RDFS-Based Information Representation of Indonesian Traditional Jamu

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***Abstract*—The need for information related to the Indonesian traditional herbal drink, *jamu*, has increased in the recent years as *jamu* becomes a more economical option for alternative treatment. Experts in *jamu* are needed to provide information such as the type of *jamu* to drink, how to brew it, or where to get it. These experts may have different concepts and/or abilities to recognize symptoms resulting in different opinions. For this reason, we propose a system that has the ability to comprehend *jamu* related information and manage that information into knowledge. This knowledge can then be accessed by the public to give them an insight on how to treat a certain disease. For this system, a standard model is needed to represent all the information concerning *jamu*. An ontology is used to model the knowledge from the *jamu* information with RDFS knowledge base to describe the schema.**

***Index Terms*—Indonesian Tradisional Jamu, RDF, ontology**

I. Introduction

INDONESIAN traditional *jamu* is widely used in Indonesia as a more economical alternative treatment. However, there is a lack of information management regarding *jamu* which causes inadequate knowledge of the benefits of *jamu* for the public. To obtain information on *jamu*, one has to ask someone who is considered an expert in *jamu*. Considering the different opinions from different *jamu* experts, a standard model is needed to represent *jamu*. This model consisting of *jamu* information can then be used by a system to be managed and accessed by the public. One of the ways to achieve this is to create RDFS-based semantic web containing *jamu* information.

Our research problem covers how RDFS-based knowledge representation model can be used to manage information concerning Indonesian traditional *jamu*. Information on how to make *jamu* can usually be obtained by people through *jamu* recipes. A *jamu* recipe consists of the benefits, ingredients and directions to make that particular *jamu*. This research uses several *jamu* recipe books [1][2][3] to gather all the necessary information which will then be transformed into RDFS-based semantic web that represents Indonesian traditional *jamu*.

There are some previous works that implement RDF as the basis data model for developing information system. Those works provide a big picture about implementing RDF in developing model data of Indonesian Tradional *Jamu*. Supriheryantono [4] represented an organization structure of a banking company based on RDF. The company's information structure was modeled in the form of an ontology, making it easier for users to obtain information. Fedila and Mustikasari [5] represented RDF-based lecture materials in a course search application. However, the usability of this application was considered insufficient because of the lack of features to support the ease of search. Related with Indonesian traditional *jamu*, Wardani, et al. [6] created Ethnomedicine, an ontology that represents expert knowledge on the use of medicinal plants in Indonesia. From these cases we can see the significance of the capibility and source of knowledge of a model in representing a domain.

II. Background Theory

A. Indonesian Traditional Jamu

Based on the beneficial proof of traditional medicine in Indonesia, the National Agency of Drug and Food Control of Indonesia (BPOM) has classified traditional medicine into three categories namely *jamu*, standardized herbal medicine and phytomedicine. Empirical, pre-clinical and clinical data are used to prove the benefits of *jamu*, standardized herbal medicine and phytomedicine respectively. *Jamu* is a traditional medicine derived from different medicinal plants with certain composition concocted by following a set of instructions in a recipe. *Jamu* can be consumed in the form of hot drink, powder, liquid, tablet, or capsule [7].

According to Sujatno (cited in [7]), the role of *jamu* as medicine in society refers to the use of *jamu* for promotive, preventive, curative and rehabilitative purposes. The following lists the purpose of *jamu* along with examples of diseases that can be treated by it: 1) Curative, to treat an illness as well as to replace or complement the use of modern medicine (cough, diarrhea, hypertension and cholesterol); 2) Promotive, for health and physical fitness purposes (adult health, child growth); 3) Preventive, to prevent sickness (anti-common colds, anti-stress); and 4) Rehabilitative, for health recovery purpose.

Apart from health purposes, *jamu* can also be used for beauty treatments such as spa treatment. *Jamu* is also beneficial for increasing sexual stamina for men and providing intimate care for women [7].

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B. Semantic Web

Semantic web can be described as a web that transforms information into knowledge so that its content can be understood by computer. The computer then intelligently uses the meaning of the web content to search, merge and process the web content which can only occur when the intended meaning, i.e. semantic, is given explicitly and can be processed [8, p. 11]. RDFS knowledge base is used in this research to provide meaning to the content.

One of the fundamental components for Semantic Web infrastructure is URI. The W3C [9] states that the design of the URI is used to identify a single resource. The term "resource" is used in the general sense for anything that may be identified by the URI. An object that is identified is often referred to as designatum (resource). Whereas as an attempt to describe a designatum designated with a unique URI, the representation (or designator) needs to be provided by taking into account the description of the content containing the metadata that matches the description of the object as its designatum.

C. Resource Description Framework

The contents in RDF format are resources for the semantic web. RDF document is depicted as a directed graph which is a pair of nodes connected by a directed edge (“arrow”). The node and edge are given different labels for identification [8, p. 20]. The data in RDF has literal values. However, when the data type is undefined, it is considered as string. XML-Schema is used to define the data type [8, p. 37]. The triple concept is a concept resulted from the serialization of RDF. This concept consists of subject, predicate and object.

RDF can be defined as a simple model to describe the relationship between resources. RDF document is information written in a format readable by machine. With RDF two terms can be linked using a binary property so that it can form a directed graph. These terms and properties are explained using URIs. Because properties can also be URIs, properties can be reused as interrelated terms with other properties. In RDF, URIs can refer to things that can be identified (for example, someone, vehicle, business, or event). RDF's basic structure was then developed into RDF Schema (RDFS) which can be used to define simple ontologies, so RDFS is also known as a simple ontology language. RDFS is a RDF-specific dictionary that can define the class model and its hierarchy as well as properties with restrictions for domains and ranges.

D. Resource Description Framework Schema

RDFS allows user to build an information schema using the terms set by the user. RDFS is unlike FOAF (Friend Of A Friend) where the user is not able to use new terms apart from the vocabulary already set by FOAF [12]. In short, RDF vocabulary and RDFS vocabulary can be categorized into three groups namely class vocabulary, property vocabulary and additional vocabulary.

Class vocabulary

Class vocabulary is a set of terms that focuses on stating class taxonomy/hierarchy. Among them are:

- `rdfs:Class` for object abstraction;
- `rdf:type` to instatiate object in a class;
- `rdfs:subClassOf` to state that a class is a subclass of a certain class;
- `rdfs:Resource` to state that a class is a resource of a domain;
- `rdfs:Literal` to state a literal class.

Property vocabulary

Property vocabulary is a set of terms that focuses on the declaration of properties (object property and data type property). Among them are:

- `rdfs:Property` to state a new term in a certain domain;
- `rdfs:subPropertyOf` to state a term that inherites rules from the class above it (inheritance);
- `rdfs:domain` and `rdfs:range` are to state domain and range boundary in a term.

E. Ontology

Ontology is developed for many reasons including to share common understanding of the structure of information to human or software agents, to reuse domain knowledge, to make domain assumption explicit, to separate domain knowledge from the operational knowledge and to analyze domain knowledge ([10], cited in [11]).

In order to evaluate the ontology, completeness check is developed. Completeness check is a formal framework developed by Cordi and Mascardi [12] to develop and prove the truth and completeness of an ontology. The steps of completeness check are:

1) Domain Analysis: This step consists of domain identification and the ontology’s aim and users. Ontology development scenario can also be included in this step. As a result, queries will arise as the foundation of ontology development. These queries are usually in the form of questions called competency questions and must be answered by the ontology.

2) Definition of Needs: This step includes the design of competency questions which are brainstorming, putting details into scenarios which will become the motivation of ontology development, trimming and identifying specific software/hardware obstacles.

3) Informal Ontology Specification: Here, ontology graphic is provided to represent the relation between different concepts in the ontology.

4) Formal Ontology Specification: The fourth step covers the definition of the ontology using formal language.

5) Testing, Validation and Verification: The main validation method used in this step is testing the ontology with informal competency questions. In doing so, adjustments to the competency questions can be done so that it can define the needs of the ontology.

6) Completeness Check: The last step uses “partially automatized” approach. The completeness check can be fully done automatically once the informal competency questions/queries are implemented as a system. This is done by running the system according to the competency questions. The ontology is considered as complete when every competency question has been answered by the result

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of system implementation.

F. Ad-hoc Information Retrieval

Information Retrieval (IR) is the activity of finding documents from a large set of documents relevant to the user's query [13]. Resources are retrieved based on the user's query. The metrics to measure the system's performance are precision, recall, and accuracy.

Recall is defined as the fraction of items taken from a set of relevant items, precision is the fraction of relevant items among the retrieved items whereas accuracy is the fraction of correctly classified items, both relevant and irrelevant [13].

III. Research Methodology

The Indonesian traditional *jamu* ontology model was developed by conducting literacy studies from several books about traditional herbal medicine. From each book, knowledge extraction was carried out by summarizing each statement in the form of simple sentences consisting of subject, predicate, and object. From each of these statements, categorization will be carried out based on subject and object. From the basis of the categorization, grouping and summarizing the predicate can be used as relations between objects (both as subjects or predicates).

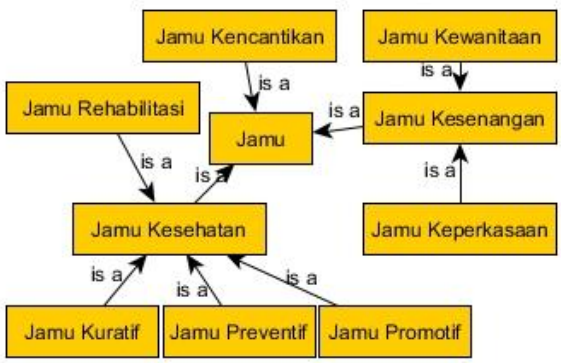

Fig 1. The taxonomy of Indonesian traditional *jamu*

A. Ontology Design

1) Domain Analysis

The domain of this research is related to Indonesian traditional drink *jamu* which is considered as Indonesian traditional medicine. As illustrated in Fig. 1, *jamu kuratif* (curative *jamu*), *jamu preventif* (preventive *jamu*), *jamu promotif* (promotive *jamu*), and jamu *rehabilitasi* (rehabilitative *jamu*) are *jamu kesehatan* (jamu for health purpose). *Jamu keperkasaan* (*jamu* to increase men's sexual stamina) and *jamu kewanitaan* (*jamu* for women's intimate area) are considered as *jamu kesenangan* (*jamu* for pleasure). *Jamu kesehatan*, *jamu kecantikan* (*jamu* for beauty), and *jamu kesenangan* fall under *jamu*. The use of each type of *jamu* is shown in Table I.

The domain of this research is *jamu* recipe. Specifically, each recipe must have at least the following information:

1. An identity in the form of a name/title.
2. Explicit/implicit information of the benefits of *jamu* as a solution for diseases/health problems.
3. Information of the name and amount of ingredients.
4. Directions on how to make the *jamu*.

The purpose of this ontology is to represent information regarding *jamu* in a semantic web. The ontology allows users to easily obtain information on *jamu*. Users refer to people who are sick or have health issues and are trying to seek alternative medication as a solution.

TABLE I
THE CLASSIFICATION OF JAMU BASED ON ITS USE [7]

Jamu		Intended use
Jamu kesehatan	*Jamu kuratif*	treat illnesses, as well as to replace or complement the use of modern medicine
	Jamu preventif	to prevent sickness
	Jamu promotif	for health and physical fitness purposes
	Jamu rehabilitasi	for health recovery purpose
Jamu kecantikan		for body slimming and to gain white/soft/youthful skin
Jamu kesenangan	*Jamu keperkasaan*	for sexual stamina
	Jamu kewanitaan	for women's intimate area

SCENARIO 1: Retrieving jamu data

The *jamu* data is retrieved from several books containing *jamu* recipes. The data needed are title, ingredients name and amount, as well as directions to make the *jamu*. The obtained data will be modeled using XML schema (.xsd) resulting in *jamu* recipe content. The content is inserted into the server in RDF format to enable searching, merging and process upon the content. Information schema on RDF *jamu* recipe is needed to create RDFS Indonesian traditional *jamu*. The end product of this process is a semantic web.

TABLE II
LIST OF DISEASES AS A RESULT OF GENERALIZATION

Diseases	
Before	After
Jantung Koroner	*Jantung Koroner*
Jantung Rematik	*Jantung Rematik*
Radang Jantung	*Radang Jantung*
Kejang Jantung	*Kejang Jantung*
Jantung Hipertensif	*Jantung Hipertensif*
Serangan Jantung	*Serangan Jantung*
Jantung Berdebar	*Jantung Berdebar*
Jantung	*Jantung*
Stroke	*Stroke*
AsamUrat	*AsamUrat*
Diabetes	*Diabetes*
Membersihkan Reproduksi, Menormalkan Fungsi Menstruasi dan Mengatasi Infeksi atau Penyumbatan	*Infeksi Penyumbatan Menstruasi*
Mioma Uteri	*Mioma Uteri*
Kemandulan Wanita	*Kemandulan Wanita*
Gangguan Reproduksi	
Gangguan Hormon	
Kerusakan Sel Telur	
Keputihan	*Keputihan*
Kemandulan Pria	*Kemandulan Pria*
Kerusakan Sperma	
Ejakulasi Dini	*Impotensi*
Gairah Seksual Rendah	
Stamina Seks Buruk	
Lemah Syawat	
Impotensi	
Ereksi Buruk	

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SCENARIO 2: Jamu data classification

We obtained a total of 120 *jamu* recipes. Each title contains herb name, its purpose and type of disease. The recipes are categorized by its title. The categorization of *jamu*/*jamu* recipe is carried out by manually separating the sentence structure of the title into subject, predicate, and object as a way to understand the meaning of each jamu recipe. The categorization resulted in 73 *jamu kuratif*, 6 *jamu preventif*, 21 *jamu keperkasaan*, and 20 *jamu kewanitaan*.

We found some diseases that can be generalized into more common diseases. Therefore, we acquired a total of 17 diseases as seen in Table II.

2) Definition of Needs

The definition of needs in the development of this ontology is found in the following competency questions:

Competency Question 1: What is Indonesian traditional jamu? Indonesian traditional *jamu* is traditional medicine originated from Indonesia. Its benefits have been proven based on empirical data. *Jamu* can be produced using *jamu* recipe and consumed in the form of hot drink, powder, liquid, tablet, or capsule.
Expected answer: The system is able to show all the information related to *jamu*.

Competency Question 2: What are the categories of Indonesian traditional *jamu*? *Jamu* can be classified into 3 categories namely *jamu kesehatan* (jamu for health purpose), *jamu kecantikan* (jamu for beauty), and *jamu kesenangan* (jamu for pleasure). *Jamu kesehatan* is divided into 4 sub-categories which are *jamu kuratif* (curative jamu), *jamu preventif* (preventive jamu), *jamu promotif* (promotive jamu), and *jamu rehabilition* (rehabilitative jamu). *Jamu kesenangan* (jamu for pleasure) has 2 sub-categories namely *jamu keperkasaan* (jamu to increase men's sexual stamina) and *jamu kewanitaan* (jamu for women's intimate area).
Expected answer: The system is able to show that the data have been correctly categorized.

Competency Question 3: What are the ingredients of Indonesian traditional *jamu*? The ingredients of Indonesian traditional *jamu* are part of medicinal plants, namely root, tuber, stalk, leaf, fruit, and flower.
Expected answer: The system is able to demonstrate the relation between ingredients and jamu.

Competency Question 4: Which diseases can use Indonesian traditional *jamu* as alternative medicine? Jamu can heal 23 different kinds of diseases.
Expected answer: The system is able to demonstrate the relation between diseases and *jamu*.

3) Informal Ontology Specification

Fig. 2 visualizes the concept and relation found in Indonesian traditional *jamu* recipe ontology. The terms of the ontology can be seen in Table III.

TABLE III
INDONESIAN TRADITIONAL JAMU RECIPE ONTOLOGY PROPERTIES

No	Property	Domain	Range	Property
1	pengobatanAlternatif	*Jamu*	*Penyakit*	Object
2	hasForm		Literal	Data type
3	hasIngredient		*Bahan*	Object
4	hasAuthor		Person	Object
5	hasName		String	Data type
6	hasName	*Bahan*	String	Data type
7	hasAmount		Non negative integer	Data type
8	hasUnit		String	Data type

4) Informal Ontology Specification

The following shows the ontology (Fig.2) formalized as TBox:

- *Jamu* is Indonesian traditional medicine
  $Jamu \sqsubseteq Obat\_Tradisional\_Indonesia$
- *Jamu* for health purpose is *jamu*
  $Jamu\_Kesehatan \sqsubseteq Jamu$
- *Jamu* for beauty is *jamu*
  $Jamu\_Kecantikan \sqsubseteq Jamu$
- *Jamu* for pleasure is *jamu*
  $Jamu\_Kesenangan \sqsubseteq Jamu$
- The intersection of *Jamu_Kesehatan*, Jamu_Kecantikan, and Jamu_Kesenangan is an empty set
  $Jamu\_Kesehatan \sqcap Jamu\_Kecantikan \sqcap Jamu\_Kesenangan \sqsubseteq \bot$
- Curative *jamu* is *jamu* for health purpose
  $Jamu\_Kuratif \sqsubseteq Jamu\_Kesehatan$
- Preventive *jamu* is *jamu* for health purpose
  $Jamu\_Preventif \sqsubseteq Jamu\_Kesehatan$
- Promotive *jamu* is *jamu* for health purpose
  $Jamu\_Promotif \sqsubseteq Jamu\_Kesehatan$
- Rehabilitative *jamu* is *jamu* for health purpose
  $Jamu\_Rehabilitasi \sqsubseteq Jamu\_Kesehatan$
- The intersection of Jamu_Kuratif, Jamu_Preventif, Jamu_Promotif, and Jamu_Rehabilitasi is an empty set
  $Jamu\_Kuratif \sqcap Jamu\_Preventif \sqcap Jamu\_Promotif \sqcap Jamu\_Rehabilitasi \sqsubseteq \bot$
- *Jamu* to increase men's sexual stamina is *jamu* for pleasure
  $Jamu\_Keperkasaan \sqsubseteq Jamu\_Kesenangan$
- *Jamu* for women's intimate area is *jamu* for pleasure
  $Jamu\_Kewanitaan \sqsubseteq Jamu\_Kesenangan$
- The intersection of Jamu_Keperkasaan and Jamu_Kewanitaan is an empty set
  $Jamu\_Keperkasaan \sqcap Jamu\_Kewanitaan \sqsubseteq \bot$
- Medicinal plant is a *jamu* ingredient
  $Tanaman\_Obat \sqsubseteq Bahan$
- Root is a medicinal plant
  $Akar \sqsubseteq Tanaman\_Obat$

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- Tuber is a medicinal plant
  `Umbi ⊑ Tanaman_Obat`
- Stalk is a medicinal plant
  `Tangkai ⊑ Tanaman_Obat`
- Fruit is a medicinal plant
  `Buah ⊑ Tanaman_Obat`
- Leaf is a medicinal plant
  `Daun ⊑ Tanaman_Obat`
- Flower is a medicinal plant
  `Bunga ⊑ Tanaman_Obat`
- The intersection of dari *Akar, Umbi, Tangkai, Buah, Daun* and *Bunga* is an empty set
  `Akar ⊓ Umbi ⊓ Tangkai ⊓ Buah ⊓ Daun ⊓ Bunga ⊑ ⊥`
- *Jamu* has ingredients which are medicinal plants
  `∀hasIngredient.Jamu ⊑ Bahan`
- *Jamu* is an alternative medicine for diseases
  `Penyakit ⊑ ∃pengobatanAlternatif.Jamu`

B. System Testing Design

1) Completeness Check

Competency questions are the parameters used to evaluate an ontology. There are 4 competency questions. For each question, there will be an example question along with the expected answer used to validate the ontology as seen in Table IV.

2) Precision, Recall and Accuracy

The system's performance in the completeness check process is measured using precision, recall and accuracy. The system's average percentage of precision, recall and accuracy are calculated using equations (1), (2), and (3).

TABLE IV
EXAMPLE OF SYSTEM TESTING

CQ 1: What is the concept of Indonesian traditional *jamu*?			STATUS
Q1	Is Indonesian traditional *jamu* considered as Indonesian traditional medicine?		VALID
	FF	`Jamu ⊑ Obat_Tradisional_Indonesia`	
	EO	*True*	

Information:
CQ = Competency Question
Q1 = Question 1
FF = Formal Form
EO = Expected Output/Expected answer

$$\bar{P} = \frac{PCQ1+PCQ2+PCQ3+PCQ4}{4} \quad (1)$$

$$\bar{R} = \frac{RCQ1+RCQ2+RCQ3+RCQ4}{4} \quad (2)$$

$$\bar{A} = \frac{ACQ1+ACQ2+ACQ3+ACQ4}{4} \quad (3)$$

Information:
$\bar{P}$ = average precision
$\bar{R}$ = average recall
$\bar{A}$ = average accuracy
PCQ = precision competency question
RCQ = recall competency question
ACQ = accuracy competency question

IV. RESULT AND DISCUSSION

The knowledge model for Indonesian traditional herbal medicine can be fully applied to RDFS and RDF. In its application, it consists of the following classes:

- *Jamu* class has 3 sub classes namely *jamu kesehatan*, *jamu kecantikan* and *jamu kesenangan*;
- *Bahan* (ingredient) has 1 sub class namely *tanaman obat*

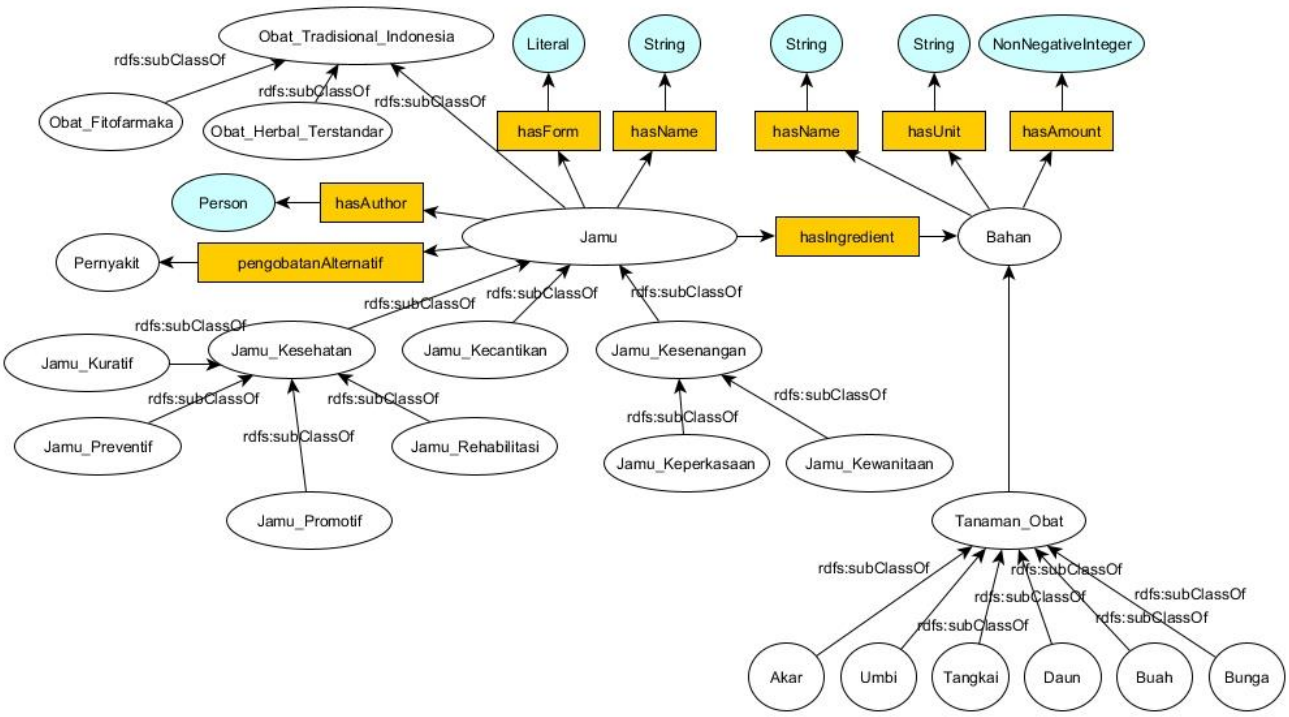

Fig. 2. Indonesian traditional *jamu* recipe ontology

(medicinal plant) class. *Akar* (root), *buah* (fruit), *bunga* (flower), *daun* (leaf), *tangkai* (stalk) and *umbi* (tuber) are sub classes of *tanaman obat*;
- Person class/foaf:Person;
- *Penyakit* (disease) class.

Besides class implementation, some fundamental properties are implemented. There are:
- `pengobatanAlternatif`, `hasIngredient` and `hasAuthor` are object properties with *jamu* class as its domain and *penyakit* class, *bahan* class and person class respectively as its range;
- `hasName`, `hasAmount` and `hasUnit` are data type properties belonging to *bahan* class;
- `hasForm` and `hasName` are data type properties belonging to *jamu* class;
- `index` is an additional data type property belonging to *jamu* class which aims to simplify the management of *jamu* recipes in this research;
- `rdfs:label` property is used by *penyakit* and person classes for the purpose of data search.

In this research, there are 120 *jamu* instances already created based on the T-Box RDFS model. Those instances consist of 79 *jamu kesehatan* instances (73 *jamu kuratif* instances, 6 *jamu preventif* instances), 41 *jamu kesenangan* instances (21 *jamu keperkasaan* instances and 20 *jamu kewanitaan* instances). In total, there are 205 *bahan* instances which consist of 16 *akar* instances, 54 *buah* instances, 7 *bunga* instances, 80 *daun* instances, 11 *tangkai* instances and 31 *umbi* instances. There are 17 *penyakit* instances and 2 person instances.

The search function in this system uses SPARQL to return information on *jamu* objects. From the results of the search experiment, the results of the performance are shown in the Table V. Search experiments that have been conducted are based on 4 questions:

TABLE V
PRECISION, RECALL, AND ACCURACY RESULT

	Precision	Recall	Accuracy	Sample
CQ 1	120/120	120/120	120/120	*Jamu*
CQ 2	79/79	79/79	79/79	*Jamu kesehatan*
CQ 3	5/5	5/5	5/5	*Kencur*
CQ 4	20/20	20/20	20/20	*Asam urat*
(%)	$\bar{P}$=100%	$\bar{R}$=100%	$\bar{A}$=100%	

CQ 1: What *Jamu* are on the system?
Result: The system displays a total of 120 records, all of which are *Jamu*.
CQ 2: What are the *jamu* that are jamu kesehatan?
Result: The system displays a total of 79 records, all of which are *jamu kesehatan*.
CQ 3: What are the *jamu* that contain *kencur* (tuber)?
Result: The system displays a total of 5 records, all of which are *jamu* containing *kencur*.
CQ 4: What *jamu* are used in alternative medicine for uric acid (*asam urat*)?
Result: The system displays a total of 20 records, all of which are *jamu* used in alternative medicine for uric acid (*asam urat*).

V. CONCLUSION

Based on Indonesian traditional *jamu* medicine literacy that is used in this research, knowledge models have been developed and tested in a controlled system environment. Utilization of SPARQL has succeeded in providing the function of finding *jamu* information to users. However the *jamu* representation model that has been developed in this study is not connected with detailed medicinal plant ontology. In addition, this Indonesian traditional *jamu* model needs to present the consumption rules or the contraindication. These things can be done for further works.

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