

## DEVELOPMENT OF AN APPLICATION TO IMPROVE TRACEABILITY AND FOOD SAFETY MANAGEMENT

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**Abstract.** Food safety has become an important food quality attribute within the last decade. Facing recent food scandals taken up by the media, consumers are more and more concerned about and interested in the provenance and authenticity of their food. Both food industry and authorities need to be able to trace back and to authenticate food products and raw materials used for food production to comply with legislation and to meet the food safety and food quality requirements as well as the increasing consumer demand. Therefore, food companies are faced with the problem of defining and implementing a series of procedures, controls and measures. Moreover, it is necessary to define an application method which is both rigorous and economically sustainable in order to guarantee the safe production of food and to be able to trace it along the food chain. The application was designed to manage traceability as well as to help in the quality control and production improvement, using a user-friendly interface. This application was developed in Visual Basic over an SQL database and its main features are: to register quality control parameters of raw materials, in-course products and final products; to manage reception, production and expedition orders; to analyse production costs, productivity, raw materials and products' consumptions; to define and print labels containing lot information and other relevant data; to trace products during the food chain (from raw materials to final client). All these informations are accessible either from pre-defined reports either exported to intranet based on Internet Explorer or other browser. Usually the process to assure traceability, specially in food products (due to the large number of ingredients involved in a single formulation) is very time-consuming, involves lots of paperwork and consequently a large number of resources are expended in this laborious task. This application can minimize efforts involved in traceability and managing food quality and safety systems.

**Keywords:** Food Safety, Traceability and Visual Basic.

### 1. Introduction

In the last few years food safety has become a major issue for European consumers. These concerns are caused by a continuous sequence of food scandals and incidents during the last decade. In response, consumers call for high quality food, food integrity, safety guarantees and transparency. This scenario led to the adoption of new policies, regarding to food safety, from Governmental Authorities and Food Industry.

To answer these consumers' requirements, quality assurance has become a cornerstone of food safety policy in the food industry that started to implement integrated quality and food safety management systems. These systems include all steps in food production chain namely the supply of raw materials, food manufacturing, packaging, transportation and logistics, research and development, maintenance of production equipment and training and education of staff. Increasingly, food quality is associated with a proactive policy and the creation of requirements to maintain a safe food supply (Folstar, 2001).

From the Governmental point of view, specially in the European Community (EC), global food safety policies were adopted. As a consequence of these policies, traceability became a legal requirement through

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regulation EC/178/2002 that defines traceability as the ability to trace and follow food, feed, and ingredients through all stages of production, processing and distribution. Traceability is the ability to track back a product and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales or internally throughout the production stages. Traceability is a generic issue, as its fundamentals are independent of the type of product, production and control system it serves (Kim, H.M. *et al*, 1995)

Traceability systems can work properly based on pen and paper versions but they are time and resource consuming which makes them difficult to implement in small and medium companies where the resources are scarce. The use of computer packages to reduce the paperwork is a very recent technology and, until now, it can be found only in larger food production units.

In the baking industry, the traceability process is very complex due to the diversity of raw-materials used and the large number of different products that a single batch can generate. Therefore, the development of computer application, using a user-friendly interface, specially designed for small and medium food companies, was necessary. PaniGest was created to respond to these needs integrating some legal requirements such as traceability with quality control, production management and HACCP systems. The program has been coded in Visual Basic 6.0 and runs on a personal computer under a Windows 95/98 or Windows 2000/XP system. It uses the most normal resources of the Windows environment to facilitate the interface with the user: mouse actions, pull-down menus, message boxes, grids, etc.

## 2. Materials and Methods

### 2.1. Database Development

A database can be understood as a collection of related files. How those files are related depends on the model used. Early models included the hierarchical model (where files are related in a parent/child manner, with each child file having at most one parent file), and the network model (where files are related as owners and members, except that each member file can have more than one owner). Relational databases offer many advantages over unstructured forms of data storage (Codd, 1970 and Harrington, 2002). Through the use of indices and other optimizing devices, speed gains for searches may be considerable. Moreover, redundancy and therefore storage space are minimized. Also, data is handled by a single computer which is easily backed up and/or mirrored by a second computer (Bradley *et al*, 2004).

Another important advantage of relational databases is the ability to rapidly summarize data with a small number of commands, usually using the structured query language (SQL). With a few of these commands, one rapidly obtains a comprehensive overview of a data set, something that could otherwise take many hours programming. But, perhaps, the most important advantage of relational databases is that they impose a consistent data format (Bradley *et al*, 2004).

The difficulty is in finding a database structure that is abstract enough to be applicable to any type of industry and, at the same time, specific enough to contain the data with sufficient structure. The relational database model was a huge step forward, because in order to relate any two files or records, they simply need to

have a common field, which makes the model extremely flexible. The relational database model, being a table-based structure, naturally groups data conditions according to type or product. For example, there might be tables containing lists of products, raw-materials, users, formulations and quality control data. One or more additional tables would store production data, and a final table would serve as a hub linking production data to product and raw-material data. By means of cross references, the complete traceability of raw-materials to final clients as well as users actions associated with any production could be derived from the database, without reference to external sources.

In order to develop a database that records all the relevant information to achieve total traceability of the product, a typical production chain had to be observed taking into account all the critical records and product stages. Figure 1 presents the result of the study made on the production chain that was used to develop the database.

According to that study the traditional baking industry produces a very large number of different final products (bread and cakes), ready to be sold, based on the same batch of ingredients. This process becomes even more complex when more than one of those batches is made during the day.

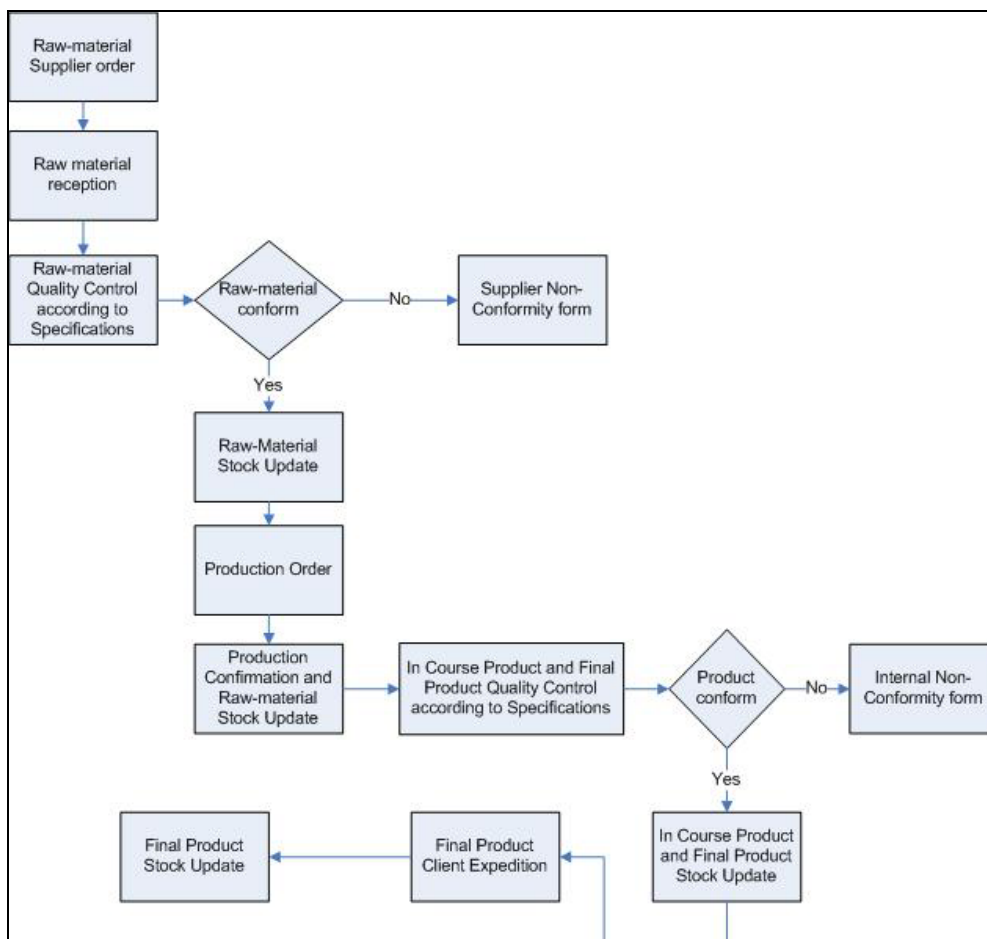
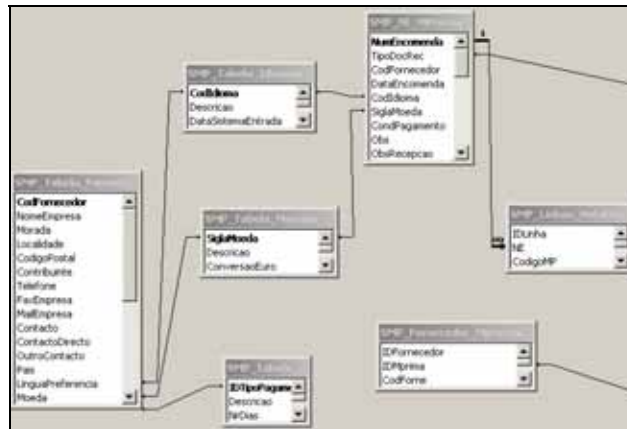


Fig. 1. Process flowchart.

The developed database is a relational database. Figure 2 exemplifies some of the multiple relationships between tables in the developed database.



**Fig. 2.** Database relationships.

For example, the field “NumEncomenda” in “SMP\_NE\_Mprimas” table is related with the field “NE” at “SMP\_Linhas\_NotaEnc...” table. In this particular example, the first table should hold suppliers order data and the second table records the multiple lines of the supplier order. The type of relationship is a one-to-many relationship because a supplier order could have multiple lines of different products.

Initially the database was developed in Microsoft Access and then was updated to SQL Server. The Access version of the application was maintained in order to reach clients that are unable to install in their units an SQL Server.

## 2.2. Interface Development

In order to provide a user-friendly computer program package, this application was developed in Visual Basic 6.0™ by Microsoft® using the Microsoft® Windows® operating system (e.g. Windows 95/98 or Windows 2000/XP). Visual Basic is a productive tool for creating fast business solutions for Windows and the Web. A comprehensive, rapid application development environment, Visual Basic helps developers quickly create and deploy client/server applications, and program easily for the Internet using familiar Visual Basic programming tools and techniques.

The application uses common know ActiveX controls and some Dynamic Link Library (DLL) from Microsoft. All other DLL’s were developed by the authors.

## 2.3. Error Handling

A major concern in software development is the error treatment and handling. PaniGest error handling concerned two major types of errors: the common and usual user errors (e.g. typing letters in instead of numbers) and the database operations errors. For the database operations errors the transaction methodology was used. Being so, in any database operation, like inserts, updates and deletes, the program executes all the code and then verifies if an error has occurred; if there are no errors, the transaction is committed, otherwise it is rolled back. The main advantage of this methodology is that it assures data integrity.

Another important measure to control errors is the implementation of an error sub-routine in any user action. If an error occurs a message to the user is generated. In background, the application records the occurred error in the database table for future analysis and correction.

## 2.4. Outputs

Considering the application of this computer package to Food Safety Managements Systems it was fundamental the development of easy-to-read output documents or pre-defined reports. Seagate Crystal Reports was used to develop all the output documents. To access the database, Seagate Crystal Reports uses an Open Database Connectivity (ODBC) connection. ODBC is a widely accepted application programming interface (API) for database access. It is based on the Call-Level Interface (CLI) specifications from X/Open and ISO/IEC for database APIs and uses Structured Query Language (SQL) as its database access language.

## 3. PaniGest<sup>®</sup>

Applying the tools and techniques from Visual Basic to deploy this application, PaniGest main features are: to register quality control parameters of raw materials, in-course and final products; to manage reception, production and expedition orders; to analyze production costs, productivity, raw materials and product's consumptions; to define and print labels containing lot information and other relevant data; to implement traceability back and forward in the food chain (from raw materials to final client).

In order to maintain total traceability (back and forward) different types of internal lots were implemented (auto-numbers): the internal lot for raw-material; the lot of finished products and the daily production reference. The use of these auto-numbers (internal lots) will be explained further in the text.

### 3.1. The main form

Within an organization with a defined hierarchy related to quality management or HACCP systems, there are different responsibilities related to filling down registries or validate them; release orders, recall procedures and so on. Being so, the software was developed using user-level authentications (Figure 3). After entering the referenced user name and password, the software does a database query to load the user permissions and validate the user log in. One of the developed DLL was used to automatically import user and computer name from a Windows Operating System. This DLL is of extreme importance not only because it limits access to the users but also because it can be used as a "signature" to determine responsibilities.

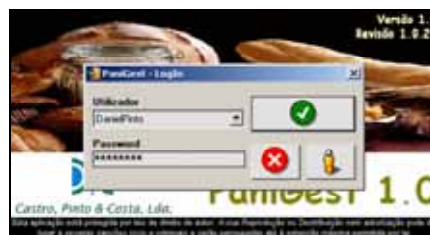


Fig. 3. User log-in.

After the user log-in, the main form (Figure 4) contains a lateral menu with the different sections of the computer package: Raw-materials; Production; Quality Control; Finish Product; Clients Definitions; Tables; Utilities; Lists and Software Configuration. It can also opens a “Status Form” showing the actual status of suppliers orders, production orders, raw-materials expiration dates and current stocks.

Inside each main menu sections there are sub-menus opening inside the main form (MDI form). This type of construction allows the left menu to be always available.



Fig. 4. Main form.

### 3.2. Raw-materials Section

This section is used to execute supplier's orders, reception of raw-materials and raw-materials stock control.

Specifications of raw-materials are extremely relevant to HACCP systems so the application is prepared to fill raw-materials forms. In this form all the relevant data namely microbiological and organoleptic data is recorded as well as acceptance/ rejection criteria. Moreover, suppliers' information, different suppliers for the same raw-material, costs, average costs, minimum and maximum stocks are also defined under this section.

Perhaps the most important feature of this section is the raw-material reception (Figure 5). This is made automatically by the attribution of a sequential number by supplier lot (first internal lot – auto number). To easily guarantee the raw-materials traceability it is advisable to attribute a new number (auto-number) for each supplier lot even if it corresponds to the same delivery (order form). Furthermore, this sequential number will be used to maintain traceability and stocks.

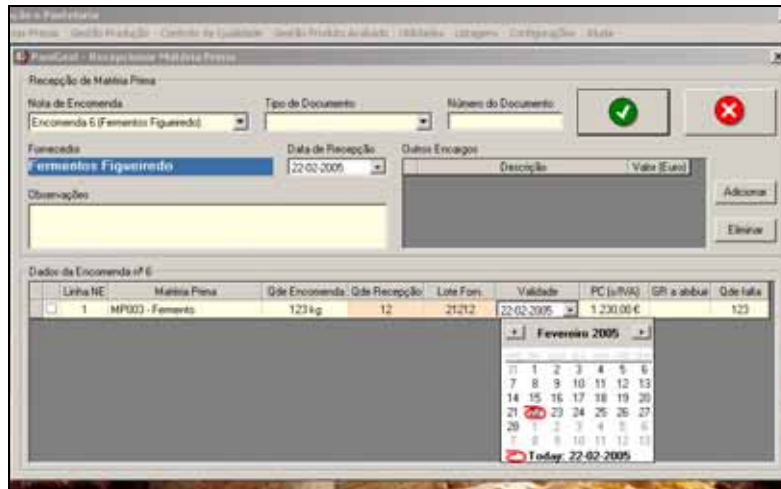


Fig. 5. Example of a raw-material reception.

### 3.3. Production Section

Another important step to food safety systems and production management is to define internal specifications for the products. Forms to on-course and final products are available in this section, including the insertion of products formulations.

The production orders (Figure 6) automatically indicate the raw-materials type, quantity and suggests the raw-material internal lot to be used as well as defines the lot number (auto-number). The suggestion of the internal lot is made by a very complex algorithm that calculates raw-materials distribution according to FIFO (First in – First out). If there are not enough raw-materials an error message will appear. The production order is a printable output used by the production section as a registry (Figure 7).

The production manager should write down in the referenced paper form the exact quantity of the used raw-materials and the correct internal lot. The lot number of a final product consists of two different parts identifying the production date (code 1) and the product code (code 2), respectively. If more then one batch of a given product is produced in the same day the lots will be identified sequentially (20050225 BREAD1, 20050225BREAD2, for example). The lot codification is defined by the company.

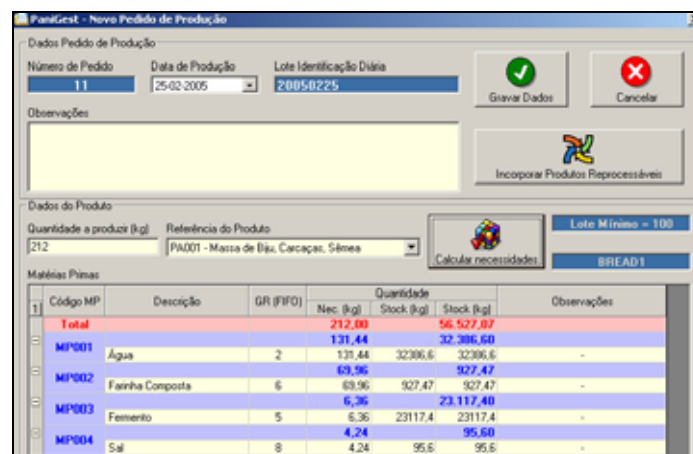


Fig. 6. Example of a production order.

PaniGest is also prepared to incorporate re-worked products (e.g. leftovers from the previous day) in a production order. This option allows tracing back re-worked products.



Pedido de Produção		17-02-2005			
Referência: PA001	Descrição:				
Lote: 20060217	Quantidade Prevista: 100,00 kg				
Lote Diário: 01.JU02	Utilizador: Daniel Pinto				
Observações pedido: -					
Formulação Matérias Primas					
Código MP	Descrição	Quantidade (kg)	GR	GR Utilizada	Quantidade gasta (kg)
MP001	Água	6200	2		
MP002	Fosfato Complexo	35,00	6		
MP003	Fosfato	3,00	6		
MP004	Sau	2,00	8		
Produtos Reprocessáveis					
Referência	Descrição	Qde (kg)	Lote - Lote Diário Reprocessável		

Fig. 7. Pre-defined report output for Production Order.

### 3.4. Quality Control Section

The application is prepared to generate and control all the data and documents that a Quality Control Department involves. The main goal of this section is to document quality control operations namely acceptance/ rejection decisions, release procedures, printing technical analysis bulletins, among others. The quality control is made according to the specifications that were inserted at the same time that the user inserts a new raw-material or product. A security measure was implemented: there is only stock movement and updates when the quality control result is conform. The program suggests the result of a quality control analysis by direct comparison with specifications or expiration date. However, an authorized user can re-analyze the raw-materials or products making them available again to production/release.

If there is a non-conformance, a non-conformance form (internal or to the supplier) is generated and printed.

Several types of specifications (e.g. microbiological, visual analysis, physical-chemical) can be used, according to the specific product to analyze. These types of specifications are defined in this section but the value for each product is inserted in other section, when the raw-material or product form need to be inserted. If a specification is numeric, the value and tolerance interval must be inserted.

Traceability is, perhaps, the most important feature of the application and runs as a sub-section of quality control. Two types of traceability queries can be made: traceability to final products (Figure 8) and traceability of raw-materials.



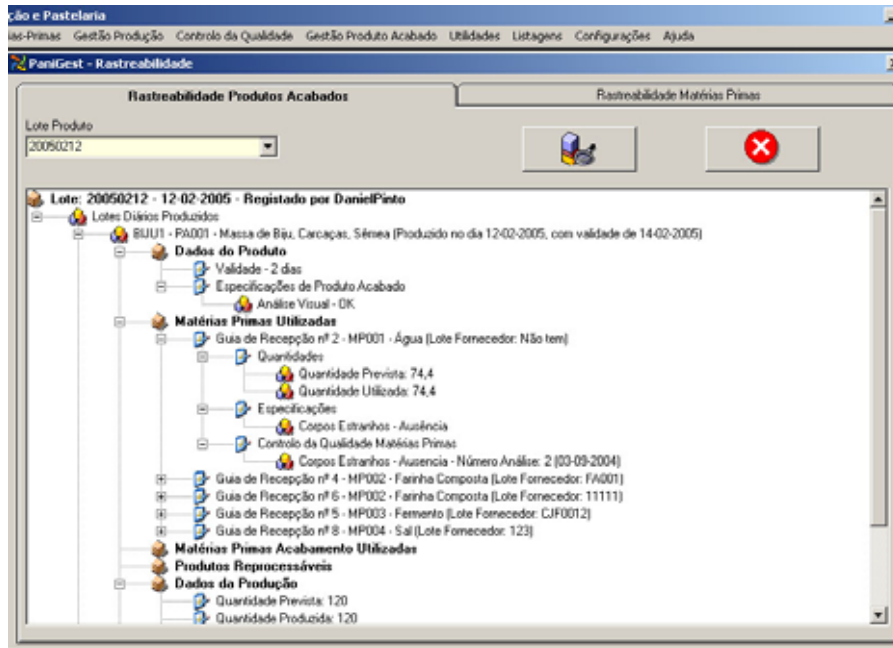


Fig. 8. Traceability form example

In the first case, the user inputs the final lot of the product (code 1 or code 1 plus code 2) and all the information of traceability is displayed in a tree form (Figure 8). The displayed information (for code 1 input) is distributed by the following sections: the daily production references; the product and production data, specifications and quality control results; the raw-materials (and lots) that were used in the production; the quantity of each raw-material that was used; the specifications and quality control results of each used raw-material; the finishing, if applicable, raw-materials used; in-course products used; the re-worked products that were used and those who have been generated within this production. It is also possible to trace if the product was released and sold and if so who was(were) the client(s) it was sold to. If the user inputs a raw-material lot the finished products lots where that particular raw-material was used are displayed.

Recall procedures have to be made concerning two major objectives: to minimize the economical losses and to guarantee safety. Being so, the more specific the records are, the fewer products need to be recalled. However, this has to be done as quickly as possible. Using PaniGest, it is just a matter of seconds to find out where the product is and to segregate it or to recall it.

### 3.5. Final Product

In this section, the final product stocks can be queried and expeditions made. The expedition can be made either to single clients or to pre-defined routes (very common in baking industry). A pre-defined route consists of a group of clients, usually in the same geographical location, with custom orders. If this is the case, the user inserts the route at the client definition section and at the expedition moment, the program, once again, suggests the lots of product and the user just has to confirm the lots and the quantity.

### 3.6. Client Definitions

In this section it is possible to introduce clients (and relevant associated data) and also to define custom orders *per* client and expedition routes. The optimization of routes considering delivery time and cost reduction considering client location is also under development.

### 3.7. Other Sections

Under Tables section, useful information can be stored which will be used by other sections. Some examples are payment conditions; type of documents; VAT taxes; languages; types of currency and measure units. The Utilities section is used to activate, inactivate or re-activate clients, suppliers, raw-materials and products.

## 3. Conclusions

PaniGest is very user friendly (runs under a common Microsoft Windows environment) because it is designed to meet the needs of the food industry, specifically baking industries, merging production management, food safety management systems with regulatory requirements.

PaniGest is currently under testing in several Portuguese baking industries. The main advantages of this application are: it allows implementing traceability in the food (baking) industry without too many paperwork and consequently a large number of resources; it facilitates recall procedures with economical and safety benefits.

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## Acknowledgments

The authors gratefully acknowledge to “Fundação para a Ciência e a Tecnologia” by the scholarship SFRH / BDE / 15509 / 2004 to author Pinto, D.B.