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Comparative Studies on Quality and Starch Digestibility of Hydrocolloid Fortified Sweet Potato Pasta Dried at Low and High Temperatures

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Abstract

Although sweet potato [*Ipomoea batatas* (L) Lam] has various nutritional advantages like low glycaemic index, high antioxidant potential and dietary fiber content, it is not extensively cultivated and utilized in most parts of the world. The present study aims at adding value to this root crop through the development of functional pasta fortified with gum sources such as guar gum, xanthan gum, locust bean gum and partially hydrolyzed guar gum. The pasta products were dried at low (55 °C) and high (70 ºC) temperatures and it was found that high temperature drying reduced the cooking loss and raised the swelling index for all the fortified pastas. *In vitro* starch digestibility of cooked pasta indicated only a progressive glucose release from 20 to 120 min, with decreased digestibility for the 70 °C dried pastas than those dried at 55 °C. Rapidly digested and slowly digested starch fractions were lower for the pasta dried at 70ºC than 55 °C, while the undigested or resistant starch was higher for samples dried at 70 ºC. Increasing the level of fortification of gums from 1% to 3% reduced the starch digestibility further. Highest firmness on cooking was obtained for the xanthan fortified pasta (70 ºC dried), while it had the lowest adhesiveness at 3% fortification. It was concluded from the study that fortification of sweet potato pasta with 1% gum and drying at 70 °C could produce pasta with low starch digestibility, good swelling index and textual characteristics, suggesting its use as food for the diabetic and obese people.

Keywords: Pasta, Sweet potato, Hydrocolloids, Quality, Drying temperature

Introduction

Pasta is a traditional food product of Italy made from wheat semolina and has gained wide popularity as an instant cooking, low glycaemic food (Malcolmson et al., 1993; Björck et al., 2000). Nevertheless, extensive research has been carried out to develop non-wheat pasta products or pasta/spaghetti from fortified wheat flour, with an objective of raising the functional value (Collado and Corke, 1996; Anthony et al., 1998; Messina, 1999; Marconi et al., 2000; Manthey et al., 2004; Limroongreungrat and Huang, 2007; Chillo et al., 2008). The possibility of using sweet potato for noodle and pasta manufacture has been explored by some researchers (Collado and Corke, 1996; Pangloli et al., 2000; Yadav et al., 2006). Gluten strength and protein content were reported as major factors contributing to the desired texture and cooking quality of pasta (Feillet and Dexter, 1996). Jyothi et al. (2011, 2012) reported the production of high protein or dietary fiber fortified pasta from sweet potato through the use of protein sources like whey protein concentrate (WPC) or defatted soy flour and fiber sources like oat bran or wheat bran respectively. Gelatinized cassava starch was used in these formulations as a binder and whey protein concentrate (WPC) was used to mimic wheat gluten. Low starch digestibility under *in vitro* conditions and high resistant starch in the cooked pasta were the characteristics of dietary fiber enriched sweet potato pasta.

Hydrocolloids (gums) have been extensively used in the food industry to modify the dough quality and have been reported to affect the pasting properties of starch, retrogradation etc. (Christianson et al., 1981; Rojas et al., 1999; Gomez et al., 2007). There are several reports on the use of various gums in bread and cake manufacturing (Collar et al., 1999; Sidhu and Bawa, 2002; Ribotta et al., 2004; Gomez et al., 2007; Shittu et al., 2009). Furthermore, the polymeric structure of gums enables their use as gluten-substitutes (Gomez et al., 2007).

Although, gums are reported to reduce the starch digestibility and behave similar to dietary fiber in foods, there are only a few reports on hydrocolloid fortified pasta or noodles (Inglett et al., 2005; Briani et al., 2006). Different hydrocolloids behave differently in baked products due to the differences in the molecular structure of hydrocolloids and/or the ionic charges in starches and hydrocolloids. Xanthan gum (anionic glucomannan) increases the water absorption in dough while guar gum (galactomannan) improves the mixing and recipe tolerance through moisture retention and higher viscosity and locust bean gum (galactomannan) improves the final texture of dough through better emulsification (Collar et al., 1999; Rosell et al., 2001; Mandala et al., 2007). Guar gum and locust bean gum have also been reported as hypocholesterolaemic agents and of use in the treatment of Type 2 diabetes (Mandala et al., 2007). The interaction of gums with starch at higher temperatures is also reported to be different depending on the type of gums and their chemical structures (Christianson et al., 1981). The cooking quality of pasta dried at high temperature is reported to be superior to that dried at low temperature (Manthey et al., 2004). Hence, it was thought worthwhile to study how guar gum, xanthan gum and locust bean gum modified the cooking and starch digestibility of sweet potato pasta dried at 55 ºC (low) and 70 ºC (high).

Materials and Methods

Pale cream fleshed sweet potato variety, Sree Arun released from the ICAR-Central Tuber Crops Research Institute was used for the study. Roots harvested at 105 days after planting were washed free of dirt and healthy roots were peeled and sliced for processing into flour. Slices (*Ca.* 1.0 cm thick round discs) were soaked in 1.0 % acetic acid for 1 h to prevent the browning of the flour and then washed in running water, dried in the sun for 36h and powdered in a hammer mill. The coarse flour was sieved through a fine mesh sieve (355 μm) and the fine flour was used in pasta making.

Edible gums such as Guar gum (GG), Xanthan gum (XG), locust bean gum (LBG) and partially hydrolyzed guar gum (PHGG; Sun Fibre) were supplied by M/s Lucid Colloids Pvt. Ltd., Mumbai, India.

Pasta formulations

Pasta mixes contained 72 % sweet potato flour (SPF) for treatments T_1, T_3, T_5 and T_7 and 1 % GG, XG, LBG and PHGG respectively and 70 % SPF for treatments T_2, T_4, T_6 and T_8 with 3 % of GG, XG, LBG and PHGG respectively. All the formulations contained 27 % refined wheat flour (RWF).

Preparation of pasta

Gums were presoaked in water and blended to make a uniform paste. The gum pastes were then mixed with the flour and uniformly kneaded in the mixing chamber of the Pasta machine (P3 Model; La Monferrina, Italy) with the requisite quantity of water. The quantity of water required to get a smooth outer finish for the various treatments was standardized. Pasta was extruded at room temperature (30±1 ºC) using the round die (No. 62) and cut into short pasta of length *Ca.* 3.0 cm. The freshly extruded pasta was divided in each case into two parts. One part was dried at 55 ºC for 22 h in an air oven, while the second part was dried at 70 ºC for 18 h.

Cooking quality

Fifty gram dry pasta from each treatment was added to 500 ml boiled water containing 1.0 g sodium chloride. Optimum cooking time (OCT) for each pasta i.e. *al dente* point, was determined by the approved AACC method 66-50 (AACC, 2000) and it corresponded to the time of disappearance of the white central part of pasta. The cooked pasta after the specific OCT for each treatment was drained and surface water removed by keeping on a thin muslin cloth.

Swelling Index (SI) of cooked pasta (g water absorbed per g dry pasta) was determined as (weight of cooked pasta-weight of dry pasta)/weight of dry pasta (Mestres et al., 1988). The water from cooking was drained and dried at 110 ºC for 18 h, to compute the cooking loss (%) as weight of the residue x 100/weight of dry pasta (Debbous and Doetkott, 1996).

In vitro starch digestibility

Total starch content in the cooked pasta samples was determined by the titrimetric method developed by

Moorthy and Padmaja (2002). *In vitro* starch digestibility (IVSD) of cooked pasta samples was determined as per the procedures of Englyst et al. (1996), McCleary and Monaghan (2002) and Kim et al. (2008) with slight modifications. Pasta samples were cooked as described above and after surface drying on filter paper (Whatman No. 1), they were cut into small pieces of *Ca.* 1.0 mm length. Five grams (3 replicates) sample were mixed with HCl-KCl buffer (pH 1.5, 10.0 ml) and equilibrated at 37 ºC for 10 min. Pepsin (SIGMA, USA) was added to initiate proteolysis (0.4 ml from 10.0 ml HCl-KCl buffer containing 1.0 g pepsin). Samples were incubated at 37 ºC for 1h, after which 40.0 ml sodium phosphate buffer (0.02 M; pH 6.9 containing 0.12 M sodium chloride) was added. After equilibrating for 10 min at 37 ºC, 1.0 ml Panzynorm N (manufactured by M/s German Remedies India, Ltd., Mumbai, India, containing 10000 units of lipase, 9000 units of alpha-amylase and 500 units of protease, was dissolved in 5.0 ml sodium phosphate buffer (0.02 M; pH 6.9) was added and incubation continued for 20 min. One milliliter of the supernatant was withdrawn and heat inactivated at 100 ºC. The aliquot was added to 3.0 ml sodium acetate buffer (0.2 M; pH 4.8) and incubated at 60 ºC for a further 10 min with 0.25 ml Dextrozyme GA (M/s Novo Industries, Denmark). Incubation of the Panzynorm assay system was continued up to 120 min and aliquots of 1.0 ml were withdrawn at every 20 min interval. Samples were treated identically with 0.25 ml Dextrozyme GA. Glucose content in each aliquot was quantified using glucose oxidase (EC 1.1.3.4)-PAP reagent (M/s Beacon Diagnostics Pvt. Ltd. Gujarat, India). Starch measured at 20 min. [Glucose expressed as [g $(100g)^{-1}$ pasta) x 0.9] was taken as the rapidly digested starch (RDS) and that measured at 120 min. was taken as RDS + slowly digested starch (SDS) (Kim et al., 2008). Resistant starch (RS; starch remaining undigested after 120 min.) was computed as 100- (RDS + SDS) on percentage starch in cooked pasta on dry basis. Separate enzyme and substrate blanks were maintained for each sample.

Texture profile analysis

Textural properties of the cooked pasta in six replicates, were measured using a Food Texture Analyser TAHDi (Stable Microsystems, UK). Shear test/Cutting test was performed using HDP/BSK Blade set with knife and the experimental conditions were: Method: Measure force in compression; Mode: Return to start; Pre-Test speed: 2mm/s; Test speed: 2mm/s; post-test speed: 2mm/s; Distance: 10mm; Trigger force: 5.0 g. From the Force-distance/Time curve, the peak force is taken as the firmness/Hardness and the area under the curve is taken as the toughness. The negative area obtained due to the withdrawal of the probe during the test was measured as adhesiveness.

Results and Discussion

The comparative effect of four edible hydrocolloids such as GG, XG, LBG and PHGG (Sunfiber®) on the *in vitro* starch digestibility and cooking characteristics of sweet potato pasta dried at low and high temperatures was studied.

Cooking behaviour

The cooking loss quantified at the OCT for each pasta was found to be significantly reduced when dried at 70 ºC. Despite more cooking time, the rigid structure might be offering resistance at the surface and once the starch-protein network is firm, chances of leaching of amylose during cooking is also reduced. Among the four hydrocolloid sources, least cooking loss (%) was observed for XG-fortified sweet potato pasta dried at 55 ºC. Cooking loss (%) was not significantly different ($p<0.05$) for the 3 % hydrocolloid fortified pasta, when dried at 70 ºC. However, at 1 % fortification, the XG-fortified pasta had the least cooking loss of 10.88% (Table 1). Longer cooking time was reported for durum wheat pasta dried at very high temperature of 100 ºC by Zweifel et al. (2003). Vansteelandt and Delcour (1998) also reported that high temperature drying increases the adhesion strength between starch and protein. Jyothi et al. (2011) reported that whey protein fortification led to lower cooking loss in sweet potato pasta than the control pasta from sweet potato-refined wheat flour mix. Malcolmson et al. (1993) reported that the cooking loss of optimally cooked spaghetti was influenced by the protein level and entrapment of gelatinized starch in protein network could prevent the leaching of starch components. Studies have shown higher cooking loss in pasta fortified with non-wheat ingredients due to the weakening of starch-protein network and dilution of gluten (Bahnassey et al., 1986; Rayas-Duarte et al., 1996; Petitot et al., 2010). Manthey et al. (2004) reported higher cooking loss for spaghetti dried at 40 ºC than 90 ºC and explained that high temperature drying strengthened the gluten matrix and protected the starch granules from rupturing during cooking.

The competitive ability of ingredients in absorbing water indicates the swelling property of pasta products. Swelling Index (expressed as g water absorbed per g of dry pasta) was found to range from 3.02-3.84 for the various pastas dried at 55 ºC and 3.95-4.68 for the pastas dried at 70 ºC (Table 1).

Among the hydrocolloid sources, the highest SI was observed for LBG-fortified pasta dried at 55 ºC and 70 ºC, while the least SI was observed for XG-fortified pasta. Gomez et al. (2007) also reported the higher capacity of LBG than GG and XG to retain water in yellow layer cakes. Swelling Index is reported to be in the range of 1.80-1.90 for durum wheat pasta (Tudoricã et al., 2002; Gelencsér et al., 2008). Spaghetti fortified with non-wheat flours like amaranth or lupin had been reported to have higher SI resulting from the discontinuity within the gluten matrix and consequent weak dough formation (Rayas-Duarte et al., 1996). Hydrocolloids have the ability to retain water and absorb more water during dough development (Glicksman, 1969). The very high SI values observed in the hydrocolloid fortified sweet potato pasta in our study might have resulted from the high water holding ability of the various gums. Fang and Kahn (1996) reported decreasing water uptake indices for pasta as the drying temperature increased from 60 to 80 ºC, which corroborates the data obtained from this study. Nevertheless, lower water uptake index was observed in pasta dried at higher temperatures than at lower temperatures by other workers (Aktan and Khan, 1992; Zweifel et al., 2003). The high SI values observed in our study in the pasta dried at high temperature (70 ºC) might have also resulted from the higher cooking time and the SI was measured at the *al dente* time (OCT) and not at a constant cooking time. Increasing the level of hydrocolloid addition from 1.0 to 3.0 % also increased the Swelling Index and this effect was uniformly noticed for the pasta dried at 55 ºC and 70 ºC. Jyothi et al. (2012) reported that pasta from sweet potato refined wheat flour blends had SI of 1.43, while fortification with fiber sources like wheat bran or oat bran at 10 % level enhanced the SI to 1.8-2.1. Gums unlike the bran sources have much higher water holding ability, which resulted in a very high SI for pasta in the present study.

In vitro starch digestibility

Pasta is characterized by the slow release property/ *lente* of glucose into the system and is reported to result from the compact microstructure of pasta due to the starch-protein network (Jenkins et al., 1983; Colonna et al., 1990; Granfeldt and Björck, 1991). It was observed that the low glycaemic nature of sweet potato was complemented by the inherent slow glucose release property of pasta and the products developed through gum fortification showed only slow and progressive release of glucose under *in vitro* systems. Approximately, 8-12 units of glucose were only released during 20 to 120 min. of

Table 1. Effect of drying temperatures on the cooking characteristics of hydrocolloid fortified sweet potato pasta[a]

Treatments	Swelling Index		Cooking loss (%)	
	55 °C	70 °C	55 °C	70 °C
T_1	3.11 ±0.47	4.15 ±0.32	14.91 ±0.91	12.98 ±1.99
T_2	3.43 ±0.45	4.33 ±0.25	14.26 ±0.82	11.76 ±0.16
T_3	2.98 ±0.37	3.95 ±0.89	13.47 ±1.53	10.88 ±1.08
T_4	3.02± 0.30	4.08 ±0.53	12.26 ±0.29	11.92 ±1.79
T_5	3.52 ±0.27	4.31 ±0.29	15.23± 1.26	12.19 ±1.11
T_6	3.80 ±0.26	4.68 ±0.34	14.63 ±0.37	11.46 ±0.15
T_7	3.67 ±0.30	4.31 ±0.31	15.34 ±1.03	12.11 ±1.19
T_8	3.84 ±0.25	4.53 ±0.32	14.41 ±0.40	11.81 ±1.67

[a] Pasta mixes contained 72% sweet potato flour (SPF) for treatments T_1, T_3, T_5 and T_7 and 1% GG, XG, LBG and PHGG respectively and 70% SPF for treatments T_2, T_4, T_6 and T_8 with 3% of GG, XG, LBG and PHGG respectively. All the formulations contained 27% refined wheat flour (RWF). Each value is Mean± Standard deviation of three replications.

incubation of the various pastas dried at 55ºC with digestive enzymes (Table 2) and among the four hydrocolloids, least starch digestibility was observed for GG-fortified sweet potato pasta. Furthermore, it was found that in the case of all the treatments, the 3% hydrocolloid fortified pastas had lower digestibility than 1% fortified samples. The lower digestibility might have resulted from a firmer structure of the pasta. Highest starch digestibility was observed for PHGG-fortified (1%) pasta and there are several reports on the biological effects of PHGG (sunfiber) like reduction in postprandial glucose, lowering of cholesterol, effect in treating irritable bowel syndrome etc. (Tsuda et al., 1998; Trinidad et al., 2004; Giannini et al., 2006). Among the four hydrocolloid sources, PHGG was the least effective, in reducing the starch digestibility (Table 2).

The effect of higher drying temperatures on the *in vitro* starch digestibility of hydrocolloid fortified pasta was evident in the samples dried at 70ºC. Glucose released after 120 min digestion under *in vitro* systems was significantly less than the samples dried at 55ºC (Table 3). Higher level (3%) of fortification with hydrocolloids resulted in lower IVSD than 1% fortification. Among the four hydrocolloids, PHGG fortified samples had the highest IVSD and the pattern was similar to the samples dried at 55ºC (Tables 2 and 3).

The enzymatic susceptibility of starch in pasta is reported to depend on the special organization and structural state of the components (Petitot et al., 2009). Low starch digestibility was reported in durum wheat pasta fortified with chick pea flour (Goñi and Valentin-Gamazo, 2003). High temperature drying reduces water permeability and decreases cooking loss (Vansteelandt and Delcour, 1998).

Rapidly digested starch (RDS) and slowly digested starch (SDS) were low for all the pastas dried at high temperature (70ºC) (Table 4).

The study clearly showed that high drying temperatures reduced the accessibility of starch to amylolytic enzymes,

Table 2: *In vitro* starch digestibility of hydrocolloid fortified sweet potato pasta dried at 55 ºC

Treatments	Glucose released [g $(100g)^{-1}$ cooked pasta on dry basis] at various time (min.) intervals					
	20	40	60	80	100	120
T_1	30.65±1.01	31.87±1.23	33.53±0.75	34.46±1.18	37.96±1.24	40.73±1.02
T_2	30.04±1.65	32.18±1.21	33.90±0.96	36.01±1.89	38.86±1.98	39.71±1.08
T_3	29.71±2.09	33.34±0.99	35.08±0.80	38.26±0.98	40.93±1.97	42.25±0.23
T_4	29.56±1.56	31.55±1.11	32.76±0.46	35.64±0.70	37.62±1.63	40.09±1.19
T_5	33.80±1.79	35.29±0.91	37.34±1.38	39.55±2.01	41.11±1.94	44.54±0.43
T_6	32.74±1.20	34.06±1.31	37.79±1.23	39.29±0.51	41.19±2.15	42.29±0.84
T_7	36.07±0.50	38.20±1.83	41.28±0.92	43.83±1.50	44.99±1.17	46.34±0.57
T_8	34.61±1.05	35.75±1.38	37.18±1.44	39.90±1.23	41.47±0.65	42.59±0.84

*Each value is Mean± Standard deviation of three replications.

Table 3: *In vitro* starch digestibility of hydrocolloid fortified sweet potato pasta dried at 70 ºC

Treatments	Glucose released [g $(100g)^{-1}$ cooked pasta on dry basis] at various time (min.) intervals					
	20	40	60	80	100	120
T_1	28.80±0.43	29.45±0.46	30.29±0.37	32.11±0.35	34.06±0.69	34.95±0.35
T_2	26.27±0.40	27.70±0.74	28.89±1.41	30.26±0.68	30.67±3.39	31.27±0.79
T_3	25.60±0.67	27.35±2.07	28.48±1.62	29.99±1.45	30.97±0.71	33.54±0.77
T_4	23.84±0.85	25.54±1.52	25.30±1.98	26.86±1.75	29.68±1.33	31.34±0.47
T_5	27.51±1.22	29.22±1.28	31.85±1.17	33.18±0.20	33.81±1.29	35.09±0.77
T_6	27.75±0.28	29.27±0.74	29.69±1.19	30.53±1.52	31.66±0.52	33.09±1.08
T_7	30.95±1.10	32.04±0.39	33.89±1.05	35.82±1.38	37.03±0.21	37.55±0.72
T_8	28.67±1.26	29.51±0.74	31.25±1.35	32.07±0.44	32.83±1.10	33.42±0.19

*Each value is Mean± Standard deviation of three replications.

resulting from a compact starch-WPC (protein) network. The reduced cooking loss of high temperature (HT) dried pasta also indicated that the leaching of amylose from swollen starch granules is less in the pasta than the low temperature (LT) drying. Hydrocolloid fortification resulted in higher SI values for HT-dried pasta than LT-dried pasta. Despite this, the starch was not accessible to amylase during *in vitro* digestion. Christianson et al. (1981) reported strong association between GG, XG and soluble amylose with a resultant decrease in its susceptibility to α-amylolytic hydrolysis. Such associations may be taking place in the hydrocolloid fortified sweet potato pasta during cooking leading to low IVSD.

Contrary to the RDS and SDS fractions, HT-dried pasta retained higher levels of RS after 120 min. cooking (undigested starch as percentage of total starch). The very high levels of RS in the cooked pasta from pasta samples dried at 55 and 70 ºC suggest that these products have potential application in the management of Type 2 diabetes and obesity. Approximately 44-51 % starch remained undigested after 120 min. in HT-dried pasta, while 33-41 % remained undigested in LT-dried pasta (Table 4).

The decrease in RDS and SDS in 3 % hydrocolloid fortified pasta corresponded with a concomitant rise the RS fraction in these samples. However, considering the probability of flatulence, bloated up feeling or irritable bowel syndrome in pasta with high levels of hydrocolloids, 1 % fortification with GG, XG or LBG could be considered equally advantageous with 3 % fortification with PHGG, as the latter is relatively free from the above side effects.

Texture profile analysis

The textural properties of cooked samples of sweet potato flour based pasta fortified with different hydrocolloids like GG, XG, LBG and PHGG at 1.0 and 3.0 % respectively and dried at 55° C are reported in Table 5. Among the various gums, pasta samples with xanthan gum had significantly higher firmness and minimum firmness was observed when LBG and PHGG were used. The firmness values increased with increase in the concentration of the gums except for GG. A similar pattern was obtained for toughness also with 5.63 Ns for 3.0 % XG fortified pasta and 3.53 Ns for GG fortified pasta. Adhesiveness, a measure of the stickiness of the cooked pasta was the highest for PHGG added at 3.0 % level (0.91 Ns) and minimum for XG (0.56 Ns) added at 1.0 % level. All the three gums except GG enhanced the Adhesiveness with increasing concentration, indicating the differential behaviour of GG in pasta systems.

As the drying temperature was increased to 70 °C, the firmness values increased, while adhesiveness decreased for the fortified pastas. Higher firmness value of 2.27 N was observed for T_4 (3.0 % XG fortified), while significantly lower value of 0.98 N was obtained for T_8 (3.0 % PHGG fortified). Unlike in the case of 55 °C, the effect of concentration of the gums on stickiness of pasta was just the reverse for samples dried at 70 °C, with increase in adhesiveness for GG fortified samples at 3.0 % incorporation (Table 5). Similar results were reported for wheat semolina pasta dried at higher temperatures by various workers and was attributed to strengthening of the protein network at high temperatures (Aktan and Khan, 1992; Cunin et al., 1995; Zweifel et al., 2003).

Table 4: Starch fractions in hydrocolloid fortified sweet potato pasta dried at two temperatures (expressed as % of the total starch in cooked pasta on dry basis)

Treatments	RDS		SDS		RS	
	55 °C	70 °C	55 °C	70 °C	55 °C	70 °C
T_1	44.88±1.48	42.85±0.42	14.76±2.57	9.16±0.88	41.14±1.50	48.00±0.25
T_2	43.62±1.75	39.48±0.46	14.00±3.07	7.49±1.19	41.50±0.94	53.04±1.00
T_3	44.07±2.32	38.86±0.58	18.56±2.69	12.04±1.02	37.27±0.32	49.39±0.29
T_4	44.95±1.83	37.09±0.65	15.98±2.43	11.64±1.62	39.01±1.34	51.22±0.22
T_5	49.51±2.48	41.50±1.79	15.73±3.19	11.45±0.68	34.75±0.52	47.07±1.11
T_6	48.37±1.12	42.22±0.44	14.12±0.63	8.13±1.67	37.48±0.72	49.65±1.65
T_7	52.56±2.08	46.16±1.58	14.93±0.03	9.85±1.12	32.66±0.92	43.98±1.02
T_8	51.93±0.63	43.09±1.90	11.97±0.35	7.15±2.00	36.07±0.59	49.77±0.29

*Each value is Mean± Standard deviation of three replications.

Table 5: Texture profile of cooked samples of hydrocolloid-fortified sweet potato pasta dried at different temperatures

Treatments	55 °C			70 °C		
	Firmness(N)	Toughness(Ns)	Adhesiveness(Ns)	Firmness(N)	Toughness(Ns)	Adhesiveness(Ns)
T_1	1.40±0.14	4.34±1.05	-0.64±0.26	1.53±0.09	3.94±1.46	-0.39±0.27
T_2	1.08±0.09	3.53±0.24	-0.61±0.03	1.18±0.32	4.12±0.90	-0.53±0.02
T_3	1.75±0.34	4.85±3.05	-0.56±0.45	2.13±0.81	4.71±1.34	-0.47±0.13
T_4	2.10±0.10	5.63±0.10	-0.57±0.09	2.27±0.24	3.66±1.06	-0.28±0.13
T_5	1.18±0.18	4.34±0.66	-0.64±0.11	1.08±0.30	3.35±0.52	-0.58±0.10
T_6	1.21±0.18	4.53±0.43	-0.86±0.10	1.37±0.29	4.07±0.45	-0.53±0.08
T_7	1.18±0.20	3.83±1.50	-0.60±0.28	1.55±0.27	4.35±0.50	-0.45±0.10
T_8	1.21±0.14	4.39±0.61	-0.91±0.11	0.98±0.15	2.86±0.49	-0.42±0.05

Baiano et al. (2006) reported reduction in stickiness of cooked (8 min.) spaghetti dried at 90 °C compared to the sample dried at 60 °C.

Stickiness of spaghetti is linked with amylose leaching and as the amount of amylose leaching increases, the amylopectin content at the spaghetti surface will be more, which results in enhanced stickiness (Zweifel et al., 2003; Baiano et al., 2006). The differential effect of the hydrocolloids on the textural properties of cooked pasta is mainly due to the differences in their structure and the networking/cross linking ability of the gums. The viscoelastic/rheological properties of the resulting products are modified through the addition of gums, the degree of which depends on the structural characteristics and concentration of the gums. Mastromatteo et al. (2012) reported that pasta firmness is related to the hydration of the starch granules during the cooking process and its embedding of gelatinized starch granules in the pasta matrix. Decreased firmness was observed in this study when GG was incorporated at 3 % level and might have resulted from the high water binding ability of GG. Highest firmness was observed for XG- fortified pasta. Galactomannans like guar gum and locust bean gum are reported to form very viscous solution with starch and hence modify the texture of starch-based foods (Sudhakar et al., 1996; Sittikijyothin et al., 2005).

Conclusions

The effect of fortification of sweet potato spaghetti with four hydrocolloids such as guar gum, xanthan gum, locust bean gum and partially hydrolyzed guar gum on its cooking quality and starch digestibility was studied. Drying at 70 ºC increased the swelling index for the gum fortified pastas, while it reduced the cooking loss. Significant reduction *in vitro* starch digestibility was observed in the gum fortified pastas dried at high temperature (70 ºC), with a high retention of undigested/resistant starch after 2 h digestion periods. Sweet potato pasta fortified with xanthan gum had the highest firmness, when dried at both 55 ºC and 70 ºC. Starch digestion proceeded in a slow and progressive manner for the hydrocolloid fortified pastas indicating that this was the best approach to obtain low glycaemic pasta from sweet potato. The study also showed that fortification with edible gums could produce sweet potato pasta with high RS content, which suggests its potential application as a food for diabetic and obese people.

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