



# Decision support for agri-food chains: A reverse engineering argumentation-based approach



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## ABSTRACT

Evaluating food quality is a complex process since it relies on numerous criteria historically grouped into four main types: nutritional, sensorial, practical and hygienic qualities. They may be completed by other emerging preoccupations such as the environmental impact, economic phenomena, etc. However, all these aspects of quality and their various components are not always compatible and their simultaneous improvement is a problem that sometimes has no obvious solution, which corresponds to a real issue for decision making. This paper proposes a decision support method guided by the objectives defined for the end products of an agrifood chain. It is materialised by a backward chaining approach based on argumentation.

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## 1. Introduction

In agrifood chains, the products traditionally go through the intermediate stages of processing, storage, transport, and packaging, and reach the consumer (the demand) from the producer (the supply). More recently, due to an increase in quality constraints, several parties are involved in production process, such as consumers, industrials, health and sanitary authorities, etc. expressing their requirements on the final product as different point of views which could be conflicting. The notion of reverse engineering control, in which the demand (and not the supply) sets the specifications of desired products and it is up to the supply to adapt and find its ways to respond, can be considered in this case.

In this article, we discuss two aspects of this problem. First, we accept the idea that specifications cannot be established and several complementary points of view – possibly contradictory – can be expressed (nutritional, environmental, taste, etc.). We then need to assess their compatibility (or incompatibility) and identify solutions satisfying a maximum set of viewpoints. To this end we propose a logical

framework based on argumentation and introduce a method of decision making based on backward chaining for the bread industry.

Since a joint argumentation–decision support approach is highly relevant to the food sector (Thomopoulos et al., 2009), the contribution of the paper is twofold. First we present a real use case of an argumentation process in the agrifood domain. Second we introduce the notion of viewpoint/goal in this setting based on the notion of backward chaining reasoning and show how to use those techniques in a concrete application.

The main alternative method to deal with the problem is the multicriteria decision approach. However multicriteria decision aims at evaluating several alternative options, whereas argumentation-based decision focuses on whether several options make sense together, which is a different perspective, addressed in this paper. Moreover, multicriteria decision is not connected to the backward chaining procedure as the argumentative approach is, by construction of the arguments, as will be explained in Section 5.2.

In Section 2, we introduce the real scenario considered in the application. In Section 3, we motivate our technical and modelling choices. In Section 4, the developed approach is introduced. It relies on an instantiation of a logic based argumentation framework based on a specific fragment of first order logic. In Section 5, we explain the technical results that ensure the soundness and completeness of our agronomy application method. In Section 6, some evaluation results are presented. Finally, Section 7 concludes the paper.

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## 2. Scenario

The case of study considered in this paper relates to the debate around the change of ash content in flour used for common French bread. Various actors of the agronomy sector are concerned, in particular the Ministry for Health through its recommendations within the framework of the PNNS (“National Program for Nutrition and Health”), the millers, the bakers, the nutritionists and the consumers.

The PNNS recommends to privilege the whole-grain cereal products and in particular to pass to a common bread of T80 type, i.e. made with flour containing an ash content (mineral matter rate) of 0.8%, instead of the type T65 (0.65% of mineral matter) currently used. Increasing the ash content comes down to using a more complete flour, since mineral matter is concentrated in the peripheral layers of the wheat grain, as well as a good amount of components of nutritional interest (vitamins, fibres). However, the peripheral layers of the grain are also exposed to the phytosanitary products, which do not make them advisable from a health point of view, unless one uses organic flour.

Other arguments (and of various nature) are in favour or discredit whole-grain bread. From an organoleptic point of view for example, the bread loses out in its “being crusty”. From a nutritional point of view, the argument according to which the fibres are beneficial for health is discussed, some fibres could irritate the digestive system. From an economic point of view, the bakers fear selling less bread, because whole-grain bread increases satiety – which is beneficial from a nutritional point of view, for the regulation of the appetite and the fight against food imbalances and pathologies. However whole-grain bread requires also less flour and more water for its production, thus reducing the cost. The millers also fear a decrease in the quality of the technical methods used in the flour production.

Beyond the polemic on the choice between two alternatives (T65 or T80), one can take the debate further by distinguishing the various points of view concerned, identifying the desirable target characteristics, estimating the means of reaching that point. The contribution of this paper is showing how using argumentation can help towards such practical goals.

## 3. Motivation

In this paper we will elicit the points of view and the desirable target characteristics by the means of interviews with agronomy experts. Once the target characteristics are identified, finding the means of reaching them will be done automatically by a combination of reverse engineering and argumentation. The reverse engineering will be used in order to find the complete set of actions to take towards a given characteristic, for all characteristics. In certain cases the actions to take will be inconsistent. Argumentation will then be employed in order to identify actions that can be accepted together.

### 3.1. Reverse engineering

While reverse engineering has been widely employed in other Computer Science domains such as multi agent systems or requirements engineering (e.g. Brunelière et al., 2014), it is quite a novel methodology when applied in agronomy. In agrifood chains, the products traditionally go through the intermediate stages of processing, storing, transporting, and packaging and reach the consumer (the demand) from the producer (the supply). It is only recently, due to an increase in quality constraints, that the notion of reverse engineering control has emerged (Perrot et al., 2011). In this case the demand (and not the supply) sets the specifications of desired products and it is up to the supply to adapt and find its ways to respond. In what follows, starting from the desired target criteria for the final product, the methods allowing one to identify ways to achieve these criteria (by intervention on the various stages of the supply chain) are named “reverse engineering”.

Reverse engineering is known to be challenging from a methodological viewpoint. This is due to two main aspects. First, is the difficulty of defining the specifications for the expected finished product. The desired quality criteria are multiple, questionable, and not necessarily compatible. The next difficulty lies in the fact that the impact of different steps of food processing and their order is not completely known. Some steps are more studied than others, several successive steps can have opposite effects (or unknown effects), and the target criteria may be outside of the characteristics of products. Second, reconciling different viewpoints involved in the food sector still raises unaddressed questions. The problem does not simply consist in addressing a multi-criteria optimisation problem (Bouyssou et al., 2009): the domain experts would need to be able to justify why a certain decision (or set of possible decisions) is taken.

### 3.2. Argumentation

Argumentation is a reasoning model based on the construction and the evaluation of interacting arguments. It has been applied to nonmonotonic reasoning, decision making, or for modelling different types of dialogues including negotiation. Most of the models developed for these applications are grounded on the abstract argumentation framework proposed by Dung (1995). This framework consists of a set of arguments and a binary relation on that set, expressing conflicts among arguments. An argument gives a reason for believing a claim, for doing an action.

Argumentation theory in general (Besnard and Hunter, 2008; Dung, 1995; Rahwan and Simari, 2009) is actively pursued in the literature. Some approaches combine argumentation and multi criteria decision making (Amgoud and Prade, 2009).

Value based Argumentation Frameworks (Bench-Capon, 2003) have been proposed, where the strength of an argument corresponds to the values it promotes. What we call viewpoint later on in this paper would then correspond to the notion of audience in such setting. Although intuitive, this approach is not adapted in the case of the considered application. Here a value can be “split” into several audiences: there could be contradictory goals even from the same viewpoint. The notion of viewpoint and goals introduced in this setting also remind those proposed by Assaghir et al. (2011).

#### 3.2.1. Logic-based argumentation

In this paper we present a methodology combining reverse engineering and logical based argumentation for selecting the actions to take towards the agronomy application at hand. The logical instantiation language is a subset of first order logic denoted in this paper *SRC* equivalent to Datalog + – (Cali et al., 2010), Conceptual Graphs or Description Logics (more precisely the  $\mathcal{EL}$  fragment (Baader et al., 2005) and DL-Lite families (Calvanese et al., 2007)). All above mentioned languages are logically equivalent in terms of representation or reasoning power. The reason why this application is using *SRC* is the graph based representation proper to *SRC* (and not to the other languages). This graph based representation (implemented in the Cogui tool (Chein and Mugnier, 2009; Chein et al., 2013)) makes the language suitable for interacting with non computing experts (Chein et al., 2013).

Here we use the instantiation of Croitoru and Vesic (2013) for defining what an argument and an attack are. While other approaches such as García and Simari (2004), Besnard and Hunter (2005) and Muller and Hunter (2012) address first order logic based argumentation, the work of Croitoru and Vesic (2013) uses the same *SRC* syntax and graph reasoning foundations. In Fig. 1 the visual interface of Cogui is depicted: knowledge is represented as a graph which is enriched dynamically by rule application. More on the visual appeal of Cogui for knowledge representation and reasoning can be found in Chein et al. (2013).

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