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An artificial intelligence-based approach to deal with argumentation applied to food quality in a public health policy

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ABSTRACT

Argumentation is a relatively new research area in Artificial Intelligence. Since the early 1980s, its use has been investigated in various frameworks. We propose a general model for recommendation-based argumentation by extending Dung's seminal argumentation system. This approach is applied to analyse argumentation on food quality in a public health policy. Cereal products, and more specifically bread, are used by decision makers as a healthy lever to fight against diseases such as obesity or diabetes. Our model outputs new recommendations based on stakeholder's argumentation by targeting some specific audiences.

1. Introduction

Food quality assessment is a highly complex procedure since it relies on numerous criteria which are classically grouped into four main types of characteristics: nutritional, sensorial, service or practicity and sanitary quality. These can be supplemented by other emerging concerns such as environmental quality, economic quality, etc. However, all of these aspects of quality and their various components are not always compatible and their simultaneous improvement is a problem that has no simple solution.

Thus the consumption of whole wheat cereal products, although beneficial from a nutritional point of view due to the micro-nutrients and the fibers they provide, raises the question of the risk of contamination, by pesticides and other contaminants. By choosing organic products or trusting regulations, can one sacrifice everything for safety and health with the risk of under-evaluating sensorial pleasure? This is a dilemma for consumers, but it also concerns agri-food chain stakeholders and decision makers.

A tradeoff between nutritional, organoleptic and sanitary quality has been built in an empirical way within agri-food chains, with progressive control of transformation processes. With the emergence of new concerns and requests, it is now necessary to re-position this tradeoff within a new balance, which especially gives greater importance to nutritional aspects. Public health programs, such as the PNNS (Programme National Nutrition Santé) which started in France in 2001, strives to cope with increasingly common diseases in Western societies (cardiovascular diseases, cancers, obesity, etc.). Consumers are becoming more receptive to these new problems and new tools are needed to meet emerging needs by adapting, innovating, optimizing decision schemes within agri-food chains.

The importance attached to the different involved criteria varies among several stakeholders. Thus the experts may evaluate a risk level due to a contaminant as perfectly acceptable in comparison with the benefit it provides (e.g. for a phytosanitary product) or in comparison to the cost of additional precautions which may not be very efficient (e.g. for mycotoxins), whereas consumers may not accept an even low food risk. The underlying scientific questioning is as follows:

- What kind of representation model is suitable for taking these contradictory points of view into account?
- How can the priorities of the different involved stakeholders and the relative importance they attach to the considered criteria be taken into account?
- Can there be different audiences representative of consumer segments?
- How can the raised conflicts be solved so as to achieve a tradeoff within an automated decision-making aid system?

This paper proposes an artificial intelligence-based approach to allow the formalization of available knowledge as elements for decision-making, including "implicit" expertise and not only analytical data which are more classically used, as well as decision-

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making through the development of a model that highlights and proposes solutions to conflicts between contradictory knowledge. The proposed approach is based on an argumentative decision system. Argumentative systems reflect how human argumentation uses conflicting information to construct and analyse arguments. They involve identifying arguments and counterarguments relevant to a given concern.

Within existing approaches, note that methods based on the comparison of risk functions, of numerical type, are not applicable here, since the project mainly relies on the formalization of highly qualitative implicit expert knowledge. Classical multi-criteria decision-making, based on the evaluation of several possible decision options on the basis of a set of criteria, is also unsuitable since it relies on the optimization of a set of objective criteria and does not allow for the representation of contradictory viewpoints and debate considerations. More precisions and syntheses on existing decision methods can be found, e.g. in Figueira, Greco, and Ehrgott (2005) and Bouyssou, Dubois, Pirlot, and Prade (2009).

At present, the closest approaches to decision-making in the presence of contradictory points of view are studies that deal with argumentative reasoning (Besnard & Hunter, 2008; Rahwan & Simari, 2009). Argumentative reasoning was first studied for its ability to understand situations where information are incoherent because they come from several sources or correspond to several points of view that possibly have different priority levels. It also appears to play an important part in decision tasks, where pros and cons have to be balanced on the basis of available knowledge. Decision and argumentation issues have been studied separately, with different objectives. Very few studies deal with the advantages of argumentative methods as explanation elements for decision support (Amgoud & Prade, 2009a), which is the question considered here.

The present paper proposes two contributions. Firstly, the paper presents an analysis of a case study concerning risk/benefit evaluation within the wheat to bread chain, according to recommendations for more whole-grain products given by the PNNS public health policy in France. Indeed, this recommendation has to cope with different viewpoints and strong reserves on behalf of the concerned wheat processing stakeholders. This case study relies on the analysis of various knowledge sources: scientific articles, technical documents, interviews, conferences and debates. Secondly, the paper proposes a formal and generic argumentation model for the representation and evaluation of such a case study, which is also suitable for other application domains. This model is a refinement and a practical application of the method presented by Bourguet, Amgoud, and Thomopoulos (2010).

2. Materials and methods

This section describes the successive steps used to run the proposed methodology: the identification of available information sources Section 2.1, the modeling of arguments Section 2.2 and the principle of argumentation systems Section 2.3.

2.1. Identification and analysis of information sources

Several kinds of information sources were used in this study. They include, from the most to the least formal ones:

1. scientific peer-reviewed articles;
2. technical reports or information published on websites;
3. scientific conferences and research project meetings;
4. expert knowledge obtained through interviews.

For the considered case study concerning the position of the bread chain regarding the PNNS recommendations, we used the following sources.

The scientific peer-reviewed articles we analyzed include Bourre et al. (2008), Slavin and Green (2007), Dubuisson-Quellier (2006) and Ginon, Lohérac, Martin, Combris, and Issanchou (2009). Bourre et al. (2008) compare different types of flours from a nutritional standpoint. Slavin and Green (2007) study the link between fibers and satiety. Dubuisson-Quellier (2006) and Ginon et al. (2009) deal with consumption behavior and consumers' acceptance to pay, especially concerning French baguettes, when fiber information is provided, based on experimental and statistical studies of consumer panels.

We also analyzed several scientific conference proceedings, and examined numerous technical reports available on official websites concerning the PNNS public health policy (PNNS (statutory documents), 2005; PNNS, 2005), the Healthgrain European project concerning the improvement of nutrition and health benefits through cereal grains (Dean et al., 2007; HEALTHGRAIN, 2009), French projects and symposiums concerning sanitary, nutritional, sensorial and technological qualities of breads (AQUANUP, 2009; CADINNO, 2008; DINABIO, 2008; FCN, 2009).

Finally, several interviews were conducted to collect expert knowledge from domain specialists covering various aspects of the bread chain, from health and organoleptic concerns to millers' and bakers' technological or economic concerns.

2.2. Modeling available information into structured arguments

Starting from the above information sources, the modeling task is an iterative task where arguments are firstly collected from different stakeholders, formalized, then validated by experts from different fields.

From PNNS public health policy motivations, seminal purposes are first considered as "reasons" that justify arguments. The first step of argument modeling is thus to extract a reason (denoted `Reason`).

Case study. Reason extraction. "Considering nutrition as a determinant lever for health, one nutritional priority is to increase the daily consumption of carbohydrates, promoting the consumption of starch based food allowing to increase fiber intake." From this sentence, the general reason of Table 1 can be extracted.

This general reason can be refined into more specific reasons that directly support actions. Consequently, in this case study, an argument is considered as a reason supporting a decision, a recommendation or more generally an action (denoted `Action`).

Case study cont. Supported action. "Bread is selected in this program as a food source for daily intake of fibers. Increasing the flour yield (↗ F.Y) results in a higher fiber content in the flour and consequently in the bread. For these reasons, PNNS consider the possibility of an evolution of common bread legislation in order to increase the fiber content in bread." From these sentences, we extract a specific reason that supports an action, as shown in Table 2.

Table 1
Reason.

Reason
"Increasing the fiber content in the diet is relevant"

Table 2
Reason supports an action.

	Reason	Action
1	"The flour extraction rate is measured by the mineral content, fiber increase in correlation with this rate"	↗ F.Y