

DESIGN OF A FOOD TROLLEY FOR HOSPITALS IN INDIA

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Abstract

Healthcare industry is a wide and intensive form of service which is related to the well being of individuals. The Indian healthcare industry is one of the fastest growing sectors. The patient's perspective towards hospitals is also changing. They expect better facilities from the hospital management. One of the most common issues patients encounter is the quality of food which they get during their stay in the hospital. Equipment is required to keep the food fresh from the kitchen to the ward. A food trolley is a cart which will keep the food hot and fresh during transit. Food trolley maintains the acceptable texture and temperature of the food. This project is an attempt to bring a better solution for hospital food service by understanding issues in the existing design.

Design process started with a primary research and an identified problem in hospital food service system. The need was identified for a better food trolley, which could simplify the hospital food service and also reduce maintenance. Data collection was carried out by adopting methodologies such as literature review, Product Study, Market Study and product environment study. Trend Study was done to understand the trends in similar products over a period of time. Stake holders were interviewed during ethnography research and personal interviews to understand their needs and aspirations. Ergonomic study was conducted for deciding product parameters. Quality Function Deployment and Product Design Specification were generated based upon data analysis. Concepts were generated with respect to the derived Product Design Specification. Various issues and needs identified through data collection have been addressed in developed concepts. Final concept was selected by weighted ranking method.

The product name has been chosen as 'Steamfresh' which highlights the function of the product in an efficient manner. A half scale mock-up model has been made to validate the final concept and feedback was collected from users. Major user needs such as handles for usability, modular design shelves, ergonomics and aesthetics were satisfied by the final design. User response on final design was positive and satisfying.

Keywords: Hospital Food Trolley, Usability, Ergonomics, Metaphor, Design research, Mock-up

Nomenclature

kg	Kilogram
mm	Millimeter

Abbreviations

CAD	Computer Aided Design
PDS	Product Design Specification
QFD	Quality Function Deployment
SS	Stainless Steel

1. INTRODUCTION

Healthcare industry is a wide and intensive form of services which are related to well being of human beings. The Indian healthcare industry is one of the fastest growing sectors. The rise of literacy rate, higher levels of income and increasing awareness through deep penetration of media channels, contributed to greater attention being paid to health. With the rise in the system of nuclear families, it became necessary for regular health check-ups and increase in health expenses. Availability of hospitals made the hospitals to be competitive in their services. In Modern Hospitals Department of Nutrition and Dietetics is considered as major department, because of increasing rate of Malnutrition cases and lack of food intake occurs in hospitals. It is an integral part of hospital healthcare,

and aims at providing the highest quality of nutrition care and education to patients.

1.1 Importance of Nutrition and Food Quality [1]

Hospital food and nutrition services play an important role in patient recovery and well-being. Foodservice quality can also influence patient's satisfaction with their overall hospital experience. With health care industry competition on the rise, many hospital foodservice operations are looking for ways to improve patient satisfaction. Many researches show that patient satisfaction is enhanced by hot food service system by using food trolleys. Temperature, quality and texture were the most important attributes that measure patient satisfaction with food. This project is an attempt to bring a solution for improvement of hospital food service trolley by understanding the existing issues in hospital food service system.

1.2 Scope of the project

The Project is aimed at conducting research on Hospital Food Service System, and to design a Food Service Trolley to enhance the quality of process. The project will mainly focus on the hospitals which are having food service for the patients. The outcome of the project will enhance the food service process and also improvise and simplify the current system for dietary department of the hospitals as well as improve the patient's satisfaction of the served food. From the point view of food serving staffs the product is aiming the easiness of maintenance and cleaning. Hence the

product will be enhancing the efficiency of the whole system. The overall objective is to develop a food trolley with enhanced and effective features than existing designs. The main scope of the project is to overcome the issues involved in the existing products.

1.3 Hospital food service [2]

Hospital food service does not operate in isolation but requires the co-operation and integration of several disciplines to provide the ultimate patient experience. Themes centered on 'patients', 'food service' and 'meal times' and results show that food quality, particularly temperature and texture, are important factors impinging on patient satisfaction, and the trolley system of delivery is an acceptable style of service. Service predisposition demonstrates little relevance to patient satisfaction towards the overall meal enjoyment. In India food trolley system is not advanced as far as the other western countries. But Indian has the food trolley service system which has to improve on both the perspective of patients and food service staffs.

1.4 Food Trolley

Food trolley is cart which is used serve food hot and fresh. It has heating elements which is keeps the food hot and fresh for a specific time. The trolley is moved on wheels. The hospitals use food trolleys for the food service in order to improve their food service and the food quality. In India the most of the major hospitals have food trolley service system. The trolleys used in hospitals are pre heated trolleys. From the kitchen the food is segregated for each ward and packed in trays. Then these trays are loaded in to the pre heated trolley. The trolley is pre heated up a specific time and taken to each room. So the food is kept hot and fresh during supply. The process helps to keep the food quality, temperature and aesthetics intact. The food trolley service helps to improve the acceptable quality texture of the food above the expectations of the patients and increases the food intake and reduces the mal nutrition during the hospital stay.

2. PROBLEM DEFINITION

The quality of patient care and food service in the hospitals are becoming one of the important concerns of the hospital reputation. One of the most common issues patients encounter is the quality of food which they get during their stay in the hospital. Food trolley maintains the acceptable texture and temperature of the food. The aim of the project is to Design a Food Serving Trolley for hospitals in India considering usability, ergonomics and aesthetics.

3. PROJECT METHODOLOGY

- Literature review about Food trolley with reference from books, journals, patents, company catalogues and websites
- Data collection will be done by product study, user study, market study through methods such as questionnaires, interviews, images, videos and visual design study through form exploration, metaphors and aesthetics.
- QFD will be generated based on identified needs to arrive at target PDS.

- Concepts of Food trolley for hospitals will be generated using sketching, ideation tools such as brain storming, mind mapping, theme boards.
- Concepts will be generated and modeled with detailed features using software such as Solid works, Alias studio tools, Adobe Photoshop.
- Rendering of cell phone currency recharging device models will be done using software such as Hyper shot and Key shot.
- Concept evaluation for selecting the final concept will be carried out by weighted ranking method
- Half scale mock up model of the Food trolley for hospitals will be made with detailed features.
- Design validation will be carried out through user feedback.

4. LITERATURE REVIEW

Literature survey and review has been carried to collect data and understand about the food service system and the food trolleys used presently in Indian hospitals. Survey also focuses on various methods used for food service in hospitals in India.

Summary of Literature Review

- Literature survey shows that, the Food trolley method of food distribution enables all foods to have a more acceptable texture and temperature than the plate system of delivery in hospitals [1].
- The amount of food eaten by the patients served with Food trolleys is considerably higher than in those without them [6].
- A hygienic and quality food delivery system in hospitals definitely has beneficial effects on the recovery of patients and their quality of life [6].
- Nutritional and Aesthetic quality is preserved throughout the service time by using a Food trolley [2].
- Patient's acceptance of served food is more towards the food served using food trolleys than the other [1].
- The present hospital service system in India definitely needs an improvisation [5].
- The hospital managements are focusing on to improve on every aspect of their patients care and satisfaction [4].
- The project has a positive scope in the modern hospital sector [4].

5. DATA COLLECTION, ANALYSIS AND PDS

Product study, product environment study, market study and user study have been conducted for data collection. As a part of data collection, Food service system in hospitals, stake holders involved in complete process are included in my research. Data collected through these primary research methods has been analyzed and utilized for deriving Quality Function Deployment (QFD) and Product design Specification (PDS).

5.1 Product Study

The product study has done to understand the function and construction of the product. Here the product is food trolley used in hospital for food service. Product study is an important step because its gives the overall idea about the existing products.



Fig. 1 Food Trolley [7]

Here product study is on Food trolley used in hospitals in India. Various products available in the market are analyzed for further improvement. The main aim is to find out the issues in the existing products. Hence the problems can be rectified in the future design process.

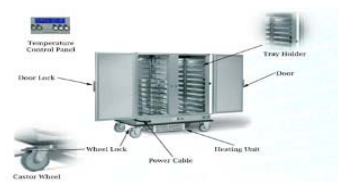


Fig. 2 Hot and Cold Storage [8]

The product anatomy is done to understand the product structure and the features included. The product sub assemblies and components are studied in detail for further improvisation. The product study is done in detail to identify the existing problems for further improvement.

5.2 Product Environment Study

Food Trolleys are used in many places like schools, hotels, marriage functions, hospitals, etc. This project is only towards the hospital sector. The environment is selected as hospitals and old age homes. The food trolley used in hospitals and old age homes are selected for the project to improve the existing design used in these places presently. In hospitals the food trolley is a very common entity but in India the product has to be improved. Some of the product environment is shown in the Figure 3.



Fig. 3 Product Environment. [10]

5.3 Market Study

Market study has done to find out the various market trends and growth of the healthcare industry. India's rapid growth has brought about a 'health transition' in terms of shifting demographics, socio-economic transformations and changes in disease patterns. The sector's growth will be driven by the country's growing middle class that can afford quality healthcare.

5.4 User Study

Research methods such as Gemba study, questionnaire survey and personal interviews are carried

out for data collection. These researches are done to find out the issues occur in the existing system or design. In order to find out least possible facts these research methods helps most significantly. Hence these researches are very important in perspective of any product design project. Questionnaire survey gives general opinion about specific question from various users. So the data can be analyzed to find out most or least favorites of the users. Interviewed personals are listed in the Figure 4.



Fig. 4 Personal Interview

Gemba study refers to learn a process by actually involving in the process or environment. Gemba study gives an excellent opportunity to find out practical issues happens during particular function. These type of facts helps heavily in the stage of concept generation. The stakeholders can be classified as hospital dietary staffs, patients, catering service providers, service personals, etc. Patients can be further classified into students, professionals, general and senior citizens. The major stake holders are given in the Figure 5.



Fig. 5 Stake Holders

User study had conducted to gather information from all the level to design a better product. User interviews have to be conducted to gather data from patients. These interviews help to understand the problems the patients experiencing regarding their food during a hospital stay. The next interview should done form the hospital side to understand their views towards the particular problem. And also to understand the procedure they follow during the routine.

5.5 Ergonomic Study

Human dimensions have been considered based upon the book "*Indian Anthropometric Dimensions, For Ergonomic Design Practice*" by Debkumar Chakrabarti.



Fig. 6 Ergonomic study

5.7 Inference from Various Studies

Below points have been identified from user study and personal interviews

- Existing Trolleys are difficult to use because, lack of ergonomic considerations and improper product size and lack of proper design.
- Existing Trolleys inside compartments are fixed and it is very difficult to access the inside parts of the trolley for cleaning purpose.
- Existing Trolleys are height is more than human average height; hence it is very difficult for an operator to use. The top of the trolley is lot of space left out due to accessibility problem.
- Positioning of the controls and switches is kept at bottom and it is difficult to access.
- There was no display for the temperature control. The control was only a knob which was difficult to understand the setting temperature.
- The food trolley corners were easily damageable during transit. The trolleys corners found as damaged.
- There was no proper insulation provided on areas of human interactions.
- The height which handles provided seems to be awkward.
- Food trolley was very difficult to move around due to its size and lack of proper handling features.

5.8 Quality Function Deployment

Quality function deployment is derived by converting customer voice in the technical voice. Here major customer words were, portable, easy to use, affordable, easy to clean, durable, easy to serve, food quality, hygiene, comfortable controls, multipurpose functions, stability and ease to store. All these customer voices had been converted in to the technical voice to assess the ranking. The technical voice derived were, form, surface finish, material, ergonomics, manufacturing process, electronic controls, sensors, multi options, positioning of features, modular design, inbuilt power source and latest technology. These data were summarized according the weight age given. This helps in comparing the value of importance and prioritizing the technical voices attributes. A pie chart has been prepared from QFD data so as to know the priority of each attributes and shown in Figure 8.

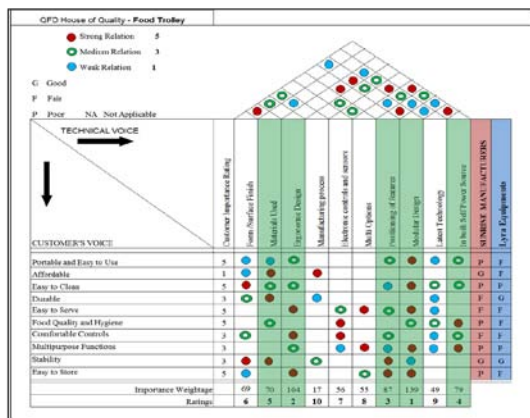


Fig. 7 QFD

5.9 Product Design Specifications

Product design specification given in table compiles requirements that have to be included in the product. This can ensure that the user's aspirations are

fulfilled. This is so formulated that technical aspects are also taken in detail and it is shown in Table 5.1.

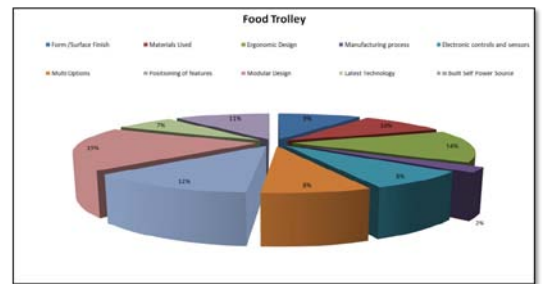


Fig. 8 QFD Analysis

Table 5.1 PDS

PDS for Food Trolley for Hospitals in India		
SI No.	Factors	Specifications
1	Product Name	Food Trolley
2	Area of use	Hospitals
3	Target Customers	Hospitals
4	Colours	White, Blue, Silver
5	Material	Stainless Steel
6	Type	Portable on Wheels
7	Screen Type	LCD Display
8	Size	700x800x1400
9	Touch Screen Size	6 inch LCD
10	Temperature	30 to 130 Degrees
11	Type of Access	Safety lock with key
12	Cost	18000 INR
13	No. of Trays	15 to 20
14	Aesthetics	Pleasant Colours
15	Life Span	10 Years
16	Maintenance	Once in 3 Months
17	Ergonomics	Reach, Ease of Use
18	Interface	Software Supported
19	Texture	Smooth
20	Sound indications	Beep
21	Features	Modular design

22	Manufacturing	Fabrication
23	Sound Indication	Beep

6. CONCEPT GENERATION

Concept generation is one of the fundamental entities of a product development. For this project various factors identified from collected data such as literature survey, product study, market study, user study and trend study are considered. These concepts have been further fine tuned to shortlist four among them for development in 3D CAD software like Solid Works.

6.1 Design Inspired by Geometrical shapes

Geometric shapes are found practically everywhere but most of the time it goes unnoticed. Geometric shapes are seen in many objects in the nature. For the design of food trolley, most suitable shapes are these because it helps in its function and intent. Fusion of many geometrical shapes gives many options in the stage of concept generation. Some of the geometrical shapes seen in nature and standard geometrical shapes are also given in the Figure 9.

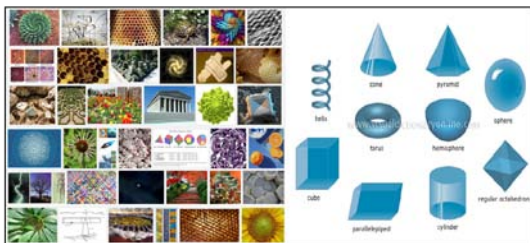


Fig. 9 Geometrical Shapes [15]

6.2 Product Name

Steamfresh reveals the prime function of the product. The main function of the food trolley is to keep the food fresh and warm. So the steam represents the heat inside and that keeps the food fresh. The name itself shows what it does. For the success of a product a good name also has a role to play. So the name 'Steamfresh' creates the feeling of the product actually do. This will definitely enhance the moral value of the product.

Steamfresh

Fig. 10 Product name

6.3 Mind mapping

Mind mapping has been used for concept generation by branching out the keywords such as ergonomics, usability, aesthetics, materials and environment. These key words are again broken down in to several sub factors to consider each and every tiny element in design concepts. Mind mapping helps to instant connections between the keywords and then it may produce the proper solution for the particular issue.

6.4 Concept Generation

Concept sketches have been randomly generated from the derived PDS and visual elements. Some of the doodles are selected and further developed for better analysis and modification. Figure 11 shows the some of the concept sketches.



Fig. 11 Concept sketches

6.5 Concept 1

Concept 1 is a basically has a rectangle shape. It has four deep tray holders in top for the conventional food carry. At front right side it has a tea/coffee vending machine. It has separate outs for coffee, tea and milk. Bottom half is made for tray holding rack and the other side a shelf is provided. The tray holding space has designed as three compartments. Three doors have been provided. In each compartment a metal frame tray holder which detachable is provided. It helps in easy access of trays and gives maximum accessibility inside while cleaning. Total number of tray it can accommodate is 15. A straight cylinder type handle is provided for handling purpose. Steel handle is fixed with the body and it is sealed with thermo set material to avoid electrical and thermal conductivity. Control panel and switches are provided below the handle as rectangular block. It is given an upward angle for the panel for easy viewing and accessing. Four castors are provided for easy mobility. Corner guards are provided to safe guard the product from impact damage. Power plug is at the bottom side opposite to the ventilator. Figure shows the outlook of the concept 1. 3D model has been created in Solid works and rendered the same in Keyshot is shown in Figure 12.



Fig. 12 Product name

6.6 Concept 2

The concept 2 is having a basic structure of a rectangular block. At the rear end side the outer side is designed with bulging curve out wards to accommodate the internal power and component system. In this concept the top part is fully covered with two sliding doors which move opposite direction. The sliding door has big handles provided for the easy use. The doors will be closed during the stage of transportation. At time of serving food the door can be operated from the side and the food storage space can be accessed. The handle

provided in this concept is stylish with curves and metallic finish. One of the sliding doors is slides through the handle hence the handle gives a sturdy support for one of the sliding door which can be used to keep the tea pots. Power point is provided front end opposite to the ventilator. The wheel castors provided is having self locking system. On the side a single door is provided which is operational 180 degree. The tray storage space is a single compartment with metal frame which has two partitions for tray holding. It can accommodate a total number of 24 trays. A wide and unique control panel and display is provided on the right side of the door. For the mass food storage four deep trays is provide at top portion. The handle is having many curved profile and it is ergonomically designed to hold from any position. Chrome finish is given for handle. 3D model has been created in Solid works and rendered the same in Keyshot. The real object rendering and material application is done Keyshot. The rendered image of concept-1 is shown in the Figure 13.



Fig. 13 Concept 2

6.7 Concept 3

Concept 3 is a pure rectangle form with depressed stand provided for tea pot base. A space for two tea pots is provided at the front side. A straight metallic finish handle is provided for handling and also as a protection for the product. For better handling two additional small handles are provided on each side. These will help in easy handling while in motion. Four chambers of food storage are provided on the top portion and the bottom side has two sections. Each cabin has individual top cover provided with a handle. One section is for the tray storage and the other one is normal shelf indented for plates and cups. The capacity of tray storage portion is 24 trays. Wheel castors provided have in built locking system. 3D model has been created in Solid works and rendered the same in Keyshot. The rendered image of concept-3 is shown in the Figure 14.



Fig. 14 Concept 3

6.8 Concept 4

Concept 4 definitely has a rectangular block but it has more curves and forms provided in order to enhance the features as well as aesthetics. At rear side a stepped base is provided for the tea/coffee storage. Below that sufficient space is provided to keep the cups and saucers. Both sides of the product a curved handle is provided as per ergonomic height.

The two handles are connected with metallic straight bar to enhance the easiness of handling. Below

the tea pot holder the space is provided for the pale and cup storage. It is made as a shelf with sliding glass pane. A transparent fiber glass is provided as sliding door. A knob is fitted for easy operation.

Adjacent to the tray storage door the control panel is planned. It has a capacity of 20 trays along with four conventional food storage compartments. The tray storage system is having a single door system. For the protection of the product the corner guard is provided on the front side. The rendered image of the Concept-4 is shown in the Figure 15.



Fig. 15 Concept 4

6.10 Concept Selection

Four concepts have been shortlisted by participatory method wherein concepts were publicized to end users for feedbacks. Participatory method is an efficient method for concept selection which could noticeably identify the positives and negatives in each concept. User interviews have been conducted among 8 to 10 end users in this phase for concept selection.

Shortlisted concepts are further weighed in weighted ranking method for finalization of concept and it is shown in the Figure 16. Each criterion has been evaluated with respect to each concept for ranking. Concept 4 has been shortlisted from weighted ranking method for further development.

CONCEPT SCORING	Weightage	Concept 1		Concept 2		Concept 3		Concept 4	
		Rating	Score	Rating	Score	Rating	Score	Rating	Score
Usability	40%	2	.80	3	1.2	3	1.2	4	1.6
Ergonomics	25%	3	.75	1	.25	4	1.0	3	.75
Portability	25%	1	.25	2	.50	2	.50	2	.50
Aesthetics	10%	4	.40	4	.40	1	.10	1	.10
Total score			2.20		2.35		2.80		2.95
Ranking			4		3		2		1
Decision			Discard		Discard		Discard		Selected

Fig. 16 Weighted ranking method

Concepts have been derived from geometric forms and inspiration board. A variety of fundamentals identified such as form, colour combinations, texture, and symmetry have very much used in the concept generation. Every concept developed is having those essentials found in ideation stage. Concept forms derived are geometrical, functional, ergonomic and easy to manufacture.

7. DETAIL DESIGN AND MOCK UP

Detailed view of Steamfresh has been captured in figure for better understanding of product features. Major components are top cover, side door, tray holder, castor wheel, control panel, crash guard and power plug. Some of the sub assemblies are removable type and others are permanently fixed.

All the electrical and electronics parts and the castor wheels are standard units readily available in

market. Major material used in Steamfresh product is stainless steel (SS 304). The additional materials used are plastics, aluminum and fiber. Each and every part of the product is marked and the detailed design is shown in the Figure 17.

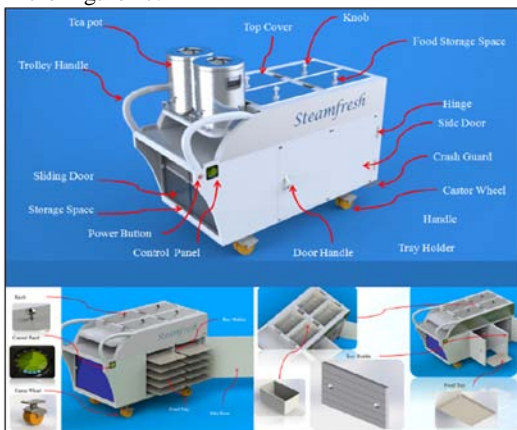


Fig. 17 Concept 4

7.1 Modifications in final concept

The necessary modifications done in final concept is numbered and explained. In the image all changes is marked with numbers and shown in the Figure 18.

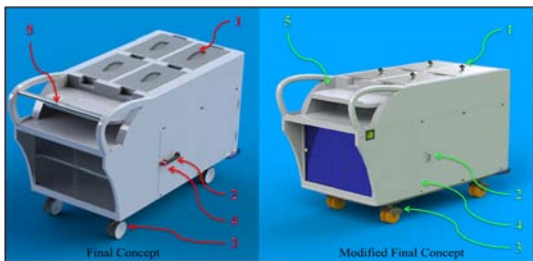


Fig. 18 Modification of Final Concept

- Handle of the top cover design is changed to Knob type holding.
- Plastic handle design of side door is changed to a metallic handle.
- Castors (Wheel) are changed to smaller diameter and design.
- Side door is changed to an internal locking with a clip catcher mechanism.
- The steel rod handle is eliminated because of usability and ergonomics issue.

7.3 Detail Design

Overall product dimension has been set as 1400mm x 800mm x 664mm. It has a rectangular frame body with four compartments in top and a single storage space at bottom side. Single door is provided at the side opening and four individual top covers are provided on top. The bottom storage space has tray storage with three numbers of tray holders.

The tray holders can be removed by sliding out. Each having slots provided for tray holding. The centre one is having more thickness than the other ones. The space for the electrical circuits and heaters is kept. The total height from the floor is 800 mm. The whole body is

stainless steel and it is insulated to prevent heat loss and electric shock. Overall Dimensions of the product is 1400mm x 800mm x 664mm.

7.4 Mock up Model

Mock up model has been made for the final concept in half scale. The materials used for model making are MDF board, 4mm fibre glass, hinges, square reaper, fevicol and nails. Tools used for model making are carpentry tools, drilling machine, steel rule, wood, and cutter, spray painting unit, grinding machine, hacksaw, chisel, compass, hammer and scissors. Model has been made in number of steps such as marking and cutting the side shapes, finishing the profiles, made groves and cut outs, adding features, final finishing process and painting. The stages of mock up model creation are shown in the Figure 20.



Fig. 20 Mock up Model Making

First process done is marking out the all side profiles and cutting that to get sheet as per dimension. Then it is joined to get the outer frame. The whole outer body is temporarily joined to do the inner profiles. The cut out profiles are the joined with nails and fevicol. The door is fixed with hinges.



Fig. 21 Final mock up model

8. VALIDATION

Validation of the final concept has been done with a 1:2 mock-up model developed to ensure the potential of the final design. Validation of the mock-up model recognized to be significant in order to understand, the product's importance in solving issues in the existing design of food trolleys used in Indian hospitals. Ergonomics parameters validation has been done in Catia software with the help of a computer. All the possible postures while using a food trolley is simulated with manikin.

The ergonomic simulation shows that the product dimension is suitable for an easy use of the product and it is shown in the Figure 22.



Fig. 22 Ergonomic Simulation

A group of 7 end users, 4 hospital food service personals and 3 nurses have been interviewed as a part of final design validation. Results identified from those interviews are compiled for future analysis and modifications in development stage. Usability, Ergonomics, and Aesthetics are the three major parameters considered in Steamfresh design concepts, hence validation has been done on those components from a group of end users and results are compiled in below list.

Ergonomic Parameters –

- Handle provided for the guiding of the product is good.
- The wheels provided for movement and the handle form is comfortable for use.
- Tray system provided is easy to maintain and use.
- Front shelf incorporated increases the easiness of functionality.
- Control panel provided for temperature control is easy to use.
- Removable tray holder system makes cleaning process stress less.

Aesthetic Parameters –

- End users are happy with the overall form and the looks of the product.
- Colours used were appreciated by most of the users.
- Some of them said they would like to have more radiuses on the edges.
- Users expressed that the name given is good and attractive.

Usability Aspects –

- Overall vision of users is that the product is very good for Indian hospitals.
- Some of the suggestions were to increase the size and capacity of the product.
- Some users said it would have been better if an additional locking system is provided than the inbuilt wheel castor lock.
- Overall response from users has been really positive for the final concept except some of the small improvements suggested.

9. CONCLUSION AND FUTURE WORKS

9.1 Summary

Project has been a blend of all the previous modules to understand the product development process followed in design. Summary of works carried out in the project work are listed below:

- Data collection through secondary research like literature survey by referring books, journals, articles, patents and internet

- Product study to understand associated products available and market study to identify the scope of a new product in present market scenario
- User study to analyze the current food service system in hospital and to find out issues in existing system
- Questionnaire survey among dieticians and hospital administrators
- QFD and PDS generation from analyzed data according to customer voice
- Visual design exploration from nature for deriving colour combinations
- Mind mapping and concept generation
- Selection of concepts and its 3-D modeling using Solid Works CAD software, rendering these concepts in Photo view 360 and Keyshot
- Final concept selection using participatory and weighted ranking methods
- Final concept detailing and mock-up model in MDF board
- Validation of the final mock-up model for usability, ergonomics and aesthetic factors

9.2 Conclusion

The complete process of developing a food trolley for hospitals has been aimed at resolving various issues identified in the existing design. Design feasibilities were regularly reviewed with academic guides for early modifications of the concepts. The results derived from 'Steamfresh' have been validated for better usability, ergonomics and easy maintenance. The user requirements identified through research are taken care of in the final concept design.

Project has enriched knowledge on product design processes right from inception, creation and realization which would help in developing successful products. Methodology followed in design with sequence of steps in developing successful products in a short period of time has been followed in this project. It has been a wonderful experience to involve as an individual and the final outcome is really satisfying.

9.3 Recommendations for future work

Indian healthcare industry is in a transforming phase of modernization. Hence, further development of 'Steamfresh' Food trolley has a good scope in the current Indian hospital sector. The project has been completed by emphasizing on academic requirements.

Some of the requirements which could be considered for future works are listed –

- Development of electrical circuits and heater channels
- Analysis on individual components and design modifications
- Development of 1:1 working model for final validation.
- Design modifications for improving DFMA.
- Branding of the product with a Logo and Tagline.
- Plan for launching this product in Indian market.

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