calculated by the formula. As a result of calculation, the amount of protein which is present in the sample 60℃ is 6.08% and for 70℃ is 4.968%. Increasing the higher temperature of the drying the protein gets degraded eventually so the broccoli powder which is dried at the temperature of 60℃ is used in the formulation of the product. The addition of protein rich foxtail millet into the pizza base gives additional enrichment of protein to the final product.

Fat and fibre:

Fat analysis contributes to the energy value and lipid content of the product. Two different temperatures of 60℃ and 70℃ are analysed. For 60℃ the fat content is 1.31% and for 70℃the fat content is 0.78%. In comparison, the dried broccoli powders had a slight difference in the fat content which has no effect in the final pizza base. The defatted samples from the fat analysis were used for the fibre analysis and the values were 7.7759 and 7.2816 for 60℃ and 70℃ respectively.

CONCLUSION:

The results are tabulated below;

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S.NO	ANALYSIS	SAMPLE DRIED AT 60℃	SAMPLE DRIED AT 70℃
1.	Moisture content	11%	7%
2.	Water activity	0.499	0.305
3.	pH	5.64	6.29
4.	Titratable acidity	Oxalic acid – 0.252% Malic acid – 0.3752%	Oxalic acid – 0.171% Malic acid – 0.2546%
5.	Total mineral content	93.07%	92.68%
6.	Acid insoluble minerals	34.40%	36.33%
7.	Water solubility index (WSI)	30.14	29.58
8.	Water absorption capacity (WAC)	6.3350	5.3975
9.	Total colour difference	13.7180	15.2705
10.	Bulk density	0.65868g/ml	0.60888g/ml
11.	Tapped density	0.819875g/ml	0.759425g/ml
12.	Flowability	19.6609	19.823550
13.	Fat	1.31%	0.78%
14.	Crude fibre	7.7759	7.2816
15.	Protein	6.08%	4.968%.

The effect of drying and the optimization of the raw materials were carried out in this study. Drying behaviour, physicochemical properties and functional properties were checked and interpreted. The blanched sample had more efficiency when compared to the unblanched dried broccoli powder. Drying at two different temperatures (i.e., 60℃ and 70℃) shows different properties. The results of the comparative study shows that broccoli powder dried at 60℃ is found to be effective to incorporate into the final product.

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