Boffin Access

Open Access Journal | Volume: 1.1

Food and Nutrition Open Access

ISSN 2517-5726

Effect of Different Methods of Instantization, Drying and Gum Addition on Quality Characteristics of Instant Noodles

Khatkar AB[1]*
Kaur A[2]

[1,2]Department of Food Science and Technology, Punjab Agricultural University, Punjab, Ludhiana, India

Abstract

In the current era, consumers' perspective towards their health put pressure on academia and industry to recommend a process as a substitute for frying methods of instant noodles preparation. Thus, present study was attempted to provide the systematic substitute for frying method to reduce the burden of high-fat in daily diet. Cooking qualities, textural, colour and sensory characteristics of noodles were significantly affected by the different methods of instantization. Both methods of instantization, (i) boiling and (ii) steaming followed by air drying, significantly reduced cooking losses and increased the cooked weight thus, improved overall cooking qualities. But, steamed air dried noodles, additionally, exhibited higher overall acceptability. Thus, noodles prepared from steamed air dried method could replace the major market of instant fried noodles.

Highlights

- Systematic substitute for frying method of noodles preparation was provided
- Developed method exhibited good cooking quality, textural and sensorial properties
- Correlation matrix for different quality attributes of noodles were explained

Keywords

Instant Noodles; Cooking quality; Instantization; Hardness

Introduction

Now a day due to urbanization, modernization and more number of working women, the demand for instant noodles is increasing at high speed not only in urban areas but, also in rural areas. Noodles are one of the major wheat based product mainly made from wheat flour and some additives like salt and gums (guar gum, xanthan gum, alginate) as a stabilizers and widely consumed throughout world [1-3]. Noodles can be prepared by different methods like extrusion and sheeting followed by air drying or oil frying but, in current market era, the oil fried instant noodles dominating the noodle market mostly due to their lower cooking time [4,5]. Consequently, the higher fat content of these noodles results in various health disorders, thus, not fit for the people suffering from obesity, high cholesterol and cardiovascular diseases [6]. Thus, consumers' perspective towards their health put pressure on academia and industry to recommend a process as a substitute for frying method which can improve the cooking quality as well as sensory attributes of noodle. Additionally, there is lot of studies about impact of formulation and raw ingredients upon noodle' quality attributes, but there is zilch information about the effect of different processing methods on quality characteristics of instant noodles [5]. Thus, the present study was designed with the aim to produce instant noodles by using various methods of instantization (steaming and boiling) and drying (air drying and frying) and also to evaluate the impact of guar gum addition on noodle's quality characteristics.

Materials and Methods

The raw materials (flour, guar gum, table salt and frying oil) were purchased from the local market. Chemicals of analytical grade were purchased from Sisco Research Laboratories Pvt. Ltd. (SRL), India.

Noodles Preparation

Instant noodles from 100% wheat flour and blend of wheat flour with gum were prepared as per the method described by Hou with slight modification. The wheat flour along with water (38 - 40ml/ 100 g) and salt (1%) was properly hydrated and uniformly mixed in a mixing bowl of dough mixer (National Mfg. Co., Lincoln, NEBR.-68508) for 17 minutes to obtain crumbly dough. The crumbled dough was rounded (shaped into a ball), covered with plastic wrap, allowed to rest for 30 minutes at room temperature. Thereafter, rounded mass was hand kneaded for 1 min and divided into approximately 100 g portions.

Article Information

DOI: 10.31021/fnoa.20181103
Article Type: Research Article
Journal Type: Open Access
Volume: 1 **Issue:** 1
Manuscript ID: FNOA-1-103
Publisher: Boffin Access Limited

Received Date: October 29, 2017
Accepted Date: December 27, 2017
Published Date: January 05, 2018

***Corresponding author:**
Khatkar AB,
Department of Food Science and Technology
Punjab Agricultural University
Punjab, Ludhiana, India
Tel: +91-987-687-0672
E-mail: abkhatkar@gmail.com

Citation: Khatkar AB, Kaur A. Physicochemical Characteristics, Effect of different methods of instantization, drying and gum addition on quality characteristics of instant noodles. Food Nutr OA. 2018 Jan;1(1):103

Then, the kneaded mass was sheeted using dough sheeter (SH-E-L Pat Pend National Mfg. Co., Lincoln, NEBR.-68508) where, the kneaded mass totally converted into dough. Further, the dough sheet was repeatedly folded (7-8 times) and pressed by gradually reducing the roller gap to the desired thickness. Thereafter, the sheet of dough was passed through noodle machine (KSC). Then, noodle instantization was done by two methods, (a) boiling in water (until it floats on surface of water) for 1 minute and (b) steaming, where the noodles were steamed for 10 minutes at 100°C. Prepared instant noodles were dried by two methods, (a) air drying (45-50°C) and (b) deep frying in vegetable oil at 140-150°C for one minute. The air dried noodles were transferred to a trey dryer and finally, dried to moisture content about 5-7 percent at 50°C. The noodles were cooled to room temperature, packed and sealed in polyethylene bags. Then, the packed noodles were stored at 12–14°C until tested.

The detailed procedure for the preparation of instant noodles from flour (Formulation I) and flour with gum (Formulation II) is described in Figure 1.

Chemical Analysis

The moisture, fat, protein, carbohydrate, sugar, free fatty acids and ash content of flour were determined by standard methods of Association of Official Analytical Chemists [7].

Functional Properties of Flour

The method of Sosulski (1962) was used for measurement of Water Absorption Capacity (WAC) and water solubility index (WSI) [8]. A fat absorption capacity was measured as per the method described by Lin et al. (1974). Least Gelation Capacity (LGC) was determined by the method described by Coffman and Garcia [9]. The method of Okaka and Potter was used for the estimation of swelling capacity [10]. For measuring bulk density, the volume of 50 g flour sample was poured in 100 ml measuring cylinder and the cylinder was tapped on a wooden platform until the constant volume was noticed and on the basis of ratio of weight and volume, the bulk density was calculated. The method described by Kulkarni et al. was adopted for the determination of dispersibility of flour [11]. For the determination of pasting properties of flour and flour with gum, the ICC standard method (No. 162) by applying standard profile having total rum time of 13 minutes and Rapid Visco Analyser (RVA Starch Master 2, Newport Scientific Pty Ltd, Warriewood, Australia) was used [12].

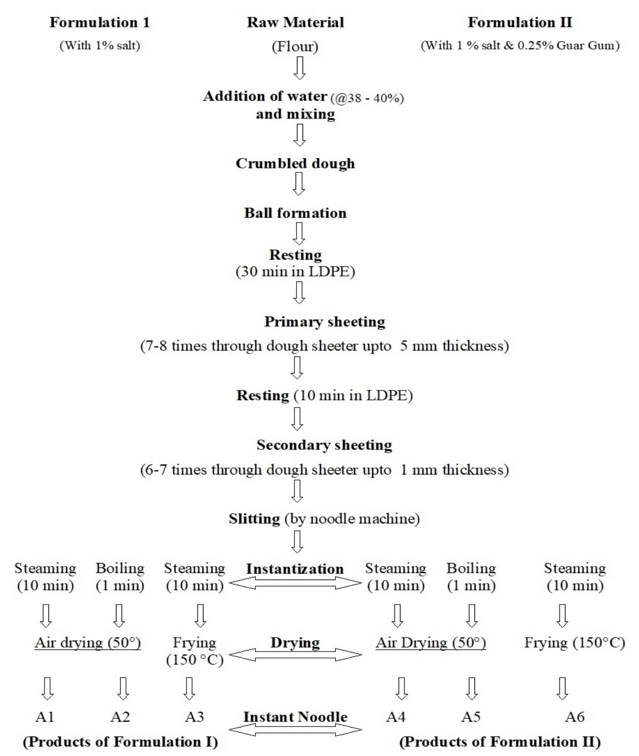

Figure 1: Layout designing for the preparation of instant noodles

Analysis of Noodles

To calculate the swelling index of cooked noodle the method of Bhise et al, was used [13]. Instant Noodles cooking quality was determined according to the method of American Association of Cereal Chemists (AACC), [14]. For the determination of instrumental colour of cooked noodle samples, Konica Minolta Spectrophotometer (CM = 500i/CM-500C) which employs the CIE-LAB colour system (L* a* b*) was used. The texture profile analysis of the cooked noodles was analyzed using a TA.XT2i Texture Analyser (Stable Micro System Ltd, United Kingdom) calibrated for a 50 kg load cell as described by Tudorica et al [15]. Cooked noodles were evaluated for different sensory attributes like surface appeal, hardness, stickiness, bite, mouthfeel and overall acceptability by panel of semi trained judges on nine point hedonic scale.

Statistical analysis

In all experiments, one way "Analysis of Variance" without interaction using SPSS 22.0 version, with a subsequent CD_{LSD} test was applied for multiple sample comparison to test significant difference ($P < 0.05$ and $P < 0.01$) in the mean values.

Result and Discussion

Chemical Composition of Flour

The wheat flour had 12.89 ± 0.03% moisture, 0.93 ± 0.01% fat, 9.94±0.03% protein, 75.83±0.03% total carbohydrate, 0.39 ± 0.02% ash and 0.056 ± 0.002% free fatty acid. Wheat flour also contained 8.36 ± 0.18% wet gluten and 21.51 ± 0.26% dry gluten content.

Properties	Flour	Flour with gum (@0.25%)
Density*	0.74	0.74
Dispersibility*	74	73
Swelling index (ml)	19.5±0.24	20.5±0.35
Least gelation capacity (%)*	9	8
Water absorption capacity	184±1.10	184.6±1.25
Water solubility index*	7.4	7.2
Oil absorption capacity#	183.2±0.46	198.5±1.56
Emulsion activity index	40.42±0.86	38.29±0.50
Emulsion stability index	38.72±0.25	38.29±0.20
Pasting profile Properties (RVU) [2]		
Peak viscosity	236.91	179.41
Final viscosity	276.16	209.66
Hold viscosity	146.83	135.16
Breakdown viscosity	90.08	44.25
Setback viscosity	129.33	74.5

Table 1: Functional properties[1] and pasting profile of wheat flour and flour with gum

[1]Data are presented as mean±SD ($n = 3$).

* Triplicate values for density, dispersibility, least gelation capacity and water solubility index were almost same hence; properties related to these values are mentioned without ±SD.

P (T<=t) two tailed 0.0017; [2]t-test value (one tailed) = 0.004 ($P < 0.01$)

Physical and Functional Properties

The physical and functional properties of formulation I and II are presented in Table 1. Addition of guar gum decreased the dispersibility of flour, while increased swelling index which might be due to hydrophilic nature of guar gum which increases WAC of flour. The guar gum addition improved gelation property of flour which might be due to interaction of hydrocolloid with biopolymer and these interaction results into firm network formation and resulted in the formation of gel at low concentration. Guar gum exhibited more affinity toward water thus, improved WAC of flour. Similar results were observed by Rodge et al. and Chandra et al. [16, 17]. The addition of gum decreased the emulsion activity index of flour which might be due to interaction of gum with flour protein and starch which alters the availability and behavior of protein on interface.

Pasting Properties

The pasting properties of formulation I and formulation II are shown in Table 1. It was observed that addition of gum reduced highly significantly ($P < 0.01$) the peak viscosity, final viscosity, hold viscosity, breakdown and setback of flour. This might be due to shear thinning/ pseudo-plastic behavior of gum which decreases the viscosity with increasing the temperature. Similar results were also reported by [18].

Cooking Qualities of Instant Noodles

Sample prepared from formulation I exhibited lesser cooking time as compared to sample prepared from formulation II except for fried sample which might be due to decreased availability of water to starch molecule in presence of hydrocolloids in noodles and results in postponed swelling and delayed gelatinization of starch (Table 2). Similar results were observed by Kaur et al [19]. Steamed air dried samples exhibited slightly higher cooking time than boiled air dried and steamed fried samples, this probably due to compete gelatinization of starch at higher temperature of boiling and extreme high temperature of frying > 150°C which causes the instant removal of water leaving behind a porous structure which facilitate rehydration during cooking and lower the cooking time of noodles. Formulation II exhibited higher cooking yield and water uptake as compared to formulation I signified that incorporation of hydrophilic guar gum which increases the water absorption of samples through hydrogen bonding, thus increased cooking yield and both exhibited highly significant ($P < 0.01$) positive correlation with each other (Table 3).

Furthermore, different methods of instantization and drying also affect the cooking yield and water uptake of the samples. This might be due to direct affect of different way of processing on the interaction of guar gum and biopolymer and resultant modified network formation. Additionally, the results of higher water uptake during boiling could be justified by the presence of plenty of water for starch in presence of heat which reduces the competency of starch for water and favors gelatinization, which results in low leaching of amylose content further reduces the cooking loss and overall increases the cooked yield. This mechanism also favors in better interaction of gum and starch which form strong network as compared to other methods. Similar observations were also recorded by Rodge et al [16].

Higher cooking loss in formulation I as compared to formulation II, except boiled air dried samples, revealed that addition of gum slightly decreased the values for cooking loss. Reduced gruel losses might be due to instant starch gelatinization during boiling which results in low leaching of amylose content. Additionally, gum addition in noodles also responsible for the formation of complex between amylose and hydrocolloids which overall decreased the solubility of starch molecules within the swollen granules [19,20]. The developed complex network also influenced the starch gelation properties with higher firmness. This increased firmness of the final gel might be responsible for low swelling index in formulation II, except steamed air dried sample. The results of correlation matrix revealed that both cooking time and swelling index fetched significant ($P < 0.05$) positive correlation with hardness of the instant noodles and also justified the above discussed results. Similar results were also obtained by Porwal et al. [21] (Table 3).

Textural Profile Analysis of Instant Noodles

Processing methods have a direct correlation on the textural attributes of instant noodles where steamed air dried samples exhibited highest instrumental hardness, gumminess, cohesiveness, chewiness and stringiness, while the least hardness and springiness was exhibited by fried samples (Table 2). This might be due to the disintegration and weakening of noodles structure and matrix during elevated temperature of frying. On the other hand, the hardness of the samples exhibited significant ($P < 0.05$) positive correlation with cooking time, swelling index, gumminess and chewiness, while cohesiveness exhibited highly significant ($P < 0.01$) positive correlation with gumminess and significant ($P < 0.05$) positive correlation with chewiness. Sample with higher hardening values

Cooking Qualities	Steamed Air Dried		Boiled Air Dried		Steamed Fried		C.D.	
	A1	A4	A2	A5	A3	A6	P<0.01	P<0.05
Cooking time (min)	4.15±0.05^{cd2}	4.27±0.09^{d2}	3.92±0.12^{c1}	4.14±0.03^{cd2}	2.77±0.25^{b}	2.38±0.05^{a}	0.31**	0.22*
Cooking yield (%)	250.27±3.09^{a}	308.20±1.90^{e}	280.84±2.03^{c}	315.61±0.47^{f}	261.56±3.03^{b}	290.41±2.02^{d}	5.66**	ns
Cooking loss (%)	10.44±0.16^{b}	10.24±0.15^{b}	6.71±0.13^{a}	6.79±0.16^{a}	13.47±0.41^{d}	12.37±0.10^{c}	0.52**	ns
Water uptake (ml/g)	1.49±0.01^{a}	2.09±0.02^{e}	1.82±0.01^{c}	2.15±0.01^{f}	1.62±0.02^{b}	1.93±0.04^{d}	0.05**	ns
Swelling index (%)	336±4.72^{e}	401±4.58^{f}	301±6.11^{d}	251±4.16^{b}	282±2.51^{c}	240±1.52^{a}	10.51**	ns
Textural profile analysis of instant noodles								
Hardness (N)	22.22±1.15^{ab34}	23.02±0.31^{b4}	20.54±1.84^{ab23}	20.22±0.92^{ab23}	18.10±0.73^{a1}	19.74±1.39^{a12}	2.91**	2.07*
Cohesiveness	0.534±0.042^{c3}	0.492±0.004^{bc23}	0.417±0.033^{a1}	0.521±0.023^{c23}	0.433±0.026^{ab1}	0.471±0.029^{abc12}	0.072**	0.051*
Adhesiveness (N)	-4.514±0.767^{ab12}	-4.685±0.849^{ab123}	-5.839±0.315^{abc23}	-6.106±0.437^{bc34}	-7.131±1.604^{c4}	-3.944±0.456^{a1}	2.131**	1.52*
Gumminess (N)	11.93±0.487^{d4}	11.342±0.256^{d34}	8.532±0.095^{ab12}	10.539±0.563^{cd3}	7.836±0.147^{a1}	9.327±1.203^{bc2}	1.475**	1.052*
Chewiness (N/ mm)	19.963±0.804^{c23}	21.144±0.659^{c3}	14.697±0.735^{a1}	18.457±1.131^{bc2}	15.321±0.495^{ab1}	15.303±2.94^{ab1}	3.497**	2.494*
Springiness (m)	1.686±0.040^{a12}	1.864±0.017^{bc3}	1.722±0.069^{ab12}	1.751±0.039^{ab2}	1.954±0.026^{c3}	1.632±0.103^{a1}	0.143**	0.102*
Stringiness (m)	0.465±0.009^{c4}	0.374±0.013^{abc23}	0.291±0.041^{a1}	0.333±0.056^{ab12}	0.406±0.011^{bc34}	0.368±0.061^{ab23}	0.096**	0.068*

Table 2: Effect of processing methods on cooking qualities and textural profile analysis of instant noodles

Data are presented as mean±SD (n = 3).
Means with the same superscript in a row are not significantly different from each other.
** Significant at $P < 0.01$ *(for a, b, c...)*, * Significant at $P < 0.05$ (*for 1,2,3,...*), ns = Not significant

	Cooking time	Cooking yield	Cooking loss	Water uptake	Swelling index	Hardness	Cohesiveness	Adhesiveness	Gumminess	Chewiness	Springiness	Stringiness
Cooking time	1	0.235	-0.716	0.197	0.614	0.751*	0.470	0.021	0.668	0.706	0.014	-0.073
Cooking yield		1	-0.455	0.999**	-0.040	0.188	0.161	0.096	0.162	0.225	-0.023	-0.634
Cooking loss			1	-0.434	-0.013	-0.324	-0.125	0.103	-0.214	-0.121	0.309	0.648
Water uptake				1	-0.053	0.171	0.127	0.109	0.132	0.192	-0.031	-0.649
Swelling index					1	0.792*	0.178	0.230	0.534	0.706	0.346	0.280
Hardness						1	0.557	0.620	0.859*	0.823*	-0.227	0.177
Cohesiveness							1	0.443	0.902**	0.800*	-0.307	0.499
Adhesiveness								1	0.593	0.362	-0.691	0.230
Gumminess									1	0.922**	-0.292	0.433
Chewiness										1	0.094	0.439
Springiness											1	0.107
Stringiness												1

Table 3: Correlation matrix for cooking qualities and textural profile analysis of instant noodles
* Correlation is significant at $P < 0.05$ level, ** Correlation is significant at $P < 0.01$ level.

Properties	Steamed Air Dried		Boiled Air Dried		Steamed Fried		C.D.	
	A1	A4	A2	A5	A3	A6	P<0.01	P<0.05
L* value	75.99 ± 0.50^{23}	73.75 ± 1.47^{1}	75.34 ± 0.14^{123}	76.75 ± 1.47^{3}	75.73 ± 0.13^{23}	74.86 ± 1.18^{12}	ns	1.78*
a* value	-2.31 ± 0.13^{bc2}	0.16 ± 0.19^{d}	$-2.56 \pm 0.16^{a\,b1}$	-2.22 ± 0.15^{c}	1.85 ± 0.04^{e}	-2.77 ± 0.12^{a}	0.35**	0.25*
b* value	17.35 ± 0.46^{c}	12.85 ± 0.94^{a}	17.26 ± 0.62^{c}	17.21 ± 0.05^{c}	14.37 ± 0.25^{b}	14.49 ± 0.05^{b}	1.36**	ns
Sensory attributes of instant noodles#								
Surface appeal	7.81 ± 0.22^{bc3}	8.16 ± 0.19^{d4}	7.56 ± 0.35^{b2}	8.06 ± 0.29^{cd4}	6.44 ± 0.32^{a1}	6.50 ± 0.46^{a1}	0.33**	0.24*
Hardness	7.87 ± 0.27^{d5}	8.03 ± 0.25^{d5}	7.56 ± 0.35^{c4}	7.31 ± 0.29^{c3}	6.50 ± 0.33^{a1}	6.91 ± 0.13^{b2}	0.31**	0.23*
Stickiness	8.09 ± 0.30^{cd3}	8.16 ± 0.26^{d3}	7.72 ± 0.25^{bc2}	7.47 ± 0.28^{b2}	6.47 ± 0.39^{a1}	6.62 ± 0.30^{a1}	0.41**	0.31*
Biting Behaviour	8.12 ± 0.38^{c3}	8.25 ± 0.27^{c3}	7.53 ± 0.28^{b2}	7.69 ± 0.18^{b2}	7.06 ± 0.32^{a1}	6.81 ± 0.29^{a1}	0.39**	0.29*
Mouthfeel	8.25 ± 0.19^{c3}	8.37 ± 0.27^{c3}	7.56 ± 0.29^{b2}	7.69 ± 0.22^{b2}	6.94 ± 0.29^{a1}	6.81 ± 0.29^{a1}	0.36**	0.27*
Overall Acceptability	8.03 ± 0.15^{c3}	8.19 ± 0.19^{d4}	7.59 ± 0.11^{b2}	7.64 ± 0.10^{b2}	6.68 ± 0.21^{a1}	6.73 ± 0.12^{a1}	0.16**	0.12*

Table 4: Effect of processing methods on instrumental colour analysis and sensory attributes of instant noodles

Data are presented as mean±SD (*n* = 3). #Data are presented as mean±SD (*n* = 8). Means with the same superscript in a row are not significantly different from each other. ** Significant at $P < 0.01$ *(for a, b, c…)*, * Significant at $P < 0.05$ (*for 1,2,3,…*), ns = Not significant.

exhibited positive sign for cohesiveness and adhesiveness, but not at significant level (Table 3). Overall, gum addition increased hardness, adhesiveness, gumminess (except steamed air dried samples), chewiness and springiness (except fried sample) which might be due to the firm network formation by the interaction of hydrocolloid and biopolymer and additionally also supported by the fact that hydrocolloid binds the water soluble starch therefore, enhancing the texture of noodles. Similar results were also observed by Raina et al. [22].

Instrumental Colour Analysis of Instant Noodles

The maximum lightness (76.75) value was observed in boiled air dried sample (A5) while, minimum lightness (73.75) was observed in steamed air dried sample (A4) which was also prepared with gum (Table 3) signified that processing conditions significantly affected the lightness value of the instant noodles. The maximum a* value (1.85) was observed in steamed fried sample (A3) prepared using formulation I. However, minimum a* value (-2.77) was also observed in steamed fried sample (A3) but, when prepared with formulation II meant that addition of gum highly significantly ($P < 0.01$) affected the a* value of instant noodles. The maximum b* value (17.35) was observed in steamed air dried sample (A1), but gum added sample (A4) of same method fetched highly significantly ($P < 0.01$) least b* value (12.85), meant that gum addition drastically decreased the yellowness of instant noodles. On the other hand, gum addition had no effect when samples were prepared from the combination of boiling with air drying and steaming with frying method.

Sensory Attributes of Instant Noodles

The samples of formulation II (A4) prepared using steamed air drying method exhibited maximum surface appeal, hardness, stickiness, biting behaviour, mouthfeel and overall acceptability (Table 4). On the other side, fried sample from formulation I exhibited least surface appeal score, hardness, stickiness, and overall acceptability, while the addition of gum in this methods showed least biting behaviour and mouthfeel scores. The sensory score of instant noodles revealed that the addition of gum increased highly significantly ($P < 0.01$) the surface appeal of the noodle samples when prepared using steaming with air drying and boiling with air drying.

Conclusion

Form the results obtained, it was observed that the boiled and steamed air dried instant noodle samples exhibited highest cooking quality like reduced cooking losses with increased cooked weight, but steamed air dried noodle samples, additionally, exhibited good textural attributes and good overall acceptability as compared to other samples. Thus, steamed air dried method can be used as good substitute for frying methods. Furthermore, guar gum addition at 0.25% level showed significant positive effect on noodle's cooking quality, textural attributes, colour as well as sensory score and also facilitate the dough handling properties. Overall, it can be concluded that the noodles prepared from steaming followed by air drying could replace the major market of instant noodles which is currently dominated by noodles prepared with oil frying. Eventually, the results of this study would provide a cost effective method for the preparation of instant noodle for health conscious consumers.

References

1. Huang YC, Lai HM. Noodle quality affected by different cereal starches. J Food Eng, 2010;97(2):135–43.
2. Li M, Zhu KX, Guo XN, Brijs K, Zhou HM. Natural Additives in Wheat-Based Pasta and Noodle Products: Opportunities for Enhanced Nutritional and Functional Properties. Compr. Rev Food Sci Food Saf. 2014;13(4): 347–357.
3. Mastromatteo M, Chillo S, Iannetti M, Civica V, Del Nobile MA. Formulation optimisation of gluten-free functional spaghetti based on quinoa, maize and soy flours. Intl J Food Sci Technol. 2001;46(6):1201–8.
4. Hou GQ. Oriental noodles. Adv Food Nutr Res. 2001;43:143–193.
5. Gulia N, Dhaka V, Khatkar BS. Instant Noodles: Processing, Quality, and Nutritional Aspects. Crit Rev Food Sci Nutr. *2014;* 54(10): 1386-1399.
6. Gatade AA, SAHOO AK. Effect of additives and steaming on quality of air dried noodles. J Food Sci Technol. 2015; 52:8395–8402.
7. AOAC. Official methods of analysis of AOAC International (17th ed.). Gaitherburg. AOAC International Inc., USA; 2000.
8. Sosulski FW, Garatt MO, Slinkard AE. Functional properties of ten legume flours. Int J Food Sci Tech. 1976;9:66–69.
9. Coffman CV, GARCIA VV. Functional properties and amino acid content of a protein isolate from mung bean flour. J Food Technol. 1997;12:473–480.
10. Okaka JC, Potter NN. Functional and storage properties of cow pea-wheat flour blends in bread making. J Food Sci. 1997;42(3):828–833.
11. Kulkarni KD. Kulkarni DN, Ingle UM. Sorghum malt-based weaning formulations: preparation, functional properties and nutritive value. Food Nutr Bull. 1991 Jan;13(4):322- 327.
12. ICC. Rapid pasting method using Newport Rapid Visco Analyser.

ICC Standard, 162. International Association for Cereal Science and Technology, Vienna; 1996.

13. Bhise SR, Kaur A, Manikantan MR, Singh B. Development of texturized defatted sunflower meal by extrusion using response surface methodology. Acta Aliment. 2015;44(2):251-258.
14. AACC. Approved methods of the American Association of Cereal Chemists. American Association of Cereal Chemists, St Paul; 2000.
15. Tudorică CM, Kuri V, Brennan CS. Nutritional and physicochemical characteristics of dietary fiber enriched pasta. J Agri Food Chem. 2002;50(2):347-356.
16. Rodge. Food Processing & Technology. J Food Proces Technol. 2012;3(2):136.
17. Chandra S, Singh S, Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. J Food Sci Technol. 2015;52(6):3681-3688.
18. Padalino L, Conte A, Nobile MD. Overview on the General Approaches to Improve Gluten-Free Pasta and Bread. Food. 2016 Dec;5(4):87.
19. Kaur A, Shevkani K, Singh N, Sharma P, Kaur, S. Effect of guar gum and xanthan gum on pasting and noodle-making properties of potato, corn and mung bean starches. J Food Sci Technol. 2015;52(12):8113–8121.
20. Singh N, Singh J, Sodhi NS. Morphological, thermal, rheological and noodle-making properties of potato and corn starch. J Sci Food Agr. 2002 Sept;82:1376–1383.
21. Porwal VB, Bharath KS, Madhumathi R, Prabhasankar P. Influence of health based ingredient and its hydrocolloid blends on noodle processing. J Food Meas Charact. 2014 Dec;8(4):283–295.
22. Raina CS, Singh S, Bawa AS, Saxena DC. Textural characteristics of pasta made from rice flour supplemented with protein and hydrocolloids. J Textural Stud. 2005;36:402-420.