Integrating Experimental Data and Expert Knowledge to Capture the Impact of Food Processing on the Quality of End Products

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Abstract. Past years research has produced an important amount of information concerning the impact of food processing on the nutritional, organoleptic and sanitary quality of end products, leading to a need for information integration so as to synthesize information in an operational way for decision-making purposes. This paper presents an approach for experimental data and expert knowledge integration, applied to durum wheat processing.
Keywords: information integration, decision-making, heterogeneous data, expert knowledge, food quality, food processing, durum wheat.

Introduction. Durum wheat processing is now relatively well-studied and considered as sufficiently well-known to allow knowledge integration on the whole process, in order to adapt the unit operations that compose the process to enhance the quality of end products. This issue is all the more essential since durum wheat products such as pasta are very widely and commonly consumed, therefore they should have a significant part to play in food-related public health solutions. Information to integrate come from various sources.

Two heterogeneous levels of information. Available knowledge is provided by:
1. **scientific publications** that bring a great amount of experimental data. A relational database and its associated graphical user interface have been implemented and allow, on the one hand, experts to enter experimental data and, on the other hand, industrials and scientists to consult and exploit the data. These data come from scientific publications and describe the impact of unit operations on nutritional, organoleptic, or sanitary characteristics of durum wheat products (vitamin content, …). See (Buche et al., 2003) for a similar approach in predictive microbiology;
2. **expert statements** that may be translated as rules. Besides experimental results registered in the database, expert rules consist in synthetic information that describe general known impact tendencies without taking into account all possible detailed cases. For several reasons (graphical representation of a logic-based formalism, ontology that allows one to include taxonomical information, management of rules, …), the formalism chosen to represent expert statements is the conceptual graph model (Sowa, 1984; Salvat et al., 1996), an artificial intelligence formalism of the semantic networks family. An example is given in Figure 1.

Detecting exceptions to expert knowledge. The experimental data of the database are, *a priori*, expected to verify the expert rules. Using an original mapping between the conceptual graph and the relational database formalisms, the system establishes a communication between both information levels (related points are considered in Buche et al., 2000). It is thus able to detect exceptions to expert rules, and to indicate a percentage of validity of a rule. E.g. for the rule represented in Figure 1, the validity test provides the following information:
"The rule is valid at 97.5 %. 158 cases illustrate this rule, including 154 which verify it".
The exceptions are shown in Figure 2. Expert rule exceptions can used in two ways: firstly, to control data validity; secondly, to determine cases where there is a lack of knowledge.

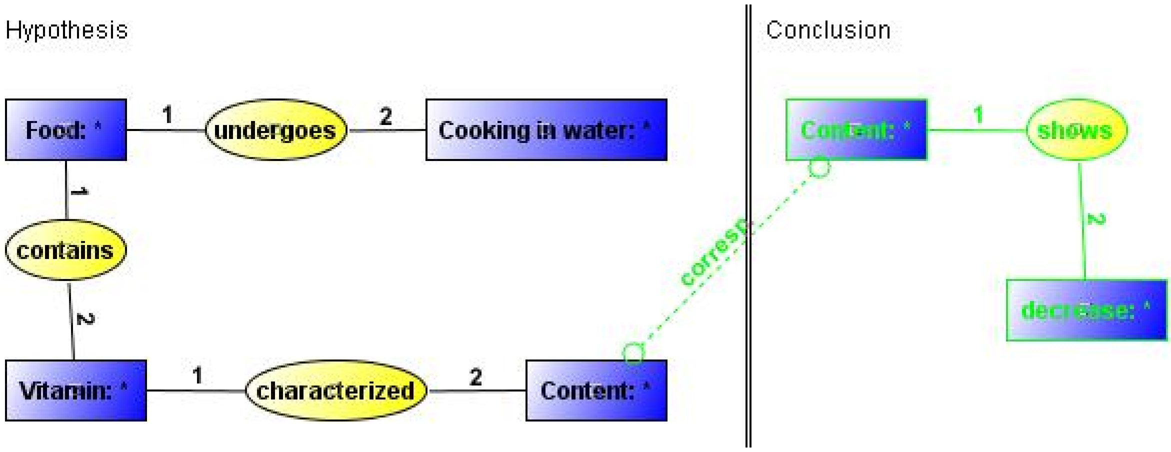

Figure 1: Conceptual graph representation of the rule « When a food product is cooked in water, its vitamin content decreases ». The CoGui user interface was used (CoGui, 2006).

Cooking in water x Vitamin Content Decrease
RULE EXCEPTIONS

Food	Parameters of the unit operation				Interactions with prior unit operations	Results				Reference
	Temperature(°C)	% of salt in water(%)	Time(mn)	Kind of water()		Name of the component	Percentage		Kind of result	
							Value	Standard deviation		
Pasta	100	Undefined	20	Undefined	Yes	Vitamin A	4%		increase	Parrish, D. B. et al.,1980
Pasta	100	Undefined	20	Undefined	Yes	Vitamin A	8%		increase	Parrish, D. B. et al.,1980
Pasta	100	Undefined	20	Undefined	Yes	Vitamin A	8%		increase	Parrish, D. B. et al.,1980

Figure 2: Database results that are exceptions to the rule of Figure 1.

Perspectives. The next step is a (semi-)automated rule refinement mechanism: when a deficience of an expert rule is detected, the system will test several transformations of this rule. These transformations can be computed as graph specializations and substitutions on the concerned conceptual graph rule. For instance, a refinement of the rule given in Figure 1 could be the following: « When a food product is cooked in water, its *hydrosoluble vitamin* content decreases ». This process should gradually lead to reformulated and more stable rules and to a more reliable operational system.

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