

Development of Ready-to-Eat (RTE) Healthy Snacks Using Pearl Millet and Maize

Dr. Aneeta Khatak¹ and Dr. R. B. Grewal²

¹Asst. Prof., Dept. of Food Technology, GJU S & T, Hisar, Haryana, India

²Director, Centre of Food Science and Technology, CCSHAU, Hisar, Haryana, India

E-mail: ¹aneetarajdabla@gmail.com, ²grewalrb@gmail.com

Abstract—Pearl millet (*Pennisetum glaucum* L.) containing foods especially ready-to-eat (RTE) food products are not available in the market, usually prepared from maize flour/starch. The present study was carried out to utilize the pearl millet flour, starch and HQPM for the preparation of value added healthy RTE snacks. Pearl millet flour from different varieties i.e., traditional variety (HC-20) and white grain variety (ICMV-221) were prepared after dry milling and starch was prepared by wet milling process. High quality protein maize (HQPM-7) was also processed to prepare grits. The process for preparation of RTE snacks with maize grits was standardized using twin screw extruder. For the preparation of value added pearl millet based RTE snacks the process and the proportion of corn: pearl millet flour was optimized using response surface methodology (RSM). The RTE snacks were evaluated for sensory and physical characteristics and for value addition various level of pearl millet starch (5- 25 %) were incorporated in best acceptable cereal mix flour i.e., HQPM: ICMV-221 variety of pearl millet (20:80) and HQPM: HC-20 variety of pearl millet (40:60). Healthy RTE snacks adjudged 'liked very much' by the judges. These snacks contained high protein, fibre and low in fat. Results indicate that pearl millet and HQPM can be processed to prepare flour, starch and grits which can be utilized to prepare value added healthy RTE snacks.

Introduction

Pearl millet containing foods especially ready-to-eat (RTE) food products are not available in market. There is need to develop simple efficient & economical technologies to enhance utility & commercial use of pearl millet (Vijayakumar *et al.*, 2010). The utilization of pearl millet for product development will help in diversifying its use for achieving food and nutrition security (Satin, 2006). Global trend toward the development of healthy snacks using traditional crops may represent a strategy or value addition of agri-products (Vanisha *et al.*, 2011).

The major component of pearl millet grain, as in all cereals, is starch. The starch content may vary from about 50 to 75 % (Hoover *et al.*, 1996, Oshodi 1999, Hadimani *et al.*, 2001). Pearl millet starch has lower amylose content than sorghum (Serna-Saldivar and Rooney, 1995). The great variability in amylose content of pearl millet starch ranging from 17.0 to 21.5% and higher 28.8 to 38 % in some varieties (Taylor, 2004; Hoover *et al.*, 1996 and Hadimani *et al.*, 2001) has been reported. The utilization of pearl millet for human food is limited to preparation of traditional foods in specific regions, mostly confined to consumers and population of lower socio-economic strata due to the non-availability of these grains in ready-to-use or ready-to-eat forms.

RTE snacks has two main attributes i.e. expansion & texture of the products. This is important for the consumer acceptance. Dietary fibres have a number of health benefits but it has been found that increasing fibre concentration in the extrudate reduces the expansion volume of extruded foods (Lobato *et al.*, 2011). In general, reduction in expansion during extrusion result in products that are dense, tough and non crispy (Lue, Hsieh & Huff, 1991). The negative effects of fibres or proteins in the extruded products can be minimized if some additives are used, such as mono glycerides, modified starches, modified gelatin, oligofructose or inulin, (Lobato *et al.*, 2011).

Materials and methods

Pearl millet varieties Haryana Composite-20 (HC-20) and White grain variety viz., ICMV-221 of pearl millet were procured from different region however corn (HQPM-7) was procured from the Regional Research Station, Uchani, Karnal. Pearl millet grains were cleaned, conditioned and dried. Dried millets were grounded to flour.

Pearl millet starch was prepared by using wet milling process (Sandhu *et al.*, 2005).

The process was standardized for the preparation of extruded snacks using corn and pearl millet flour mixed in different combination corn: pearl millet (80:20, 60:40, 40:40, 20:80, 0:100) to obtain an optimized good quality extruded product

The process for preparation of quality extrudates was standardized with the RSM experimental design. The central composite rotatable design (CCRD) for the three independent variables was performed. The independent variables considered were feed composition, feed rate (9-17 kg/hr) and feed moisture content (10-18%). The extrudates were prepared using BTPL lab model twin-screw extruder.

For the preparation of value added ready-to-eat extruded snacks various level of starch (5-25 %) were incorporated in optimized formulation for extruded snacks prepared with maize and pearl millet. Extrudates were evaluated for their physical properties. Acceptable ready-to-eat extruded snacks were evaluated for nutrient composition.

Result and discussion

Physical characteristics

Data regarding physical and overall acceptability of ready-to-eat extruded snacks prepared using different feed compositions containing pearl millet varieties (ICMV-221) and corn, feed rate and moisture level is presented in Table 1. Bulk density, expansion ratio, sectional expansion index, hardness and overall acceptability of extrudates prepared from pearl millet variety (ICMV-221) and corn ranged from 0.049 to 0.075 g/cc, 2.87 to 3.56, 8.26 to 12.69, 4.51 to 9.32 kg, 7.43 to 8.2, respectively.

The results indicate that minimum bulk density was observed with formulation containing 40 % corn extruded at 14 % moisture content and 10 kg/hr feed rate and maximum value was observed for formulation containing 20 % corn, 80 % pearl millet extruded at 12 % moisture content with 11 kg/hr feed rate. Further, formulation containing 40 % corn, 60 % pearl millet extruded at 14 % moisture content and 13 kg/hr feed rate showed more expansion ratio as compared to 40 % corn, 60 % pearl millet extruded at 11 % moisture content with 13 kg/hr feed rate. The formulation containing 20 % corn, 80 % pearl millet extruded at 16 % moisture content with 15 kg/hr feed rate higher value of expansion ratio was observed. Similar trend was followed by sectional expansion index. On the other hand, minimum hardness was observed with formulation containing 20 % corn, 80 % pearl millet at 16 % moisture content and 11 kg/hr feed rate whereas, maximum hardness was observed with formulation containing 20 % corn, 80% pearl millet extruded at 12 % moisture content with 15 kg/hr feed rate. The extrudates prepared from 60 % corn, 40 % pearl millet extruded at 16 % moisture content with 11 kg/hr feed rate were assigned highest overall acceptability scores (Table 1).

Starch was isolated from the pearl millet varieties (ICMV-221 and HC-20) and the starch obtained from these varieties was incorporated (5-25 %) in respective cereal mix flour prepared with corn and pearl millet flour of ICMV221 variety, (20:80); corn and pearl millet flour of HC-20 variety, (40:60) (Table 4.29). The bulk density, expansion ratio, sectional expansion index and hardness of RTE snacks prepared from cereal mix flour containing corn and pearl millet flour of ICMV-221 variety, (20:80) were 0.051 g/cc, 3.24, 10.48 and 5.20 kg, respectively (Table 4.29). With every 5 % increase in level of pearl millet starch in the formulation; significantly ($P < 0.05$) increased in expansion ratio and sectional expansion index whereas significantly ($P < 0.05$) decreased in bulk density and hardness of value added RTE snacks was observed (Table 2). Higher the level of pearl millet starch higher was the expansion ratio and sectional expansion index and lower was the bulk density and hardness. As a result RTE snacks prepared with pearl millet starch upto 25 % were acceptable.

Similar trend in bulk density, expansion ratio, sectional expansion index and hardness was noticed in ready-to-eat (RTE) extruded snacks prepared with incorporation of pearl millet starch (5-25 %) in cereal mix flour containing corn and pearl millet flour of HC-20 variety, (40:60). The bulk density, expansion ratio, sectional expansion index and hardness of cereal mix flour containing corn and pearl millet flour of HC-20 variety (40:60) were 0.056 g/cc, 3.30, 10.89 and 6.29 kg, respectively (Table 2). Higher the level of pearl millet starch in the cereal mix flour, higher was the expansion ratio and sectional expansion index whereas, lower was the bulk density and hardness.

Results indicate that with incorporation of pearl millet starch obtained from either of the pearl millet variety i.e. ICMV-221 or HC-20; bulk density and hardness of value added RTE extruded snacks was decreased whereas expansion ratio and sectional expansion index was increased.

Sensory characteristics

Starch was isolated from the pearl millet varieties (ICMV-221 and HC-20) and the starch obtained from these varieties was incorporated (5-25 %) in respective cereal mix flour prepared with corn and pearl millet flour of ICMV221 variety (20:80); corn and pearl millet flour of HC-20 variety, (40:60). The extrudates prepared from these blends were assessed for various sensory attributes. Mean score for color & appearance, taste, texture, aroma and overall acceptability of control extrudates prepared from cereal mix flour containing corn and pearl millet flour of ICMV-221 variety, (20:80) were 8.50, 8.33, 8.00, 8.50 and 8.33, respectively (Table 3). No significant difference in mean scores for all the sensory attributes was observed. Incorporating of pearl

millet starch up to 25 % in the formulation either improved or did not change the sensory characteristics of value added RTE snacks and were adjudged 'liked very much' (fig.1).

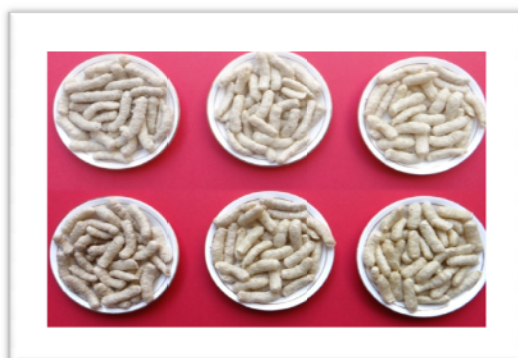


Fig. 1: Value added RTE extruded snacks prepared by incorporating of 0 (Cereal mix flour), 5 (A), 10 (B), 15 (C), 20 (D) and 25 (E)% pearl millet starch in cereal mix flour (corn: pearl millet flour of ICMV-221 variety, 20:80)

Similar result were obtained for RTE snacks prepared by incorporating pearl millet starch in cereal mix flour containing corn and pearl millet flour of HC-20 variety, (40:60). Mean score for color & appearance, taste, texture, aroma and overall acceptability of control extrudates prepared from cereal mix flour containing corn and pearl millet flour of HC-20 variety, (40:60) were 8.67, 8.33, 8.50, 8.17 and 8.42, respectively (Table 3). Incorporating of starch up to 25 % in the formulation either improved or did not change the sensory characteristics of value added RTE snacks and was adjudged 'liked very much to liked modretaly' (fig. 2).

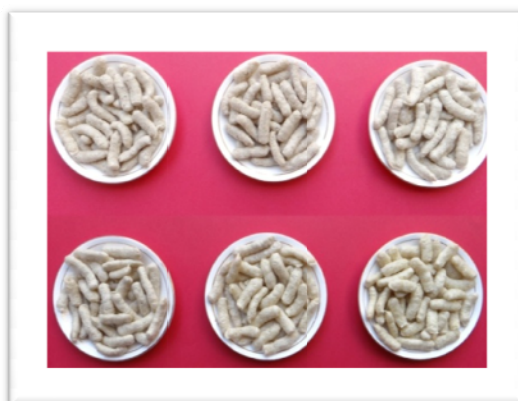


Fig. 2 Value added RTE extruded snacks prepared by incorporating of 0 (Cereal mix flour), 5 (A), 10 (B), 15 (C), 20 (D) and 25 (E)% pearl millet starch in cereal mix flour (corn: pearl millet flour of HC-20 variety, 40:60).

Result indicate that RTE snacks containing pearl millet starch (5-25 %) either improved or did not changed the sensory characteristics .

Conclusion

Bulk density, expansion ratio, sectional expansion index and hardness was noticed in ready-to-eat (RTE) extruded snacks prepared with incorporation of pearl millet starch (5-25 %) in cereal mix flour. With every 5 % increase in level of pearl millet starch in the formulation; expansion ratio and sectional expansion index increased whereas bulk density and hardness of value added RTE snacks was decreased. RTE snacks prepared with pearl millet starch up to 25 % were acceptable and adjudged "liked very much" by judges.

Acknowledgements

Rajiv Gandhi national fellowship (RGNF) awarded by UGC, New Delhi was fully acknowledged as financial support and grateful to CCSHAU, Hisar for extending all the facilities required during the course of investigation.

Table 1: Physical and sensory characteristics of ready-to-eat extruded snacks prepared by using ICMV-221 variety at different feed composition, feed rate and feed moisture level

Sr. No.	Feed Composition* (%)	Feed rate (kg/hr)	Feed moisture content (%)	Bulk density (g/cc)	Expansion Ratio	SEI	Hardness (kg)	Overall acceptability
1	40:60	11	12	0.052	3.45	11.92	5.76	7.78
2	40:60	15	12	0.065	3.16	10.00	8.72	7.80
3	40:60	11	16	0.057	3.56	12.69	4.83	8.10
4	40:60	15	16	0.058	3.49	12.20	6.71	7.83
5	80:20	11	12	0.075	2.87	8.26	9.32	7.68
6	80:20	15	12	0.067	3.24	10.48	5.21	7.80
7	80:20	11	16	0.060	3.52	12.39	4.51	7.88
8	80:20	15	16	0.051	3.47	12.04	6.92	7.88
9	60:40	10	14	0.049	3.31	10.93	4.88	7.48
10	60:40	16	14	0.059	3.54	12.49	5.29	7.83
11	60:40	13	11	0.066	3.05	9.28	8.85	7.63
12	60:40	13	17	0.063	3.51	12.34	5.93	7.68
13	26:74	13	14	0.066	3.56	12.65	6.27	7.80
14	94:06	13	14	0.059	3.06	9.37	7.12	7.70
15	60:40	13	14	0.059	3.30	10.86	6.44	7.53
16	60:40	13	14	0.059	3.30	10.86	6.44	7.53
17	60:40	13	14	0.059	3.30	10.86	6.44	7.53
18	60:40	13	14	0.059	3.30	10.86	6.44	7.53
19	60:40	13	14	0.059	3.30	10.86	6.44	7.53
20	60:40	13	14	0.059	3.30	10.86	6.44	7.53

*Pearl millet: corn

Table 2 Physical characteristics of value added ready-to-eat (RTE) extruded snacks prepared with various levels of pearl millet Starch

Level of pearl millet starch (%)	Bulk density (g/cc)	Expansion ratio	Sectional expansion index	Hardness (kg)
Corn: Pearl millet flour of ICMV-221, (20:80)				
Control*	0.051±0.001	3.24±0.00	10.48±0.00	5.20±0.01
5	0.048± 0.005	3.38±0.01	11.45±0.07	5.17±0.01
10	0.043± 0.003	3.45±0.01	11.93±0.04	5.10±0.02
15	0.039± 0.002	3.51±0.01	12.33±0.05	5.04±0.02
20	0.033± 0.003	3.61±0.00	13.06±0.04	4.97±0.03
25	0.029± 0.001	3.63±0.00	13.19±0.02	4.88±0.06
CD at 5% level	0.01	0.01	0.07	0.05
Corn: Pearl millet flour of HC-20, (40:60)				
Control**	0.056±0.00	3.30±0.00	10.89±0.00	6.29±0.00
5	0.059±0.002	3.42±0.04	11.73±0.29	6.26±0.04
10	0.055±0.002	3.48±0.02	12.12±0.15	6.20±0.03
15	0.050±0.002	3.53±0.02	12.49±0.13	6.13±0.01
20	0.042±0.004	3.59±0.01	12.89±0.07	6.04±0.04
25	0.037±0.002	3.64±0.03	13.26±0.22	5.92±0.04
CD at 5% level	0.00	0.04	0.31	0.06

*RTE snacks prepared using cereal mix flour (corn: pearl millet flour of ICMV-221, 20:80)

** RTE snacks prepared using cereal mix flour (corn: pearl millet flour of HC-20, 40:60), Values are mean± S.D of three replicate

Table 3 Mean score for sensory characteristics of value added ready-to-eat (RTE) extruded snacks prepared with various level of pearl millet starch

Level of pearl millet starch (%)	Color and appearance	Taste	Texture	Aroma	Over all acceptability
Corn: Pearl millet flour of ICMV-221, (20:80)					
Control *	8.50± 0.55	8.33±0.52	8.00±0.63	8.50±0.55	8.33±0.30
5	8.50±0.55	8.33±0.82	8.00±0.00	8.33±0.52	8.29±0.29

10	8.33±0.52	8.33±0.52	8.00±0.63	8.17±0.98	8.21±0.37
15	8.17±0.41	8.17±0.75	7.83±0.75	8.00±0.63	8.04±0.40
20	8.00±0.89	8.00±0.63	8.00±0.63	8.00±0.00	8.00±0.32
25	8.00±0.63	8.00±0.63	8.00±0.63	8.00±0.63	8.00±0.227
CD at 5% level	NS	NS	NS	NS	NS
Corn: Pearl millet flour of HC-20, (40:60)					
Control **	8.50±0.55	8.33±0.52	8.50±0.55	8.17±0.41	8.33±0.26
5	8.67±0.52	8.50±0.55	8.50±0.55	8.17±0.41	8.46±0.33
10	8.50±0.55	8.33±0.52	8.33±0.52	7.83±0.41	8.25±0.27
15	8.33±0.52	8.17±0.41	8.17±0.75	7.67±0.52	8.08±0.34
20	8.17±0.41	8.00±0.89	8.00±0.89	7.67±0.52	7.96±0.49
25	8.17±0.41	8.00±0.00	8.00±0.00	7.67±0.52	7.96±0.19
CD at 5% level	NS	NS	NS	NS	NS

*RTE snacks prepared using cereal mix flour (corn: pearl millet flour of ICMV-221, 20:80), ** RTE snacks prepared using cereal mix flour (corn: pearl millet flour of HC-20, 40:60), Values are mean± S.D of three replicates

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