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Food Security Management System: Model for Dripping used for Cooking Purposes

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ABSTRACT

In 2009, The World Summit on Food Security introduced four pillars of food security namely; availability, access, utilization, and stability. Food security could be substantially improved by increased investment and policy reforms. The ISO 22000:2005 family of international standards is one of leading food safety security management systems and it specifically addresses food safety management. The purpose of this study is to develop an extended framework of standards opposed to ISO 22000:2005 food safety standards considering one additional pillar in food security, which is food safety, with a special reference to edible oil and oil-based products. Among 745 Colombo Municipal Council (CMC) registered food preparation facilities, 75 facilities were selected as a stratified random sample. A self-administered online questionnaire was used to identify gaps in local food security practices in edible oil. Data analysis was performed using SPSS version 21 and characteristics of sample were analyzed using descriptive statistics. The results of the survey revealed that the Sri Lankan food preparation facilities are significantly behind in food security practices. Therefore, in addition to food safety management system, we suggest to include four pillars in food security systems into the existing food safety standard due to lack of food security practices in food preparation facilities. Considering the deviated areas in the practice, which were identified through our questionnaire, we developed a novel model of food security management system for a comprehensive assessment of food preparation facilities.

KEYWORDS

Cooking oil; Food preparation facility; Food safety; Food security

1. INTRODUCTION

Food safety and food security are interrelated concepts with a profound impact on quality of human life. In 2009, the World summit on food security introduced food security concept which defined as a concept with four pillars namely, availability, access, utilization and stability [1,2]. Of those pillars, availability and access have been divided further. Sub components of the availability are considered as procurement, distribution and exchange. Also, access been considered as a combination of affordability and allocation. Quality of

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the food has a profound impact on quality of human life. Many studies show the efforts of several food security policy researcher's attempt to examine policy options and their impacts on food security. Food security could be substantially improved by increased investment and policy reforms. The ISO 22000:2005 family of international standards is one of leading food safety security management systems and it specifically addresses food safety management. However, the scope of food security is insufficiently addressed by the ISO 22000:2005 food safety standards [3-6].

Although food safety standards are the main regulatory bodies in current food regulation in worldwide but there are some areas needing improvement. Concept of food security has been introduced recently with the aim of supplying sufficient, safe and nutritious food to the consumers. Edible oils are one of most common food item to be used in food preparation facilities and of cooking oils, palm oil is estimated the most consuming oil type. Under some conditions cooking oil's chemical properties can be changed such as producing trans-fatty acids, free radical cooking at high temperature, and these factors are not well addressed in the current food safety [7-11].

There are different types of oil use in cooking purposes. Vegetable oils are oils or fats extracted from a plant. The most common oil type's use in food preparation facilities include palm oil, soybean oil, canola oil and sunflower seed oil. Palm oil is extracted from the flesh of the palm fruit, which is primarily found in the tropical climate of Africa, South America and South East Asia [12,13]. It is estimated that about 90 percent of palm oil is used for food consumption, whereas industrial consumption such as cosmetic products or fuel and diesel claim the remaining 10 percent [8].

According to the statistics, global consumption of vegetable oils has been progressively increased and in 2012/13 palm oil consumption has increased from 55.5 million metric tons to 64 million metric tons but coconut oil consumption has reduced from 3.75 million metric tons to 3.4 million metric tons [8].

The general impression is that cooking at high temperatures would degrade the quality of the oil. Few studies have been done so far to find the effect of cooking temperature on quality of oil, however; a study published in 2011 in Sri Lanka also found that most of phenolic antioxidants present in coconut oil is thermally stable compared to other oils and therefore greater composition of anti-oxidants is that simmering for a long time at a high temperature dissolved more anti-oxidants into the oil [14].

The usual usage of edible oil during the cooking process in hotel industry, is according to the Table 1.

Step	Process flow chart	Stage of the production
01.		Purchasing cooking oil according to the requirement
02.		Incoming inspection
03.		Storing under required temperature
04.		Internal distribution
05.		Cooking oil use for cooking and inspection
06.		Cooked product severed to customer

Table 1: Usage of edible oil during the cooking process.

The purpose of this study is to develop an extended framework of standards opposed to ISO 22000:2005 food safety standards considering one additional pillar in food security, which is food safety, with a special reference to edible oil and oil based products in Sri Lanka.

Through this study we analyzed the international and local food security practices in relation to cooking oil types in different cooking methods. Thus, we developed a hypothetical model of food security management system in usage of edible oil and oil-based products which can be used for a very comprehensive assessment of food preparation facilities instead of using the existing food safety standard alone [15-17].

2. METHODOLOGY

Research framework was derived by identifying the external environmental factors through the analysis of literature review. Then identified the risk based on internal factors under man, method, machine and materials, which are affected to the food security system which consists of four pillars including: Availability, access, utilization and stability [17-20] (Figure 1).

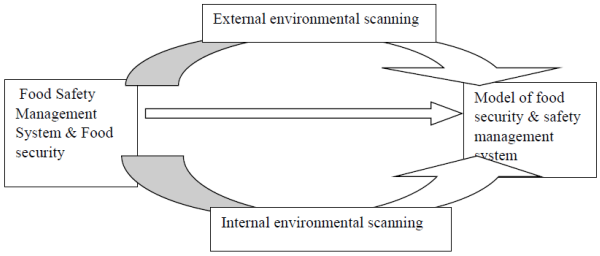


Figure 1: Conceptual research framework.

Conceptual research framework shows how the model of food security and safety management system is developed by analyzing the gaps of internal and external environment and identifying the defects in the existing Food Safety Management System & Food security [21-23].

With regard to the research framework presented, there are five main constructs to operationalize: availability, access, utilization, stability and safety. However, these indicator statements were modified where ever necessary applicable to local food preparation facilities [24-29]. Each indicator statements were measured on 0-5 Likert scale; Strongly agree (5), Agree (4), Neither agree nor disagree (3), Disagree (2) or Strongly disagree (1), Not sure (0).

The indicator statements relevant to each concept variables/ pillars are listed as follows:

Procurement

- Purchasing requirement is an important pre-requisite to be taken by the company.
- Brand of the required oil is considered as an important fact when purchasing by the company.
- Quality of the purchasing product is a mandatory requirement.
- Purchasing company is a system certified one.
- Cost of the product is the most important fact consider during purchasing.
- Next purchasing order before reaching the threshold volume of the buffer stock of the product.

Distribution and exchange

- The vehicle condition during transportation of purchased oil.
- The packing material of the oil during transportation.
- Cooking oil receiving packing materials are according to the requirement is important.
- Internal material distribution system in order to fulfil the requirement.
- The storing temperature, during the storage of the cooking oil.
- Internal material distribution system to supply the most suitable oil for the relevant cooking method.
- Material distribution system as it is important for food security.
- Traceability system to ensure the safety of the product.

Affordability

- Even in a higher price, company is capable of purchasing the exact required quality edible oil to fulfil the demand without any shortage.
- Quality of the product is the key factor to decide about the purchasing particular branded product.
- Price of the product and brand name are considered as important factors to consider in purchasing.

Allocation

- Most of the time procurement management system is capable in providing the requirement continuously.

- A single oil type is adequate for all cooking purposes.
- Due to cost effectiveness, choice of oil should be restricted to one or few brands.
- As there are no wide variety of food types it is acceptable to use a single brand/type of oil.

Utilization

- Deep fat frying is commonly used due to the tasty of the food and increased demand from customers.
- Deep fat frying is commonly used due to the shelf life stability of the fried food.
- The fact that not all types of edible oil are suitable for deep fat frying.
- The fact that oil absorption to food is high during deep fat frying.
- The fact that Oil absorption to food is increased with increasing the frying time.
- The fact that Oil absorption to food is decreased by adding some natural ingredients, coating and batters.
- The fact that Oil absorption to food mostly occurs during post frying cooling.
- The fact that High pressure vacuum fryers increase oil absorption to food.
- The fact that Low pressure fryers maintain the colour and nutrient contents of the food, quality of the cooking oil and thus reduces toxic generation.

Following criteria to select frying oil

- Long frying stability of the cooking oil.
- Low tendency to foam or form smoke.
- Low tendency to gum.

Price of the oil

- Cooking in high temperature can affect to the quality of the oil.
- Repeated usage of used cooking oil can be resulted in unhealthy food.
- Uncleansed utensils used for the cooking purpose can affect the cooked product's nutritional value.
- Monitoring the water quality is a mandatory requirement.

Stability

- Usually we encounter shortage of cooking oil.
- Maintain the minimum required quantity for the cooking oil.
- Equipment for controlling and monitoring the temperate in cooking.
- Calibrate all the monitoring equipment and keep monitoring records.
- Preventive maintenance according to the plan.

Safety

- Personal hygiene including hand washing before and after handling the cooking oil.
- Health check-ups and health certificate for food handlers.
- Pest controlling methods can affect the cooking product safety.
- Wear personal protective equipment during food handling.
- Identify the critical points such as cooking temperature, pH level when designing the menu.
- Food safety team or company workers have a knowledge about food security in relation to the product utilization and nutritional value.
- Food safety team or company workers have knowledge about food security in relation to the product health status of the individuals consuming the food.
- Food safety team or company workers have knowledge about food security in relation to the product principle of post-harvest, food preservation and quality control.

These statements were converted to questions in the questionnaire. In addition to the main questions, a set of general questions about category of food preparation

facility, current certified standard, and usage of cooking oil were also included to the questionnaire.

Research was limited: Only food processing facilities registered under Colombo municipal council (CMC) were recruited for the study, only the food security concept was considered for the study and only hazards developing during the cooking process were considered.

Among 745 Colombo municipal council (CMC) registered food preparation facilities, 75 facilities were selected as a stratified random sample. A self-administered online questionnaire was used to identify gaps in local food security practices in edible oil.

3. DATA ANALYSIS

We used interviewer administered questionnaire to gather information's and of total responders, 60% were chefs and 40% were hotel managers. Most of the responders (39%) had 6 years to 10 years' experience in the hotel industry but 8% of total responders had less than 2-years' experience in the hotel industry. Out of 75 food preparation outlets, food security practices were evaluated in majority from eating houses i.e.73% and 13% were restaurants, 11% were hotels and 3% were guest houses. Majority of responders (59%) were aware of food safety management systems for 2 years - 5 years. Around 10% have known about the safety systems for more 10 years and 13% mentioned that they aware about this aspect for less than 2 years despite of presence of food safety management system. Of total, ten food preparation outlets were certified for good manufacturing practices (GMP), Hazard analysis critical control points (HACCP) and ISO 22000:2005 food safety management system. As a percentage, 30% had GMP certification, 20% had HACCP and 50% of certified outlets has certified with ISO 22000. About 55% food outlets used palm oil as the main cooking oil and cost, availability and popularity were the main reasons for selecting it as main cooking oil type. Only 5% of the sample, considered nutritional value and health impact in using cooking oil. However, 52% of the sample used palm oil for frying despite of the awareness on adverse health consequences from frying with palm oil [30].

Before using any inferential statistical analysis on the data, the validity of the research items was assessed. The concept of the research was based on multiple dimensions; therefore, the validity of these dimensions was evaluated using Factor Analysis. Using SPSS 21 software, Factor analysis was used to confirm if the research items measured what was proposed to measure in the conceptualization [28].

The validity and consistency of measures is very important to evaluate the credibility of the items in order to move ahead with the rest of the analysis. The adequacy of the measures was calculated by using Kaiser-meyer-olkin (KMO). KMO values between 0.5 and 1 indicate the sampling is adequate. KMO values less than 0.5 indicates the sampling is not adequate (Table 2). Bartlett's test of sphericity tests the null hypothesis that the correlation matrix is an identity matrix, which indicates that variables are unrelated and thus unsuitable for structure detection. Values less than 0.05 of the significance level indicate that factor analysis is useful with our data (Table 2).

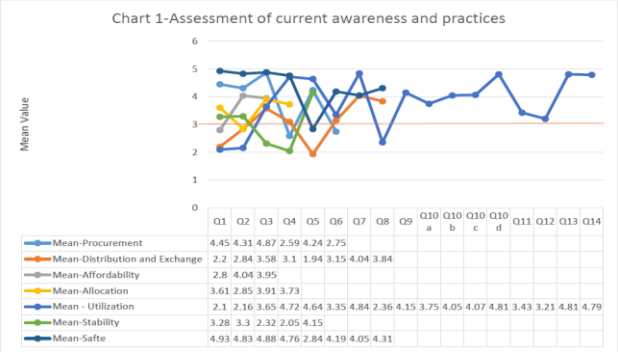
Variable	KMO	Bartlett's test of sphericity: p-value	Number of indicators
Procurement	0.565	<0.001	6
Distribution and exchange	0.844	<0.001	8
Affordability	0.551	<0.001	3
Allocation	0.601	<0.001	4
Utilization	0.693	<0.001	14
Stability	0.625	<0.001	5
Safety	0.572	<0.001	8

Table 2: KMO and Bartlett's test of sphericity.

KMO value in variable procurement, affordability and safety were less than 0.6, allocation, utilization and stability were less than 0.7 and distribution and exchange more the 0.8. (Table 2). Therefore, distribution and exchange variable sample was adequate. Procurement, affordability and safety variable samples were not

adequate. However, all the variables Bartlett's test of Sphericity was less than 0.05 of the significance level indicate that factor analysis was useful with our data.

One sample t- Test was used to determine the statistically significant difference exist between respond of the sample used in the study and the mean of the standard respond. Here we assessed all practices in all dimensions proposed in the framework for an average value of 3. Value 3 represents an indifferent practice or awareness. If the average was not significantly equal to 3, then we assessed the nature of the differences.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10 a	Q10 b	Q10 c	Q10 d	Q11	Q12	Q13	Q14
Mean-Procurement	4.45	4.31	4.87	2.59	4.24	2.75											
Mean-Distribution and Exchange	2.2	2.84	3.58	3.1	1.94	3.15	4.04	3.84									
Mean-Affordability	2.8	4.04	3.95														
Mean-Allocation	3.61	2.85	3.91	3.73													
Mean - Utilization	2.1	2.16	3.65	4.72	4.64	3.35	4.84	2.36	4.15	3.75	4.05	4.07	4.81	3.43	3.21	4.81	4.79
Mean-Stability	3.28	3.3	2.32	2.05	4.15												
Mean-Safte	4.93	4.83	4.88	4.76	2.84	4.19	4.05	4.31									

Figure 2: Assessment of current awareness and practices in each variables.

Referring to the Figure 2, the mean values for procurement pillar indicator 1,2,3 and 5 carry an average mean greater than 3, which indicates that the responses were more toward agreeing to the questions based on involvement according to the Likert scale (Appendix - 01). This implies that sampling food outlets are considering the purchasing requirement as an important prerequisite and the quality, brand and the cost of the product are considering before purchasing. But procurement indicators 4 and 6 were less than 3, which indicates that the responses were more towards disagreeing to the questions based on involvement according to the Likert scale. This revealed that sample food preparation facilities were not considering the cooking oil buyer's company system certification before purchasing and not requesting the next purchasing order before reaching the threshold volume of the buffer stock of the product. This could be due to their lack of knowledge on importance of quality standard system and maintenance of a buffer stock.

The mean values for distribution and exchange pillar's indicator 3,4,6,7 and 8 carried an average mean greater than 3. This implies that sample facilities more concerned about the quality of the cooking oil packing material, maintenance of a proper internal material distribution system and a proper traceability system to ensure the safety of the product. But 1,2 and 5 indicators were less than 3, and this revealed that sample food preparation facilities were not giving much attention to the transporting vehicle condition, packing material during transportation and storing temperature and not considering them as impacting factors on food security.

Conferring to the Figure 3, the mean values for indicator 2 and 3 in affordability pillar, carry an average mean greater than 3, thus, sample food preparation facilities had considered the quality, price and the brand name of purchasing product. But indicator 1 was less than the test mean, and this implies that price became the limiting factor when purchasing and in higher prices most of the time they have shortage of quality edible oil so they go for much cheaper products to avoid the shortage.

The mean values for indicator 1,3 and 4 in allocation pillar, carried an average mean greater than 3, means that sample facilities had limited choices of edible oil due to cost and they believed that restricting to a single brand or type acceptable as there no much variability in food. Further, most of the time their procurement management system was capable of providing continuous supply. But indicator 2 was less than the test mean, implies that despite of above mentioned limitations they believed a single oil type was not adequate for all cooking purposes. The mean values for indicator 3-7 and 9-14 in utilization pillar, carry an average mean greater than 3. This implies that the knowledge on deep fat frying like extent of oil

absorption compare to cooking, suitable oil type, factors which reduce or increase oil absorption, impact of high temperature on quality of oil, risk of repeated usage of same oil, importance of monitoring water quality and using cleaned utensils and low-pressure fryers, among the responders were significantly high except on very few aspects. But indicator 2 was less than the test mean, which indicates that the shelf life stability of the fried food was not the main reasons behind the deep fat frying. Although indicator 1 and 8 were less than mean, those carried negative answers, which we were expecting, therefore the demand from customers and high-pressure vacuum, were actually not less than the mean. Further most of the responders were unaware of the impact of high pressure vacuum fryers on oil absorption.

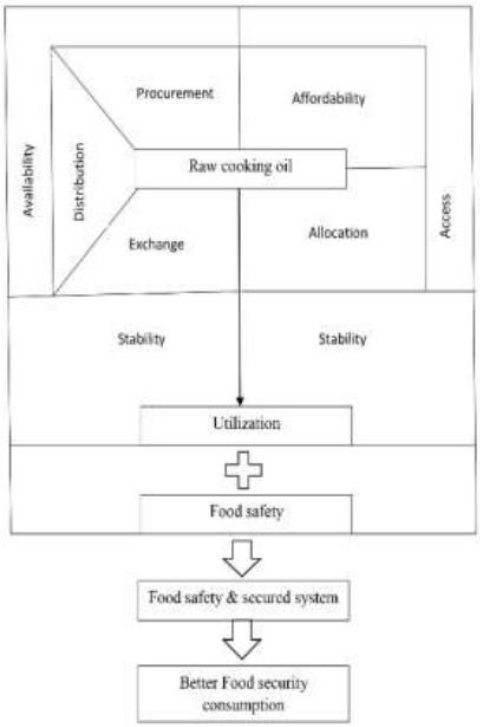


Figure 3: Proposal model for the food safety and security framework.

The mean values for indicator 1,2 and 5 in stability pillar, carry an average mean greater than 3, implies that sample food preparation facilities did preventive maintenance as scheduled and maintain the minimum required quantity. Despite of that they usually encountered shortage of cooking oil. But indicator 3 and 4 were less than the test mean, which implies that food preparation facilities usually did not calibrate all the monitoring equipment or keep monitoring records as well as not using equipment for monitoring the cooking temperature.

Except indicator 5, the mean values for other indicators in safety pillar carried an average mean greater than 3, implies that sample food preparation facilities were more concern about the personal hygiene of the food handlers basically hand washing, wearing personal protective equipment's and regular health check-ups. They also aware of impact of pest controlling methods on cooking product safety and they assure that their food safety team or company workers have a faire knowledge of impact of food preservation, quality control etc. on food security. But indicator 5 was less than the test mean, which indicates that the responses were more towards disagreeing to the questions. This implies that food preparation facilities did not consider cooking temperature, pH level like critical points in designing the menu.

4. CONCLUSION

Whether the business is a restaurant, a school, or a hotel food safety regulation must be followed by each to ensure that customers are consuming food that is prepared in safe conditions. In our study population, majority of the participants were aware of safety measures recommended in the ISO 22000:2005 food safety standard. But the concern on impact of physical parameters on nutritional status when preparing a menu, was significantly poor among participant food outlets. It is known that cooking induces significant changes in chemical composition, influencing the concentration and bioavailability of bioactive compounds specially in vegetables. But this fact was not evaluated in the current safety standard and most of the study population did not have a clear image about importance of considering the impact of cooking conditions on nutritional value of processed food when preparing food items.

Purchasing higher quality ingredients is a paramount important step in delivering quality nutritious food to the consumer. Quality, brand reputation and the cost of the purchasing product were considered as most important pre-requisites when selecting a supplier by our study population. But system certification of the supplier was not considered as a required fact during supplier selection. Product certification verifies that a food product complies with the safety and are according to the standard specifications. This will not only give a competitive advantage in the marketplace but provide assurance of the product quality. But food outlets of the current study neglect the supplier's quality standards. Further, when we elaborating the number of certified companies in our study population, it was 13% of the total and this implies that most of the small-scale food outlets have poor understanding about the importance of system standards. Despite of launching new food regulatory concepts, reasons for not giving much attention for regulatory standards should be evaluated. This could be due to lack of their knowledge or purposeful negligence. This can be strengthened by developing a well-prepared food security system in addition to the current safety standard.

Current consumer requirements are directed towards improving the quality of foodstuffs expecting that certain processed foods and the ones prepared by frying will exhibit in addition to sensorial attributes nutritional qualities as well. There is a constant concern towards the effects that the various factors involved in a thermal, industrial or culinary process have on the nutritive value of the food that is processed. The knowledge on impact of deep fat frying on food and its health impact were significantly higher among our study population but their selection of oil types was not complying with their knowledge during day to day practice. Cost and unavailability of quality edible oil in the market were mentioned as common reasons behind using cheap poor-quality products by the current study population. This emphasis the necessity of establishing proper, well monitored in house industrial scheme to manufacture healthy cooking oil like virgin cooking oil to make healthy edible oil widely available in the local market. Further, establishment of monitoring process via including check list of deep fat frying and other cooking methods with suitable oil type and comply with physical parameters of cooking oil is an important step to consider.

The results of the survey revealed that the Sri Lankan food preparation facilities are significantly behind in food security practices because they match more considerable about food safety management principles. Therefore, in addition to food safety management system, we suggest to include four pillars in food security systems into the standard because of significantly food security practices are lacking in our current system. Therefore, our recommended model for food safety and security system is illustrated in Figure 3.

5. KEY FACTORS

The key factors which determine the fulfilment of each category of food security concept must be evaluated and analyzed via a check list during standard certification of food selling outlets. Unfortunately, current food safety standard certification has a significant vacant space in terms of assessing food security in food preparation facilities. Our conceptual model (Figure 3) adopts and expands the existing food safety concept into much comprehensive and realistic by integrating the food security concept to develop a novel concept called food safety and security system. Our model is grounded in the assumption that it is essential to map the food system as an integrated set of processes to more fully understand the influencing environmental, social, economic, and human factors that shape access to adequate food resources. Our model identifies points of vulnerability in the food system in general and the consumer subsystem in particular to provide greater conceptual clarity to

protect against food insecurity. Because of that, this proposed model will be a road to integrate conceptual work in food safety and security to create a framework to guide research, practice and policy relevant to increase the population food security. Focusing on food system vulnerabilities and system and individual-level barriers influencing the consumer subsystem facilitates a more systematic and organized conceptual framework to guide research, practice, and policy relevant to food systems and food security.

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