*IOSR Journal of Nursing and Health Science (IOSR-JNHS)*
*e-ISSN: 2320–1959.p- ISSN: 2320–1940 Volume 4, Issue 3 Ver. I (May. - Jun. 2015), PP 34-41*
*www.iosrjournals.org*

# Development of Energy Dense Cost-Effective Home-Made Enteral Feed For Nasogastric Feeding

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***Abstract:*** *The purpose of this study was to develop cost-effective home-made nasogastric feeds for long-term use so that the care-giver could use it without wasting the time or without any extra burden in family food budget. The commercially available are very expensive therefore are heavy economic stress on family. Economic stress can be reduced by these twenty home-made nasogastric feeds formulated in this study. Twenty Nasogastric home-made feeds with three variations of energy density (1 kcal/ml, 1.5 kcal/ml, and 2 kcal/ml); according to the standards of macronutrient distribution ranges were formulated in this study for normal and medically compromised patients. These feeds include standard feeds, standard feeds with fiber, diabetic feeds, high protein feeds, low protein feeds, fat-restricted feeds, and therapeutic lifestyle change feeds (TLC feeds). The feeds are for the long-term feeding purpose, and they are cost-effective, convenient and efficient. The cost of the feeds ranges from rupees 44/- to rupees 80/-. These feeds are convenient in preparation, efficient, cost-effective, and the ingredients are easily available.*

***Keywords:*** *Enteral feeding (tube feeding), nasogastric tube, energy density.*

## I. Introduction

Enteral feeding refers to the delivery of liquid or pureed form of feedings (providing proteins, fats, vitamins, carbohydrates, minerals and fluid) through a tube. Most eternal feeds contain 80 – 85% water content. Enteral feeding is given to the patients, who are not able to feed themselves orally (Hahn, 2007). Home-made tube feedings mostly contain common foods like milk, eggs, meat, soft fruits, and vegetables pureed in a blender. The feed may be made from a base of a commercial nutritional powder with water or other liquid, and with this other foods can be added to modify the consistency or nutritional composition of the diet (Sullivan et al. 2004). Enteral feedings should always be monitored for intestinal tolerance for the feed composition to avoid nausea, vomiting, diarrhea, abdominal distension, and bowel movements. The diet made can be for specific problems, for example, for malnutrition of any nutrient or according to specific response to the nutrient absorption and tolerance by excluding or limiting one, supplementing other or both (Forchielli & Bines, 2008).
In a hospitalized patient an elemental diet is usually used that is a commercially prepared diet that is directly administered in the nasogastric feeding tube. This elemental diet is composed of amino acids, fats, sugars, vitamins, and minerals. This diet, however, lacks whole or partial protein due to its ability to cause an allergic reaction in some people.

Blenderized feeds can be prepared at home as an alternative to commercially prepared formulas and such alternative homemade feeds were used for five major burn patients who were successfully treated with this diet high in caloric and protein (Bailey et al. 1982). In a country like Pakistan these commercially prepared formulas are expense for long term use and pose a further financial burden on the affected family thus, opening a window for the development of homemade blenderized formulas.

The home-made enteral nutritional tube feeding care program had evaluated its effect on the clinical outcomes of the patients who are being enterally fed at home since 12 months before and after the specialized home-made enteral tube feeding care program. Specialized home-made enteral feeding care program had reduced the rate of hospital admissions, morbidity rate, and time duration of stay in hospital and intense care units, and cost of long-term home enteral nutritional feeding (Klek et al. 2011). Standardized enteral nutrition order forms, used for estimating patient's nutritional caloric needs and requirements, were tested for evaluating their efficacy. The standardized eternal nutrition order forms decreased the time duration by 3.1 days before those who were not introduced to the form, to reach their goal of estimated caloric needs, and so it is concluded to be effective nutritional therapy for patients (Chapman et al. 1992).

The enteral nutrition in the post-operative esophageal cancer patients in China was evaluated. The researchers evaluated that enteral nutritional feeding is better than parenteral feeding and it reduces the need of

parenteral nutrition by providing adequate nutrition. Enteral nutritional support also reduced the post-operative problems and complications, and was cost effective (Feng et al. 2010).

## II. Methodology

**Study Design**

The Study design was experimental and experiments were conducted for formulation of Nasogastric feed. Every feed was prepared with three energy density variations, i.e. 1 kcal/ml; 1.5 kcal/ml; 2 kcal/ml.

**Development of Nasogastric Feeds**

**Selection of Ingredients**

The ingredients used for the preparation of the feed were divided broadly into base and macronutrients.

**Base:** The bases used for the preparation of the Nasogastric feed were both energy contributing and non energy contributing fluid which included the following:

**a. Energy Contributing Fluid**

I. Fruit juice
II. Milk

**b. Non-energy Contributing Fluid**

i. Water
ii. Broth

**Macronutrients:** Real food was used instead of any concentrate for the contribution of macronutrients to the formula.

Foods were divided into three major groups i.e. carbohydrates, proteins and fats. The foods were selected not only on the basis of their macronutrients contribution but also on the basis of functionality.

**Measurement of Ingredients**

- Solid and semi-solid ingredients were weighed by the "Arshia" weighing machine. The no error point was adjusted with the bowl.
- Liquid ingredients were measured with calibrated measuring spoons and cup.
- Powered ingredients were either weighed or measured with measuring spoons.

**Procedure**

The food safety guidelines established by Food and Drug Administration was used for the safe preparation of the feeds.

The raw ingredients which needed cooking were washed, cut and cooked separately. All the ingredients which did not require cooking were placed in a bowl; the cooked food was cooled and added to the ingredients. All the ingredients were mixed and transferred to the jug of the blender. Base fluid was added to the ingredients and the formula was blenderized at a speed of point 2 (marked on the blender) for few seconds to 1 minute. The feed was then removed from the blenderized jug and checked for consistency.

**Consistency**

The consistency of the formula feed was assessed by passing the formula feed through the 18 French nasogastric feeding tube.

**Energy Density**

The energy density of the feed was calculated using the following formula:

$$Energy\ density = \frac{\text{Total energy (kcal)}}{\text{Total amount of feed (ml)}}$$ (Whitney & *Rolfes*, 2005)

**Nutritional Composition**

The nutritional composition of the feed was calculated using the United States exchange lists and USDA National Nutrient Database for standard reference, release 25. The feeds' macronutrient distribution is according to the macronutrient distribution ranges given by USDA (United States Department of Agriculture), ADA (American Diabetes Association), NIH (National Institutes of Health) and Food and Nutrition Board (n.d.).

**Quality Definition:** The Nasogastric feeds had been made from natural foods and are free of any additives, food color and preservatives.

**Cost Calculations**

The cost of the feeds was calculated by using the market price of every ingredient in the feeds.

**Theoretical Framework**

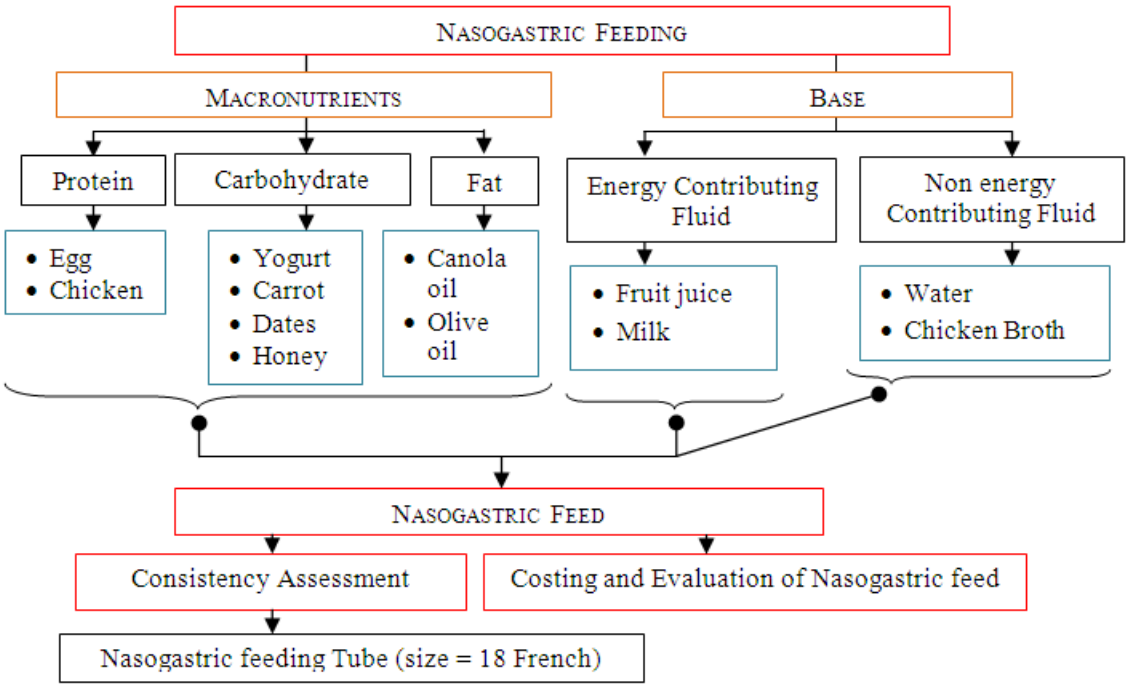


**Figure 1** Theoretical framework for the development of Nasogastric feeds.

## III. Results And Interpretation

In this study twenty feeds had been prepared with variations of energy density. The feeds were further formulated according to various medical conditions.

**Development of Standard Feeds**

Standard feeds can be used by any patient who does not require any special formula for medical conditions. The macronutrients' distribution was kept according to the standard ranges.

**Table 1 Variations of standard feeds in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | | |
|---|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml | 2 kcal/ml |
| **Milk** | cup | 1 | 1 | 1 |
| **Nido milk powder** | tbsp | 3 | 6 | 9 |
| **Nestle fruit juice** | ml | 100 | 200 | 200 |
| **Olive Oil** | tbsp | 2 tsp | 1 | 1 |
| **Honey** | tbsp | 2 | 3 | 3 2/3 |
| **Water** | ml | 100 | ---- | ---- |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Carbohydrates** | % | 58 | 58 | 58 |
| **Protein** | % | 13 | 13 | 13 |
| **Fats** | % | 29 | 29 | 29 |
| **Total calories** | kcal | 512.6 | 798.9 | 973.1 |
| **Cost** | Rupees | 44/- | 68/- | 80/- |
| **Preparation time** | Minutes | 3 | 3 | 3 |
| **Total feed quantity** | ml | 500 | 500 | 500 |

The table showed that the standard feed was prepared and the same ingredients in varied proportions were used for different energy densities. Carbohydrates are kept 58%, proteins 13% and fats 29% in the feeds. 500ml feeds were prepared.

**Development of Standard Feeds with fiber**

Standard feeds can be used by any patient who does not require any special formula for medical conditions. Dietary fiber is added in this diet and so this diet can be used by patients with disturbed lipid profile and by the patients suffering from constipation (Simmers, Nartker, & Kobelak, 2008).

**Table 2 Variations of standard feeds with fiber in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | | |
|---|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml | 2 kcal/ml |
| **Milk** | cup | 1 | 1 | 1 |
| **Nido milk powder** | tbsp | 3 | 6 | 9 |
| **Nestle fruit juice** | ml | 100 | 200 | 200 |
| **Olive Oil** | tbsp | 2 tsp | 1 | 1 |
| **Honey** | tbsp | 2 | 3 | 3 $^{2}/_{3}$ |
| **Water** | ml | 100 | ---- | ---- |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Carbohydrates** | % | 58 | 58 | 58 |
| **Protein** | % | 13 | 13 | 13 |
| **Fats** | % | 29 | 29 | 29 |
| **Total calories** | kcal | 512.6 | 798.9 | 973.1 |
| **Cost** | Rupees | 44/- | 68/- | 80/- |
| **Preparation time** | Minutes | 3 | 3 | 3 |
| **Total feed quantity** | ml | 500 | 500 | 500 |

The table showed that the standard feed was prepared and the same ingredients in varied proportions were used for different energy densities. Dates were added in the feeds for fiber content.

**Development of Diabetic Feeds**

Diabetic feeds are recommended for patients suffering from diabetes mellitus. Dates and pulpy orange juice have been used for the dietary fiber content in the feed.

**Table 3 Variations of diabetic feeds in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | |
|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml |
| **Milk (low-fat)** | cup | 1 | ½ |
| **Nido milk powder** | tbsp | ---- | 3 |
| **Yogurt** | cup | ¾ | ¾ |
| **Carrots** | cup | ½ | ½ |
| **Minute Maid pulpy orange juice** | ml | 100 | 200 |
| **Dates** | Count | 2 | 4 |
| **Egg** | Count | ---- | 1 |
| **Olive Oil** | tsp | 1 | 1 |
| **Turmeric powder** | tsp | ¼ | ¼ |
| **Carbohydrates** | % | 50 | 53 |
| **Protein** | % | 18 | 16 |
| **Fats** | % | 32 | 31 |
| **Total calories** | kcal | 410 | 771 |
| **Fiber** | gram | 8 | 12.6 |
| **Cost** | Rupees | 52/- | 70/- |
| **Preparation time** | Minutes | 17 | 17 |
| **Total quantity** | ml | 450 | 500 |

The table showed that the diabetic feed was made with different ingredients to make variations in energy density. In this feed 2 kcal/ml energy density is not calculated as it is not recommended for diabetic patients.

**Development of High Protein Feeds**

High protein feeds may be used for hemodialysis patients. These feeds can be used for the better immune response, recovery from a major surgery, burns, trauma, healing wounds, fever, and infection (Simmers et al. 2008).

**Table 4 Variations of high protein feeds in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | | |
|---|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml | 2 kcal/ml |
| **Nido milk powder** | tbsp | 3 | 3 | 6 |
| **Yogurt** | Cup | ¾ | 1 ½ | 2¼ |
| **Dates** | Count | 3 | 3 | 3 |
| **Egg** | Count | 1 | 1 | 1 |
| **Canola Oil** | tbsp | $^1/_3$ | 1 | $^1/_3$ |
| **Honey** | tbsp | $1^1/_3$ | 3 | 3 |
| **Water** | ml | 250 | 125 | ---- |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Carbohydrates** | % | 50 | 53 | 52 |
| **Protein** | % | 18 | 17 | 20 |
| **Fats** | % | 32 | 30 | 28 |
| **Total calories** | kcal | 531.3 | 804.4 | 996.2 |
| **Cost** | Rupees | 35/- | 46/- | 62/- |
| **Preparation time** | Minutes | 14 | 14 | 14 |
| **Total feed quantity** | ml | 500 | 500 | 500 |

The table showed that the high protein feed was made with different ingredients to make variations in energy density. In this feed protein is kept >15% and $\leq$20% according to the recommendations.

**Development of Low Protein Feeds**

Low protein feeds are recommended for the CKD (Chronic Kidney Disease) patients and for chronic renal failure (Alvare, Dugan, & Fuzy, 2005). Low proteins in the feeds minimize the load of the kidneys. Low protein diet can also be used for patients with encephalopathy. The protein content in the feed was kept $\leq$10% of the total calories and the rest of the calories had been taken from carbohydrates and fats.

**Table 5 Variations of low protein feeds in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | | |
|---|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml | 2 kcal/ml |
| **Yogurt** | cup | 1 ½ | 1 ½ | 1 ½ |
| **Nestle fruit juice** | ml | 200 | 250 | 200 |
| **Canola Oil** | tbsp | 1 | 2 | 3 |
| **Honey** | tbsp | 2 | 3 | 5 |
| **Water** | ml | 40 | ---- | 40 |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Carbohydrates** | % | 60 | 58 | 60 |
| **Protein** | % | 10 | 9 | 8 |
| **Fats** | % | 30 | 33 | 32 |
| **Total calories** | kcal | 597.6 | 783.9 | 931.5 |
| **Cost** | Rupees | 45/- | 54/- | 55/- |
| **Preparation time** | Minutes | 13 | 13 | 13 |
| **Total quantity** | ml | 500 | 500 | 500 |

The table showed that the low protein feed was made by keeping the protein content in the feed $\leq$10% of the total calories.

**Development of Fat Restricted Feeds**

Fat restricted feeds may be used for patients with dyslipidemia, suffering from cardiovascular disease (CVD). It is also used for the patients suffering from fat malabsorption, diseases of liver, gallbladder, atherosclerosis, intestines and pancreas (Simmers et al. 2008).

**Table 6 Variations of fat restricted feeds in the energy density of kcal/ml**

| Ingredients | Serving units | Energy Density | | |
|---|---|---|---|---|
| | | 1 kcal/ml | 1.5 kcal/ml | 2 kcal/ml |
| **Nido milk powder** | tbsp | 6 | 9 | 9 |
| **Dates** | Count | 2 | 2 | 3 |
| **Canola Oil** | tsp | 1 | 1½ | 3 |
| **Honey** | tbsp | 1 | 2 | 2 |
| **Nestle fruit juice** | ml | 200 | 200 | 400 |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Water** | ml | 250 | 250 | 50 |
| **Carbohydrates** | % | 61 | 60 | 62 |
| **Protein** | % | 12 | 13 | 11 |
| **Fats** | % | 27 | 27 | 27 |

| | | | | |
|---|---|---|---|---|
| **Total calories** | kcal | 553.3 | 757.1 | 968.1 |
| **Cost** | Rupees | 52/- | 65/- | 92/- |
| **Preparation time** | Minutes | 13 | 13 | 13 |
| **Total feed quantity** | ml | 500 | 500 | 450 |

The table showed that the fat content in the feeds had been kept 27% for fat restriction.

**Development of TLC (therapeutic lifestyle change) Feeds for Dyslipidemia**

TLC feeds are used for patients with Dyslipidemia and cardiovascular diseases (Deen & Hark, 2007). Canola oil has been used in this feed because it is low in saturated fats and contains cholesterol-lowering fats, which is beneficial for lowering the cholesterol and LDL levels and increasing the HDL levels in the blood.

**Table 7 Variations of TLC feeds for Dyslipidemia in the energy density of kcal/ml**

| **Ingredients** | **Serving units** | **Energy Density** | | |
|---|---|---|---|---|
| | | **1 kcal/ml** | **1.5 kcal/ml** | **2 kcal/ml** |
| **Milk** | cup | 1 | 1 | 1 |
| **Nido milk powder** | tbsp | 2 tsp | 4 | 9 |
| **Chicken** | oz | 1 | 1 | 1 |
| **Dates** | Count | 3 | 4 | 4 |
| **Canola Oil** | tbsp | 1 | $^{2}/_{3}$ | $^{1}/_{3}$ |
| **Honey** | tbsp | 2 | 3 | 2 |
| **Chicken broth** | ml | 50 | 50 | 100 |
| **Water** | ml | 100 | 100 | 100 |
| **Turmeric powder** | tsp | ¼ | ¼ | ¼ |
| **Carbohydrates** | % | 55 | 55 | 54 |
| **Protein** | % | 16 | 16 | 17 |
| **Fats** | % | 29 | 29 | 29 |
| **Total calories** | kcal | 537.2 | 717.9 | 932.9 |
| **Cost** | Rupees | 51/- | 64/- | 82/- |
| **Preparation time** | Minutes | 17 | 17 | 17 |
| **Total feed quantity** | ml | 450 | 450 | 450 |

The table showed that the TLC feed was made with different ingredients to make variations in energy density.

**Cost Evaluation of the feeds**

The feeds are efficient and cost-effective from the commercially available formula feeds, because when the cost of the feeds were compared with the cost of the commercially available formula feeds, the cost varied as shown in the table given below:

**Table 8 Comparison of the costs of commercially available formula feeds with Home-made nasogastric feeds**

| **Type of feeds** | **Cost of commercial formula feeds (in Pakistani rupees)** | **Cost of the feeds prepared in this study (in Pakistani rupees)** |
|---|---|---|
| **Standard feeds** | Isocal = 500/- per 500ml feed<br>Ensure = 400/- per 500ml feed | 44/- to 80/- per 500ml feed |
| **Low protein feeds** | Peptamen = 760/- per 500ml feed | 45/- to 55/- per 500ml feed |
| **Diabetic feeds** | Glucerna = 500/- per 450ml feed<br>Nutren Diabetes = 550/- per 450ml feed | 50/- to 69/- per 450ml feed |
| **High protein feeds** | Novosource Renal = 450/- per 500ml feed | 35/- to 62/- per 500ml feed |

The table showed the comparison between the costs of the commercially available enteral feeding formulas and home-made nasogastric feeds prepared in this study. This comparison showed that all the feeds prepared in this study are cost-effective.

## IV. Discussion

In the present study twenty feeds were prepared with three variations of energy density, as 1 kcal/ml, 1.5 kcal/ml, and 2 kcal/ml. The feeds were further formulated according to various medical conditions. Feeds had been prepared according to the FDA food safety guidelines. Home enteral tube feeding can improve the quality of life as it prevents from further weight loss and malnutrition (Loeser et al. 2003). High energy density (1.5 kcal/ml) feeding tolerance and results had been evaluated in the previous research study. The energy-enriched formula was found more effective in improving the nutritional status of children suffering from cancer during the intensive stages of treatment. Protocolized administration of an energy-enriched formula should be initiated as soon as one of the criteria for initiation of tube feeding is met (Lippens et al. 2000).

Six standard feeds with and without fiber were prepared that can be used by those patients who do not require any special formula for medical conditions. The macronutrients' distribution was in according to the

standard ranges given by USDA, and Food and Nutrition Board. Same ingredients were used in each three feeds for the preparation of varied energy densities as 1 kcal/ml, 1.5 kcal/ml, and 2 kcal/ml. macronutrients content in three standard feeds without fiber are carbohydrates as 58%, proteins 13% and fats 29% in 500ml feeds (Table 1).

In the three standard feeds with fiber content, dates were added for fiber (Table 2). Macronutrients are kept in the standard ranges.

Special diabetic feeds were prepared for the diabetic patients. In this feed dates, carrots and pulpy orange juice was added for the dietary fiber content which is beneficial in controlling the blood glucose levels and helps reducing the incidence of hyperglycemia and hypoglycemia. Dates, carrots and pulpy orange juice also have low glycemic index as 42, 39 and 50, respectively, that is why it is added in the diabetic feeds (Table 3). High protein feeds are useful in efficient wound healing purpose, and can be used for hemodialysis patients, better immune response, and recovery from a major surgery, burns, trauma, fever, and infection (Simmers et al. 2008). In these feeds protein content is kept according to the recommendations as >15% of the total calories in the feed (Table 4).

Low protein feeds had been prepared for the patients suffering from kidney problems, diseases and kidney failure (Alvare, Dugan, & Fuzy, 2005). The protein content was kept <10% of the total calories. Low proteins in the feeds minimize the load of the kidneys (Table 5).

Nasogastric feeds were focused for the CVA (cerebrovascular accident) patients as they usually have more complications related to heart diseases that are why fat restricted feeds were prepared. These feeds are used for patients suffering from cardiovascular disease (CVD) and for weight reduction purpose to make it easier for the care-giver to handle the condition of the patient. It is also used for the patients suffering from fat malabsorption, diseases of liver, gallbladder, atherosclerosis, intestines and pancreas (Simmers et al. 2008). The fat content in the feeds had been kept 27% for fat restriction (Table 6).

Therapeutic lifestyle change feeds (TLC feeds) had been formulated for the patients suffering from dyslipidemia and cardiovascular diseases (Deen & Hark, 2007), in order to minimize cholesterol and LDL levels in the blood and to maintain the lipid profile normal (Table 7).

Turmeric powder was used in every feed prepared in this study, as through many researches it is proved that turmeric powder is an antiseptic.

The enteral formula feeds that are available in the market are very expensive, and they can disturb the budget of the family. Simple ingredients had been used in the feeds in this study in order to make them cost-effective. The ingredients used are easily available in the market and in homes. The feeds are efficient and cost-effective from the commercially available formula feeds, because when the costs of the feeds were compared with the cost of the commercially available formula feeds, the cost varied (Table 8).

The consistency of the feeds was evaluated by passing the feeds through the 18-French nasogastric feeding tube, as it is the standard used for the administration of long term feeds. The consistency of all the feeds was accurate as they all easily passed through the nasogastric tube, without any blockage.

Cost-effective home-made nasogastric feeds were developed to be used for enterally fed patients at home, nursing homes, old homes and hospitals.

## V. Conclusion

Twenty Nasogastric home-made feeds with three variations of energy density according to the standards of macronutrient distribution ranges were formulated in this study. These feeds include standard feeds, standard feeds with fiber, diabetic feeds, high protein feeds, low protein feeds, fat-restricted feeds, and therapeutic lifestyle change feeds (TLC feeds). The feeds are for the long-term feeding purpose, and they are cost-effective, convenient and efficient.

## Acknowledgements

First and foremost, all praise to Allah Almighty for helping me throughout this research. I would like to offer my sincere gratitude to my exceptional supervisor, Ms. Mahnaz Nasir Khan, for helping me in the research project and making it possible for me in conducting and making my research worth. It would not have been possible to perform and write this thesis without my supervisor's sincere support and help. I would like to thank Ms. Memoona Khalid for checking my literature review in initial days, and to Ms. Nasreen Kausar for helping me out in doing my evaluation experiments. Last but not the least I would like to thank my friends and my parents, my family for supporting me during my research project, and also for their patience and giving me time in doing my work with full dedication.

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