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Process technology development of maize-legume mix *Bari*

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Abstract
To utilize surplus maize production in Bihar and by-products of Dhal milling industry, a need was felt to mix maize flour with legume flour (Moong & Masoor) to produce *baris*. Two types of *baris* were prepared by blending of maize-legume using different mixing proportion percentages (100:00, 75:25, 50:50, 25:75 and 00:100), Drying characteristics and quality characteristics of prepared *baris* were studied. The average drying rate was observed ranging from 0.101 to 0.302 KgW/Kg.dm.h. The highest average drying rate for mixing proportion 100% M + 00% GG was achieved at 65ºC. It was observed that the *Baris* of 00% M + 100% GG or L mixing proportion were found best for their sensory quality attributes having highest water absorption capacity also and 25% M + 75% GG or L was found to be second best for their sensory quality attributes.

Keywords: Drying characteristics, quality characteristics, maize, legume, pulse, dhal, Bari, lentil (Masoor) and green gram (moong)

Introduction
Maize (*Zea mays* L.) also called as corn is the highest produced cereal grain crop of the world. Maize occupies an important position in sustainable agriculture. Maize is one of the most intensively cultivated crops in Bihar which is grown throughout the year in *kharif*, *rabi* & summer season. Maize has three possible uses: as food, as feed for livestock and as raw material for industry. Maize is one of the main constituents of a daily human diet. As a food, the whole grain, either mature or immature, may be used. Maize grown in subsistence agriculture continues to be used as a basic food crop. Maize serves as a raw material for processed consumer products. It may be used as an ingredient of livestock feed. In developed countries, more than 60 percent of the production is used in compounded feeds for poultry, pigs and ruminant animals.

The maize may be processed by dry milling techniques to give a relatively large number of intermediary products, such as maize grits of different particle size, maize meal, maize flour, and flaking grits. These materials in turn have a great number of applications in a large variety of foods. The multipurpose utility of this crop facilitates the farmers to take up its cultivation on large areas. Maize can be processed into various foods and feed ingredients, industrial products, and alcoholic beverages. Dry milling industry produces various food products out of corn such as grits, flakes, corn meal, corn cones and corn flour which are used to make food like breakfast cereals, snack foods (pancake, cookie, muffin), fortified foods etc.

In India, dhal milling is the third largest food grain processing industry after rice and wheat milling. There are about 6,000 large scale dhal mills spread all over the country with capacities of 8-10 tonnes per day, processing about 10 million tonnes of different pulses. Milling of pulse essentially consists of the removal of the tightly bound external 'husk' from the grain and recovery of the cotyledon in the form of 'dhal' (dehulled split pulse). The average yield of dhal in the commercial mills is about 75% and the rest of the grain material (about 25%) is obtained in the form of various types of by-products (Kurian and Parpia, 1968) [1]. It is estimated that about 2.5 million tonnes of by-products are generated annually from dhal mills in the country. These comprise of husk, powder, large and small broken, shriveled and under-processed grains. So far, attempts have not been made to recover the cotyledon material from these by-products fraction and hence, these are presently disposed-off only as feed grade material, fetching low remunerative prices. The by-products obtained have been found to contain substantial quantity (about 40%) of the valuable cotyledon material amounting to about 1 million tonne (Ramakrishnaiah *et al*, 2004) [2].

Maize and other cereal grains constitute important sources of carbohydrates, proteins, vitamin B and minerals. Maize contains small amounts of lysine and tryptophan. Lentil and Green gram can be used for the enrichment of lysine and tryptophan.

The niacin in maize is in a bound form and not entirely available to humans. In Mexico and some other countries, maize is treated with an alkaline solution of lime which releases the niacin. In some regions, maize serves as the primary staple food while in other regions; maize is combined with other cereals. Similarly, legumes are very important from the nutritional point of view because they are widely available vegetable food containing good quantities of protein and vitamin B in addition to carbohydrates. Most legumes contain more protein than meat.

When pulses and cereals (maize) are eaten together as one meal, they supply a protein mixture containing good quantities of all the amino acid, which improves the protein value of the diet. In India, many extruded foods are prepared either at home or by skilled artisans from maize and/or legume flours. *Bari* is one of such product which is mostly prepared by wet grinding of different legumes with required addition of salt & other spices.

Materials and Methods

Materials

Baris were prepared by mixing of maize grains, pulse of lentil and Green Gram brokens. Hot spices mixture (*garam masala*), asafoetida (*heeng*), sodium bicarbonate (edible soda) were also used as other minor ingredients for taste and flavour of *baris*.

Experimental setup

Maize powder and pulse powders were accurately weighed and mixed as per different mixing proportions given in Table 1**.** Ten experimental *baris* were prepared by hand mixing the pre-weighed powder mixture with an appropriate quantity of water along with other minor ingredients (hot spices mixture, asafoetida solution, and sodium bicarbonate) in required quantities. Prepared *baris* were put in ten different aluminium trays of tray dryer. Each tray was having a representative sample of five *baris* kept in a pre-weighed paper plate. Drying experiments of prepared *bari* were conducted at 50ºC, 57.5ºC, and 65ºC in a tray dryer. The initial weight of each representative sample was taken on a digital electronic top loading balance. The weight loss in *baris* was observed by accurately weighing the representative sample from each tray at different time intervals. The drying experiment was continued till 2/3 readings of weights were almost constant indicating the end of drying.

Table 1: Percentage of Mixing Proportions

Maize (M) %	Green Gram (G) %	Maize (M) %	Lentil (L) %
100	00	100	00
75	25	75	25
50	50	50	50
25	75	25	75
00	100	00	100

Physical properties

The physical properties (average weight, bulk density, moisture content) were determined as per the methods/techniques given below:

Determination of average *bari* weight

Five representative samples of raw *bari* were weighed by digital electronic top pan balance (ANAMED) of 4000/400 g capacity and 0.1/0.01 g sensitivity and the average weight of *baris* was calculated.

Determination of bulk density

Dried *baris* were put in a beaker of a known volume of 150 CC to its full capacity. Then the whole content of beaker (*baris*) was weighed to obtain the bulk density as per following formula:

$$\text{Bulk density (Kg/m}^3\text{)} = \frac{\text{Mass}}{\text{Volume}}$$

Determination of moisture content

Three samples were selected randomly for determining the moisture content at each time interval. Cleaned and empty moisture boxes were weighed on a digital electronic top balance (SHIMADZU) with a capacity of 330 g and a sensitivity of 0.001 g. Moisture boxes with samples were weighed again and kept in hot air oven (controlled by digital temperature controller) maintained at 102±2ºC temperature for 24 hours. Finally, the weight of dried samples was again recorded and the moisture content was calculated by using the following

$$\text{Formula Moisture content (\% d.b.)} = \frac{\text{Wt.of moist sample} - \text{Wt.of bone dried sample}}{\text{Wt. of bone dry sample}} \times 100$$

$$\text{Moisture content (\% w.b.)} = \frac{\text{Wt.of moist sample} - \text{Wt.of bone dried sample}}{\text{Wt. of moist sample}} \times 100$$

$$\text{Drying Rate (kg water / Kg. dm. h)} \times 10^{-3} = \frac{\text{Moisture removal} \times 60}{\text{Elapsed time} \times \text{Bone dry material}}$$

Determination of water absorption capacity

Two hundred ml of water was poured into each beaker and each beaker was covered with a watch glass and placed on an electric heater till its boiling. Then the pre-weighed *baris* samples were put into boiling water for 10 minutes each. After ten minutes boiling, beakers were removed from the heater and excess water was drained off from the *baris*. The rehydrated samples of *baris* were weighed to determine the water absorption capacity as follows:

Water absorption capacity (g by wt.) = Weight of *baris* after boiling - Weight of *baris* before boiling

Sensory evaluation

All the dried *baris* (30 samples) were subjected to sensory evaluation by a panel of expert judges for their colour, appearance and flavour as per 9 point hedonic rating test. Nine out of the 30 best samples on the basis of best quality attributes were selected for sensory evaluation of taste, flavor, and overall acceptability by little frying in a frying pan and soaking in boiled water for 10 minutes.

Results and Discussion

Effect of mixing proportions and drying temperature on average drying rate of *baris*

Average drying rate increases with increasing drying air temperature for all mixing proportions in both types of *baris* (Fig.1 and Fig.2). The overall variation in average drying rate was observed from 0.101 to 0.302 KgW/Kg.dm.h. The highest average drying rate of 0.302 KgW/Kg.dm.h was achieved at 65ºC for mixing proportion 100% M + 00% GG, whereas the combination of 50ºC drying air temperature with 00% M + 100% GG mixing proportion yielded minimum average drying rate of 0.101 KgW/Kg.dm.h. The average drying rate of *baris* was varied at any drying temperature due to different initial moisture content of *baris* and also due to varying proportions of constituents (Table 2).

Table 2: Variation in physical parameters of nine best samples of dried *baris* with different mixing proportions

Mixing proportions	Average *bari* weight (g)	Bulk density (Kg/m^3)	Moisture content (%d.b.)	Water absorption capacity (g by wt.)
100 % M + 00 % GG	3.34	562.20	5.298	28.36
75 % M + 25 % GG	2.99	547.93	5.235	25.90
50 % M + 50 % GG	3.91	475.47	5.230	24.29
25 % M + 75 % GG	4.52	445.53	6.118	28.86
00 % M + 100 % GG	4.13	428.87	5.022	30.36
75 % M + 25 % L	3.51	459.13	5.448	27.21
50 % M + 50 % L	3.75	446.73	6.284	26.80
25 % M + 75 % L	3.67	383.53	5.034	28.64
00 % M + 100 % L	4.17	363.53	5.484	32.00

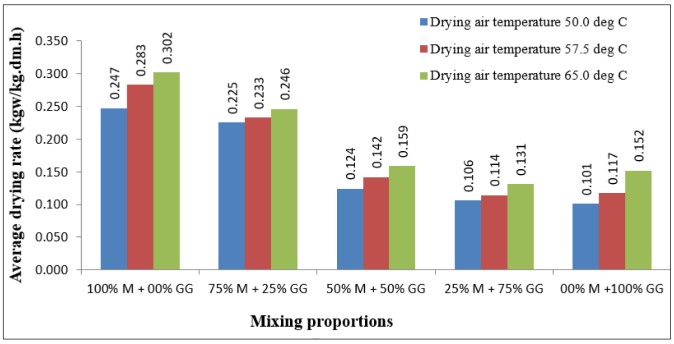

Fig 1: Effect of mixing proportions (maize and green gram) and drying temperature on average drying rate of *baris*

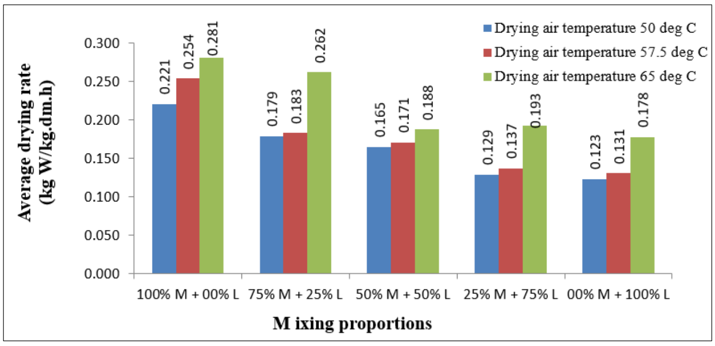

Fig 2: Effect of mixing proportions (maize and lentil) and drying temperature on average drying rate of *baris*

Variation in drying time (min) to reach 6.00 % d.b. moisture content at different mixing proportions at different drying air temperatures

It was found that total drying time decreased with increasing drying air temperature at all mixing proportions. The total drying time varied between 747 to 1055 minutes for the *baris* prepared with maize and green gram as shown in Fig. 3. However, it varied between 689 to 1068 minutes for the *baris* prepared with maize and lentil as shown in Fig. 4.

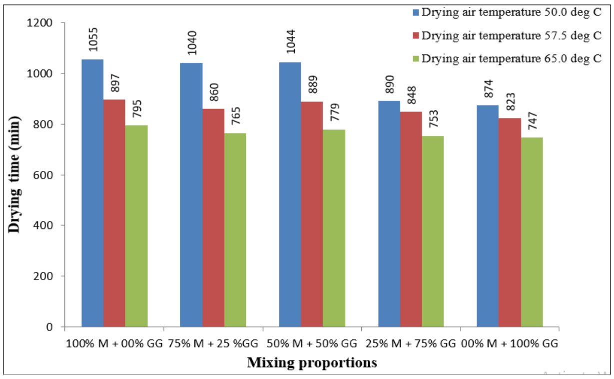

Fig 3: Variation in drying time (min) to reach 6.00 % d.b. moisture content at different mixing proportions (maize and green gram) at different drying temperatures

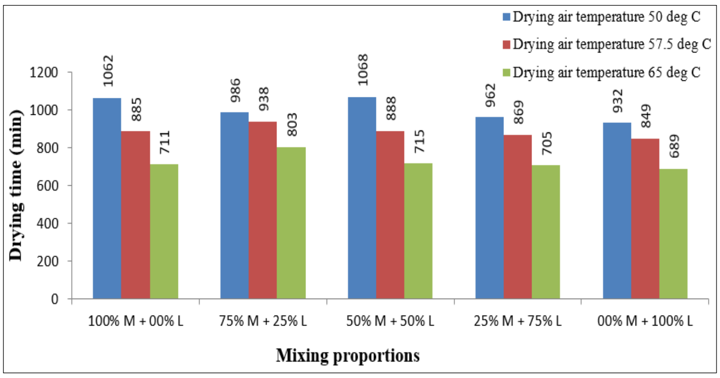

Fig 4: Variation in drying time (min) to reach 6.00 % d.b. moisture at different mixing proportions (maize and lentil) at different drying temperatures

Effect of mixing proportions on physical parameters of 9 best samples of dried *baris*

Variation in different physical parameters of 9 best samples of dried *baris* having different mixing proportions as shown in Table 2. The moisture content of dried *baris* varied from 5.022 to 6.284 (% d.b.). The maximum moisture content was obtained by *baris* of mixing proportion 50 % M + 50 % L and the minimum moisture content was obtained by *baris* of mixing proportion 00 % M + 100% GG. It was observed that the average weight of dried *baris* varied from 2.99 to 4.52. The maximum average *bari* weight was obtained by *baris* of mixing proportion 25 % M + 75 % GG and the minimum average *bari* weight was obtained by *baris* of mixing proportion 75 % M + 25 % GG. There was not much effect of mixing proportions on average *bari* weight. The bulk density of dried *baris* varied from 363.53 to 562.20 Kg/m^3. The maximum bulk density was obtained by *baris* of mixing proportion 100 % M + 00 % GG and the minimum bulk density was obtained by *baris* of mixing proportion 00 % M + 100 % L. The water absorption capacity was varied from 24.29 to 32.00 g by wt. The maximum water absorption capacity was obtained by *baris* of mixing proportion 00 % M + 100 % L and the minimum water absorption capacity was obtained by *baris* of mixing proportion 50 % M + 50 % GG. It was also observed that *baris* of 00 % M + 100 % GG or L had maximum water absorption capacity followed by the *baris* of 25 % M + 75 % GG or L among the same categories of *baris* of different mixing proportions.

Effect of mixing proportions on sensory quality of cooked *baris*

The average scores for different quality attributes earned by cooked *baris* of 9 the best mixing proportions are presented under Table 3.

Table 3: Average scores of sensory evaluation of cooked *baris*

Mixing proportions	Taste	Flavour	Overall acceptability
100 % M + 00 % GG	3.11	2.78	3.44
75 % M + 25 % GG	2.78	3.11	3.11
50 % M + 50 % GG	3.11	3.44	3.22
25 % M + 75 % GG	1.89	2.22	2.11
00 % M + 100 % GG	1.89	1.67	1.78
75 % M + 25 % L	3.89	3.67	3.89
50 % M + 50 % L	3.33	3.33	3.56
25 % M + 75 % L	2.89	2.78	3.00
00 % M + 100 % L	2.56	2.78	2.44

It was revealed in Table 3 that the *baris* of mixing proportion 00 % M + 100 % GG and 00 % M + 100 % L earned lowest average scores for taste (1.89 and 2.56), flavour (1.67 and 2.78) and overall acceptability (1.78 and 2.44). The next best samples were for *baris* of mixing proportion of 25 % M + 75 % GG or L having average scores of 1.89 and 2.89 for taste, 2.22 and 2.78 for flavour and 2.11 and 3.00 for overall acceptability. The overall range of variation was observed as 1.89 - 3.89 for taste, 1.67 - 3.67 for flavour and 1.78 - 3.89 for overall acceptability.

It was observed that the *baris* of 00 % M + 100 % GG or L mixing proportion were found best for their sensory quality attributes having the highest water absorption capacity also. The mixing proportion of 25 % M + 75 % GG or L was found the second best for their sensory quality attributes supported by higher water absorption capacity also.

Conclusion

The production of legume mix *bari* with proportion of 00 % M + 100 % GG or L is most feasible with best sensory characteristics, enhanced nutritive value and optimal functional properties.

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