Process Optimization for Paneer Production from Milk Powder

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Abstract: A study was conducted to prepare paneer of desirable quality from whole milk powder. Various reconstitution levels of whole milk powder (whole milk powder : water) viz., 1:2, 1:3, 1:4, 1:5 and 1:6, along with control (fresh milk), were used for the manufacture of paneer. The study revealed that the control milk, 1:5 and 1:6 reconstitution levels resulted in paneer with higher values for yield, total solids recovery and all sensory characteristics compared to other reconstitution levels. However, moisture, fat, protein, fat in dry matter, moisture absorption, pH and requirement of coagulant did not elicit any significant variations within the reconstitution levels. Therefore, it is suggested that reconstitution levels of 1:5 and 1:6 can be used for the manufacture of good quality paneer without any need for the modifications in the processing conditions.

Keywords: paneer; reconstituted milk; whole milk powder; sensory quality.

1. Introduction

Paneer is an Indian variety of soft unripened cheese manufactured by high heat treatment and direct acidification. It belongs to the non-renneted, directly acidified cheese which also includes most
of the Latin American white cheese used throughout the south and central Mexico and Caribbean islands (Torres and Chandan, 1981; Chandan, 2007a). Paneer is a highly popular product throughout the country, having many uses starting from its consumption in raw form to the preparation of several varieties of culinary dishes and snacks and sweet meats like *rasogolla, rasamalai, sandesh* etc. which are actually produced from *chhana* which is an unpressed form of paneer. Good quality paneer is characterized by a marble white color, sweetish, mildly acidic taste, nutty flavour, spongy body and closely knit smooth texture. It is estimated that about 50 per cent of total milk produced in India is converted into various milk products like ghee, butter, paneer, *chhana, khoa* etc., among these paneer is one of the major milk products produced in India, especially in the north. According to an estimate about 5 per cent of milk produced in India is converted into paneer (Chandan, 2007b). Due to the variation in milk production in different seasons, the milk in high production seasons is converted to milk powder to be used during the lean periods instead of fresh milk as the dried milk powder is shelf stable. Furthermore, it at times, becomes unavoidable to use milk powder during lean periods for the manufacture of various milk products. The milk powder thus developed has to be utilized for manufacture of various milk products. It has been noticed that the properties of milk gets altered after conversion to milk powder. So the present study was carried out to examine the effects of drying milk on the paneer quality and thereby optimizing the processing parameters for its production.

2. Material and Methods

2.1. Raw Material

A low heat spray dried whole milk powder (WMP) manufactured locally was used for pursuing this study. About 2000 g of whole milk powder (consisting of fat 26%, protein 25%, lactose 35%, minerals 7%) was reconstituted with 4000, 6000, 8000, 10,000, 12,000 mL (w/v) of warm water (~50 °C) to obtain reconstituted milk with different levels of solids having final milk solids to water ratio of 1:2, 1:3, 1:4, 1:5 and 1:6, respectively. The reconstituted milk thus obtained was allowed to stand undisturbed for 30 min for complete hydration of milk powder and then converted into paneer as per the method suggested by Pal et al. (1991) with some modifications.

2.2. Preparation of Paneer

Various reconstitution levels viz., 1:2, 1:3, 1:4, 1:5 and 1:6 of spray dried whole milk powder was used for paneer manufacture along with one control (fresh cow milk). The milk was heated up to 90 °C without holding, cooled to 70 °C and coagulated using 2 per cent citric acid as coagulating agent at 70 °C with continuous but gentle stirring. The coagulum thus obtained was left undisturbed for
approximately 5 min and the temperature of the contents was not allowed to drop below 60 °C at this stage. Whey was drained by filtering contents through a fine muslin cloth. The coagulum was then filled in wooden hoops with holes on the all sides and bottom to facilitate quick and efficient expulsion of whey. The hoops were lined with strong and clean muslin cloth from inside and the whole mass was then pressed in hoops by applying pressure of about 230 kg/m² on the lid of the hoop for about 15 min. The pressed block of curd was cut into pieces of suitable size (7.5 × 7.5 × 7.5 cm³) and immersed in chilled water (4 °C) for 1 h. The paneer was then taken out of water and drained well, wiped clean and weighed to obtain paneer yield. The product was then subjected to physico-chemical and sensory evaluation.

2.3. Physico-chemical Analysis

The reconstituted milk and whey was analyzed for various physico-chemical parameters viz., moisture by gravimetric method, total proteins by micro-Kjeldahl method, fat by Gerbers method (IS, 1977), pH by combined electrode digital pH meter and SNF by difference. Paneer was evaluated for moisture, fat, proteins and ash by AOAC (2003). The pH of paneer was determined by the method of O’ Keeffe et al. (1976). Fat on dry matter basis, total solids recovery and yield was calculated.

2.4. Sensory Evaluation

The sensory evaluation of paneer was carried out by the panel of 10-15 semi-trained judges. Panelists evaluated samples for appearance, flavor, texture and overall acceptability as per 9-point Hedonic scale.

2.5. Statistical Analysis

The data generated was analyzed by one way ANOVA using SPSS® software package and means were compared by using Duncans multiple range test.

3. Results and Discussion

The data pertinent to the characteristics of raw reconstituted milk used for paneer manufacture is reflected in Table 1.

3.1. Physico-chemical Characteristics of Paneer

The results obtained after analyzing the paneer manufactured using various levels of reconstituted whole milk are presented in Table 2. As is evident from the table under reference, the moisture levels did not elicit any variation (p > 0.05) amongst the samples of various reconstitution
levels. The control values were also comparable. The values were within the range prescribed by ISI (1983) and PFA (2003) and closer to the values obtained by (Sachdeva et al., 1991; Pal et al., 1996; Jadhavar et al., 2009). The fat content of control samples was significantly (p ≤ 0.05) higher compared to all other samples of varying reconstitution levels. The values for fat content in control samples observed in our study are in agreement with those reported by Sachdeva et al. (1991) in cow milk paneer. The higher fat content in control samples can be attributed to higher fat: SNF ratio in control milk samples than all reconstituted milk samples. This ratio is an important factor that determines the fat content of the paneer (Sachdeva and Singh, 1988; Chandan, 2007b). However, within the reconstitution levels, it was observed that the fat content amongst various samples were comparable, although there was a progressively decreasing trend in numerical value with decrease in TS in milk. Same trend was also observed by Singh and Kanawjia (1992) in paneer made from reconstituted milk of varying TS levels. The protein content of all the paneer samples including the control did not show any significant difference (p > 0.05) up on comparison. It varied over a narrow range of 17.89 ± 0.21 to 18.11 ± 0.06. The results for control samples agree favorably with those of Sachdeva et al. (1991), Pal et al. (1996), Jadhavar (2009) for cow milk paneer. However, the protein content values for all reconstituted milk samples were observed to be comparatively lower than what have been reported by Singh and Kanawjia (1992). The use of different processing conditions might be the possible cause for such difference. It was found that the control samples had significantly (p ≤ 0.05) lower ash content compared to all other samples of varying TS levels, the latter showed progressive decrease in value with the decrease in the TS levels in reconstituted milk. The results in cow milk paneer were somewhat closer to the values reported by (Pal et al 1991, Sachdeva et al., 1991; Jadhavar et al., 2009). However, within the reconstitution levels, the progressively decreasing trend in ash content with the decrease in the TS of milk could be attributed to gradual increase in moisture content in paneer resulting in concomitant decrease in the concentration of ash per unit mass of paneer. The TS recoveries of control, 1:5 and 1:6 reconstitution level samples had comparable (p > 0.05) values, however, they had significantly (p ≤ 0.05) higher values than the rest of reconstitution level. The values for control samples (cow milk) fall within the range of reported values (Sachdeva et al., 1991; Pal et al., 1996; Jadhavar et al., 2009). However, TS recoveries increased progressively in reconstituted milk samples from higher TS levels to lower TS levels. A similar phenomenon was noted by Singh and Kanawjia (1992) in paneer made from reconstituted milk of varying TS levels. The probable reason could be the formation of a weak and crumbly coagulum by higher TS levels which was observed on sensory evaluation as they obtained comparatively lesser scores for body and texture, thus resulting in losses of TS in the form of fines into the whey. The reason for this could be that the lesser amount of water must be inadequate to distribute the acid properly to each casein particles thus affecting in their precipitation and attachment with nearby casein particles during coagulation. The fat recovery per cent followed the
same trend as that of TS recovery. It was observed that, with the decrease in TS recoveries from 1:6 to 1:2 reconstitution level samples there was concomitant decrease in the fat recovery as less compact coagulum made from higher TS milk was less efficient in entrapping the free fat in it. The per cent protein recovery values were found to be comparable between control, 1:5 and 1:6 reconstitution level samples. However, they had significantly higher values compared to other reconstitution levels (1:2, 1:3 and 1:4). The lower protein recoveries in higher TS levels could be discussed on the same lines as for TS recoveries. The FDM (%) of control samples had significantly higher values than all the reconstituted milk samples. The latter in turn were comparable with one another. The higher values of FDM in control paneer samples can be attributed to higher fat: SNF ratio in control milk samples than all the reconstituted milk samples in the study, closely relevant results have been reported in the literature (Sachdeva and Singh, 1988; Pal and Yadav, 1991; Kumar et al., 2008). It is explicit from the results that the FDM values of all the samples in study did not meet the PFA standards (FDM ≥ 50%). However, several authors (Chawla et al., 1985; Chandan 2007b) have reported that the FDM values as low as 42 per cent corresponding to 3.5 per cent of fat in milk can result in an acceptable quality of paneer. This could be beneficial in two ways, firstly the savings in terms of the costliest milk constituent viz., milk fat, secondly, the calorie conscious people can resort to this comparatively low fat product. This contention is also substantiated by (Sanyal et al., 2004). It was also observed that to meet the PFA standards about 5.5-6.0 per cent fat in milk is required which also results in appreciable losses of fat in whey compared to paneer from lower fat milk (Kumar et al., 2008). In the light of these observations the PFA standard of not less than 50 per cent FDM seems to be too high and needs to be revised. Similar concerns have also been raised earlier (Chawla et al., 1987; Sachdeva et al., 1991; Sanyal and Yadav, 2000). The yield of control, 1:5 and 1:6 reconstitution level paneer samples were comparable with one another and they possessed significantly (p ≤ 0.05) higher values than the rest of reconstitution level samples, the latter in turn showed decreasing trend with the decrease in reconstitution levels from 1:4 to 1:2. The lower yield in higher TS levels particularly corresponding to 1:2, 1:3 and 1:4 reconstitution levels might be due to lower moisture retention as well as lower TS recoveries which have consequently resulted in proportionate decrease in yield of paneer in these levels. The loose body and crumbly structure of the paneer resulted in the loss of fines into the whey which could be a possible reason for lower TS recoveries in these samples. The pH of all the samples including the control samples had comparable values. The coagulant amount required for paneer manufacture was almost similar (p > 0.05) in all the samples in study with no significant difference. The reason, however, for this could be that there were almost similar amount of milk solids in all the samples thus requirement for acid for coagulating the same amount of milk solids remained practically the same.
Table 1. Physico-chemical parameters of reconstituted milk at various levels of reconstitution

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Reconstitution Levels (milk powder: water)</th>
<th>Control</th>
<th>1:2</th>
<th>1:3</th>
<th>1:4</th>
<th>1:5</th>
<th>1:6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (%)</td>
<td></td>
<td>3.73±0.03a</td>
<td>9.17±0.09b</td>
<td>6.88±0.07c</td>
<td>5.50±0.03d</td>
<td>4.62±0.04e</td>
<td>3.97±0.02f</td>
</tr>
<tr>
<td>Protein (%)</td>
<td></td>
<td>3.22±0.10a</td>
<td>8.79±0.05b</td>
<td>6.60±0.12c</td>
<td>5.27±0.06d</td>
<td>4.43±0.07e</td>
<td>3.80±0.03f</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td></td>
<td>12.44±0.31d</td>
<td>34.15±0.33b</td>
<td>25.59±0.39c</td>
<td>20.44±0.34d</td>
<td>16.96±0.18e</td>
<td>14.55±0.07f</td>
</tr>
<tr>
<td>Fat/SNF</td>
<td></td>
<td>0.43±0.05a</td>
<td>0.37±0.01b</td>
<td>0.37±0.02b</td>
<td>0.37±0.05b</td>
<td>0.37±0.01b</td>
<td>0.37±0.01b</td>
</tr>
</tbody>
</table>

Note: Row-wise group means with different superscripts differ significantly (p ≤ 0.05); Mean ± S.E; N = 3.

Table 2. Effect of reconstitution levels on physico-chemical quality of paneer

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Reconstitution levels (milk powder: water)</th>
<th>Control</th>
<th>1:2</th>
<th>1:3</th>
<th>1:4</th>
<th>1:5</th>
<th>1:6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td></td>
<td>57.02±0.14</td>
<td>56.62±0.52</td>
<td>56.97±0.52</td>
<td>57.12±0.08</td>
<td>57.41±0.14</td>
<td>57.44±0.37</td>
</tr>
<tr>
<td>Fat (%)</td>
<td></td>
<td>21.00±0.54a</td>
<td>19.80±0.03b</td>
<td>19.47±0.06c</td>
<td>19.30±0.18d</td>
<td>19.06±0.13b</td>
<td>19.01±0.07b</td>
</tr>
<tr>
<td>Protein (%)</td>
<td></td>
<td>17.97±0.26</td>
<td>17.89±0.21</td>
<td>17.95±0.15</td>
<td>18.02±0.21</td>
<td>18.09±0.05</td>
<td>18.11±0.06</td>
</tr>
<tr>
<td>Ash (%)</td>
<td></td>
<td>1.68±0.07a</td>
<td>2.38±0.04c</td>
<td>2.24±0.04d</td>
<td>2.09±0.02e</td>
<td>1.93±0.01b</td>
<td>1.91±0.01b</td>
</tr>
<tr>
<td>TS recovery (%)</td>
<td></td>
<td>59.10±0.19a</td>
<td>54.91±0.41b</td>
<td>55.18±0.22b</td>
<td>55.87±0.94b</td>
<td>58.67±0.21a</td>
<td>58.85±0.06b</td>
</tr>
<tr>
<td>Fat recovery (%)</td>
<td></td>
<td>95.91±0.29a</td>
<td>90.79±0.72b</td>
<td>91.33±0.75b</td>
<td>92.12±0.85b</td>
<td>95.22±0.27a</td>
<td>95.61±0.72a</td>
</tr>
<tr>
<td>Protein recovery (%)</td>
<td></td>
<td>94.92±0.27a</td>
<td>84.81±0.27b</td>
<td>86.83±0.17c</td>
<td>88.44±0.64d</td>
<td>93.40±0.51a</td>
<td>93.92±0.73a</td>
</tr>
<tr>
<td>FDM (%)</td>
<td></td>
<td>48.85±1.10a</td>
<td>45.66±0.55a</td>
<td>45.25±0.41b</td>
<td>45.01±0.43b</td>
<td>44.74±0.19b</td>
<td>44.67±0.46b</td>
</tr>
<tr>
<td>Yield (Kg/100 kg WMP)</td>
<td></td>
<td>127.50±2.50a</td>
<td>119.50±1.61c</td>
<td>121.50±1.53c</td>
<td>123.50±1.80b</td>
<td>130.17±0.60a</td>
<td>131.00±1.32a</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>5.97±0.03</td>
<td>5.85±0.01</td>
<td>5.85±0.01</td>
<td>5.86±0.01</td>
<td>5.89±0.04</td>
<td>5.89±0.05</td>
</tr>
<tr>
<td>Coagulant amount (L/100 kg WMP)</td>
<td></td>
<td>†56.67±2.20</td>
<td>55.83±0.83</td>
<td>55.83±2.20</td>
<td>57.50±1.44</td>
<td>57.50±1.44</td>
<td>59.17±0.83</td>
</tr>
</tbody>
</table>

Note: Row-wise group means with different superscripts differ significantly (P ≤ 0.05); Mean ± S.E; n=3; FDM: fat on dry matter basis, WMP: whole milk powder. † Yield of paneer from cow milk equivalent to 100 Kg milk powder.

3.2. Sensory Characteristics of Paneer

All the sensory parameters like appearance, flavour, body and texture and overall acceptability were significantly affected by the level of reconstitution and exhibited almost the same trend (Fig. 1). It was observed that the appearance scores were similar in control, 1:4, 1:5 and 1:6 reconstituted samples but significantly (p ≤ 0.05) lower in case of 1:2 and 1:3 levels than the former four samples. The lower scores in latter two samples were probably due to the withered appearance in these two samples which might have developed due to poor acid distribution in these samples during coagulation. The flavour scores were significantly (p ≤ 0.05) better in case of control, 1:5 and 1:6 samples than 1:2, 1:3 and 1:4 samples. The latter three were criticized for having acidic and heat
induced flavours. This was due to the relatively higher exposure of milk solids to both acid and heat as milk solids are in the form of comparatively thick and viscous liquid in higher TS milk which is more prone to both acidic and heat induced flavours than diluted milk where these affects were more or less neutralized by comparatively more amount of water. These results corroborate the findings of Singh and Kanawjia (1992), who also observed that with the increase in TS in reconstituted milk there was decrease in the flavour scores of paneer. Body and texture scores of paneer were also found to be comparable (p > 0.05) among control, 1:5 and 1:6 reconstitution level samples. All these samples scored significantly higher (p ≤ 0.05) than 1:2, 1:3 and 1:4 reconstitution level samples. The lower scores in latter three treatments may be ascribed to hard, dry and crumbly body with poor matting of paneer solids. The comparatively lower body and texture scores of paneer from higher solid reconstituted milk were also observed by Singh and Kanawjia (1992). The overall acceptability scores of control, 1:5 and 1:6 levels again were not significantly (p > 0.05) different from one another. However, they had significantly (p ≤ 0.05) higher values than the rest of the three samples. The former three samples (control, 1:5 and 1:6 level) were rated between like moderately (7) to like very much (8) whilst, the latter three samples scored between like slightly (6) and like moderately (7). Finally in terms of sensory quality, the study revealed that reconstituted milk paneer from 1:5 and 1:6 reconstitution levels were very close to control samples.

![Figure 1](image.png)

**Figure 1.** Effect of reconstitution levels on the sensory quality of reconstituted milk paneer.

3.3. *Whey Characteristics*

Perusal of the data elucidates that the TS losses in whey were significantly (p ≤ 0.05) lower in control samples compared to other samples of varying reconstitution levels. The latter in turn exhibited a significant and progressive decrease in TS losses from 1:2 to 1:6 reconstitution level samples (Table 3). The values observed in control samples in this study are in tune with the values reported by
Sachdeva et al. (1991) in cow milk whey. However, within the reconstitution level samples there was progressive increase in TS losses in whey with increase in TS of milk. This could be attributed to poor TS recovery which in turn was due to poor matting and formation of weak curd which resulted in losses of milk solids in the form of fines that escaped the strainer into the whey. The fat losses in whey had comparable values among control, 1:5 and 1:6 reconstitution level samples. However, they had significantly (p ≤ 0.05) lower values compared to 1:2, 1:3 and 1:4 reconstitution level samples. The higher losses of fat in latter three samples could be due to weak body and relatively poor matting of the paneer proteins which do not prevent free fat to flow with whey. The protein losses were again found to be comparable between control, 1:5 and 1:6 reconstitution level samples. However, these samples possessed significantly (p ≤ 0.05) lower protein content compared to rest of samples (1:2, 1:3 and 1:4). The higher values in case of latter three samples could be due to formation of weak and crumbly coagulum which resulted in loss of milk proteins in the form of fines with the whey. The yield of whey varied appreciably amongst the treatments. The yield of whey was significantly (p ≤ 0.05) higher in control than the rest of samples, the latter showed increasing trend from 1:2 to 1:6 reconstitution levels. This is because of difference in the amount of water used for reconstitution which reflected in the yield of whey accordingly. The lower whey yield could be beneficial as it can help in reducing the pollution of water bodies and lower the cost for its scientific disposal. The pH of all the samples including the control samples had similar values. These values are in the range of the reported values in the literature (Chawla et al., 1987; Pal et al., 1999).

Table 3. Effect of reconstitution levels on physico-chemical quality of whey

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Reconstitution Levels (milk powder: water)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>TS (%)</td>
<td>6.07±0.13&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>0.18±0.02&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>0.20±0.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Yield (L)</td>
<td>625.00±2.89&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>pH</td>
<td>5.40±0.00</td>
</tr>
</tbody>
</table>

Note: Row-wise group means with different superscripts differ significantly (p ≤ 0.05); Mean ± S.E; n=3. † Yield from cow milk equivalent to 100 Kg milk powder.

4. Conclusions

From the findings of this study, it might be concluded that a paneer of desirable quality comparable with control cow milk paneer can be prepared from reconstituted milk with 1:5 or 1:6 level
of reconstitution. Reconstitution levels below 1:5 level has some adverse effects on the quality of paneer, although all the paneer samples were acceptable.

References


