Identification of Suitable Spray Dryer and Fluid Bed Dryer Temperature for Standard Milk Powder in MILCO (Highland) Spray Dryer Milk Factory Ambewela

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Abstract
Ambewela MILCO (Highland) Spray Dried Milk Factory produces milk powder under the brand name of “Highland Milk Powder” among five factories belongs to MILCO Company. Moisture content of the final milk powder can hold up to 3.00%. Newly upgraded powder plant produces milk powder with moisture percentage under 2.75%. Spray Drying Inlet Temperature and Fluid Bed Dryer Inlet Temperatures are the main variables that can be controlled in the main process of milk powder production. A study was conducted to find out the possible temperature ranges of both Spray Drying Inlet and Fluid Bed Dryer Inlet in order to select the most suitable temperature range which produces good quality milk powder with acceptable bulk density value (0.56 kg/m³), scorched particles grade (“A” grade) and moisture content value closer to the 3.00%. A trial experiment was conducted to find out the suitable temperature ratio of both Spray Drying Inlet temperature and Fluid Bed Dryer Inlet Temperatures by considering bulk density, scorched particles and moisture content. Possible Spray Dryer Inlet temperatures were 175 °C, 176 °C, 177 °C, 178 °C, 179 °C, 180 °C and 181 °C. Possible Fluid Bed Inlet Temperatures were 55 °C, 60 °C, 65 °C, 70 °C, 75 °C, and 80 °C. Based on the trial experiment, T1 (SPI: 175 °C, FBD: 75 °C), T2 (SDI: 176 °C, FBD: 70 °C), T3 (SDI: 177 °C, FBD: 65 °C), T4 (SDI: 178 °C, FBD: 60 °C), T5 (SDI: 179 °C, FBD: 55 °C) selected as treatments. Final moisture content, bulk density; scorched particles level and fat levels were taken into consideration for the quality parameters of milk powder. Fat level of the final milk powder indicated that there was no any significant difference (p>0.05) between treatments. Spray Dryer Inlet Temperatures of 177 °C, 178 °C and Fluid Bed Dryer Inlet Temperatures of 65 °C, 60 °C (T3 and T4) produced acceptable bulk density levels and moisture content levels of 0.562 kg/m³, 0.556 kg/m³ and 2.895%, 2.911% respectively. There was no any significant difference (p>0.05) between treatments.

Keywords: Spray dryer inlet temperature; Fluid bed dryer inlet temperature; Moisture content; Bulk density; Scorched particles level; Fat level

Introduction
Milk is defined as the lacteal secretion obtained by the complete milking of one or more mammalian animals. It is a white liquid produced by the mammary gland of mammals and the primary source of nutrition for infant mammals before they are able to digest other type of food. In more recent times, milk has been dried in thin films on heated rollers. Such roller drying was the main method of producing milk powders until the 1960s when spray drying became prevalent.

Ambewela MILCO (Highland) Spray Dried Milk Factory is located in the upcountry region (Ambewela) of Sri Lanka. From year 2000 onwards MILCO (Pvt) Ltd Company taken by government and currently it has 4 milk processing factories located in Colombo, Ambewela, Digana and Polonnaruwa. Ambewela factory produces instant full cream milk powder and butter. Final Moisture content of the milk powder plays an important role in physiological quality of the milk powder as well as the economical aspect. Final moisture content of milk powder is mostly affected by Spray Dryer and Fluid Bed Dryer input conditions (Figure 1).

Standard final moisture content of the Highland Milk powder ranges 2.3-3.00% from its total weight. Highland milk powder contains lower moisture content than standard value (3.00%). Therefore, this study was conducted in Ambewela MILCO (Highland) Spray Dried Milk Factory to find out the most suitable ratio of both spray drier inlet air temperature and fluid bed inlet air temperature for achieving the standard moisture level of 3.00% (maximum), standard bulk density level 0.56 kg/m³, standard scorched particle’s grade A and standard fat level 26.0% (minimum).

Figure 1: Relationship of Mean Values of Bulk Density Reduction and Fluid Bed Dryer Inlet Temperatures.
Materials and study

This research study was conducted in Ambewela MILCO (highland) Spray Dried Milk Factory to find out the most suitable combinations of both Spray Drier Inlet Temperature and Fluid Bed Dryer Inlet Temperature to obtain standard fat level (26.0%), bulk density level (0.56 kg/m³) and moisture content (near to 3.00%) in the milk powder.

Trail experiment was conducted by giving different combinations of Spray Drier Inlet Temperatures and Fluid Bed Dryer Inlet Temperatures. First sample was collected from the bottom of the spray dryer. Second sample was collected from the inlet of the fluid bed dryer. Final sample was collected from the outlet of the fluid bed dryer. Every time approximately 60 g of milk powder was collected. Laboratory tests were carried out to find out the Fat Level, Moisture Level and Bulk Density Level of the milk powder.

Among them, suitable temperature combinations were selected based on the bulk density level and scorched particle levels and moisture content level. Main experiment was carried out by providing selected temperature combinations. Among them best Spray Drier Inlet Temperature and Fluid Bed Dryer Inlet Temperature combination was selected based on the moisture content of the milk powder near to 3% with optimum powder quality levels of other parameters such as bulk density, fat level and scorched particles.

Data of the trial experiment and main experiment were analyzed by Analysis of Variance (ANOVA) (α=0.05) and mean separation was done with Tukey’s Honest Significant Difference test.

Results and Discussion

Trail experiment

Results of trial experiment were analyzed and best five treatments were selected for further experiment. In this context, Presence of Scorched particles and bulk density levels were compared with quality standards of milk factory and five Spray Dryer Inlet and Fluid Bed Dryer Inlet temperatures were selected according to those results (Table 1, 2).

Spray dryer inlet temperature

Possible range of Spray Dryer inlet temperature was 175°C to 179°C. Due to the presence of scorched particles at higher temperatures, further increment of inlet temperature was avoided. Inlet temperature of spray dryer shows negative correlation with scorched particles value [1]. When the inlet air temperature was raised to 225 °C from 155 °C, the bulk density and the mean powder particle density were decreased whereas the vacuole volume was increased. This was evidently caused by rapid drying and moisture expansion in the powder particles [2] (Table 3).

Fluid bed dryer inlet temperature

The values are means of replicates ± standard error

The means with the same letters are not significantly different at Tukey’s test 5% level

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Figures:

Figure 2: Relationships of Mean Values of Moisture Content Reduction and Fluid Bed Dryer Inlet Temperatures.

Figure 3: Relationship between Inlet Temperatures of Spray Dryer and Fluid Bed Dryer on the Fat Level of Milk Powder.

Figure 4: Relationships between Treatments and Final Powder Bulk Density.

Figure 5: Relationships between Treatments and Final Moisture Content of the Milk Powder.
Temperatures  | Bulk Density  | Scorched Particles  
---|---|---
175°C  | 0.55a ± 0.02  | A  
176°C  | 0.53b ± 0.01  | A  
177°C  | 0.53c ± 0.02  | A  
178°C  | 0.50d ± 0.01  | A  
179°C  | 0.47e ± 0.02  | A  
180°C  | 0.45f ± 0.01  | B  
181°C  | 0.41G ± 0.01  | B  

Table 1: Bulk Density Levels and Scorched Particle Grades of the Powder Samples Collected from the Bottom of the Spray Dryer.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Spray Dryer Inlet Temperature</th>
<th>Fluid Bed Dryer Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>175°C</td>
<td>75°C</td>
</tr>
<tr>
<td>T2</td>
<td>176°C</td>
<td>70°C</td>
</tr>
<tr>
<td>T3</td>
<td>177°C</td>
<td>65°C</td>
</tr>
<tr>
<td>T4</td>
<td>178°C</td>
<td>60°C</td>
</tr>
<tr>
<td>T5</td>
<td>179°C</td>
<td>55°C</td>
</tr>
</tbody>
</table>

Table 2: Selected Treatments for the Main Experiment

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Scorched Particle Grade</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
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<tr>
<td>T3</td>
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<td>A</td>
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<tr>
<td>T4</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
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</tr>
<tr>
<td>T5</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Scorched Particle Grade Results.

Results from the trial experiment indicated that possible Fluid Bed Dryer inlet temperature ranged from 55°C to 75°C. Along with constant spray dryer inlet temperature (178°C) at different fluid bed dryer, results indicated that at higher fluid bed inlet temperatures tend to reduce the bulk density of milk powder and overall powder moisture content. Increment of fluid bed dryer temperature causes the reduction of final moisture content as well as reduction of bulk density of milk powders [3]. Increase in drying temperature increases moisture evaporation thus reduces the final moisture content of the milk powders [4] (Figure 2).

Treatments

Based on the results of above trial experiment, following five treatments were selected for Main experiment.

Main experiment

For each treatment, four replicate samples were collected.

Scorched particles

All treatment temperature combinations gave “A” Grade scorched particles value according to the ADMI (American Dry Milk Institute) standards. Results were proved that scorched particles do not only depend of the inlet temperatures of Spray Dryer and Fluid Bed Dryer. Scorched Particles may be the result of powder deposits in the spray drying chamber which are coming free to contaminate product. Spray dryer air flow must be managed effectively to avoid powder accumulations which may result in scorched particles and the linked problem of fire and explosions [5] (Table 3).

Homogenization distributes small fat globules uniformly throughout the milk powder particles. Standardization process was the main factor that affected the final fat content in the milk powder. Final fat content level of dried milk powder was influenced by standardization procedures at greater scale [6] (Figure 3).

Bulk density

Results of the Bulk revealed that selected treatments showed no any significant differences (p>0.05) between the means of bulk density.

Reduction in Fluid Bed Dryer Temperature reduces the agglomeration process and bulk production of milk particles. This causes to produce more fine particles. Bulk density and degree of shrinkage increase with increase in inlet temperature [7] (Figure 4).

Moisture content

Results indicated that increasing of Spray Dryer inlet temperature and simultaneous reduction of Fluid bed Dryer Inlet temperatures had a noticeable effect on the final moisture content. Increment of residual moisture content of the powder can be obtained by reduction of inlet air temperatures [8]. Inlet air temperature shows maximum negative effect on the moisture content. The increase in moisture content at lower inlet air temperatures is due to the smaller temperature gradient between the atomized feed and the drying air, resulting in a smaller driving force for water evaporation and thus produces powders with higher moisture content [9] (Figure 5).

Conclusion

During trial experiment, higher Spray Dryer Inlet Temperatures such as 180°C and 181°C produced scorched particles which were undesirable for commercial production of milk powder. Based on the trial experiment, most suitable Spray Dryer Inlet and Fluid Bed Dryer Inlet temperature combinations were selected as treatments. Most suitable temperature combinations were 177°C, 178°C and 65°C, 60°C (Treatment 4 and 5). Treatment 3 and 4 indicated increment of moisture content (respectively 2.895%, 2.911%) as compared with other treatments.

Increment of moisture content in Milk Powder increased the bulk weight of the final product and increases the bulk production of the milk powder in Ambewela MILCO (Highland) Spray Dried Milk Powder Factory. According to the quality standards in the factory, adjustment of milk powder moisture content was desirable to produce high quality milk powder with good consumer acceptance.

References
