Development of Potato and Barnyard Millet Based Ready to Eat (RTE) Fasting Food

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Abstract

In view of the health conscious demography and increasing preference towards use of oil free products by people, the present work was undertaken to develop microwave puffed barnyard millet based ready-to-eat (RTE) fasting foods. The experiment was conducted to develop cold extrudate, followed by microwave puffing, oven toasting to prepare ready-to-eat fasting foods. The microwave puffed product was well comparable with products available in market as per the sensory evaluation. The fat and ash content were least affected due to processing while protein content was found to be decreased due to oven toasting. The oil content in microwave puffed product was considerably less as compared to that in oil fried product.

Keywords: Cold extrudates, microwave puffing, oven toasting, RTE, fasting foods.

Introduction

Ready to eat (RTE), quick cooking and instant foods have become very common largely due to today’s life style and the demand for quick-to-serve foods. The aim is to put together various nutrients in the desired proportion and impart the organoleptic qualities through the use of suitable process technology at an acceptable cost. According to Gopalan et al. (2002), the grains are the storehouses of many chemical components including nutrients, phytochemicals, and non-nutritive plant protective functional constituents. The nutritive value of millets is comparable to other cereals with slightly higher contents of protein and minerals. Studies by Veena et al. (2005) on several varieties of Barnyard millet revealed that their total mineral content range between 1.5 to 4.0 percent. Barnyard millet was reported to contain crude fibre in the range of 5.35 to 7.90 per cent in nine different varieties. Millets in general are rich in dietary fibre content (9 to 15%). It was reported that Barnyard millet recorded a highest proportion of soluble fibre of about 6.0 - 6.5 per cent (Hadimani and Malleshi, 1993; Veena et al., 2005). Dietary fibre which is present as soluble and insoluble form is proved to play an important role in the management of metabolic disorders like diabetes mellitus, hyperlipidemia, improve bowel motility and in turn reduce the incidence of colon cancer (Ugare, 2008).

Jaybhaye et al. (2011) prepared cold extruded dough sheet pieces from barnyard millet flour, potato mash and tapioca powder in the proportion 60:37:3 and steam cooked and puffed it in hot air puffing setup. It was found that cold extrudates formed by using barnyard millet flour (58%) and potato mash (42%) were too wet, gritty and disintegrating during handling. Therefore, tapioca powder was added to increase the intactness and reduce gritty texture of dough and extrudates. Cold extrudates were steam cooked in autoclave for gelatinization of the starch and giving firm shape so that these extrudates can be handled and puffed in hot air (Yewale and Chattopadhyay, 2013).

The review of past research reveals that there are various process technologies to develop RTE foods from whole grain cereals like rice (Chandrasekhar and Chattopadhyay, 1989), legumes (Han et al., 2010), potato (Mukherjee, 1997), potato powder and soy flour (Nath, 2006), wheat-soy flour (Pardeshi and Chattopadhyay, 2010) and millets (Delost-Lewis et al., 1992), barnyard millet flour (Jaybhaye et al., 2011). However, no work found to have been done on microwave puffing of cold extrudate prepared from steamed raw ingredient like potato mash and flours of barnyard millet (Echinochloa frumentacea L.). In view
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of the aforesaid discussion, the present study has been undertaken to develop microwave puffed product from barnyard millet flour and optimize the process parameters. For this purpose, Central Composite Rotatable Design (CCRD) and response surface methodology (RSM) (Design Expert program, Version 7.0 of the STAT-EASE software (Stat-Ease, 2002) were used to fit a second order polynomial by a least square technique.

Material and Methods

Raw materials: The barnyard millet flour and potato mash were the primary raw material for preparation of fasting snack in the present investigation.

Preparation of barnyard millet flour: The barnyard millet flour was obtained by grinding the dehusked barnyard millet in mixer. The flour was sieved through 30 mesh sieve (Pardeshi, 2008). The moisture content of barnyard millet flour was found to be 0.0869 kg/kg dm.

Preparation of potato mash: Potato was steamed at 1kg/cm$^2$ pressure and crushed to prepare the potato mash (Manay and Shadaksharswamy, 2004). The moisture content of potato mash was found to be 3 kg/kg dm.

Starch gelatinization: The mixture of barnyard millet flour and potato mash was moulded in 5 cm thick rolled dough and was subjected to steaming for varied time from 10 to 20 min in kitchen pressure cooker (Pardeshi et al., 2013).

Preparation of barnyard millet based cold extrudate: The basic ingredients (barnyard millet flour and potato mash) were mixed together in varied proportion to obtain moisture content liable for cold extrusion. The cold extrudate was prepared using Dolly Mini P3 Pasta Machine (LaMonferrina Make, Italy) in rectangular shape (Pardeshi, 2008; Pardeshi and Chattopadhyay, 201; Jaybhye et al., 2011).

The above cold extrudate was subjected to steaming for specific time so as to impart gelatinization effect. As a preliminary trial, the cold extrudate was obtained from a proportionate mixture of barnyard millet and potato mash at about 0.55 to 0.58 kg/kg dm moisture content (as compared to potato-soy flour cold extrudate prepared at about 0.58 kg/kg dm by Nath (2006). These cold extrudates were steamed for 10 min (Pardeshi, 2008) at 1 kg/cm$^2$ in kitchen pressure cooker. It could be observed that cold extrudate obtained was rough and became very sticky after steaming and posing difficulty in handling. The variation in proportions of basic ingredients to vary moisture contents of cold extrudate also did not avoid surface roughness. Therefore, the dough prepared by mixing basic ingredients was initially steamed for 10 min at 1 kg/cm$^2$ cooking pressure and was kneaded for 10 to 15 min so as to obtain granular mixed dough followed by cold extrusion to get flat cold extrudates having smooth surface and allowing easy handling. It was, therefore, thought to optimize the cold extrusion and steaming process by varying proportion of basic ingredients and steaming duration at 1 kg/cm$^2$ cooking pressure.

The experimentation was conducted to prepare appropriately steamed cold extrudate by varying proportions of basic ingredients so as to vary moisture content of mixture and steaming duration (10 to 20 min) at 1 kg/cm$^2$ cooking pressure as given in Table 1. The steaming duration were decided on the basis of optimal steaming duration (of about 10 min) used by Pardeshi (2008) for preparing wheat-soy and rice-soy based cold extrudates for their hot air puffing.

Experimental design for microwave puffing of barnyard millet based ready-to-eat fasting foods: The Combo Microwave oven available in Laboratory of All India Coordinated Research Project on Post Harvest Technology, Dr. PDKV, Akola (Maharashtra) was used for the experimentation of microwave puffing. In the present study, the ranges of experimental parameters were selected based on preliminary trials. The process variables considered were convective heating temperature (190 to 230 °C), convective heating time (120-360 s), microwave power (60-100 % of 1350 W), microwave heating time (0-120 sec).

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Table 1: Design of experimentation for preparation of cold extrudate

<table>
<thead>
<tr>
<th>No.</th>
<th>Preparation of mixture of basic ingredients</th>
<th>Moisture content, kg/kg dm</th>
<th>Steaming time (min) at cooking pressure of 1 kg/cm$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50</td>
<td>50</td>
<td>0.7091</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
<td>45</td>
<td>0.6168</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>10</td>
<td>0.5347</td>
</tr>
</tbody>
</table>

The visual observations and sensory feeling was taken as response variable to decide appropriate cold extrudate.
s). The experimental design was applied after selection of the ranges. Thirty experiments were performed according to a second order CCRD with four variables and five levels of each variable. Table 2 gives the levels of variables used in the CCRD. Experiments were randomized in order to minimize the effects of unexplained variability in the observed responses due to extraneous factors. The center point in the design was repeated six times to calculate the reproducibility of the method (Montgomery, 2001).

Microwave puffing experiments were conducted according to the CCRD design and RSM was applied to the experimental data using a commercial statistical package, Design Expert Program (version 7.0) of STAT-EASE software (Stat-Ease, 2002).

Table 2: Levels, codes and intervals of variation for Microwave puffing process

<table>
<thead>
<tr>
<th>Name of process variable</th>
<th>Range (°C)</th>
<th>Code (%)</th>
<th>Levels</th>
<th>Interval of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convective heating temperature (CT)</td>
<td>150-250</td>
<td>X1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Convective heating time (Ct)</td>
<td>15-300</td>
<td>X2</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Microwaves power (MP)</td>
<td>80-100</td>
<td>X3</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Microwave heating time (Mt)</td>
<td>1-4</td>
<td>X4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

The relative effect of the process variables (Convective heating temperature, CT, convective heating time, Ct, microwave power, MP, microwave heating time, Mt) on the responses was studied and the microwave puffing process was optimized in order to get best quality microwave puffed barnyard millet based ready to eat fasting food. The responses studied were final moisture content (MC, kg/kg dm) (AOAC, 1984), expansion ratio (ER) (Segini et al., 2004), hardness (HD, g) and crispness (CSP, no. of +ve peaks) using TPA texture analyser (Chandrasekhar and Chattopadhyay, 1989; Khodke, 2002; Pardeshi, 2008) and sensory colour score (CL) (BIS, 1971).

Experimental design for oven toasting of microwave puffed barnyard millet based ready-to-eat fasting foods: Oven toasting experiments were conducted in Combo Microwave oven, with inside chamber (450x350x300 mm) having temperature range of 50-300 °C. The ranges of temperature and time for oven toasting were fixed on the basis of preliminary trials. Puffed sample of 100 g was selected for each oven toasting treatment. The experimental design used is given in Table 3. The HTST air puffed material was spread in single layer over a perforated tray and placed inside the oven at desired temperature. The time was noted by stopwatch (least count 0.1 s). As soon as the retention time reached the predetermined level, the materials were taken out from the oven and kept at room temperature for cooling before being packed in air tight containers for further analyses. Changes in moisture content, hardness and crispness, sensory colour score were measured as discussed earlier. The statistical analysis in CCRD using RSM technique was carried out as discussed above.

Results and Discussion

Preparation of cold extrudate using barnyard millet flour and potato mash: The cold extrudate using barnyard millet flour and potato mash (as basic ingredients) was prepared with the help of Dolly mini P3 Pasta machine. The dough prepared from basic ingredients was steamed and was used for preparation of flat and rectangular shaped (20 mm x 10 mm x 1 mm) cold extrudate. In order to obtain optimal cold extrudate (Pardeshi, 2008) from barnyard millet flour and potato mash, the experimentation on varied proportion of basic ingredients and on varied steaming duration was conducted as shown in Table 1. The proportion of barnyard millet flour and potato mash varied as 50:50, 55:45 and 60:40 indicating respective variation in moisture content of mix as 0.7094, 0.6168 and 0.5337 kg/kg dm. The cold extrudate prepared at moisture content of 0.5337 kg/kg dm was very hard, rough and with distorted edges. This may be due to low moisture content of mix prepared from basic ingredients. The cold extrudate prepared using basic ingredients with moisture content of 0.7094 kg/kg dm was having smoother surface but it was too soft to handle. The similar observations were recorded by Pardeshi (2008) for cold extrudate prepared from wheat and rice flours at higher moisture contents. However, the cold extrudate prepared using the basic ingredients having moisture content of 0.6168 kg/kg dm had smoother surface, uniform shape and was easy for extrusion, cutting and handling.

The cold extrusion prepared as above was steamed so as to impart puffing ability (Pardeshi, 2008), in a kitchen pressure cooker. The cold extrudate after steaming for 10 min, became very sticky and difficult for further processing. Therefore, the dough was prepared from mix of barnyard flour and potato mash (moisture content of 0.6168 kg/kg dm) and rolled in thickness of 50 mm and steamed in kitchen pressure cooker (at 1 kg/cm² pressure) for varied steaming...
duration as 10, 15 and 20 min. The steamed samples of
dough of mixture were cold extruded as discussed in
earlier. It could be observed that the cold extrudate
prepared after steaming for 10 min was very white
while that prepared after steaming for 20 min was very
brown in colour. The light white colour of sample may
be due to less gelatinization effect and overbrowning
observed in sample may be due to extra heating
imparting non-enzymatic browning (Fennema, 1971).
Therefore, the medium white coloured sample of cold
extrudates prepared after steaming for 15 min was
preferred. Thus, the appropriate cold extrudate was
obtained from mixture of barnyard millet flour and
potato mash in proportion of 55:45 (0.6168 kg/kg dm
moisture content) after steaming the dough rolled in 50
mm thickness and keeping in kitchen pressure cooker
(at 1 kg/cm² pressure) for 15 min.

Microwave puffing of cold extrudate: The
microwave puffing of steamed cold extrudate prepared
from mashed potato and barnyard millet was conducted
as discussed in materials and methods. Numerical and
graphical optimization was carried out for the process
parameters for microwave puffing for obtaining the best
product. To perform this operation, Design-Expert
program (Version 7.0) of the STAT-EASE software
(Stat-Ease, 2002), as per Pardeshi (2008), was used for
simultaneous optimization of the multiple responses.
The software generated ten optimum conditions of
independent variables with the predicted values of
responses. Solution No.1, having the maximum
desirability value (0.687) was selected as the optimum
conditions of puffing.

The optimum values of process variables obtained by
numerical optimization as shown in superimposed
contours (Fig. 1) were chosen as;
Convective heating temperature (CT): 220 °C;
Convective heating time (Ct) : 274 s; Microwave Power
(MP) : 80% 1350 W; Microwave heating time (Mt) :
60 s.

Oven toasting of Microwave puffed Barnyard millet
based RTE fasting foods: The puffed product
prepared from barnyard millet flour and potato mash
mix by microwave puffing, was found to have low CSP
(17) and higher moisture contents (0.234 kg/kg dm) as
indicated in Fig 1 and were unsuitable for consumpt
as ready-to-eat product (Dhumal, 2010). Therefore,
Oven toasting was performed to have RTE product with
increased CSP and reduced MC (kg/kg dm) (Nath,
2006; Pardeshi, 2008).

Numerical and graphical optimization was
carried out for the process parameters for oven toasting.
To perform this operation, Design-Expert program
(Version 7.0) of the STAT-EASE software (Stat-Ease,
2002), as per Pardeshi (2008), was used for
simultaneous optimization of the multiple responses.
The software generated two optimum conditions of
independent variables with the predicted values of
responses and desirability values. Solution No.1, having
the maximum desirability value (0.6268) was selected
as the optimum conditions of oven toasting. The

(A) At MP = 80% and Mt=60 s

(B) At CT =220°C and Ct = 274 s

Fig 1: Superimposed contours for MC (kg/kg dm), ER, CSP (+ve peaks) and CL for microwave
puffing of barnyard millet based RTE fasting foods at varying (A) CT, Ct and (B) MP and Mt
optimum oven toasting process variables were observed to be as, Oven toasting temperature (OT) of 125 °C and Oven toasting time (Ot) of 12.5 min. The range of optimum values of process variables by numerical optimization as shown in superimposed contours (Fig 2) were chosen as below;

Oven toasting temperature (OT): 125 °C;
Oven toasting time (Ot): 12.50 min

The oven toasting of microwave puffed product could reduce the moisture content from 0.234 kg/kg dm to 0.099 kg/kg dm and could improve the crispness from 17 to 37 (Fig 1 and Fig 2). The similar observations were recorded by Nath and Chattopadhyay (2007) during oven toasting of potato-soy ready-to-eat snacks.

Study on changes in bio-chemical composition of product during process: Since the process for preparation of RTE snack foods involved heat treatments at the stage of convective heating, microwave heating and oven toasting, it is necessary to verify the changes occurring during each step of process. Therefore, the various bio-chemical composition viz., fat, protein, ash (Thimmaiah, 2006) and moisture content (AOAC, 1984) were determined at each stage of process as shown in Table 4. The changes in ash content and fat content were found to be minimum during steaming, cold extrusion, convective heating, microwave heating and oven toasting while protein content were found to be similar till microwave puffing but reduced upto 6.6 % after oven toasting. However, the moisture content was reduced prominently at each stage of process. The final microwave puffed barnyard millet based RTE fasting food was having similar moisture, protein and as content as that in oil fried barnyard based fasting food except less fat content in microwave puffed product than that in oil fried product. This shows that the microwave puffed product is more stable than the oil fried product does.

Sensory evaluation: The sensory evaluation of the microwave puffed barnyard millet based fasting food (with and without addition of spices) as compared to commercially available similar RTE snack foods, was carried out following 9-point hedonic scale as per BIS (1971). The sensory scores given to respective optimally prepared product and commercially available similar products are shown in Table 5. The scores given for various sensory quality attributes by judges were statistically analyzed using Analysis of variance (Montgomery, 2001).

From Table 5 showing analysis of variance, it could be seen that the coefficient of variance amongst the scores
by different judges was 16.41 %., indicating considerable coherence amongst the scores attributed by the judges. The F-value was significant and the CD (5%) indicated that the product coded 04 (oil fried) was most liked followed by the microwave puffed RTE fasting food (both with and without application of vinegar and black pepper). However these three products were at par with commercially available potato chips and banana chips. The oil fried RTE fasting food applied with vinegar and black pepper were liked significantly least as compared to other products. This indicates that the microwave puffed barnyard millet based RTE fasting foods developed were well liked by the judges.

Conclusions

The cold extrudates were obtained from barnyard millet flour and potato mash in proportion of 55:45 and at moisture contents of 0.6168 kg/kg dm and steamed in kitchen pressure cooker for 15 min, kneading for 10-15 min in Dolly Mini P3 Pasta machine (LaMonferra, Italy) could yield cold extrude in rectangular strip of 20 mm long and were useful for further processing. The optimal microwave puffing of the steamed cold extrudate could be conducted by convective heating at 220 °C for 275 s followed by microwave heating with 80 % of total power 1350 W for 60 s.

References


