1 Choice of environment-friendly food packagings
2 through argumentation systems and preferences

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13 **Abstract**

14 Food packaging plays a crucial part in the post-harvest environmental im-
15 pact of fresh foods. Packaging is usually wrongly considered as additional
16 economical and environmental costs. However, by minimizing food waste
17 and losses, it could significantly contribute to decrease the overall environ-
18 mental impact of the food itself. A good balance between environmental
19 burden (resource consumption and additional waste management issues) and
20 real benefit in usage condition (reduction of food losses) should be thus de-
21 fined when dimensioning a packaging for a given application. Beyond food
22 waste and environmental impact reduction, various kinds of considerations
23 about packaging, sometimes conflicting, are generally expressed by the stake-
24 holders (food and packaging industries, health authorities, consumers, waste
25 management authority, etc.) related to safety, practicality, perceptions of
26 the packaging material, etc. Therefore, to help the parties deciphering all
27 these arguments, we designed an argumentation-based tool to take into ac-
28 count the conflicting preferences expressed. The requirements concerning

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packagings are modeled by several arguments provided by the stakeholders expressing their viewpoints and expertise. Based on a new attack relation, the argumentation tool computes sets of compatible arguments which are used to rank alternative packagings under debate. In this paper, we present a complete workflow implemented as a software prototype starting by defining a structured representation of experts arguments and poll results, and ending by a ranking of packaging solutions. We show and discuss the results obtained by the software on a use case study (fresh strawberries) to determine the justifiable choices between several packaging materials based on stakeholders' arguments.

Keywords. Food Packaging, Logic-Based Argumentation, Argumentation Tool, Preference Management, Decision Support System.

1. Introduction

We propose a Multi-Criteria Decision Support system (MCDSS) which permits to take into account the points of view of several stakeholders of a food chain about a question under debate. In this paper, we want to be able to choose a packaging solution in a given list of possible alternatives, for a given food to pack. The case study chosen in this paper is fresh strawberries. Stakeholders' opinions (consumers, scientists, manufacturers, etc.) in favor or against specific options are expressed on different criteria (for instance the environmental impact of the packagings). The MCDSS, which implements an argumentation process, must be able to help the manager in charge of

Figure 1: Global insight of the MCDSS.

the decision (for instance, a strawberry producer) to determine a ranked list of the alternative solutions taking into account food chain stakeholders' opinions and preferences expressed on the associated criteria.

For instance, a strawberry producer expresses the need for a new packaging to pack strawberries. The design of this new packaging needs to take into consideration the packaging industry constraints (ability to scale-up the production process, the availability of the raw material, etc.), the waste management administration rules about packaging end of life (biodegradability, recyclability, incineration, burying, etc.) and consumer preferences (trans-

60 parent packaging, environment-friendly packaging, no extra-cost due to pack-
61 aging, etc.).

62 In order to gather consumers' viewpoints, multiple methods can be used:
63 text mining, gathering reviews, etc. We chose to focus on online polls so as
64 to easily gather arguments from a variety of consumers.

65 Stakeholders' opinions are expressed as text arguments. As illustrated in
66 Figure 1, these arguments are the input of the argumentation system which
67 distinguishes for each option (wood packaging, open plastic packaging, etc.)
68 the reasons leading to its acceptance or its rejection. Then, the argumen-
69 tation system detects the conflicts among the arguments and computes the
70 sets of coherent arguments which defend themselves against contradicting
71 arguments. After that, it ranks the packaging solutions under debate using
72 a given prioritization of the requirements.

73 Thus, packagings have to be selected according to several aspects or crite-
74 ria (food conservation, shock protection, packaging end of life management,
75 etc.) highlighted by arguments expressed by the stakeholders involved in
76 the project. The problem at hand does not simply consist in addressing a
77 multi-criteria optimization problem Bouyssou et al. (2009), since we want
78 the MCDSS to be able to justify why certain packagings are chosen. To this
79 aim, we use argumentation theory Dung (1995); Besnard and Hunter (2008);
80 Rahwan and Simari (2009), in which some approaches combine argumenta-
81 tion and multi-criteria decision making such as Amgoud and Prade (2009)
82 or recently Delhomme et al. (2017).

83 This paper details how arguments are modeled within a structured argu-
84 mentation system and how the delivered justified conclusions can be used in
85 the packaging ranking process. It extends the first stage presented in Yun
86 et al. (2016) with several new contributions: (i) beside textual arguments,
87 survey results are now integrated as a possible knowledge source; (ii) this
88 raises a scaling-up issue, since high data volumes now have to be managed
89 and automatically analyzed; (iii) the reasoning process, which was based on
90 the computation of several coherent viewpoints, is now able to rank them
91 using a prioritization of criteria.

92 The main contributions of the work are the following:

- 93 1. A MCDSS based on an argumentation system (*AS*). Arguments may
94 be either manually entered or automatically generated from a set of
95 responses to a given web survey.
- 96 2. A MCDSS designed to allow the ranking of packaging alternative solu-
97 tions using the consensual sets of arguments (called extensions) com-
98 puted by the argumentation system and a prioritization of require-
99 ments.
- 100 3. An evaluation of the MCDSS tool, based on the strawberry case study,
101 in the framework of the Pack4Fresh project with an interdisciplinary
102 collaboration between experts of packaging research, consumer behav-
103 ior research, and computer science research.

104 The paper is structured as follows: in Section 2, we present the MCDSS
105 global workflow which implements the desired functionalities expressed by

106 the partners of the Pack4Fresh INRA-CIRAD project which financed this
 107 work. In Section 3, we briefly recall Dung’s argumentation framework, used
 108 to compute extensions (maximal consistent sets of arguments) and we present
 109 the structured argumentation model we use and the way we automatically
 110 generate arguments from a set of answers to a given web survey. In Section
 111 4, we present the model proposed to rank extensions according to a priori-
 112 tization on requirements. Section 5 presents the case study and its results.
 113 Section 6 is dedicated to the implementation of the approach and Section 7
 114 to related works. Finally, Section 8 recalls our contributions and introduces
 115 some perspectives.

116 2. MCDSS workflow overview

117 Figure 2 presents the main tasks of the MCDSS workflow.

Figure 2: MCDSS workflow overview.

- 118 • *Task 1: Argument structuring*: in this task, a textual opinion is encoded
119 into a logic-based structured argument thanks to a dedicated graphical
120 user-friendly interface (GUI).
- 121 • *Task 2: Automatic argument generation*: this task automatically trans-
122 forms some poll's answers into formal arguments made of concepts and
123 rules using the framework described in Section 3.
- 124 • *Task 3: Logical arguments derivation*: Using the framework described
125 in Section 3.2, this task builds all possible arguments by a derivation
126 process.
- 127 • *Task 4: Attacks detection*: According to the definition of attacks de-
128 fined in Section 3.2, this task computes an argumentation graph made
129 of arguments (nodes) and attacks (edges).
- 130 • *Task 5: Extensions computation*: This task computes the set of exten-
131 sions, i.e. the subsets of non-conflicting (consistent) arguments which
132 defend themselves from attacking arguments (cf. Section 3.1). To
133 scale up and manage high volumes of arguments from web survey re-
134 sults, connection with the Aspartix platform Dvorak et al. (2011) is
135 performed.
- 136 • *Task 6: Extension rankings*: the computation of extensions delivers one
137 or several extensions. In the case of several extensions, the system uses
138 the prioritization on criteria using the framework described in Section

139 4.1 in order to rank the extensions and to select the top-ranked. Finally,
 140 the selected extension is then used to extract preferences associated
 141 with its arguments.

142 Next section introduces the model we propose for argument formalization
 143 and the way arguments may be automatically generated from a poll.

144 **3. Logic argumentation model and poll-based arguments genera-** 145 **tion**

146 In this section, we recall Dung’s argumentation principles and present an
 147 instantiation of this framework thanks to a logical language, then we show
 148 how arguments are automatically generated from a set of answers to a given
 149 web survey.

150 *3.1. Dung argumentation principles*

151 A Dung’s argumentation framework (AF) Dung (1995) is a tuple $(\mathcal{A}, \mathcal{C})$,
 152 where $\mathcal{C} \subseteq \mathcal{A} \times \mathcal{A}$ is a binary attack relation on the set of arguments $\mathcal{A}$. For
 153 each argument $X \in \mathcal{A}$, X is *acceptable* w.r.t. a set of arguments $\mathcal{E} \subseteq \mathcal{A}$ if
 154 and only if any argument attacking X is attacked by an argument of $\mathcal{E}$. A
 155 set of arguments $\mathcal{E} \subseteq \mathcal{A}$ is *conflict free* if and only if $\forall X, Y \in \mathcal{E}, (X, Y) \notin \mathcal{C}$.
 156 $\mathcal{E}$ is an *admissible extension* if and only if it is conflict-free and $\forall X \in \mathcal{E}$, X is
 157 acceptable w.r.t. $\mathcal{E}$; $\mathcal{E}$ is a *complete extension* if and only if $\mathcal{E}$ is admissible and
 158 $X \in \mathcal{E}$ whenever X is acceptable w.r.t. $\mathcal{E}$; $\mathcal{E}$ is a *preferred extension* if and
 159 only if it is a set inclusion maximal complete extension; $\mathcal{E}$ is the only *grounded*

160 *extension* if and only if it is the set inclusion minimal complete extension;
 161 $\mathcal{E}$ is a *stable extension* if and only if it is preferred and $\forall Y \notin \mathcal{E}, \exists X \in \mathcal{E}$
 162 such that $(X, Y) \in \mathcal{C}$. For a given semantics, the set of extensions of an
 163 argumentation framework is denoted by E .

164 **Example 1.** *Figure 3 illustrates some examples of argumentation graphs,*
 165 *upon which extensions under the Dung’s semantics (admissible, complete,*
 166 *preferred, grounded and stable) are computed (nodes in green color). Note*
 167 *that sub-graphs (b) and (c) illustrate the two preferred extensions in the ar-*
 168 *gumentation graph.*

169 3.2. Logic argumentation model

170 A knowledge base contains the concepts of the considered domain ex-
 171 pressed using a logical language $\mathcal{L}$ (such as propositional logic in this paper),
 172 the alternative choices in debate and two reserved concepts ACC , REJ
 173 referring to the decisions (respectively the *accepted* and *rejected* denomi-
 174 nations) with $\neg ACC = REJ$ and conversely. An argumentation system
 175 $\mathcal{AS} = (\mathcal{L}, \neg, \mathcal{R}_s, \mathcal{R}_d)$ is composed of the logical language $\mathcal{L}$, a negation func-
 176 tion, a set of strict rules $\mathcal{R}_s$ and a set of defeasible rules $\mathcal{R}_d$. A strict sub-
 177 sumption, denoted $\sqsubset$, expresses natural inclusion in the domain, as “*Plastic*
 178 *trays are packagings*”. A defeasible subsumption, denoted $\sqsubseteq$, expresses an
 179 inclusion which is not always true, as “*Plastic packagings can be reusable*”.
 180 A knowledge base in an $\mathcal{AS} = (\mathcal{L}, \neg, \mathcal{R}_s, \mathcal{R}_d)$ is a tuple $(\mathcal{K}, Cr)$ such that

Figure 3: Examples of different Dung semantics.

181 $\mathcal{K} \cup Cr \subseteq \mathcal{L}$, where $\mathcal{K}$ contains the alternative choices in debate and Cr
 182 contains the reasons/criteria that may underlie an argument.

183 An argument A is of the form $\emptyset \sqsubseteq c_0 \sqsubset_1 c_1 \sqsubset_2 c_2^1$, where $\sqsubset_i \in \{\sqsubset, \sqsubseteq\}$,
 184 $c_0 \in \mathcal{K}$, $c_1 \in Cr$, $c_2 \in \{ACC, REJ\}$ and for all $i \in \{1, 2\}$, there exists a
 185 strict (resp. defeasible) rule in $\mathcal{R}_s$ (resp. $\mathcal{R}_d$) of the form $c_{i-1} \sqsubset c_i$ if $\sqsubset_i = \sqsubset$
 186 (resp. $c_{i-1} \sqsubseteq c_i$ if $\sqsubset_i = \sqsubseteq$). We denote by $Choice(A) = c_0$ the alternative

¹The notation $\emptyset \sqsubseteq c_0$ indicates that the alternative c_0 is given and does not necessitate any justification in general.

$\sqsubset$	Strict subsumption
$\sqsubseteq$	Defeasible subsumption
$\sim$	Logical negation

Table 1: Summary of logical symbols used in arguments

concerned by the argument A , $Reason(A) = c_1$ the reason associated with the argument A and $Den(A) = c_2$ the decision associated with the argument A .

We say that an argument A attacks an argument B iff at least one of the two following conditions is satisfied:

- $Choice(A) = Choice(B)$, $Den(A) \neq Den(B)$ and B is of the form $\emptyset \sqsubseteq c_0 \sqsubset_1 c_1 \sqsubseteq c_2$.
- $Choice(A) \neq Choice(B)$, $Den(A) = Den(B) = ACC$ and B is of the form $\emptyset \sqsubseteq c_0 \sqsubset_1 c_1 \sqsubseteq c_2$.

Example 2. We consider the following arguments expressed about biodegradability of packaging materials considered here as one possible alternative of end of life management:

- *Life Cycle Analysis (LCA) results are not in favor of biodegradable materials, regarding their high environmental impact,*
- *Consumers are in favor of biodegradable materials since they help to protect the environment.*

203 We model these arguments by using the proposed logical language as fol-
 204 lows:

- 205 • BP is a concept referring to biodegradable packaging materials,
- 206 • PEV , HIP are concepts referring to packagings which respectively pro-
 207 tect the environment and have a high environmental impact (according
 208 to LCA),
- 209 • ACC , REJ are concepts referring to the decisions (accepted, rejected).

210 The set of rules $\mathcal{R} = \mathcal{R}_s \cup \mathcal{R}_d$ is:

- 211 • $\mathcal{R}_s = \{BP \sqsubset HIP, \neg HIP \sqsubset \neg BP, HIP \sqsubset REJ, \neg REJ \sqsubset \neg HIP\}$
- 212 • $\mathcal{R}_d = \{BP \sqsubseteq PEV, PEV \sqsubseteq ACC\}$

213 Please notice that strict rules are used to model reliable knowledge based on
 214 measured parameters by using well-defined and stated procedures, or expressed
 215 with linguistic terms such as “must”, “shall”, “mandatory”, “important”, etc..
 216 Instead, defeasible rules model knowledge based on empirical observations or
 217 expressed with linguistic terms such as “may”, “can”, “optional”, etc. Here,
 218 the rules involve HIP are considered as strict and those involving PEV are
 219 defeasible.

220 The following structured arguments can be built on the knowledge base
 221 $(\mathcal{K}, Cr)$ with $\mathcal{K} = \{BP\}$ and $Cr = \{HIP, PEV\}$:

- 222 • $A : \emptyset \sqsubseteq BP \sqsubset HIP \sqsubset REJ$

223 • $B : \emptyset \in BP \in PEV \in ACC$

224 Argument A attacks argument B since $Choice(A) = Choice(B)$, $Den(A) =$
 225 REJ , $Den(B) = ACC$ and $B : \emptyset \in BP \in PEV \in ACC$.

226 3.3. Poll-based argument generation

227 Let us now describe the process used to generate poll-based arguments.
 228 It is composed of several steps:

229 • *Step 1: Creation of the poll:* as defined in Section 3.2, elements of
 230 $\mathcal{K}$ represent the alternatives that are in discussion. They may be dif-
 231 ferent packagings, products, etc. We propose to design a set $\mathcal{Q}$ of
 232 general questions that can be answered by “Yes”, “No” or “Neutral”
 233 about concepts, i.e. elements of Cr , which will be used as criteria
 234 to rank the alternatives under discussion. An example of a question
 235 can be $q_1 =$ “Do you think that $x \in \mathcal{K}$ protects the environment?” or
 236 $q_2 =$ “Do you think that $x \in \mathcal{K}$ is harmful for strawberries?” The set
 237 of questions $\mathcal{Q} = \{q_1, q_2, \dots, q_m\}$ is asked for every alternative of $\mathcal{K}$.
 238 Please note that we denote by $Con(q_1) = Protect_environment$ (resp.
 239 $Con(q_2) = Harmful$), the underlying concept of question q_1 (resp. q_2).
 240 We also define a function $\sigma : Cr \rightarrow \{ACC, REJ\}$, given by domain ex-
 241 perts, that tells us if a concept is an element in favor (ACC) or against
 242 (REJ) a given alternative. For instance, $\sigma(Con(q_1)) = ACC$ (resp.
 243 $\sigma(Con(q_2)) = REJ$).

244 • *Step 2: Getting the answers:* The poll is proposed to an audience
 245 composed of n persons. The result of the poll can be represented with
 246 three functions:

247 – *positive* : $\mathcal{Q} \times \mathcal{K} \rightarrow \mathbb{N}$ that takes as input a question and an
 248 alternative and returns the number of persons that answered “Yes”,
 249 – *negative* : $\mathcal{Q} \times \mathcal{K} \rightarrow \mathbb{N}$ that takes as input a question and an
 250 alternative and returns the number of persons that answered “No”
 251 and

252 – *neutral* : $\mathcal{Q} \times \mathcal{K} \rightarrow \mathbb{N}$ that takes as input a question and an alterna-
 253 tive and returns the number of persons that answered “Neutral”.

254 It is obvious that for every $k_i \in \mathcal{K}$ and every question $q_j \in \mathcal{Q}$,
 255 $positive(q_j, k_i) + negative(q_j, k_i) + neutral(q_j, k_i) = n$.

256 • *Step 3: Processing the answers:* Once the answers received, we process
 257 them using an aggregation function *agg* for filtering purposes.

$$258 \quad agg(q_j, k_i) = \begin{cases} 0 & \text{if } neutral(q_j, k_i) > positive(q_j, k_i) + negative(q_j, k_i) \\ -1 & \text{else if } positive(q_j, k_i) < negative(q_j, k_i) \\ 1 & \text{otherwise} \end{cases}$$

259 We do not use answers to questions with $agg(q_j, k_i) = 0$ because the
 260 answers are not pertinent enough w.r.t. the metric used.

261 • *Step 4: Creating the arguments:* In this step, we first select a “certainty”
 262 threshold $\alpha \in \{0, 1, \dots, n\}$ and create the following arguments:

263 $\forall k_i \in \mathcal{K}, \forall q_j \in \mathcal{Q} :$

264 – if $agg(q_j, k_i) = 1$ and $|positive(q_j, k_i) - negative(q_j, k_i)| > \alpha$ then

265 $\emptyset \in k_i \in Con(q_j) \sqsubset \sigma(Con(q_j)),$

266 – if $agg(q_j, k_i) = 1$ and $|positive(q_j, k_i) - negative(q_j, k_i)| \leq \alpha$ then

267 $\emptyset \in k_i \in Con(q_j) \subseteq \sigma(Con(q_j)),$

268 – if $agg(q_j, k_i) = -1$ and $|positive(q_j, k_i) - negative(q_j, k_i)| > \alpha$

269 then $\emptyset \in k_i \in \tilde{Con}(q_j) \sqsubset \tilde{\sigma}(Con(q_j)),$

270 – if $agg(q_j, k_i) = -1$ and $|positive(q_j, k_i) - negative(q_j, k_i)| \leq \alpha$

271 then $\emptyset \in k_i \in \tilde{Con}(q_j) \subseteq \tilde{\sigma}(Con(q_j)).$

272 **Example 3.** Suppose that there is a question $q =$ “Do you think that x

273 protects strawberries from shocks?” and that *Plastic_not_closed* is an al-

274 ternative in $\mathcal{K}$ corresponding to a plastic packaging that is not closed. We

275 ask the question q to the consumers and we get that 394 persons answered

276 “No”, 179 persons answered “I do not know” and 272 persons answered “Yes”.

277 Since we have that

$$278 \quad \begin{aligned} neutral(q, Plastic_not_closed) &\leq positive(q, Plastic_not_closed) \\ &\quad + negative(q, Plastic_not_closed) \end{aligned}$$

279 and

280 $positive(q, Plastic_not_closed) < negative(q, Plastic_not_closed),$

281 we compute that $agg(q, Plastic_not_closed) = -1$. Now, if we define $\alpha =$

282 200, the only argument produced, meaning that “not closed plastic packagings

283 are rejected because they do not protect strawberries from shocks”, is:

284 $\emptyset \in Plastic_not_closed \in \sim Shocks_protection \in REJ$

285 4. Ranking extensions

286 We suppose in this section that arguments generated from polls as de-
 287 scribed in Section 3.3 or manually entered by experts are available in the
 288 knowledge base. Extensions are computed using the semantics recalled in
 289 Section 3.1. We explain in this section the proposed method to rank exten-
 290 sions according to preferences expressed on requirements.

We first define the necessary notions used in this section. Let $\mathcal{E}$ be an extension. We define the *accepted requirements* and the *rejected requirements* of an extension $\mathcal{E}$ as:

$$AReq(\mathcal{E}) = \bigcup_{A=\emptyset \in c_0 \sqsubset_1 c_1 \sqsubset_2 ACC \in \mathcal{E}} \{c_1\}$$

$$RReq(\mathcal{E}) = \bigcup_{A=\emptyset \in c_0 \sqsubset_1 c_1 \sqsubset_2 REJ \in \mathcal{E}} \{c_1\}$$

291 Considering the definition of attacks provided in Section 3.2, it must be
 292 noticed that for a given extension $\mathcal{E}$, $AReq(\mathcal{E})$, if not empty, gathers positive
 293 arguments in favor of a given alternative in debate and $RReq(\mathcal{E})$ gathers
 294 negative arguments against all the other alternatives in debate.

295 4.1. Refining extensions using semantics

296 In this section, we introduce our method for ranking a set of exten-
 297 sions E using the locally, Pareto and globally optimal semantics inspired by
 298 Croitoru et al. (2015). These semantics return subsets of the original set
 299 of extensions. We introduce here the three notions which are based on the
 300 notion of domination (preference) between concepts of the accepted require-
 301 ments.

302 An extension $\mathcal{E}$ is said not to be locally optimal if we can find another
 303 extension $\mathcal{E}'$ such that the concepts of $\mathcal{E}$ are either included in $\mathcal{E}'$ or dominated
 304 by elements of $\mathcal{E}'$ (there is at most one concept dominated).

305 **Definition 1.** *We say that an extension $\mathcal{E} \in E$ is locally optimal if and*
 306 *only if $\nexists x \in AReq(\mathcal{E})$ and a concept y such that there exists $\mathcal{E}' \in E \setminus \{\mathcal{E}\}$,*
 307 *$((AReq(\mathcal{E}) \setminus \{x\}) \cup \{y\}) \subseteq AReq(\mathcal{E}')$ and $x < y$.*

308 An extension $\mathcal{E}$ is said not to be Pareto optimal if we can find another
 309 extension $\mathcal{E}'$ such that the concepts of $\mathcal{E}$ are either included in $\mathcal{E}'$ or dominated
 310 by elements of $\mathcal{E}'$ (they are dominated by a single concept).

311 **Definition 2.** *We say that an extension $\mathcal{E} \in E$ is Pareto optimal if and*
 312 *only if $\nexists X \subseteq AReq(\mathcal{E})$ and a concept y and $X \neq \emptyset$ such that there exists*
 313 *$\mathcal{E}' \in E \setminus \{\mathcal{E}\}$, $((AReq(\mathcal{E}) \setminus X) \cup \{y\}) \subseteq AReq(\mathcal{E}')$ and for every $x \in X$, $x < y$.*

314 An extension $\mathcal{E}$ is said not to be globally optimal if we can find another
 315 extension $\mathcal{E}'$ such that the concepts of $\mathcal{E}$ are either included in $\mathcal{E}'$ or dominated
 316 by elements of $\mathcal{E}'$ (no restrictions).

317 **Definition 3.** *We say that an extension $\mathcal{E} \in E$ is globally optimal if and*
318 *only if $\nexists X \subseteq AReq(\mathcal{E})$ and a set of concepts Y and $X \neq \emptyset$ such that there*
319 *exists $\mathcal{E}' \in E \setminus \{\mathcal{E}\}$, $((AReq(\mathcal{E}) \setminus X) \cup Y) \subseteq AReq(\mathcal{E}')$ and for every $x \in X$,*
320 *there exists $y \in Y$ such that $x < y$.*

321 Note that while those semantics allow to refine the set of considered ex-
322 tensions, they may be unable to output only one extension. This is of course
323 dependent of the preferences the user has expressed: the more preferences
324 are used, the more refinements are going to happen. Note also that it is
325 possible to use the preferences differently, namely in a more “quantitative”
326 fashion based on argument count. We study this new approach in the next
327 section.

328 4.2. Ranking methods using scores

329 This new approach using scores is interesting in many ways. First, it
330 is obviously easier and faster to compute than the approach introduced in
331 the previous section (and based on Croitoru et al. (2015)). Furthermore, an
332 extension can be accurately scored (using the preferences) even if we do not
333 have the entire set of extensions. This can be useful in the event that we
334 do not have enough time to compute all the extensions. In this section, we
335 introduce two scores for ranking extensions.

336 *4.2.1. First scoring: Higher score based on positive arguments means less*
 337 *dominated*

338 The first method only considers positive arguments in favor of one of the
 339 alternatives in debate. It gives the highest score to the extension that is the
 340 least dominated. Namely, the score of an extension $\mathcal{E}$ is:

341 **Definition 4.** $Score_1(\mathcal{E}) = \sum_{a \in AReq(\mathcal{E})} |\{c \mid c \text{ is a concept and } c < a\}|$

342 With this score, the best extension is the one with the highest score.

343 *4.2.2. Second scoring: Higher score based on negative arguments means less*
 344 *dominated*

345 The second method only considers negative arguments against the alter-
 346 natives in debate. It gives the highest points to the extension whose negative
 347 arguments are the most dominated. Namely, the score of an extension $\mathcal{E}$ is:

348 **Definition 5.** $Score_2(\mathcal{E}) = \sum_{a \in RReq(\mathcal{E})} |\{c \mid c \text{ is a concept and } a < c\}|$

349 Again, with this score, the best extension is the one with the highest
 350 score.

351 A research issue is to find a way to combine the two scores in order
 352 to produce a more efficient ranking. This can be achieved by using multi-
 353 criteria methods. We provide a naive way to combine the two scores, namely

354 $Score_3(\mathcal{E}) = Score_1(\mathcal{E}) + Score_2(\mathcal{E})$.

Figure 4: Four considered packaging options: Plastic not closed, Wood packaging, Plastic rigid lid, Plastic with plastic film.

5. Use-case

The use case is coming from the INRA Glofoods Pack4Fresh project which, as explained in the introduction, aims at designing innovative packaging solutions for fresh food products. For best packaging selection support, one aspect to take into account is the consumers' expectations in terms of packaging characteristics. In the project it has been tested for strawberries. Four packaging options have been considered (see Figure 4):

- an opened plastic basket (without lid or film)
- a wood packaging (without lid)
- a plastic basket with rigid lid
- a plastic basket with plastic film

5.1. Automated generation of arguments from the poll

A survey upon a sample of 840 people has provided the following arguments using the poll-based argument automatic generation process presented in Section 3.3 with a “certainty” threshold of 756 people (90% of the

370 840 respondents, which indicates a very certain, nearly consensual, general
 371 opinion):

Arg id	Textual argument	Formal argument
a1	Consumers are in favour of wood packaging because it preserves the flavour of strawberries	$Wood_packaging$ $\in Protect_flavor \in ACC$
a2	Consumers are in favour of wood packaging because it preserves strawberries from shocks	$Wood_packaging$ $\in Shocks_protection \in ACC$
a3	Consumers are in favour of wood packaging because it is reusable	$Wood_packaging$ $\in Reusable \in ACC$
a4	Consumers are in favour of wood packaging because it is recyclable	$Wood_packaging$ $\in Recyclable \in ACC$
a5	Consumers are in favour of wood packaging because it incites to eat strawberries	$Wood_packaging$ $\in Incite_to_eat \in ACC$
a6	Consumers are in favour of wood packaging because they can see the strawberries	$Wood_packaging$ $\in Can_see \in ACC$
a7	Consumers are in favour of wood packaging because they can smell the strawberries	$Wood_packaging$ $\in Can_smell \in ACC$
a8	Consumers are in favour of wood packaging because they think it protects the environment	$Wood_packaging$ $\in Protect_environment \in ACC$
a9	Consumers are not in favour of wood packaging because it harms strawberries	$Wood_packaging$ $\in Harmful \in REJ$
a10	Consumers are in favour of plastic packaging with plastic film because they can see the strawberries	$Plastic_with_plastic_film$ $\in Can_see \in ACC$
a11	Consumers are not in favour of plastic packaging with plastic film because it is not reusable	$Plastic_with_plastic_film$ $\in \neg Reusable \in REJ$
a12	Consumers are not in favour of plastic packaging with plastic film because it does not preserve strawberries from shocks	$Plastic_with_plastic_film$ $\in \neg Shocks_protection \in REJ$
a13	Consumers are not in favour of plastic packaging with plastic film because it is not recyclable	$Plastic_with_plastic_film$ $\in \neg Recyclable \in REJ$

Arg id	Textual argument	Formal argument
a14	Consumers are not in favour of plastic packaging with plastic film because it does not enable good fridge conservation	<i>Plastic_with_plastic_film</i> $\in \neg Good_fridge_conservation \in REJ$
a15	Consumers are not in favour of plastic packaging with plastic film because they think it does not protect the environment	<i>Plastic_with_plastic_film</i> $\in \neg Protect_environment \in REJ$
a16	Consumers are not in favour of plastic packaging with plastic film because it does not enable good ambient conservation	<i>Plastic_with_plastic_film</i> $\in \neg Good_ambient_conservation \in REJ$
a17	Consumers are in favour of plastic packaging with plastic film because it incites to eat strawberries	<i>Plastic_with_plastic_film</i> $\in Incite_to_eat \in ACC$
a18	Consumers are not in favour of plastic packaging with plastic film because they cannot smell the strawberries	<i>Plastic_with_plastic_film</i> $\in \neg Can_smell \in REJ$
a19	Consumers are in favour of plastic packaging with plastic film because it preserves the flavour of strawberries	<i>Plastic_with_plastic_film</i> $\in Protect_flavor \in ACC$
a20	Consumers are in favour of plastic packaging with plastic film because it does not harm strawberries	<i>Plastic_with_plastic_film</i> $\in \neg Harmful \in ACC$
a21	Consumers are in favour of plastic packagings with rigid lids because they can smell the strawberries	<i>Plastic_rigid_lid</i> $\in Can_smell \in ACC$
a22	Consumers are in favour of plastic packagings with rigid lids because they protect the environment	<i>Plastic_rigid_lid</i> $\in Protect_environment \in ACC$
a23	Consumers are not in favour of plastic packagings with rigid lids because they are not reusable	<i>Plastic_rigid_lid</i> $\in \neg Reusable \in REJ$
a24	Consumers are in favour of plastic packagings with rigid lids because they are recyclable	<i>Plastic_rigid_lid</i> $\in Recyclable \in ACC$

Arg id	Textual argument	Formal argument
a25	Consumers are in favour of plastic packagings with rigid lids because they are not harmful for strawberries	$Plastic_rigid_lid$ $\in \neg Harmful \in ACC$
a26	Consumers are in favour of plastic packagings with rigid lids because they protect flavour	$Plastic_rigid_lid$ $\in Protect_flavor \in ACC$
a27	Consumers are in favour of plastic packagings with rigid lids because they incite to eat strawberries	$Plastic_rigid_lid$ $\in Incite_to_eat \in ACC$
a28	Consumers are in favour of plastic packagings with rigid lids because they can see the strawberries	$Plastic_rigid_lid$ $\in Can_see \in ACC$
a29	Consumers are in favour of plastic packagings with rigid lids because they preserve strawberries from shocks	$Plastic_rigid_lid$ $\in Shocks_protection \in ACC$
a30	Consumers are not in favour of plastic packagings that are not closed because they do not protect the environment	$Plastic_not_closed$ $\in \neg Protect_environment \in REJ$
a31	Consumers are in favour of plastic packagings that are not closed because they are reusable	$Plastic_not_closed$ $\in Reusable \in ACC$
a32	Consumers are in favour of plastic packagings that are not closed because they are recyclable	$Plastic_not_closed$ $\in Recyclable \in ACC$
a33	Consumers are not in favour of plastic packagings that are not closed because they are harmful for strawberries	$Plastic_not_closed$ $\in Harmful \in REJ$
a34	Consumers are in favour of plastic packagings that are not closed because they permit to see the strawberries	$Plastic_not_closed$ $\in Can_see \in ACC$
a35	Consumers are in favour of plastic packagings that are not closed because they permit to smell the strawberries	$Plastic_not_closed$ $\in Can_smell \in ACC$

Arg id	Textual argument	Formal argument
a36	Consumers are in favour of plastic packagings that are not closed because they protect flavour	$Plastic_not_closed$ $\in Protect_flavor \in ACC$
a37	Consumers are not in favour of plastic packagings that are not closed because they do not protect strawberries from shocks	$Plastic_not_closed$ $\in \neg Shocks_protection \in REJ$
a38	Consumers are in favour of plastic packagings that are not closed because they incite to eat strawberries	$Plastic_not_closed$ $\in Incite_to_eat \in ACC$

372 5.2. Arguments provided by experts

373 The previous consumers' arguments have been assessed by experts in food
374 packaging. The experts have then provided other arguments. This process
375 allows us to "simulate" a kind of debate.

Arg id	Textual argument	Formal argument
a39	Experts are not in favour of wood packaging because it does not concentrate the smell	$Wood_packaging$ $\in \neg Concentrate_smell \in REJ$
a40	Experts are in favour of wood packaging because, due to exudate absorption, it contributes to good ambient conservation	$Wood_packaging$ $\in Good_ambient_conservation \in ACC$
a41	Experts are in favour of wood packaging because, due to exudate absorption, it contributes to good fridge conservation	$Wood_packaging$ $\in Good_fridge_conservation \in ACC$
a42	Experts are not in favour of plastic packaging with rigid lid because, due to consumers' manipulations to see under the pack, it contributes to shocks	$Plastic_rigid_lid$ $\in \neg Shocks_protection \in REJ$
a43	Experts are in favour of plastic packaging with rigid lid because it concentrates the smell	$Plastic_rigid_lid$ $\in Concentrate_smell \in ACC$

Arg id	Textual argument	Formal argument
a44	Experts are not in favour of plastic packaging with plastic film because condensation may hide strawberries	$Plastic_with_plastic_film$ $\in Condensation \in REJ$
a45	Experts are in favour of plastic packaging with plastic film because it permits to reduce waste (thanks to modified atmosphere)	$Plastic_with_plastic_film$ $\in Protect_environment \in ACC$
a46	Experts are not in favour of non-closed plastic packaging because it does not concentrate the smell	$Plastic_not_closed$ $\in \neg Concentrate_smell \in REJ$

376 5.3. Extensions computation

377 Using the argumentation model presented in Section 3.2, 1519 attacks
378 have been generated upon the 46 arguments. Thanks to these arguments
379 and attacks, five preferred extensions have been calculated using Aspartix.
380 Please note that the preferred semantics is used because it is simple and
381 allows to preserve every existing point of view (cf. Section 3.1). One can
382 observe that the first four extensions are composed of:

- 383 • the set of positive arguments in favor of a given alternative,
- 384 • the set of negative arguments against the other alternatives in debate.

385 For instance, extension $\mathcal{E}_4$ is associated with the alternative Wood Pack-
386 aging. Arguments a1, a2, a3, a4, a5, a6, a7, a8 are positive arguments in
387 favor of Wood Packaging and arguments a11, a12, a13, a14, a15, a16, a18,
388 a23, a30, a33, a37, a40, a41, a42, a44, a46 are negative arguments against
389 the three other alternatives.

$\mathcal{E}_1$	{a9, a10, a17, a19, a20, a23, a30, a33, a37, a39, a42, a45, a46}
$\mathcal{E}_2$	{a9, a11, a12, a13, a14, a15, a16, a18, a23, a31, a32, a34, a35, a36, a38, a39, a42, a44}
$\mathcal{E}_3$	{a9, a11, a12, a13, a14, a15, a16, a18, a21, a22, a24, a25, a26, a27, a28, a29, a30, a33, a37, a39, a43, a44, a48}
$\mathcal{E}_4$	{a1, a2, a3, a4, a5, a6, a7, a8, a11, a12, a13, a14, a15, a16, a18, a23, a30, a33, a37, a40, a41, a42, a44, a46}
$\mathcal{E}_5$	{a9, a11, a12, a13, a14, a15, a16, a18, a23, a30, a33, a37, a39, a42, a44, a46}

Table 4: Preferred extensions of the use-case.

390 The remaining extension $\mathcal{E}_5$ contains all the negative arguments associ-
391 ated with all the alternatives. In this use case, this last extension will be
392 considered as useless since negative arguments are already available in the
393 other extensions.

394 5.4. Scenario analysis

395 We will consider the following three scenarios:

- 396 • Scenario SECURE: “not nefast effect” (i.e. not harmful) concept is
397 preferred to all the other concepts.
- 398 • Scenario GREEN: “Protect_environment”, “recyclable” and “reusable”
399 are preferred to all the other concepts.
- 400 • Scenario PLEASURE: “can see”, “can smell”, “protect flavor” and “incite
401 to eat” are preferred to all the other concepts.

402 In the following, we only detail the results obtained for scenario SECURE
403 and we present globally the results obtained for the three scenarios. The in-

Locally optimal	$\{Plastic_with_plastic_film, Plastic_rigid_lid, Wood_packaging\}$
Pareto optimal	$\{Plastic_with_plastic_film, Plastic_rigid_lid\}$
Globally optimal	$\{Plastic_with_plastic_film, Plastic_rigid_lid\}$

Table 5: Results obtained for scenario SECURE refining extensions using the locally, Pareto and globally optimal semantics.

404 terested reader will find the detailed results for the other scenarios in Section
405 AppendixA.

406 Preferences associated with concepts for scenario SECURE are the fol-
407 lowing:

- 408 • $Protect_flavor < \neg Nefast_effect$
- 409 • $Protect_environment < \neg Nefast_effect$
- 410 • $\neg Protect_environment < \neg Nefast_effect$
- 411 • $Shocks_protection < \neg Nefast_effect$
- 412 • $\neg Shocks_protection < \neg Nefast_effect$
- 413 • $Reusable < \neg Nefast_effect$
- 414 • $Recyclable < \neg Nefast_effect$
- 415 • $\neg Reusable < \neg Nefast_effect$
- 416 • $\neg Recyclable < \neg Nefast_effect$
- 417 • $Incite_to_eat < \neg Nefast_effect$

Packaging	Score ₁	Score ₂	Score ₃
<i>Wood_packaging</i>	0	14	14
<i>Plastic_with_plastic_film</i>	21	8	29
<i>Plastic_not_closed</i>	0	12	12
<i>Plastic_rigid_lid</i>	21	14	35

Table 6: Results obtained for scenario SECURE ranking extensions using scoring functions.

- 418 • $Can_see < \neg Nefast_effect$
- 419 • $Can_smell < \neg Nefast_effect$
- 420 • $\neg Can_smell < \neg Nefast_effect$
- 421 • $Nefast_effect < \neg Nefast_effect$
- 422 • $\neg Good_fridge_conservation < \neg Nefast_effect$
- 423 • $\neg Good_ambient_conservation < \neg Nefast_effect$
- 424 • $Good_ambient_conservation < \neg Nefast_effect$
- 425 • $Good_fridge_conservation < \neg Nefast_effect$
- 426 • $Concentrate_smell < \neg Nefast_effect$
- 427 • $Condensation < \neg Nefast_effect$
- 428 • $\neg Concentrate_smell < \neg Nefast_effect$

429 We can see in Table 7 that the results obtained using the two indi-
430 cators *Globally_optimal* and *Score₁* are the same for the alternatives in
431 first position. *Score₃* indicator is more discriminant than *Globally_optimal*

Scenario	Globally optimal	Score ₁	Score ₃
SECURE	{ <i>Plastic</i> <i>_with_plastic_film</i> , <i>Plastic_rigid_lid</i> }	<i>Plastic</i> <i>_with_plastic_film</i> $\sim$ <i>Plastic_rigid_lid</i> $>$ <i>Wood_packaging</i> $\sim$ <i>Plastic_not_closed</i>	<i>Plastic_rigid_lid</i> $>$ <i>Plastic</i> <i>_with_plastic_film</i> $>$ <i>Wood_packaging</i> $>$ <i>Plastic_not_closed</i>
GREEN	<i>Wood_packaging</i>	<i>Wood_packaging</i> $>$ <i>Plastic_rigid_lid</i> $\sim$ <i>Plastic_not_closed</i> $>$ <i>Plastic</i> <i>_with_plastic_film</i>	<i>Wood_packaging</i> $>$ <i>Plastic_rigid_lid</i> $>$ <i>Plastic_not_closed</i> $>$ <i>Plastic</i> <i>_with_plastic_film</i>
PLEASURE	{ <i>Plastic_not_closed</i> , <i>Plastic_rigid_lid</i> , <i>Wood_packaging</i> }	<i>Wood_packaging</i> $\sim$ <i>Plastic_rigid_lid</i> $\sim$ <i>Plastic_not_closed</i> $>$ <i>Plastic</i> <i>_with_plastic_film</i>	<i>Wood_packaging</i> $\sim$ <i>Plastic_rigid_lid</i> $>$ <i>Plastic_not_closed</i> $>$ <i>Plastic</i> <i>_with_plastic_film</i>

Table 7: Summary of the results obtained for the three scenarios.

and $Score_1$. Indeed, in scenarios SECURE and PLEASURE, $Score_3$ provides an advantage to alternatives with less negative arguments which are *Plastic_rigid_lid* and *Wood_packaging*.

The same scenarios have been presented to a food packaging expert in order to assess the MCDSS results. Concerning scenario SECURE, the expert agrees with results obtained with *Globally_optimal* and $Score_1$ indicators and disagrees with result obtained with $Score_3$. Indeed, the expert prefers *Plastic_with_plastic_film* to *Plastic_rigid_lid* as the first one permits to control in a better way modified atmosphere which extends shelf life (expressed in Argument *a45*) and avoids moisture and microorganism growth.

It may be noticed that this last argument was not present in the MCDSS knowledge base as an expert argument but it exists as a consumer argument (*a20*). The addition of this new argument will not change the ranking for

all the indicators as the MCDSS does not take into account the fact that the same argument may be expressed by different stakeholders. An option could be to introduce a weight which will provide more power to arguments which are supported by several stakeholders; such an approach could benefit from the notion of ranking semantics such as Amgoud and Ben-Naim (2013); Amgoud et al. (2016); Bonzon et al. (2016); Baroni et al. (2018) where arguments' strength is computed based on the attacks in the framework. So, $Score_3$ seems to bring an additional piece of information which is not taken into account by the expert.

Concerning scenario GREEN, the expert has defined three individual rankings for each of the criteria Protect environment, Reusable and Recyclable:

- **Protect environment:** $Plastic_with_plastic_film > Wood_packaging > Plastic_rigid_lid = Plastic_not_closed$ considering that *Plastic_with_plastic_film* (with modified atmosphere) permits to reduce waste and *Wood_packaging* has less impact on environment than *Plastic_rigid_lid* and *Plastic_not_closed* in terms of biodegradability duration.

- **Reusable:** $Wood_packaging = Plastic_not_closed > Plastic_rigid_lid > Plastic_with_plastic_film$ considering the practical point of view of reuse of the packaging material for another usage.

- **Recyclable:** $Wood_packaging > Plastic_not_closed =$

467 *Plastic_rigid_lid* = *Plastic_with_plastic_film* considering that
468 none of the three plastic materials are recyclable at the state of the
469 art and that wood packaging is the only recyclable one.

470 Considering that *Wood_packaging* is the only one appearing in first position
471 for “Reusable” and “Recyclable” and in second position for “Protect environ-
472 ment”, we can state that the expert agrees with the result proposed by the
473 MCDSS for the three indicators *Globally_optimal*, *Score₁* and *Score₃*.

474 Concerning scenario PLEASURE, the expert did not want to assess the
475 criterion *Incite_to_eat* as it is a question of consumer’s perception. How-
476 ever, the expert considers that all packagings are ex-aequo for the three
477 remaining criteria (*can_see*, *can_smell* and *protect_flavor*). This corre-
478 sponds to the result expressed by the MCDSS for the indicators *Globally_*
479 *optimal* and *Score₁*, except for the case of *Plastic_with_plastic_film*
480 which is ranked behind the other packagings by the MCDSS. This is due
481 to the fact that consumers consider the *Plastic_with_plastic_film* pack-
482 aging not to allow smelling the strawberries (Argument a18), whereas the
483 expert considers this is compensated by its ability to concentrate smell. The
484 latter compensation effect, however, is not coded in the MCDSS.

485 We may note that in several of the above evaluation cases, discordances
486 between MCDSS and expert rankings are not due to the ranking method
487 itself but to missing information to be included into the MCDSS, or pieces of
488 information included in the MCDSS but not taken into account by the expert
489 (by example negative arguments). This highlights the interest of an iterative

490 process for argument elicitation in order to obtain complete information in
491 the MCDSS, as recommended in Thomopoulos et al. (2013); Johnson et al.
492 (2010); Thomopoulos et al. (2009). On the contrary, similar information lead
493 to similar rankings, which constitutes a positive expert validation feedback
494 on the MCDSS reasoning engine. Another significant finding was that in
495 complex cases, as in the GREEN scenario for instance, providing a unique
496 global ranking was a difficult task for the expert. Thus we can conclude that
497 (i) there is a recognized added value of providing MCDSS results and (ii)
498 expert evaluation has to be achieved firstly on simple cases, which can be
499 intuitively apprehended by human reasoning. Interestingly, these remarks
500 are in line with a well-known distinction between different approaches to
501 decision support Tsoukiàs (2007). The normative approach, more common
502 in the Anglo-Saxon school of decision support, derives decision models from
503 rationality norms established a priori. Expert decision deviating from these
504 norms is interpreted as a mistake which highlights the need for MCDSS aid
505 in order to decide in a rational way Fishburn (1970). On the contrary, in
506 the descriptive approach, more common in the European school of decision
507 support, decision models are derived from observing how expert make de-
508 cisions, in order to reproduce their way of reasoning in the MCDSS Bell
509 et al. (1988). In our system, normative decision support is expected from
510 the MCDSS in complex cases, whereas the descriptive approach is used for
511 MCDSS evaluation in simple cases.

Conflicts And Extensions	BEFORE
<p>[Wood_packaging Protect_flavor, Shocks_protection, Reusable, Recyclable, Incite_to_eat, Can_see, Can_smell, Protect_environment, Good_ambient_conservation, Good_fridge_conservation Plastic_with_plastic_film, Plastic_rigid_lid, Plastic_not_closed Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_fridge_conservation, Not Protect_environment, Not Good_ambient_conservation, Not Can_smell, Not Reusable, Not Protect_environment, Nefast_effect, Not Shocks_protection, Not Shocks_protection, Condensation, Not Concentrate_smell]</p> <p>[Plastic_rigid_lid Can_smell, Protect_environment, Recyclable, Not Nefast_effect, Protect_flavor, Incite_to_eat, Can_see, Shocks_protection, Concentrate_smell Wood_packaging, Plastic_with_plastic_film, Plastic_not_closed Nefast_effect, Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_fridge_conservation, Not Protect_environment, Not Good_ambient_conservation, Not Can_smell, Not Protect_environment, Not Shocks_protection, Not Concentrate_smell, Co</p> <p>[Plastic_not_closed Reusable, Recyclable, Can_see, Can_smell, Protect_flavor, Incite_to_eat Wood_packaging, Plastic_with_plastic_film, Plastic_rigid_lid Nefast_effect, Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_fridge_conservation, Not Protect_environment, Not Good_ambient_conservation, Not Can_smell, Not Protect_environment, Not Good_ambient_conservation, Not Can_smell, Not Reusable,</p>	

(a) Extensions outputted by the argumentation framework.

Conflicts And Extensions	AFTER
<p>Preferred With Preferences:</p> <p>Globally optimal:</p> <p>[Plastic_with_plastic_film Can_see, Incite_to_eat, Protect_flavor, P</p> <p>[Plastic_rigid_lid Can_smell, Protect_environment, Recyclable, Not Shocks_protection, Concentrate_smell Wood_packaging, Plastic_wi</p> <p>Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_frid</p> <p>Not Good_ambient_conservation, Not Can_smell, Not Protect_environ</p> <p>Pareto optimal:</p> <p>[Plastic_with_plastic_film Can_see, Incite_to_eat, Protect_flavor, P</p> <p>[Plastic_rigid_lid Can_smell, Protect_environment, Recyclable, Not Shocks_protection, Concentrate_smell Wood_packaging, Plastic_wi</p> <p>Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_frid</p> <p>Not Good_ambient_conservation, Not Can_smell, Not Protect_environ</p> <p>Locally optimal:</p> <p>[Plastic_with_plastic_film Can_see, Incite_to_eat, Protect_flavor, P</p> <p>[Plastic_rigid_lid Can_smell, Protect_environment, Recyclable, Not Shocks_protection, Concentrate_smell Wood_packaging, Plastic_wi</p> <p>Not Reusable, Not Shocks_protection, Not Recyclable, Not Good_frid</p> <p>Not Good_ambient_conservation, Not Can_smell, Not Protect_environ</p> <p>[Wood_packaging Protect_flavor, Shocks_protection, Reusable, Rea</p> <p>Protect_environment, Good_ambient_conservation, Good_fridge_cons</p> <p>Plastic_not_closed Not Reusable, Not Shocks_protection, Not Recyc</p> <p>Not Protect_environment, Not Good_ambient_conservation, Not Can,</p> <p>Nefast_effect, Not Shocks_protection, Not Shocks_protection, Conder</p>	

(b) Extensions outputted by the argumentation framework after preferences filtering.

(c) Preference elicitation interface.

Figure 6: Interfaces for preference management and extension ranking.

inputting preferences which enables users to clearly visualize the preferences implied (see Figure 6c). The preferences are saved in a database and are specific to a particular argumentation case. We also implemented all the preferences methods discussed in this paper. The processing of the argumentation framework is hidden to the user and only the different extensions produced are displayed (see Figure 6a). The user can then add preferences and use the refining methods introduced in Section 4.1 (see Figure 6b).

529 7. Related work

530 This work presents a novel application of preference based logical argu-
531 mentation systems for food science. As illustrated in Figure 2, our approach
532 follows the following work-flow: generation of arguments (from text or polls),
533 attack computation and generation of argumentation framework and, last,
534 use of preferences for extension ranking.

535 Regarding the first step of the work-flow, i.e. the argument generation,
536 we used the structured argument definition of Prakken (2010) but changed to
537 our particular application needs (our arguments are always in favour or not
538 of an option). In the second work-flow step, the attack used in this paper,
539 albeit satisfying the rationality postulates of Caminada and Amgoud (2007),
540 also follows the intuition of Prakken (2010). Last, the preferences are applied
541 to the extensions of the argumentation framework built upon the first two
542 steps. Ordinal preference handling follows the work of Croitoru et al. (2015).
543 This work differs from classical argumentation approaches (for an overview
544 please check Modgil and Prakken (2013)) in the fact that the attack relation
545 is not modified (i.e. changed, deleted) but the preferences are used directly
546 on the outputted extensions. The numerical preference handling takes this
547 work further in a cardinal setting. A discussion on the rationales of different
548 kinds of attacks can be found in Yun et al. (2018).

549 This work uses the software interface described in Tamani et al. (2015)
550 for logical argument elicitation from text. This software, similarly to other
551 argumentation software such as Araucaria Reed and Rowe (2004), Argunet

552 Schneider et al. (2007) and DebateGraph², allows the expression of arguments
553 as texts to manually formalize them as hypothesis and conclusions but also to
554 compute the extensions and the preference induced ranking. In this respect,
555 our interface is the only software allowing to compute all steps of the work-
556 flow described in Figure 2.

557 While this work presents a significant and original application of argumen-
558 tation theory in food science, let us also highlight other numerous argumenta-
559 tion applications developed recently in various fields: ArgTrust Parsons et al.
560 (2013), in which the authors considered argumentation frameworks for de-
561 cision making; CISpaces framework Toniolo et al. (2014), which supports col-
562 laborative intelligence analysis of conflicting information;
563 “*Quaestion-it.com*” Evripidou and Toni (2014) which is a social intelligence
564 debating platform that demonstrates a question-and-answer web application
565 providing support for user-posed questions; Carneades Gordon (2013), which
566 provides software tools based on a common computational model of argument
567 graphs useful for policy deliberations, etc.

568 8. Conclusion

569 In this paper we proposed a complete methodology, from texts and online
570 polls, until final decision support, in order to (i) model possibly conflicting
571 arguments from various actors involved and regarding several criteria, (ii)

²www.debategraph.org

572 structure an argumentation system, (iii) deliver justified conclusions based
573 on extension computation, (iv) use criteria prioritization to rank the solu-
574 tions. Using this methodology, a case study concerning the choice of the
575 most suitable eco-packaging for fresh food products is presented and its ex-
576 pert evaluation discussed.

577 This system is a significant breakthrough in two different fields. On the
578 one hand, it extends explanatory approaches of multi-criteria and multi-actor
579 decision by allowing for scaling up to high data volumes, which have to be
580 managed and automatically analyzed, due to the use of online polls as a data
581 source. On the other hand, it opens the way to sustainable choices to reduce
582 the post-harvest environmental impact of fresh foods, since food packaging
583 plays a crucial part in it. Moreover, in opposition to classical “black box”
584 approaches, users can access and assess the reasons behind the provided
585 decision, which allows the iterative process of adding new arguments if some
586 pieces of information are missing. This guarantees the fact that decision
587 biases can be corrected by knowledge enrichment.

588 The aim of this paper was to present, assess and show the relevance of
589 the MCDSS workflow. An interesting future methodological study would be
590 to fine-tune the current MCDSS workflow parameterization, notably with re-
591 gards to the aggregation function used to compute arguments from the polls,
592 the “certainty” threshold used to distinguish between strict and defeasible
593 arguments, and the semantics used to compute extensions.

594 Moreover, as a future work, this methodology is promising to support

595 innovation by guiding the design of new-generation, biosourced, “intelligent”,
 596 eco-efficient food packagings. Research is active in this area but mainly
 597 focused on technical aspects such as the properties of the materials in an
 598 extremely small size scale. However, to be acceptable and used, these new-
 599 generation solutions have to take into account all the considerations and ex-
 600 pectations raising from end-users all along the supply chain, from production
 601 to consumption and after use, with a life-cycle sight.

602 **Appendix AppendixA: Detailed results for the use case**

Locally optimal	$\{Plastic_rigid_lid, Wood_packaging\}$
Pareto optimal	<i>Wood_packaging</i>
Globally optimal	<i>Wood_packaging</i>

Table A.8: Results obtained for scenario GREEN refining extensions using the locally, Pareto and globally optimal semantics.

Packaging	Score₁	Score₂	Score₃
<i>Wood_packaging</i>	57	42	99
<i>Plastic_with_plastic_film</i>	19	24	33
<i>Plastic_not_closed</i>	38	36	74
<i>Plastic_rigid_lid</i>	38	42	82

Table A.9: Results obtained for scenario GREEN ranking extensions using scoring functions.

Locally optimal	$\{Plastic_not_closed, Plastic_rigid_lid, Wood_pack\}$
Pareto optimal	$\{Plastic_not_closed, Plastic_rigid_lid, Wood_pack\}$
Globally optimal	$\{Plastic_not_closed, Plastic_rigid_lid, Wood_pack\}$

Table A.10: Results obtained for scenario PLEASURE refining extensions using the locally, Pareto and globally optimal semantics.

Packaging	Score ₁	Score ₂	Score ₃
<i>Wood_packaging</i>	72	56	128
<i>Plastic_with_plastic_film</i>	54	32	86
<i>Plastic_not_closed</i>	72	48	120
<i>Plastic_rigid_lid</i>	72	56	128

Table A.11: Results obtained for scenario PLEASURE ranking extensions using scoring functions.

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