# Antimicrobials On-line: Concept and Application for Multidisciplinary Knowledge Exchange in the Food Domain

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**Abstract:** *Industrial food developers need reliable, comprehensive, and complete information on the application of food preservative agents. To this end, we have collected and integrated knowledge from food technologists, microbiologists and food specialists in universities, research institutes, and industry. This knowledge has been implemented in a web-based expert knowledge system. Presently it holds the properties and practical applications of five natural antimicrobial preservatives and their relation to a large number of microbes and food types. Experiments described in literature are available at a user-specified level of detail. For example, given a type of microbe and food, users can search the system automatically to find the antimicrobial compound that guarantees a required shelf life time. Scientists can search the same system for detailed information on the degree in which certain strains of microbes are sensitive to a certain combination of anti-microbial compounds.*

*The technical objective behind the design of the system was to support associative search methods, which yield a higher recall and relevance for the search results than traditional database queries. Therefore, the food domain knowledge was modelled using ontologies, which enabled us to store context knowledge in a semantic network. The ontologies developed were implemented and made accessible using a conceptual query language (SeRQL) and a metadatabase (Sesame). This has resulted in a highly flexible and easy to maintain knowledge base. A second advantage of structuring the food domain knowledge in this way is that in future project the already gathered knowledge can easily be reused and extended.*

## 1 INTRODUCTION

In western society, food safety is a high priority issue. The consumer is to be protected against food induced risks, and extensive research efforts are devoted to eliminate or minimise the presence of pathogens in foodstuffs. In addition to standard preservation techniques, such as drying, cooling, etc, new technologies are being developed such as ultra-high pressure processing, pulsed electric field, etc. Traditional preservatives are replaced by or supplemented by chemical compounds that protect food products against microbial activity. In the work we present here, we focus on preserving additives, in particular those that have a natural origin, such as nisin, natamycin, carvacrol, lactic acid, etc. However, our framework is open for future extension towards other preservatives, preserving technologies, and combinations of these (hurdle approach).

The main aim of the service is to provide structured information on the properties and applications of antimicrobial compounds through a web-based knowledge system for industrial and scientific users. In order to develop such a system, a co-operation between knowledge modellers and food specialists has been set up. The problem in applying preservatives in practical food design is that often the effectiveness of these compounds in specific circumstances is unknown. Moreover, restrictions may apply due to legislation. This makes it difficult for industrial users to decide which preservative could be applied for their products and for which specific markets this would be allowed. Much knowledge about anti-microbial compounds is available in academic research through scientific and semi-scientific publications. However, this knowledge is not ready to use for practical food developers, since most articles deal with the use of anti-microbials in laboratory media under idealised circumstances. In these cases, it is not clear how effective the compounds are in non-ideal, commercial food products. Furthermore, the information is scattered and unstructured and therefore difficult to locate and apply.  The ambition of A/OL, Antimicrobials Online, is to assist industrial (small scale and large scale) users of preservatives. Therefore, the information provided is interpreted and summarised by domain experts, assessed with respect to its practical use and structured according to the preferences of the user.

A/OL does not stand alone if we consider computer-based support for food preservation. An example of a related application is Combase [1]. Combase provides a framework and database for modelling and simulation of microbial growth. Its approach is complementary to A/OL in the sense that A/OL provides information on growth limiting compounds and Combase on microbial growth. In the related domain of flavour components, FlavourWorks exists, which is a tool in which information on flavour compounds can be found.

## 2 USING ONTOLOGIES

Presently, knowledge modelling is leaving its academic playground in artificial intelligence to become a standard activity in 'real world' application development. This is due to the fact that for the next generation of Internet, the Semantic Web [ref], search methods will be based on *meaning* of text rather than simple

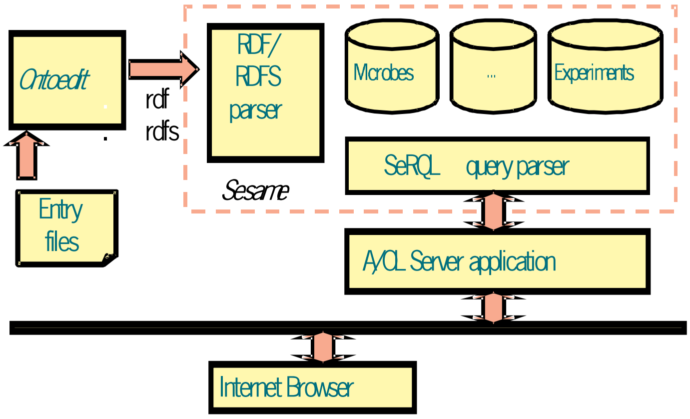



Figure 1: Structure of system architecture

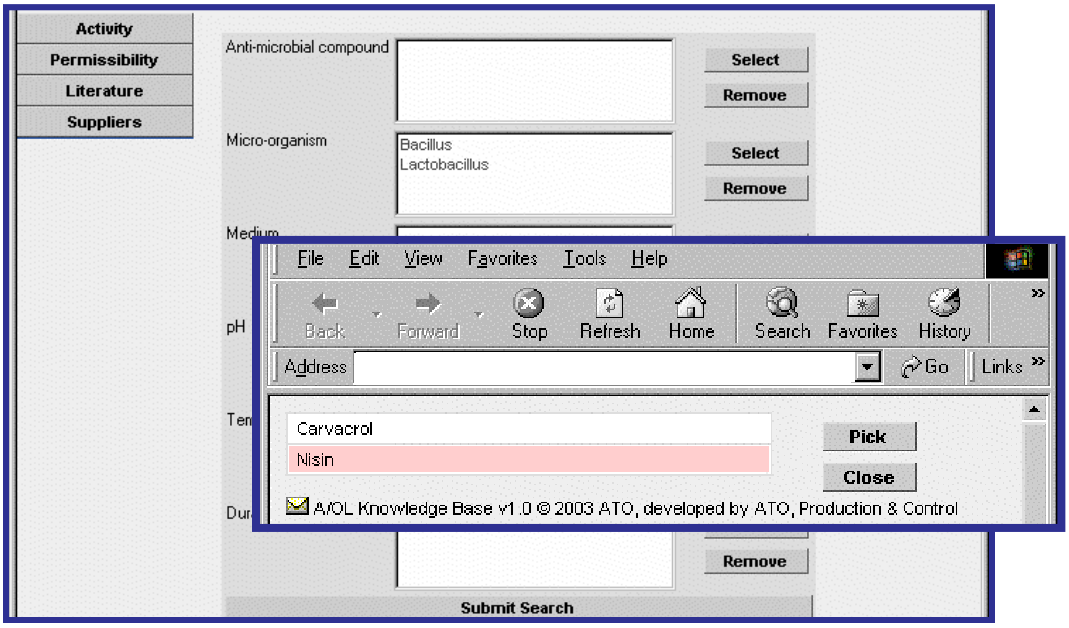



Figure 2: Search screen for experimental information

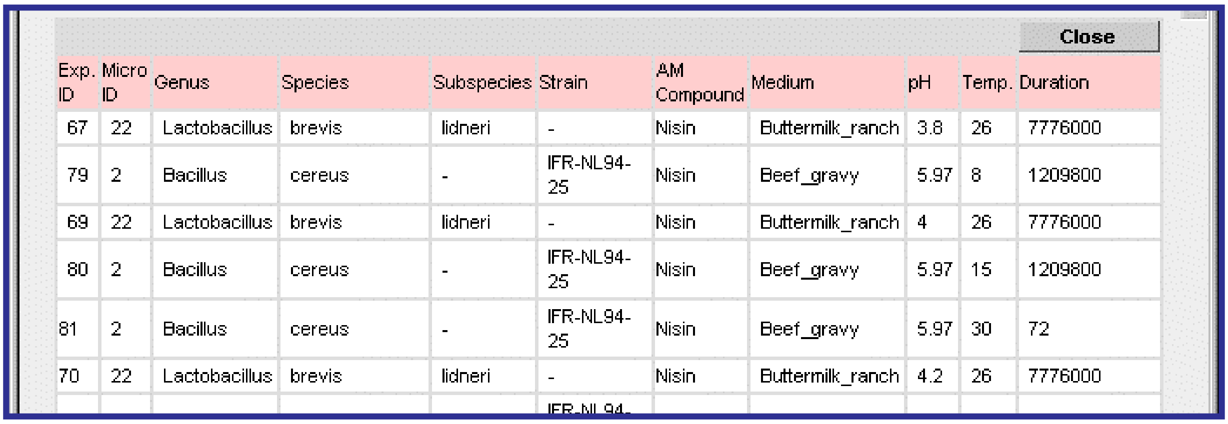
string pattern matching. This will significantly enhance the usefulness of the web as a world-wide knowledge and information source. To give meaning to information, this information has to be viewed in the light of its knowledge domain. The concepts and relations between these concepts in the knowledge domain are formally described in knowledge models. These models are also known as ontologies. The thing that makes an ontology special from knowledge modelling in general is that an ontology is an agreed explicit structure in a certain domain, which can also exist outside the application for which it was developed. Ontologies can be reused by other applications and maintained for a particular knowledge domain. The knowledge modelling for databases and software applications usually are drawn from scratch and are only used for that certain application, implicating poor maintenance and reusability.

For the A/OL project we have developed ontologies for the various knowledge domains in OntoEdit [ref]. The ontologies are expressed in RDF format and imported in Sesame [ref]. With the query language SeRQL [ref], an enhanced version of RQL, the ontologies and their instances are questioned and the results are displayed in the user interface (see Figure 1).

## 3 MICROBES, ANTIMICROBIALS AND FOOD

The basic concepts in A/OL are antimicrobials, microbes, and food products. The service essentially provides information on experimental studies concerning the effectiveness of antimicrobial compounds in laboratory circumstances. The antimicrobial knowledge in A/OL contains information on physical and chemical properties, like boiling point, solubility, stability, toxicity, etc. The microbial information is stored in a taxonomy, in which relations between families of microbes are indicated. In A/OL three main types of media are distinguished: real food, food models and laboratory media.

Besides knowledge on these three components, the largest amount of data in A/OL consists of the inhibitory working of anti-microbials against microbes in certain environments (food, food model or laboratory medium). Typical properties in these experiments are pH, temperature, duration, etc. Experiment descriptions can be found, as well as results and conclusions. All these data have been assessed by experts in the field of food preservation.



| Exp. ID | Micro ID | Genus | Species | Subspecies | Strain | AM Compound | Medium | pH | Temp. | Duration |
|---|---|---|---|---|---|---|---|---|---|---|
| 67 | 22 | Lactobacillus | brevis | lidneri | - | Nisin | Buttermilk_ranch | 3.8 | 26 | 7776000 |
| 79 | 2 | Bacillus | cereus | - | IFR-NL94-25 | Nisin | Beef_gravy | 5.97 | 8 | 1209800 |
| 69 | 22 | Lactobacillus | brevis | lidneri | - | Nisin | Buttermilk_ranch | 4 | 26 | 7776000 |
| 80 | 2 | Bacillus | cereus | - | IFR-NL94-25 | Nisin | Beef_gravy | 5.97 | 15 | 1209800 |
| 81 | 2 | Bacillus | cereus | - | IFR-NL94-25 | Nisin | Beef_gravy | 5.97 | 30 | 72 |
| 70 | 22 | Lactobacillus | brevis | lidneri | - | Nisin | Buttermilk_ranch | 4.2 | 26 | 7776000 |
| | | | | | IFR-NL94- | | | | | |

Figure 3: Part of the list of resulting experiments for the inserted query.

## 4 USER INTERACTION

In the web-based user-interface, we distinguish several user roles, like food scientist, marketeer, etc, where each role has its own preferences of search criteria. We discern four different categories of search criteria: (1) activity, in which information on the actual working of preservatives is contained, (2) permitted usage, in which information on the legal status of food preservatives in certain countries can be found, (3) literature, in which articles are presented for detailed information on anti-microbial compounds, and (4) suppliers, where information can be found on sellers of preservatives. In Figures 2 and 3, an overview of the search steps in the user interface are given. In Figure 2, the screen is shown in which the user can select on which criteria the data have to be searched. Figure 3 displays a list of the resulting experiments. Clicking on of these experiments, results in detailed information.

The described user interface is accessible via the Internet. The web-address is: http://www.atoapps.nl/AOLKnowledge, where one can apply for a guest account.

## 5 CONCLUSIONS

A/OL is becoming an informative system with reliable data on the activity of antimicrobial compounds. Because of the ontological knowledge structure, the system is highly flexible. The ontology-based searching enables interesting access capabilities of the data. In future, the system will be extended to other antimicrobial compounds, and a consumer front end will be added.

## 6 REFERENCES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