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Incorporation of coconut milk residue in pasta: Influence on cooking quality, sensory and physical properties

P.P. Shameena Beegum*, Monika Sharma[1], M.R. Manikantan*, R. Pandiselvam and R.K. Gupta[2]

ICAR-Central Plantation Crops Research Institute, Kasaragod-671 124, Kerala, India
[1]ICAR-National Dairy Research Institute, Southern Regional Station, Adugodi, Bengaluru-560 030, Karnataka, India
[2]ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana-141 004, Punjab, India

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Abstract

A study was conducted to explore the potentiality of coconut milk residue (CMR) for cold extrusion (pasta preparation). Proximate analysis revealed that coconut milk residue is a rich source of crude fibre (24.03%) in addition to crude fat (41.55%), crude protein (5%), total carbohydrates (26.24%) and ash content (0.97%) at 2.23 per cent moisture. The effect of coconut milk residue upon replacing durum wheat semolina on cooking qualities, colour parameters, textural property and overall sensory acceptability of pasta samples were evaluated. Incorporation of coconut milk residue significantly influenced the observed parameters ($P<0.01$). Cooking time was unaffected by incorporating milk residue up to 10 per cent ($P<0.05$). Though the addition of residue increased the gruel loss (0.84 to 1.34%), the per cent loss was below the technologically acceptable limit (<8%). A similar effect was visualized in water absorption. Conversely, the firmness gets reduced with an increased concentration of coconut milk residue beyond 10 per cent. Pasta with 5 per cent and 10 per cent coconut milk residue were accepted as that of control by the sensory panel. Free fatty acid content was not affected by the period of storage ($P>0.05$). Thus, the study recommends incorporating 10 per cent coconut milk residue in durum wheat semolina for pasta preparation. Moreover, the entrepreneurs engaged in the coconut milk/milk powder and virgin coconut oil industry would be benefitted by adopting this venture, wherein they would be able to fetch huge additional income by placing their residue product on an upgraded fast-moving consumer good (FMCG) value chain.

Introduction

Coconut milk residue (CMR) is one of the by-products obtained during the extraction of coconut milk during the production of packaged milk or coconut milk powder, flavoured coconut milk or virgin coconut oil (VCO). The processing of 500 coconuts generates approximately 25 kg of coconut milk residue (Beegum *et al.,* 2016). Per cent recovery of coconut milk residue, based on pulverized gratings, generally ranges from 38.5 to 55.6 (Manikantan *et al.,* 2016). Dried and powdered coconut milk residue with a moisture content of 2.86 per cent consists of 5.29 per cent crude protein, 49.24 per cent crude fat, 25.51 per cent crude fibre with 46.50 per cent dietary fibre and 0.93 per cent ash content (Manikantan *et al.,* 2015). The fibre content present in coconut milk residue is higher than cereals, including rice bran, oats, and barley bran; in fact, it is double than wheat bran (Lalitha, 2014). Further, Sindurani and Rajamohan (1998) stated that neutral detergent fibre extracted from coconut kernel effectively reduced serum total cholesterol, LDL cholesterol and triglycerides concentrations in rats. Characterization of CMR revealed that the soluble, insoluble and total dietary fibre content in CMR is 2.7 per cent, 28.4 per cent and 31.1 per cent, respectively, which was more than those present in fruits such as orange, peach and pear (Ng *et al.,* 2010; Gunathilake *et al.,* 2009).

*Corresponding Authors:shameena.pht@gmail.com, manicpcri@gmail.com

CMR is effective against diabetes, colon cancer, and coronary heart diseases (Trinidad *et al.,* 2003). Despite being an excellent source of nutrients, its use is limited to only a few baking industries and is mainly utilized for animal feed or haphazardly thrown as waste (Trinidad *et al.,* 2003; Manikantan *et al.,* 2016). CMR was explored for protein and dietary fibre enrichment in wheat bread with up to 20 per cent substitution of wheat flour (Gunathilake *et al.*, 2009). Manikantan *et al.* (2015) attempted the feasibility of CMR in hot extrusion and found that it could be very well utilized in extrusion. However, limited studies have been undertaken to explore the feasibility of CMR for cold extrusion processing.

Pasta is a convenient food prepared through the cold extrusion method. It is the most common processed cereal product next to bread, which people of all ages relish. Pasta products are healthy, delicious and convenient, especially for working women. It is one of the fastest-growing categories in the packaged food market in our country, particularly in urban clusters. Wheat is usually used for pasta preparation because of its gluten content. The addition of water causes the plasticization of proteins, thereby shaping the wheat flour or semolina during extrusion. Due to the properties of gluten and the natural yellow pigment, durum wheat semolina is preferred for pasta making (Padmaja *et al.,* 2015). With the backdrop of several health benefits associated with coconut milk residue, especially as a source of good fibres and further its limited utilization in food products, the present study has been planned to explore the potential of fibre and other components present in the CMR to make pasta. Utilizing CMR in pasta making would serve as a practical solution for residue management and provide an additional source of income for the stakeholders involved in coconut processing.

Materials and methods

Raw materials

Semolina was purchased ('Rajdhani' brand) from the local market. CMR obtained after extracting coconut milk was dried at 60-65°C in a tray dryer up to 2.5 per cent moisture level and sieved (60 BSS 0.251 mm) by a standard sieve shaker.

Pasta preparation

Preliminary standardization revealed that replacement of semolina with more than 20 per cent affects the shape and texture of pasta during cooking. Hence, semolina was supplemented with CMR up to 20 per cent (0, 5, 10, 15 and 20%). The mixing chamber of the cold extruder was filled with the prepared flour (Model: Dolly, La Monferina, Asti, Italy). Further, water was added and mixed uniformly for 10 min. A metal extruder attachment was placed in the machine fitted with a spiral-shaped die. The length of each pasta was fixed to 5cm. Samples were then dried at 50 ±5°C for 5 h in a hot air oven till they attained 6-7 per cent moisture. It was packed in 100µ thick polyethylene bags without any preservative under ambient conditions (32± 3°C) till further use.

Cooking time and cooking quality evaluation

Pasta samples were cooked as per the method followed by Yadav *et al.* (2014). Pasta sample (25 g) was added to 250 mL boiling water (in a 500 mL glass beaker) and cooked until the disappearance of the hard central core. Time taken for cooking was noted.

Solids lost in cooking water (gruel loss) and water absorption was found using the following formula (AACC method 66-50). Cooking loss was determined in water collected from each sample after cooking by evaporation to constant weight in a hot air oven at 105°C.

$$\text{Gruel loss (\%)} = \frac{\text{Weight of dry residue}}{\text{Initial weight of raw pasta}} \times 100 \quad (1)$$

$$\text{Water absorption (\%)} = \frac{\text{Weight of cooked pasta-weight of raw pasta}}{\text{Weight of raw pasta}} \times 100 \quad (2)$$

Colour

The colour of the pasta samples (raw and cooked) was measured using a Hunter Lab colorimeter (Mini Scan XE Plus). Since the pasta samples were light yellow, *L* (lightness) and b (yellow-blue) values were observed. *L* represents black to white (0-100), +*b* is yellow and -*b* is blue. The measurements were performed in two replications and repeated 3 times per replicate.

Textural analysis

The texture of the cooked pasta samples was measured using a Texture Analyzer (TA-HDi, Stable Micro Systems Ltd., Surrey, UK). The settings were followed, as stated by Yadav *et al.* (2014). Maximum force in the force-time graph was taken as firmness. Six measurements were taken for each sample.

Sensory acceptability

A panel of 10 semi-trained judges evaluated the sensory acceptability of cooked pasta samples. 100 g sample was cooked in 500 mL water added with 3 g table salt. After completion of cooking, excess water was drained and 25 g of cooked pasta from each treatment were served to the panel for comparing evaluating the sensory attributes such as appearance, flavour, taste, texture, mouthfeel, and overall acceptability (OA) using a nine-point hedonic scale. The overall acceptability was considered for the statistical analysis.

Storage studies

The optimized pasta sample containing CMR packaged in low-density polyethylene (LDPE) pouches and stored at ambient temperature (33±3°C) was analysed for changes in free fatty acid content during the three months storage at 30 days interval. To estimate FFA, crude fat was extracted using soxhlet apparatus at every 30 days interval. Fat (1 g) was mixed with 10 mL neutral solvent mixture (Diethyl ether and ethanol as 1:1) and titrated against 0.01 N KOH with phenolphthalein as indicator. The persistence of pink colour for 15 seconds was taken as the endpoint.

Statistical analysis

The data obtained were analyzed with the analysis of variance (ANOVA) using a completely randomized design (CRD), and the significance among the mean values was tested using the least significant difference (LSD) method

Results and discussion

The proximate composition of the raw materials is given in Table 1, which is in accordance with the earlier reports on the composition of semolina and coconut milk residue, respectively (Kaur *et al.,* 2012; Manikantan *et al.,* 2015). Crude fibre obtained from CMR was 24.03 g 100 g^{-1}, indicating the feasibility to enrich the fibre content in pasta. The crude fibre content in rice bran and barley bran are reported to be 11.5 per cent and 14.9 per cent, respectively (Kaur *et al.,* 2012). The fibre content in whole oats is 12.45 per cent (Usman *et al.,* 2010). Thus, it is evident that coconut milk residue is a rich source of crude fibre compared to all these cereals. Similarly, the protein content obtained from CMR (5%) was comparable with that of maize (5.5%), as reported by Hager *et al.* (2012). CMR is also rich in crude fat (41.55%), especially with medium-chain fatty acids that give immense health benefits. The addition of fat improves the pasta texture and makes dough that easily extrudes from the machine apart from enhancing flavour (Fuad and Prabhasankar, 2010). Trinidad *et al.* (2006) mentioned the relevance of CMR substituted foods with respect to their healthy fatty acids, low glycemic index and weight management. In addition, a good amount of minerals (in terms of ash content) is present in CMR (0.97%), which is higher than that of semolina. It contains only 26.24 per cent carbohydrates indicating its role as a low carbohydrate product than wheat, rice and other cereals.

Preparation of pasta

Preliminary experiments revealed that replacement of semolina with more than 20 per cent CMR resulted in complete disruption of the shape during cooking. Hence the level of incorporation

Table 1. Proximate analysis of the ingredients - Average composition (g 100 g^{-1}) ± SD

	Moisture	Crude protein	Crude fat	Total carbohydrates	Crude fibre	Ash
CMR	2.23±0.31	5.00±0.02	41.55±0.13	26.24±0.67	24.03±2.2	0.97±0.02
Wheat semolina	13.5±0.14	11.67±0.15	1.79±0.03	71.07±0.24	1.42± 0.03	0.5±0.02

Values represented as mean of three replications with standard deviation of CMR in pasta was fixed at 0, 10, 15, and 20 per cent.

Cooking quality

Pasta quality is primarily decided by the cooking performance, which is the ultimate test of acceptability of pasta. During cooking, volume increases and dry matter loss occurs while maintaining the shape without any disintegration (Cleary and Brennan, 2006). The structural changes include starch gelatinization and protein coagulation.

The average time taken for cooking in CMR-supplemented samples varied from 6.5 to 8.0 min (Table 2), which was lesser than the cooking time of traditional durum wheat pasta, i.e. 7.0 to 9.0 min (Petitot *et al.,* 2010). Jalgaonkar *et al.* (2019) reported a cooking time of 5.15 min as one of the desirable traits of pasta. Substitution up to 10 per cent CMR did not show any significant effect on cooking time ($P<0.05$). As the concentration increased further, it took more time to cook, which might be due to the fibres present in CMR, and it took more time for the disappearance of the centre core of pasta. Semolina pasta supplemented with mushroom powder (0-12%) and defatted soy flour (0-15%) also lead to an increase in cooking time (Kaur *et al.,* 2013). In addition, enrichment of pasta with protein through CMR might also result in increased cooking time.

Gruel loss

Gruel loss is the total solids leached out in gruel during the cooking of pasta, or it is the resistance of pasta against disintegration. The lesser the amount of solids in the cooking water, better is the quality of pasta (Pagani *et al.,* 2007). The gruel loss in the pasta samples was varied from 0.84 to 1.34 per cent ($P<0.05$) (Table 2). The lowest gruel loss was observed for the control pasta, whereas the highest was for pasta with 20 g CMR 100 g^{-1} semolina. The addition of CMR with comparatively larger particle size may increase the cooking loss by loosening the compact structure of pasta (Padmaja *et al.,* 2015). Nevertheless, per cent gruel loss was lesser than previous reports (Eman *et al.,* 2012, Yadav *et al.,* 2014). Pasta samples containing 5 per cent and 10 per cent CMR showed no significant difference in the gruel loss during cooking ($P>0.05$). The addition of non-gluten additives causes more disruption to the structure resulting in higher cooking losses (Piwinska *et al.,* 2015). Also, the weaker starch-protein interaction might get disrupted during cooking. Gunathilake and Abeyrathane (2008) observed an increasing tendency for breakage of noodles at a higher level (more than 20%) of coconut flour addition due to lowering the gluten content. Nonetheless, the cooking loss in all the samples was below the technologically acceptable limit as per BIS standard (≤8%) (Jalgaonkar *et al.,* 2019). As a thumb rule, the residue shall not surpass 7-8 per cent of the dry weight of pasta (Gull *et al.,* 2015). The addition of stabilizers such as carboxymethyl cellulose could be suggested for more than 10 per cent CMR levels so that the residual loss during cooking can be avoided.

Water absorption

It is the absorption of water $gram^{-1}$ of dry pasta and a test for the nature and type of ingredients and its capability to absorb and hold water. Significant variation was observed ($P<0.05$) among the samples (Table 2). As the level of incorporation of CMR

Table 2. Effect of CMR on cooking quality and textural parameter of pasta

Level of CMR (g 100 g^{-1})	Cooking time (min) **	Gruel loss (%) **	Water absorption (%) **	Firmness (N) **
0	6.53±0.03^{c}	0.84 ±0.15^{c}	114.52 ±0.31^{e}	24.43 ±0.37^{a}
5	6.58±0.01 ^{c}	0.95 ±0.07^{bc}	131.66 ±2.09^{d}	21.78±0.74^{b}
10	6.71 ±0.25^{c}	0.96 ±0.05^{bc}	145.72 ±1.37^{c}	21.90±0.06^{b}
15	7.03±0.06^{b}	1.10±0.14^{b}	150.03 ±0.22^{b}	18.78 ±0.22^{c}
20	8.03±0.06 ^{a}	1.34±0.15^{a}	182.44 ±0.58^{a}	16.54±0.38^{d}

**Significant at 1%, Mean value with different letters differ significantly
Values are mean replications ± standard deviation

increased, the water absorption was also increased (114.52 to 182.44% for 0 to 20% CMR incorporation). This increase in water absorption was due to the weaker gluten network. Besides, the high fibre content present in CMR allowed easier water penetration, which resulted in a substantial increase in water absorption. The strong binding ability of fibre can disrupt the gluten matrix (Chillo *et al.,* 2008; Chen *et al.,* 1988). Coconut fibre has the highest water holding, swelling and water retention capacity (Raghavarao *et al.,* 2008).

Colour

It is an imperative parameter influencing the visual quality of pasta. *L* and *b* values are considered important colour attributes in pasta made from semolina (Rayas-Duarte *et al.,* 1996). Colour parameters *L* (white to black), *b* (yellow to blue) of raw and cooked pasta are revealed in Table 3. *L* value of raw pasta ranged from 66.76 to 75.19, while after cooking, there was an increase from 77.60 to 80.57. Control pasta showed the maximum value for lightness followed by 20 per cent CMR, 15 per cent CMR, 10 per cent CMR and 5 per cent CMR incorporated sample, respectively (P<0.001). An increase in *L* value indicates loss of colour during cooking. Nonetheless, samples with 10 per cent and 15 per cent CMR did not show any significant difference (P>0.05). Similarly, the highest value for *b* was obtained for the control pasta. Though the samples behaved similarly after cooking to that of raw samples, significant differences were observed among each other (P<0.05). It was evident that to get a significant change in the yellowness of cooked semolina pasta, at least 10 per cent CMR incorporation was needed. Pasta with 15 per cent and 20 per cent CMR showed a similar *b* value.

Table 3. Colour attributes of CMR incorporated pasta

Treatments	*L* value		*b* value	
	Raw **	Cooked *	Raw **	Cooked **
0	75.19^{a}	80.57^{a}	17.82^{a}	12.74^{a}
5	66.76^{d}	77.60^{c}	13.75^{b}	12.58^{ab}
10	70.15^{c}	78.47^{bc}	13.13^{b}	12.50^{b}
15	72.26^{b}	77.86^{bc}	13.30^{b}	12.13^{c}
20	72.33^{b}	79.67^{ab}	13.58^{b}	12.12^{c}

** and * Significant at 1% and 5% respectively.

Mean value with different letters differ significantly

Values are mean replications ± standard deviation

Texture

The texture is one of the most significant quality attributes of cooked pasta. A significant effect was shown by different pasta samples on the firmness after cooking. Table 2 shows that firmness value reduced significantly (P< 0.05) from 24.43 N to 16.54 N, which is in accordance with Marti and Pagani (2013) in gluten-free pasta. Increasing non-gluten proteins weaken the gluten strength and overall structure of the pasta (Rayas-Duarte *et al.,* 1996). Due to the weakening in gluten strength, there was a loss in firmness in cooked pasta (Kaur *et al.,* 2012). However, the semolina pasta replaced with 5 per cent and 10 per cent CMR could retain a similar firmness as that of the control (P>0.05). This clearly indicated that more than 10 per cent replacement of semolina with CMR would affect the quality of cooked pasta.

Overall acceptability

The sensory parameters such as appearance, colour, texture, flavour and taste of cooked pasta are essential for acceptability. The overall acceptability (including all sensory parameters) was maximum for control pasta with a mean value of 8.46 (liked very much) and the minimum for pasta containing 20 per cent CMR with 3.7 (Dislike moderately) (Fig.1). The non-significant effect between pasta with 5 per cent and 10 per cent CMR indicates its applicability up to 10 per cent replacement level in pasta. Gunathilake *et al.* (2009) also mentioned the declining effect of sensory parameters on increasing coconut flour concentration in bread. Bread and noodles with 20 per cent substitution with CMR showed maximum sensory acceptability (Gunathilake and Abeyrathne, 2008).

Free fatty acid content during storage

FFA content in the control and pasta with 10 per cent CMR incorporation ranged from 0.55 to 0.65 per cent and 0.56 to 0.84 per cent, respectively. Fig. 2 represents the trend in FFA over 90 days of storage period. Though there was a gradual increase in FFA during storage, the level was not enough to give noticeable changes in the product, which was in accordance with the earlier reports (Yadav *et al.,* 2014; Manthey *et al.,* 2008; Kaur *et al.,* 2012).

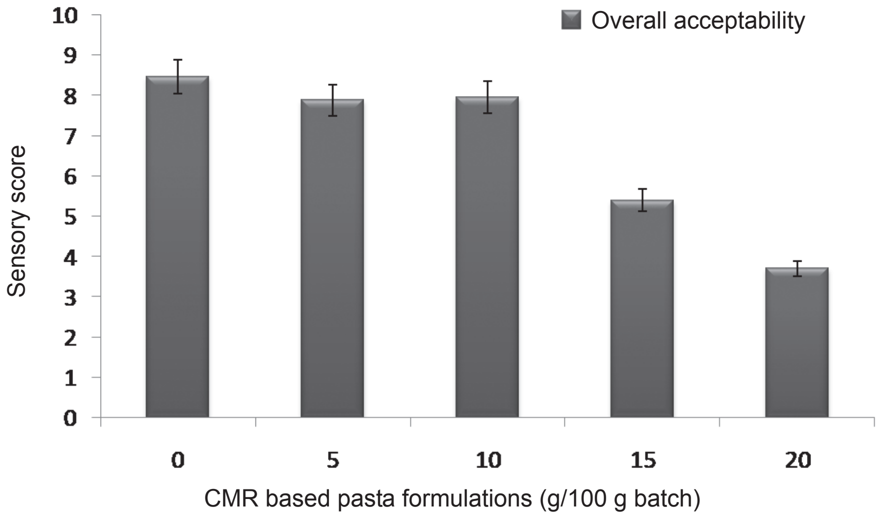

Fig.1. Sensory scores of cooked pasta

Conclusion

The study exploited the potential of coconut milk residue for the preparation of pasta. The developed pasta had good structural integrity, as evident from the low gruel loss. However, firmness value of the cooked pasta was lower for the fortified sample as compared to control. Results also revealed that coconut milk residue could be incorporated into durum wheat semolina at 10 per cent level as a source of fibre due to its high fibre content (24%). Recovery of CMR during the extraction of coconut milk ranged from 38.5 to 55.6 per cent. If a coconut processing firm processes coconut milk with 500 nuts per day capacity, then approximately 25 kg milk residue is generated. The selling price of CMR is ₹ 10-15 kg^{-1}. If it is incorporated for pasta making along with durum wheat semolina, a firm can sell the product at a better price of ₹ 300-700 kg^{-1}. The fortified pasta can provide more than 50 per cent of recommended dietary allowance of fibre in addition to enrichment of pasta with protein. Thus, fortifying semolina pasta with CMR is encouraging due to its nutritional, textural and sensory quality attributes.

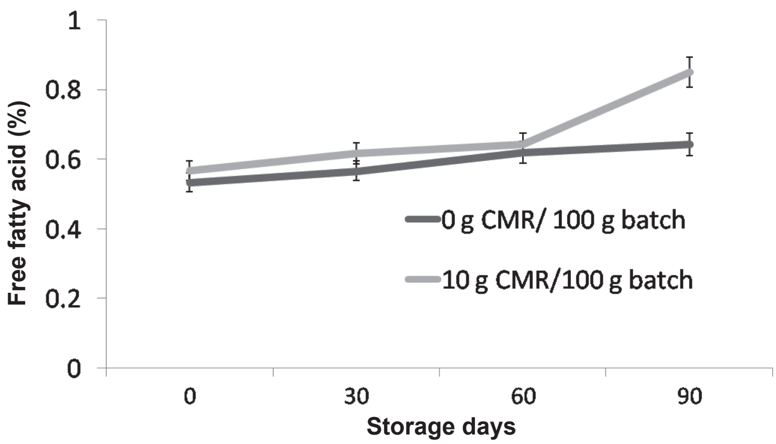

Fig. 2. Effect of incorporation of CMR on the free fatty acid content of pasta during storage

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