A GIS BASED TRACEABILITY SYSTEM SUGGESTION FOR A PASTRY FIRM OPERATING NATIONWIDE

DOI: http://dx.doi.org/10.18509/GBP.2018.47
UDC: 004:528.8/.9]:664.6(560)

Evren Gölge [1]
Tarık Türk [2]
[1] Cumhuriyet University Food Engineering Department, 58140 Sivas, **Turkey**
[2] Cumhuriyet University Geomatics Engineering Department, 58140 Sivas, **Turkey**

ABSTRACT

Logistics and traceability are important issues for big scale firms. Traceability is primarily viewed as a tool for the food safety by providing a mean for recall as well as proof for the authenticity of food, but it is also related to food quality. Maintaining the cold chain not only effecting the customer's preference and satisfaction but also the profitability, production and logistic costs for big scale firms especially producing perishable food products. Recently, the trend of utilizing GIS based traceability systems is increasing, which facilitates to minimize the production and distribution of unsafe and low quality food products. This paper presents a GIS based system enabling network analysis, which might be efficiently and effectively used in the firms operating in ready-to-eat pastry sector, intended to be used for full-automation through all the stages from production to retail was developed and a partial application was performed.

Keywords: GIS, Tracebility, Food safety

INTRODUCTION

Food products require cautious and strategic handling procedures, because they easily deteriorate and they have a short life span. On the other hand, food poisoning, such as food-borne illnesses and microbiological contamination, occurs easily if food is improperly handled during its production, storage, and distribution. Food industry is always susceptible to the outbreak of foodborne illnesses such as Salmonella, Campylobacter and Escherichia coli O157:H7, etc. Incidents such as these focus consumer concern on the safety and quality of food [1], [2].

Due to nationwide and international operating food firms and global food trade, food chain integrity not only includes safety concerns but also origin fraud and quality concern. It appears to be a great problem for many firms to ensure the cold chain not only effecting the customer's preference and satisfaction but also the profitability, production and logistic costs and maintain proper logistics for big scale firms especially producing perishable food products. Consumers demand verifiable evidence of traceability as an important criterion of food quality and safety. In order to cope with these requirements, a traceability system is needed giving information on origin, processing, retailing and final destination of foodstuffs.

In general terms quality can be defined as "conformance to requirement", "fitness for use or consumption". According to ISO definition, "Quality is the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs" [3]. However, food quality is very general, implying many expectations which may differ

dramatically from each individual consumer. Quality includes attributes that influence a product's value to the consumer. A product can appear to be of high quality (i.e. well coloured, appetizing and flavourful, etc.), but it can be unsafe because it might be contaminated with undetected pathogenic organisms, toxic chemicals, or physical hazards [4]. The CAC defines food safety as an assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use [5]. Food safety refers to all hazards, whether chronic or acute, that may make food injurious to the health of the consumer. It is not negotiable and a global issue affecting billions of people who suffer from diseases caused by contaminated food. In ensuring food safety, Hazard Assurance Critical Control Point (HACCP) is regarded as the best method. In addition, it is the best way to demonstrate commitment to food safety [6].

Effective logistics management requires delivering the right product, in the right quantity, in the right condition, to the right place, at the right time, for the right cost [7]. Due to logistics greatly affect the profit of producers, the price of food products, and the consumer satisfaction, logistics management has an important effect on the success of food producers [8]. In result, in the process of developing improved logistics, detailed location analysis (mapping/clustering raw material suppliers, production and retail points, etc.) and route analysis (creating best routes for product collection and distribution, simulating route distance and delivery time) are essential.

According to ISO 9000 standards, traceability is defined as: ''the ability to trace the history, application or location of that which is under consideration". ISO guidelines further specify that traceability may refer to the origin of materials and parts, the processing history, and the distribution and location of the product after delivery. The European Union (EU) regulation 178/2002 [9] narrows the definition to the food industry by defining traceability as the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution. The Codex Alimentarious Commission [5] defines a more concise definition of traceability as the ability to follow the movement of a food through specified stage(s) of production, processing and distribution.

According to Golan et al. the three main objectives of the food traceability systems are to improve supply management; to facilitate trace back for food safety and quality; and differentiate and market foods with subtle or undetectable quality attributes [10]. The benefits of these objectives appear as lower cost distribution systems, reduced recall expenses, and expanded sales of products with attributes that are difficult to discern. It was also suggested that an efficient traceability system should be characterized by breadth (i.e. the amount of information collected), depth (i.e. how far back or forward the system tracks the relevant information) and precision (i.e. degree of assurance to pinpoint a particular movement of a food product) to be able to balance cost and benefits).

Consumers increasingly concern about food safety and properties of the food they buy and eat. It has been recognized that there is an increasing need for transparent information on the quality of the entire food chain, supported by modern tracking and tracing methods [11], [12]. Moe mentioned that traceability is an essential subsystem of quality management. Thus, a well-developed internal traceability system is necessary for quality management [13]. It would efficiently improve data collection, production flow control, and quality assurance.

Geographical Information System (GIS) is an informative system, which includes the data acquisition, storage, processing, inquiry, analysis and the certification steps as a whole,

is used commonly in many applications throughout the world. Food sector is appeared as one of the application fields [14], [15], [16], [17], [18].
In this study it was aimed to reveal a control system for efficient and safe execution of the product transportation process with the help of GIS in ready-to-eat pastry sector. For this reason a nationwide operating firm excelling in various milk and dough type of pastry production was selected.

MATERIALS AND METHODS

In this study, a nationwide operating firm STP Gıda A.Ş. having a total of four production facilities of which two located in İstanbul, one in İzmir and Ankara, and 190 subsidiaries [19] in which only retail process of the products takes place, was selected as the model firm. The total number of the subsidiaries and their locations are presented in Table 1. According to Table 1 the firm has the highest number of subsidiaries in Marmara and Aegean regions and the lowest in Eastern and South Eastern Anatolia regions. This distribution is quite understandable since the home city of the company Izmir is located in the Aegean region, hosts the main production facility having the highest capacity.

Table 1. The location of the firm's subsidiaries

Region	Provinces and the number of subsidiaries									Total number of subsidiaries	Percent
Marmara	Bursa	Çanakkale	İstanbul	Kırklareli	Kocaeli	Tekirdağ				61	35.4
	5	2	48	1	3	2					
Aegean	Afyon	Aydın	Balıkesir	Denizli	İzmir	Manisa	Muğla	Uşak		47	27.3
	2	5	3	3	28	1	4	1			
Central Anatolia	Aksaray	Ankara	Eskişehir	Kayseri	Kırıkkale	Kırşehir	Konya	Niğde	Sivas	25	14.5
	1	13	1	3	1	1	3	1	1		
Mediterranean	Adana	Antakya	Antalya	Isparta	Mersin	Osmaniye				18	10.5
	3	1	9	2	2	1					
Black Sea	Bolu	Düzce	Ordu	Samsun	Sinop	Tokat	Trabzon	Zonguldak		12	7.0
	1	1	1	4	1	1	1	2			
South Eastern Anatolia	Batman	Diyarbakır	Gaziantep	Mardin	Şanlıurfa					5	2.9
	1	1	1	1	1						
Eastern Anatolia	Elazığ	Erzurum	Malatya	Van						4	2.3
	1	1	1	1							
									Total	172	100

Milk desserts constitute the great portion of the products of the firm. Apparently, milk products are perishable type of foods. Parallel to the scope of this study, these type of products must be swiftly transported to subsidiaries and customers following their production. From this point of view the strategies in the process of product delivery followed by the firm are strictly critical for the profitability and hence implicating a great risk. All the retail data of the each 172 subsidiaries was created between 1 to 100 retails for each product daily for 365 days through three consecutive years (2013-2015) by random data generation function of the Excel programme in Microsoft Office Professional Plus.
A GIS based system was established considering all the steps in the transportation of the product. In this system both geographical and non-geographical data exist. Firstly, the firm's product tree were formed. The geographical locations of the subsidiaries were transferred the created system by detecting on the satellite view and on the map considering the data exist on the website of the firm. Turkey's transportation web and province border data was used as exist geographical data (Fig. 1).
On the other hand, a database including the parameters for the retail of the products of the firm and the cold chain was designed (Fig. 1).This database was integrated in

ArcGIS10.1 GIS software environment. Besides a user-interface program was developed to facilitate the interaction between the software and the user that enables the utilization of the software without requiring software background [20], [21]. In result, the user can reach and query the desired data for all the production facilities and subsidiaries of the firm in which retail process occur (Fig. 1 and Fig. 2).

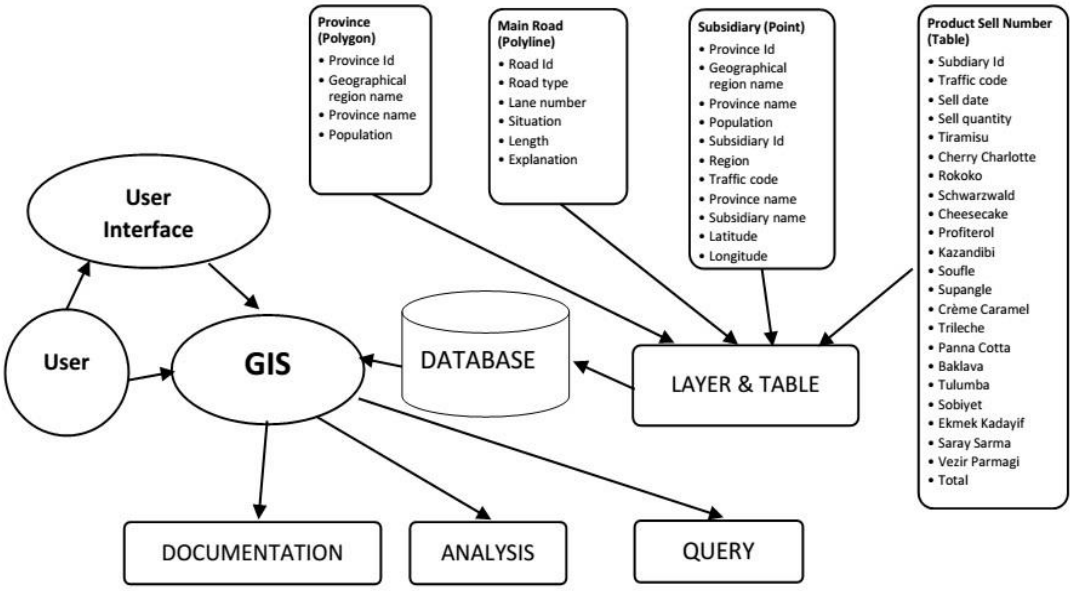

Figure 1. Schematic description of the created system

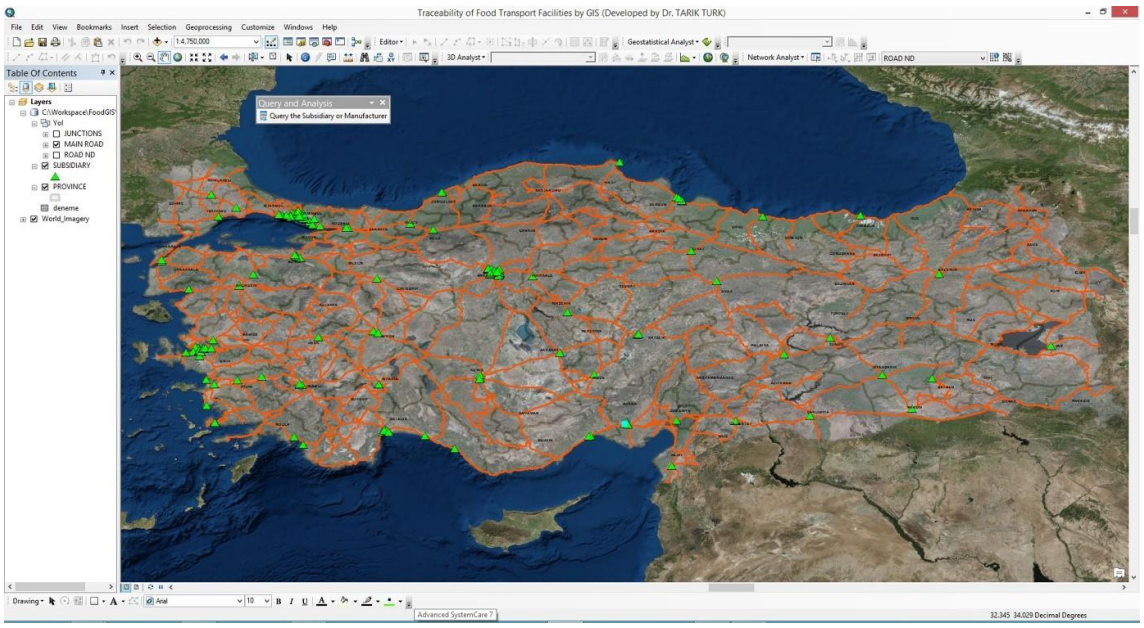

Figure 2. General view of the created system and user interface program developed on ArcGIS Software environment

RESULTS AND DISCUSSION

In this study, a GIS based system established aiming to maintain full automation of the operations from production stage to retail stage in subsidiaries of a selected nationwide operating model firm in ready-to-eat pastry sector in Turkey. The capability of the established system was as follows:

- Monitoring by a GIS based system,
- Accessing the geographical location and the detailed information of the production sites and the subsidiaries of the firm (Fig . 2 and 3),
- Requirement of the new production sites or subsidiaries in the strategic planning of the firm, and if necessary with the help of geographical analysis (Buffer Analysis, Density Analysis, Clustering Analysis, Network Analysis etc.) the determination of the geographical location of the new production site to be installed,
- Determination of retail statistics of any product type produced by the firm with respect to subsidiaries and profitability of any subsidiary with one click (Fig. 3),
- Selection of the production site for any random subsidiary to be supplied from (Fig. 4)

The difference and originality of the system proposed in this paper from similar previous systems could be listed as many operations executed by the firm are GIS based and performed with the help of the user interface program developed in the frame of this study [14], [22]. Besides the retail statistics of the firm's products can be obtained with one click through the created system (Fig. 3). In addition a wide perspective was presented for the profitability of the firms operating in this sector by performing Network Analysis applications in a GIS based system.

As the firm is operating nationwide, the 4 production facilities and 190 subsidiaries have been dispersed all over Turkey. The locations of each 4 production facilities and each 190 subsidiaries have been shown on the map of the created system using ArcGIS10.1 software (Fig. 2). With the help of these programs not only the statistical data on the product retail of the firm but also the geographical locations of the subsidiaries on the map could be selected and all the data on the selected subsidiary is obtainable with one click (Fig. 3).

In this paper it is not possible to present most of the query and geographical analysis that could be accessed provided by the system. For this reason some of these were presented in the following scenarios.

Scenario 1

In this scenario, all the retail information of the selected product type "Tiramisu" for the subsidiary selected "Adana Real" can be queried on day, month and annual basis with one click by the user interface program developed (Fig. 3).

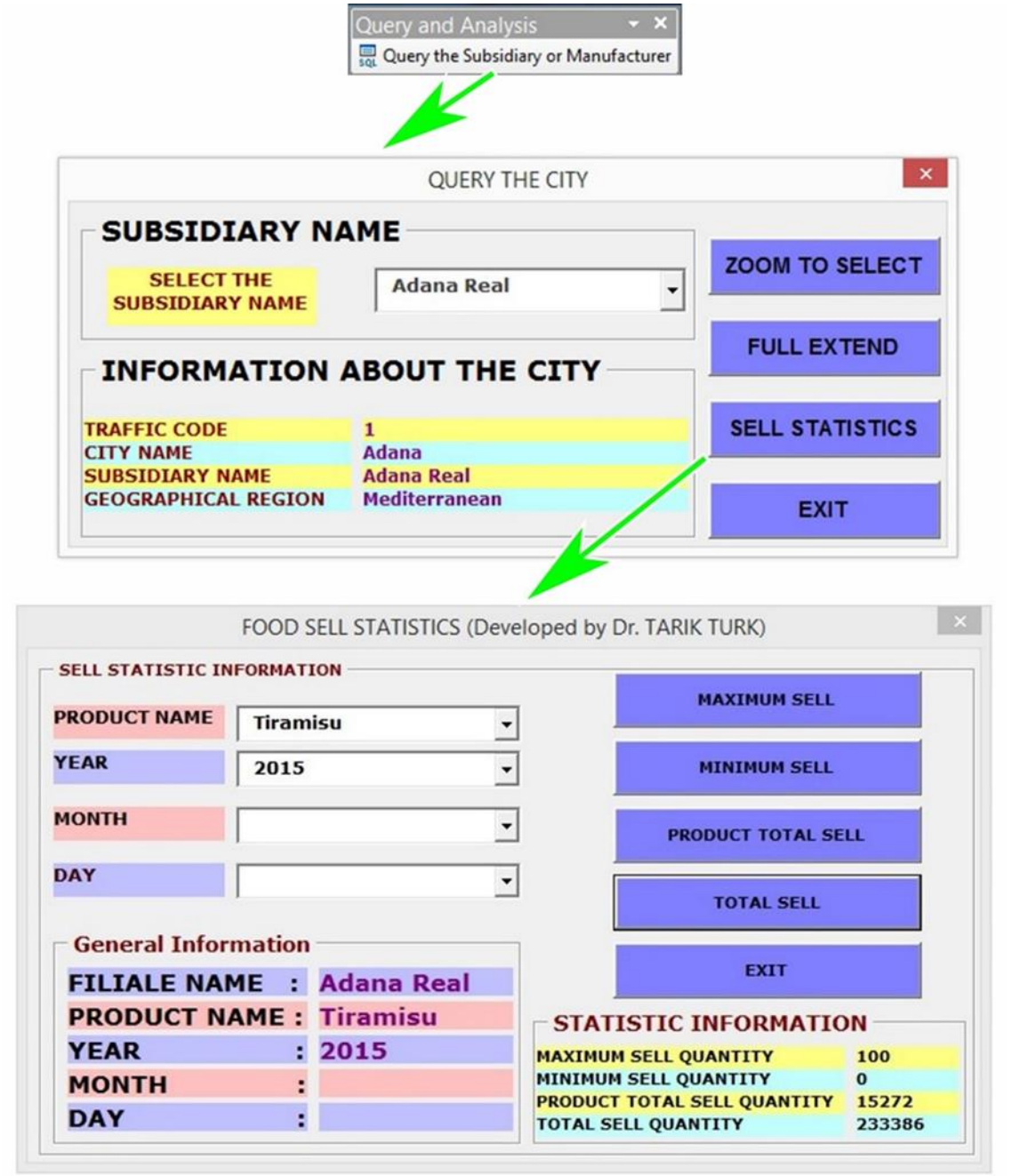

Figure 3. The user interface programs developed

Scenario 2

In the present study a GIS based system enabling network analysis was established. This apparently simplifies the logistical decision of the selection of the supply centre as in the case of İstanbul, where 48 of the 190 (25%) subsidiaries and two of the four (50%) production sites are located. The optimum production site in the supply chain of the firm was queried for a subsidiary. Thanks to Network Analyst the logistical planning of the products to subsidiaries can be reached within the frame of the system developed. The optimum production centre for again the same subsidiary namely "Adana Real" operating in Adana was found to be as Ankara (Fig. 4).

Figure 4. Route map according to the subsidiaries and production places

Alongside the optimum route determination, regarding to the position of the subsidiary and the effective utilization of the sources, the address matching and resource allocation and similar applications of network analysis the production, retail and logistic activities of the firm can be executed swiftly, effectively and efficiently. In addition, with the help of buffer analysis or network service area analysis the location of the newly formed production sites could be determined by the established GIS based system.

CONCLUSIONS

A GIS based system, which might be efficiently and effectively used in the firms operating in ready-to-eat pastry sector, intended to be used for full-automation through all the processes from production stage to retail stage was developed and a partial application was performed within the scope of this study. Thus, all the activities of the firm was stored in a geographical database and all kind of information is instantly reachable by inquiry. Furthermore, differing from the classical database in addition to geographical analysis operations, the implemented system can answer geographical based questions such as, considering the costs from which present production site the product must be transported to the retail subsidiaries as well as the determination and optimization of the geographical site of the potently established production sites. By this means the implemented system have a potential to increase the profit of the firms and facilitates the delicate products of the ready-to-eat pastry sector be transported safely to consumers situated far away.

Product-tracing systems are essential for food safety and quality control. Traceability systems help firms isolate the source and extent of safety or quality control problems. The more precise the tracing system, the faster a producer can identify and resolve food safety or quality problems. Quality and safety are both linked to traceability whereas safety is implicated by traceability more often.

Traceability is primarily viewed as a tool for the food safety by providing a means for recall as well as proof for the authenticity of food, but it is also related to food quality. Since both quality and safety were shown to be related to confidence, traceability may indeed boost consumer confidence through quality and safety assessments.
Cold chain is a critical issue for food sector. It has direct and indirect effects on human health, company profitability, etc. In the present study the system was designed both considering the production and expiry date and time of the product. As if the production and expiry data for each product would have been entered into the database and the vehicle tracking and navigation systems would have been integrated with the system established, the process from production stage to final user could be easily tracked on real-time basis.
On the other hand, different from the other systems presented in literature, when the desired retail prices of the products are set to the established system, the retail revenues of each individual subsidiary could be calculated on daily, monthly and annual basis for each different product type.
In result GIS based control systems certainly help a food firm especially operating with perishable products in resource allocation, route optimization, product traceability, etc. As the technology develops with the use of sophisticated sensors (e.g. RFID technology, nanosensors), the control parameters of the food product will increase which directly effects the level of real-time monitoring and efficiency of the GIS control systems. Thus, food safety management will be promoted and gain much more flexibility and accuracy.

REFERENCES

[1] Bertolini M., Bevilacqua M. & Massini R. Approach To Product Traceability In The Food Industry. Food Control, vol.17, pp 137-145, 2006.

[2] Trienekens J.& Zuurbier P. Quality And Safety Standards In The Food Industry, Developments And Challenges. International Journal Of Production Economics, vol. 113(1), pp 107-122, 2008.

[3] Guidelines For Quality Management In Soil And Plant Laboratories. Available Online: Http://Www.Fao.Org/Docrep/W7295e/W7295e00.Htm (Accessed On 22.08.15).

[4] Safety And Quality Of Fresh Fruit And Vegetables: A Training Manual For Trainers. Available Online: Http://Www.Unctad.Org/En/Docs/Ditccom200616_En.Pdf (Accessed 15.08.12).

[5] Basic Texts On Food Hygiene. Available Online: Http://Www.Fao.Org/Docrep/006/Y5307e/Y5307e00.Htm (Accessed On 13.07.15).

[6] Iso 22000. Available Online: Http://Www.Iso.Org/Iso/Catalogue_Detail?Csnumber¼35466 (Accessed On 10.08.15).

[7] Aghazadeh, S. Improving Logistics Operations Across The Food Industry Supply Chain. International Journal Of Contemporary Hospitality Management, vol. 16(4), pp 263-268, 2004.

[8] Brimer R.C. Logistics Networking: A Consideration Of The Components Essential To An Integrated Logistics Support Network. Logistics Information Management, vol. 8 (4), pp 8-11, 1995.

[9] EU. Regulation (EC) No 178/2002 Of The European Parliament And Of The Council. 2002.

[10] Golan E., Krissoff B., Kuchler F., Calvin L., Nelson K.& Price G. Traceability In The U.S. Food Supply: Economic Theory And Industrial Studies. Agricultural Economic Report Number 830, 2004.

[11] Beulens A.J. M., Broens D.F., Folstar P., & Hofstede, G. J. Food Safety And Transparency In Food Chains And Networks. Food Control, vol. 16(6), pp 481-486, 2015.

[12] Rijswijk W.V. & Frewer L.J. How Consumers Link Traceability To Food Quality And Safety: An International Investigation. In 98th EAEE Seminar "Marketing Dynamics Within The Global Trading System: New Perspectives", Greece, 2006, pp. 1-7.

[13] Moe T. Perspectives On Traceability In Food Manufacture. Trends In Food Science & Technology, vol. 9(5), pp 211-214, 1998.

[14] Bosona T.& Gebresenbet G. Cluster Building And Logistics Network Integration Of Local Food Supply Chain. Biosystems Engineering, vol. 108: pp 293-302, 2011.

[15] Bosona T.& Gebresenbet G. Food Traceability As An Integral Part Of Logistics Management In Food And Agricultural Supply Chain. Food Control, vol. 33, pp 32-48, 2013.

[16] Eckert J.& Shetty S. Food Systems, Planning And Quantifying Access: Using Gis To Plan For Food Retail. Applied Geography, vol. 31, pp 1216-1223, 2011.

[17] Mcmeekin T.A., Baranyi J., Bowman J., Dalgaard P., Kirk M., Ross T., Schmid S. & Zwietering, M.H. Information Systems In Food Safety Management. International Journal Of Food Microbiology, vol. 112, pp 181–194, 20016.

[18] Suprem A. Mahalik N. & Kim K. A Review On Application Of Technology Systems, Standards And Interfaces For Agriculture And Food Sector. Computer Standards & Interfaces, vol. 35, pp 355–364, 2013.

[19] Özsüt Company Website. Available Online: Http://En.Ozsut.Com.Tr/ (Accessed On 01.09.15).

[20] Turk T. Gumusay U.& Tatar O. Creating Infrastructure For Seismic Microzonation By Geographical Information Systems (GIS): A Case Study In The North Anatolian Fault Zone (NAFZ). Computers & Geosciences, vol. 43, pp 167–176, 2012.

[21] Turk T. Investigating Health Studies Using Geographical Information Systems: Cancer Case Study. Polish Journal Of Environmental Studies, vol. 22(5), pp 1505-1517, 2013.

[22] Hashemi Beni L., Villeneuve S., Leblanc D.I., Côté K., Fazil A., Otten A., Mckellar R.& Delaquis P. Spatio-Temporal Assessment Of Food Safety Risks In Canadian Food Distribution Systems Using GIS. Spatial and Spatio-Temporal Epidemiology, vol. 3, pp 215–223, 2012.