Effect of different binding agents on the cooking quality of glutinous rice-based pasta.

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Abstract

A variation in the level of xanthan gum (0.5-2.5 %), vital gluten (2-10 %) and pre-gelatinized flour(10-50 %) was used to study the effect of these different binding agents on the quality characteristicsof low amylose rice-based pasta. The pasta samples produced were assessed for their cooking qualitywhich includes minimum cooking time, water absorption, swelling volume, and gruel solid loss.Increasing the level of xanthan gum resulted in increased water absorption and swelling volume whilethe gruel solid loss decreases. Increasing the content of vital gluten resulted in pasta with lower waterabsorption, swelling volume, and gruel solid loss. The content of pre-gelatinized flour had aninverse relationship with the water absorption and swelling volumeand a non-linear effect on thegruel solid loss. Evaluation of cooking quality suggests that the use of different additives improves thecooking quality of the low amylose rice-based pasta by decreasing the gruel solid losses in cooking water, enhancing the water absorption and swelling volume due to theirbinding properties. The obtained results from the study suggested the use of 2 % of xanthan gum, 4 %of vital gluten and 30 % of pre-gelatinized flour for preparation of low amylose rice-based pasta witha goodcooking and sensoryquality.

Keywords

Pasta, glutinous rice, pre-gelatinized flour, xanthan gum.

Introduction

Pasta is gaining popularity around the world due to its convenience, ease of preparation anddesirable-taste properties. Conventionally, high-quality pasta is prepared from durum wheat semolinaand they possess a good texture, firm structure, resists surface disintegration and low gruel solid loss(Liuet at., 1996). This is because gluten protein in wheat flourplays a major role in contributing tothe cooking performance and texture of cooked pasta and its absence in non-wheat pasta results intechnologicaland qualityproblems.

However, there have been demands of pasta from other cereals like rice due to its attractivewhite color, hypo-allergenicity, and bland taste. Various efforts had been made to produce non-wheatpasta that is almost comparable to wheat pasta. However, the non-wheat pasta currently available inthe market still could not meet the consumer demands in terms of acceptability (Marti &Pagani,2013). Variety of binders had been used toreplacethe role of gluten in non-wheat cereals to preparegluten free pasta. Supplementing the right quantity of proteins, hydrocolloids, pre-gelatinized flour,andmoisturecan helpaccomplishthedesiredqualityattributes(Larrosaetal., 2013).

Thefirstattemptinthisdirectionexploitedthecharacteristicphenomenaofstarchretrogradation.Pre gelatinized starch obtained by heating and cooling formed a rigid networkofretrograded starch that can be used as an alternative to gluten networking(Cabrera-Chávez et al.,2012; Mariotti et al., 2011). Hydrocolloids such as xanthan gum, carboxymethyl cellulose, alginates,locustbeangumandguargumaidingelling,thickening,hydrationpropertiesandtextureimproveme nt (Gallagher et al. 2004). They can be used to substitute the role of gluten and plays anessential part in development of non-wheat pasta (Sozer 2009). Due to its ability to bind water andtheirviscoelasticproperties,gums mimicthepropertiesofglutentoformtheelastictextureofpasta.

Reduced amylose/glutinous starch based noodles like the Udon noodles had been commonlyconsumed in Japan and Korea. These noodles have a soft texture with a firm surface (Nagao 1996).Thedesirableattributesincludehighpasteviscosityandbreakdown,highswellingpowerofstarchand low gelatinization temperature which are associated with reduced amylose contents (Endo et al.,1988;Crosbie1991;Panozzoand McCormick1993).

The current work was proposed with the aim to improve the quality of pasta produced fromlowamylosericebystudyingtheircookingqualityandsensorycharacteristics.Tofulfilthisobjective, the followingstudies weremade:i) the relationship betweenglutinous rice flour anddifferent bindersand qualityfeatures of cooked pasta was analyzed; ii) theaccurate quantityofbinders required to obtain a high-quality gluten-free pasta from low amylose rice was establishedbased on theresponse fromcookingquality and sensory analysis.

Materials and methodsRawmaterials

A local variety of low amylose rice (*kawnglawngbuhban*) from Mizoram was procuredthrough KrishiVigyan Kendra (KVK), Mizoram, India. The rice grain was grounded to flour usinghammermill fitted with a sieve 1.5 mm. Xanthan gum was purchased from Thames Chemicals (SDFine Chemicals Limited), Ludhiana, Punjab. Vital gluten (VG) was purchased from a local market,Ludhiana,Punjab,India.

PreparationofPre-gelatinizedFlour(PGF)

Rice grains were soaked in water to a moisture content of about 40%. The soaked grains werekept on a cheesecloth and steamed at 85 ^{0}C for 45 minutes (Cai and Diosady 1993) and then dried in ahot air oven at 50 ^{0}C. The dried pre-gelatinized rice grains were ground using hammermill fitted withsieve1.5mm.

Preparationofpasta

Low amylose rice flour was mixed with various levels of binding agents viz. xanthan gum,vital gluten and pre-gelatinized flour as seen in table 1. Extrusion was performed using a cold extruder(Model: Dolly, La Monferina, Asti, Italy). Weighed and mixed of low amylose rice flour and bindingagents were placed into the pastamixerandapproximately35 ml water was addedslowly. Mixingwas done in the mixer for about 10 minutes to properly distribute the water in the flour particles. Thedough mixture was then extruded through the die in shell shape and cut toan uniform size with acutter connected to the die. The pasta produced were dried in ahot air oven at 50 $\pm^0$C for 3 hours.Thedriedpastawerecooled andpackedinHigh-density polyethylenebagsuntilanalysis.

Table1: Levelsofdifferentbindingagentsusedforthepreparationofpasta.

Bindingagent	**Level%**
Xanthangum	0.5,1,1.5, 2,2.5
Vitalgluten	2,4,6,8,10
Pre-gelatinizedflour	10,20,30, 40,50

Determination of product

responsesCookingquality

To find out the minimum cooking time (MCT), 10 grams of the pasta samples were cooked in100 ml of boiling distilled water. MCT corresponds to the cooking time required for disappearance ofthestarchycentralcoreofthepastaafterpressingthembetweentwoglassslides.Theswellingvolume and gruel solid loss were evaluated at MCT in triplicates. Swelling volume was measured bythe volume increase of the pasta before and after cooking. Water absorption was measured as theincreaseinweightofthepastaaftercookingandwasexpressedaspercentweightgainwithrespectto

the weight of uncooked pasta. Gruel solid loss was calculated from the remaining solids obtained afterdryingup of thecookingwaterin ahotair ovenat100°C(Bonomi etal., 2012).

Evaluationofoverallacceptability

The cooked pasta was evaluated for sensory analysis by semi-trained panel of 10 judges using9 points hedonic scale in terms of overall acceptability (Larmond 1977) from like extremely (9) todislikeextremely(1). Fivesampleswerepresentedatatimeto thejudgesinplates.

Statisticalanalysis

Data related to the cooking quality of the pasta samples prepared with various levels ofbindingagentswerestatistically evaluatedby analysisofvarianceusingStatisticalPackageforSocialSciences (SPSS Inc., Chicago) software version 20. Tukey's tests were used to determine thedifferenceamong meansatthelevelof0.05.

Resultsanddiscussions

Glutinous rice based pasta prepared by mixing low amylose rice flour with various levels ofbinding agents viz. xanthan gum (0.5-2.5 %), vital gluten (2-6 %) and pre-gelatinized flour (10-50 %)areshown in figure 1.

Fig.1:Pictureofglutinousricepasta preparedwithdifferentbinders.

Determination of cooking quality is a basic test in checking the quality of pasta. Duringcooking, various changes occur in pasta due to the effect of the heat and water uptake which results instarch gelatinization, the formation of protein network, increase in pasta weight and volume andreleaseof solubleorganicmattersin thecookingwater.

Gruel solid loss in cooking water and swelling volume are two crucial factors determining thequality of pasta. Excessive loss of gruel solids in cooking water is undesirable as it indicates highsolubilization, low cooking tolerance and sticky mouthfeel. The extent of swelling volume is directlyproportional to the water holding capacity. Low swelling volume results in hard coarse pasta whileexcessiveswelling resultsin soft textureofthepasta.

Effectof levelsofXanthangumoncookingqualityofthepasta

Supplementation of xanthan gum at different levels (0.5 - 2.5) to pasta formulation does notcause any significant differences in the optimum cooking time as all the pasta samples were cookedwithin 8 minutes. However, they cause significant differences ($p \leq 0.05$) in water absorption, swellingvolume, and cooking losses. With an increase in the level of xanthan gum (0.5 – 2.5), the waterabsorptionandswellingvolumeincreasesignificantlyasshownintable2.Thisisduetothehydrophilic nature of gums which resulted in increased in hydration properties. Thus enhances waterabsorptionand swelling ability(YalcinandBasman2008).

The cooking loss decreased significantly with an increase in the level of xanthan gum. This isdue to the fact that xanthan gum acts as a binder thus increasing its toughness, cooked resistance anddo not allow leaching of starch particles.It resulted in increased elasticity due to an increase innumber of polymers in the system and have a more marked effect than added protein in gluten-freepasta. The best level of xanthan gum addition in rice flour for preparation of pasta was reported to be2.5%(Larossaetal2013).

Table2: Effectofxanthangumonthecookingqualityofpasta

Levelofxanthan gum(%)	MCT (mins)	Waterabsorption (%)	Swelling volume(%)	GSL(%)	Overall Acceptability
0.5	8	131.4±3.5c	172.7±8.8d	3.1±.2a	5.83c±0.54
1	8	138.2±6.5bc	180.2±4.1cd	2.8±.3ab	6.64b±0.54
1.5	8	144.7±4.0 abc	186.5±3.1bc	2.4±.2b	7.64a±0.44
2	7.5	149.5±6.6 ab	193.2±5.1ab	1.9± .2c	7.75a±0.29
2.5	7.5	153.3±6. 9a	200.6±8.4a	1.8± .3c	7.44a±0.39

Effectoflevelsofvitalglutenoncookingqualityofthepasta

The effect of vital gluten on cooking quality is depicted in table 3. No significant differencewas observed in cooking time of pasta supplemented with different levels (2-10) of vital gluten as allthe pasta samples were cooked within 7:30 to 8 minutes. Addition of vital gluten seems to have a non-linear effect on the water absorption and swelling volume with an increase in the level of protein asshown in table 3. The water absorption and swelling volume increase up to 4% addition of vital glutenprotein but seems to decrease with further increase in protein content. This indicates that the optimumlevel of gluten to form protein network is about 4%. Larossa et al. (2013) also reported that theoptimumlevelofproteinincorporation for theformulation ofgluten-freepastais4.7%.

Delcouretal(2012)explainedtheimportanceofoptimallycross-linkedproteinswhichfunctions as a continuous framework contributing to the structure of the product. During cooking, thestarch granules present in pasta absorbs water, undergo swelling and gelatinization. At the same timeprotein components also polymerizes into a continuous network. Thus making pasta into a mixedpolymer system of starch and protein as main structuring agents. As the cooking proceeds, there is acompetitionforwaterbindingfortherespectiveprocessesofproteinpolymerizationandstarchswelling. If there is an inadequate crosslinking of proteins, they form un-associated masses that lacksthe desired structurethereby forming networkwhich is susceptible to high cooking losses,thusproducing a soft and sticky textured pasta (Pagani et al. 1986, Resmini&Pagani 1983). On the otherhand,excessive cross-linkingof proteins leads tolackofresilience tocope withstarchswelling,which is detrimental for the cooking quality of the pasta (Bruneel et al. 2010). Therefore, there shouldbeanoptimaldegreeofcross-linkingofglutenproteinsratherthanmaximalcross-linkingoftheglutennetwork.Optimumcross-linkingofproteinnetworkentrapsthestarchgranules,andsubsequently limits their swelling and leaching into the cooking water, which contributes to thefirmnessof thecooked pasta(Resmini and Pagani1983,Vansteelandtand Delcour 1998).

The gruel solid loss decreased from a percentage of 2.976 to 1.821 with 2 - 10 % addition ofvital gluten. The gluten protein polymerizes to form a dense and continuous network which to someextent encapsulates the starch granules (Bruneel et al. 2010, Zweifel et al. 2003). The protein networkdoes not allow leaching of starch particles in the cooking water which resulted in decrease gruel solidloss. At insufficient gluten concentration, the gluten network lacks compactness and elasticity, thisleads to more granular swelling of starch and higher loss of soluble matter into the cooking water. Onthe other hand, excessive addition of gluten protein resulted in formation of a strong dough with hardtexture and cause difficulty in handling and extrusion (Resmini and Pagani 1983). The optimum levelof vital gluten required is determined by the quality of proteins in the raw material (Kovacs et al.2004).

Table3 Effectofvitalglutenoncookingqualityofpasta

Levelofvital gluten(%)	**MCT**	**Water absorption(%)**	**Swelling volume(%)**	**GSL(%)**	**Overall Acceptability**
2	8	141.4±5.2a	167.1±3.2 a	2.9± .2a	5.86c±0.34
4	8	142.1±7.9a	168.1±2.4a	2.7±.1ab	6.64b±0.24
6	8	135.4±6.7 ab	158.2±1.1b	2.5±.3b	7.93a±0.31
8	8	131.4±8.7 ab	154.3±4.3 b	2.1±.1c	7.58^{a}±0.20
10	8	123.7±2.2b	147.2±2.7 c	1.8± .2c	7.92^{a}±0.24

Effectoflevelsofpre-gelatinizedflouroncookingqualityofthepasta

Some variations existed but no clear trend was observed in the cooking quality and hydrationproperties of pasta supplemented with different levels of pregelatinized flour as shown in table 4. Theobtained results are in contrast with most of the studies which utilized pregelatinized starch forimproving the quality of gluten-free pasta due to the formation of rigid network based on retrogradedstarch(Cabrera-Chavezet al., 2012;Marti&Pagani, 2013).

This could only be explained by the nature of starch used to produce pre-gelatinized flour. Incontrast to the previously reported investigation that implies the utilization of regular rice flourcontaining 20-30% of amylose for the preparation of pre-gelatinized flour the present investigationexplorethepotentialoflowamylosericeflourfortheproductionofthesame.

Amyloseisresponsible forcreatingthethree-dimensionalnetworkbasedonretrogradedstarchbyforming astrong linkageofstarchchains on thejunctionzones (Mestresetal.,1988).

Table4Effectofpre-gelatinizedflouron cookingqualityofpasta

Levelofpre-gelatinizedflour(%)	**MCT**	**Water absorption(%)**	**Swelling volume(%)**	**GSL(%)**	**Overall Acceptability**
10	7	110.2±4.1a	144.2±5.9a	3.4±.1ab	4.53^{d}± 0.24
20	7	87.9±16.2ab	130.9±5.3b	3.0± .2b	5.78^{c}± 0.44
30	7	87.3±15.4 ab	128.1±8.3b	3.3±.1ab	6.29^{a}±0.16
40	7	85.7±14.6b	120.8±7.5b	3.5±.3ab	5.44^{b}± 0.34

50	7	85.1+6.4b	118.2+6.5b	3.6+ .3a	5.05^{c}± 0.33

Conclusion

Development of pasta from non-wheat flours is a major technological challenge due to theabsenceofnetworkforminggluten protein.Xanthangum,vitalgluten,andpregelatinizedflourare binderscommonlyusedin foods.Xanthangumandvitalglutenimproved the cooking quality due to lower cooking loss and better firm texture development. Thestarch in the surface of pasta appears to be held more tightly with the addition of different binders.Cooking loss and texture are major attributes for determining the quality of noodles, it appears that theuse of these different binders improves the cooking quality of pasta and plays an important role inoverall quality. The use of xanthan gum gave a comparable quality attribute as vital gluten. Therefore,xanthan gum can be used on non-wheat flours to prepare gluten free pasta.On the other hand,pregelatinized flour prepared from low amylose rice does not impart a noteworthy enhancement ofthe cooking quality and organoleptic profile of the resultant pasta. This is due to the inability of lowamylose ricestarch to formanetwork ofretrograded starch.

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