Chapter IV

RESULT AND DISCUSSION

This Chapter covers the following topics:

1. Thai herbal medicine database

2. Thai herbal medicine ontology

3. Evaluation of ontology and semantic search system

    3.1. Ontology evaluation

    3.2. Semantic search system evaluation

1. Thai herbal medicine database

A Thai Herbal Database has been developed to store data on herbal medicine. The scope of data collection is described in chapter 1. Table 3 shows the data by different types of information in the database.

Table 3 data collection in Thai herbal database

Data contained in Database	Number of
List of plants	132
List of herb ingredients (include plant, animal and material	139
Herbal medicine and formulations	32
List of health problems/illness	24
List of indication	34

2. Thai herbal medicine ontology (THMO)

The knowledge base construction of Thai herbal medicine has been developed so called Thai herbal medicine ontology (THMO), contains 323 concepts which can be divided into three major components of ontology as follow:

2.1 Classes of Thai Herbal Medicine Ontology (THMO)

2.2 Object properties

2.3 Data properties

2.1 Classes of Thai Herbal Medicine Ontology (THMO)

THMO consists of 10 major classes: Formulation, Indication, Adverse Reaction, Finished Product Form, Herb Material, Clinical Warning, Taste, Tri-That, Health Problem, Use Method and Formulation preparation for use.

1) **The Herb material class** represents the materials used for the medicinal

purposes according to two of the official Thai traditional medical books,

TamraPramuanLakPhesatchakam (ตำราประมวลหลักเภสัชกรรม)

(Watphrachetupol, 1978) and Wetchasuksa, phaetthayasatsangkhep (เวช

ศาสตร์ศึกษา แพทยศาสตร์สังเขป): *Manual for student of Thai traditional*

medicine (Thai Language Institute, 1999). The main component of herb

material is the Plant material. It represents information of plants under

heading include plant botanical name, synonym, taste of plant, part of

plant use as medicine and clinical warning of plant. Other types of

materials used in Thai pharmacy are animal materials and mineral

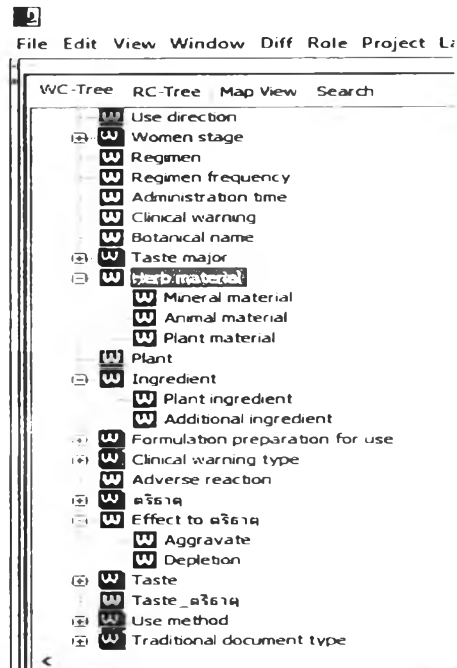materials, were also defined under this class as shown in Fig.8

Figure 8 A Herb material class

2) **The Taste class** is defined according to the principle of Thai traditional pharmacy principle (Watphrachetupol, 1978) in which the tastes of herb are not merely sensation on the tongue but indicate their medicinal properties. When a traditional doctor prescribes herbs or makes herbal remedies for their patients, taste is one of th factors which they usually consider. Here tastes are classified according to two principles. The first divides tastes into three major sensations: hot, cool and su-khum (mild taste). The second classifies them into nine medicinal tastes: sour, sweet, astringent, bitter, salty, spicy, oily, maobua (เมาเบื่อ) and, mild and fragrant (หอมเย็น). The class hierarchy of tastes is shown in Fig.9
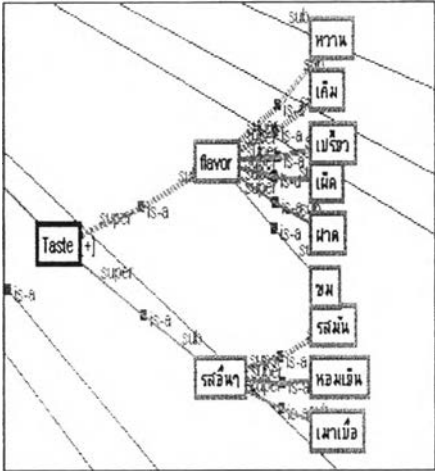

Figure 9 Hierarchy of Taste class

3) **The Tri-That (ตรีธาตุ) class** represents the concept of the three body elements namely; Vata, Pitta and Kapha. The Tri-That theory is one of foremost classification concepts of body elements in Thai traditional medical text, influenced by Ayurveda (Bamber, 1989). When the balance of these elements is disturbed, symptoms and illnesses will occur. The relationships between Taste and Tri-That are represented as 'aggravation' and 'depletion' properties.
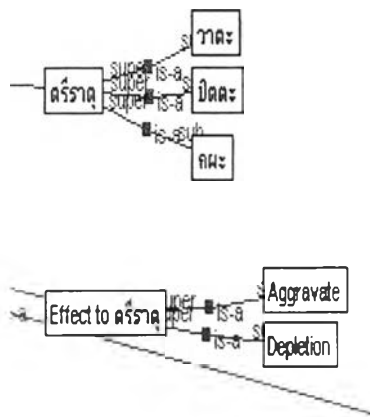

Figure 10 Tri That class and effect to Tri That class

4) **The Formulation class** is the main class in THMO. It aimed to represent necessary information available for users, including information of ingredients, indication, regimen, clinical warning, adverse reactions and dosage form of the herbal formulation. This class serves as a connecting class of important concepts in THMO. The relationships among the classes obtained through the object properties are shown in Fig.11
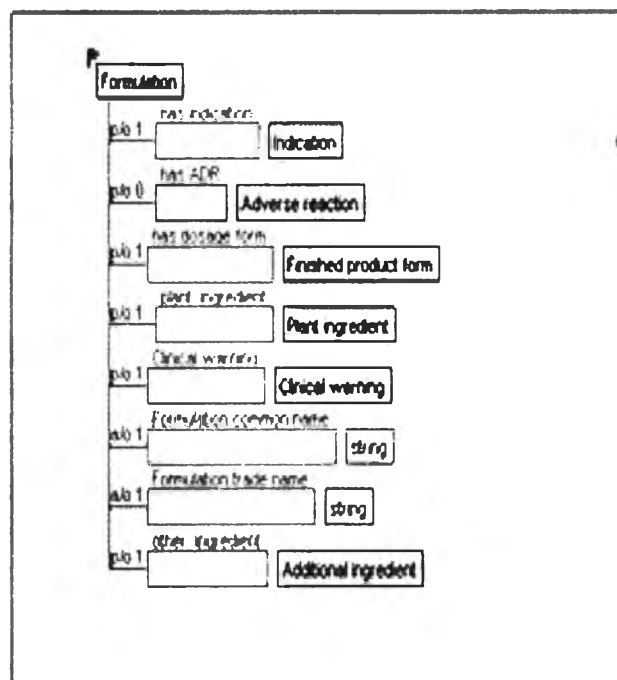
Figure 11 The Formulation class and *part-of* relationships

5) **The Use method class** conceptualizes the methods of administration covering all the route of herbs or herbal formulations are taken into the body as practiced in Thai traditional pharmacy and folk medicine. Although, Thai traditional pharmacy textbooks describe 23 methods of administration, other unusual methods including roasting, sudation, and body wrapping are practiced by folk doctors and people in communities around the country. These practices, though not officially recorded, are also included under this class. The conceptualized of all the method was achieved by a survey and interviews with traditional and folk medicine

practitioners conducted by Dr. Supaporn Pitiporn, Chao Phya Abhaibhubejhr Hospital Foundation [(Pitiporn, 2011), (Pitiporn, 2012) and (Pitiporn, 2014)]. The taxonomy of the Use Method is shown in Fig.12
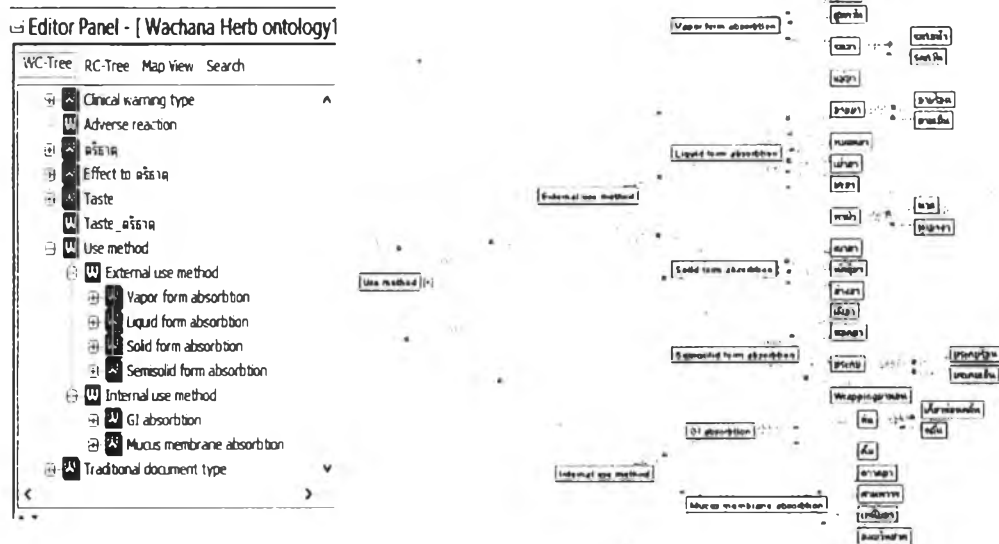

Figure 12 the Use method class

6) **The Health problem class** represents groups of health problems in accordance with Thai traditional medicine as well as the major systems of the body as described in convention medicine. THMO has classified Thai traditional diseases such as "Ka-sai" in the systematic symptom and disease sub-class. "Ka-sai' is a disease unique to Thai traditional context, affecting has several organs and causing a wide range of symptoms. Additionally, Fever, Element deficiency (That Phi Kan, ธาตุพิการ) and RokLom (โรคลม) are the common illnesses frequently mentioned in several textbooks and are conceptualized in this ontology. The

relationship between health problems and formulations are established by means of the Indication concept via the relationship of *hasHealthProblem*.
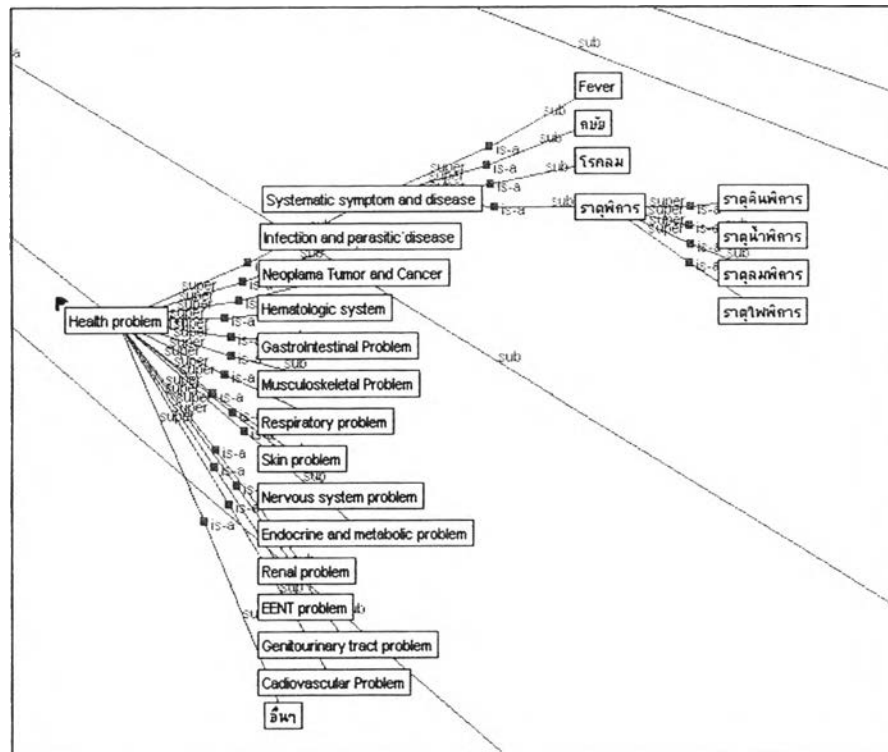
Figure 13 The Health problem hierarchy

7) **Indication class** represents the recommended uses of formulation for treating of health problems and, regimens of the formulas. Regimen class contains information of administration time and frequency of using the formulation.
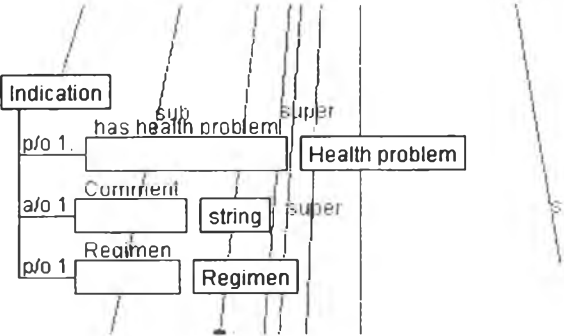
Figure 14 Indication class

8) **Finished Product Form class** represents the classification of the forms of herbal product used in Thai herbal medicine classified according to the physical form of products.
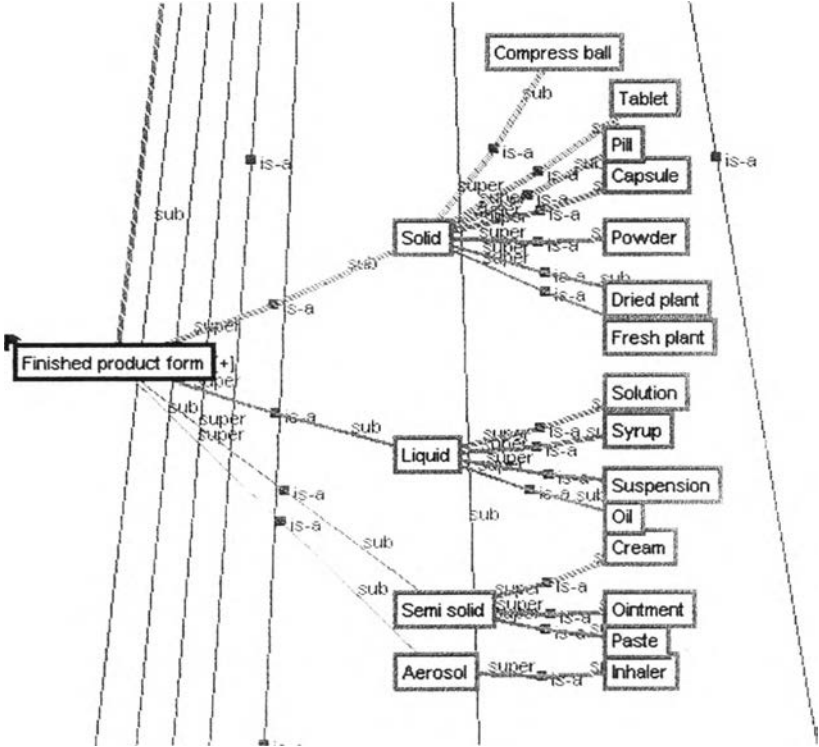
Figure 15 Finish Product Form class

9) **Formulation Preparation For Use** represents the methods of preparation of herbal medicine for use as shown in Fig.16. Some forms of finished products or dosage forms, such as dried herbs and fresh herbs, require preparation steps before administration. These preparation methods include those described in Thai traditional pharmacy textbooks as well as common preparation practices such as fermentation with sugar, salt or honey.
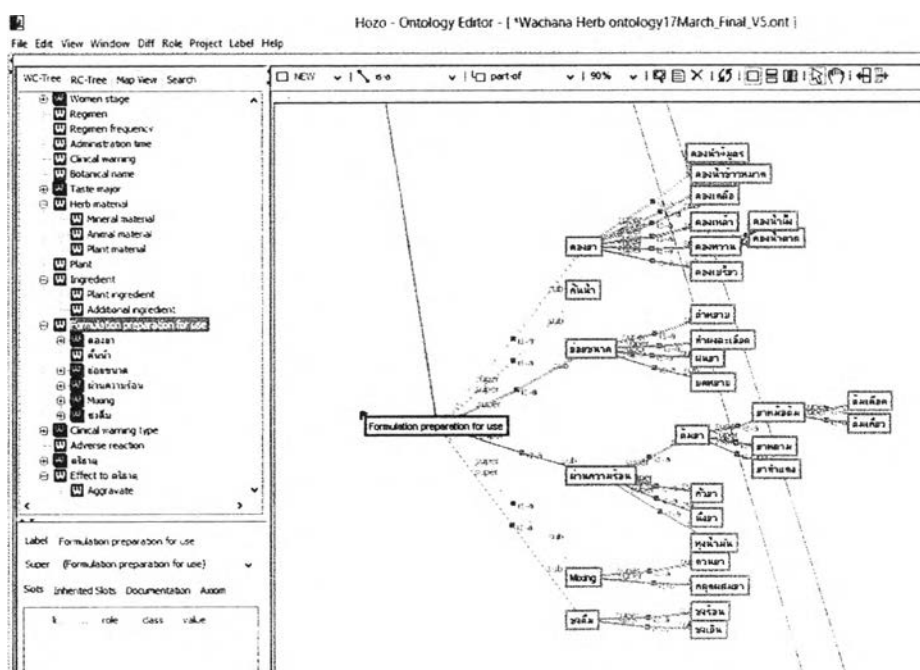
Figure 16 Formulation Preparation For Use

10) **Plant Usage** represents plant parts used in herbal formulations. Different part of the same plant may differ in medicinal properties or potency. Herb parts are classified according to plant morphology as shown in Fig. 17
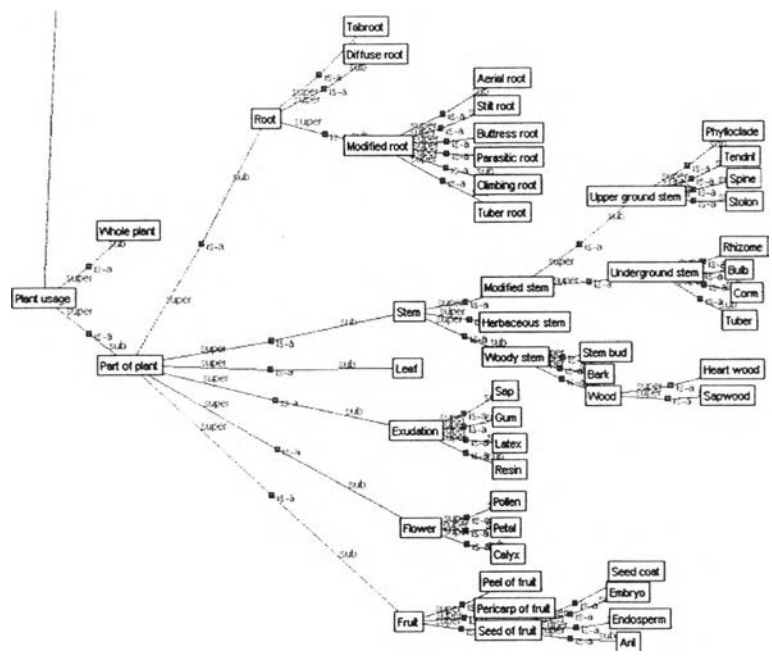
Figure 17 Plant Usage class

11) **Adverse reaction class** represents the adverse reactions associated with herbs or formulations. These are classified by severity into three sub-classes: mild, moderate and severe as shown in Fig.18
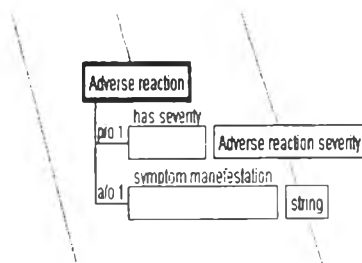
Figure 18 Adverse Reaction class

12) **Clinical Warning class** represents warnings for herbs or formulations including contraindication, precaution and other special conditions of user.
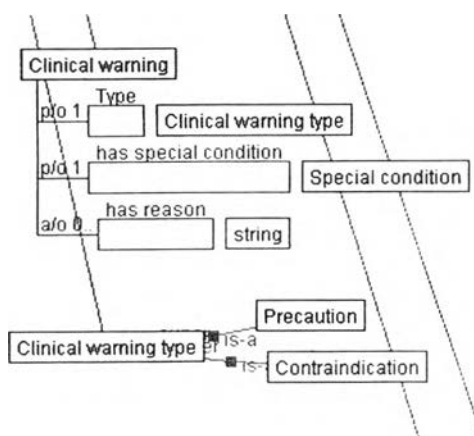
Figure 19 Clinical Warning class

13) **Special Condition class** represents cautions against using herbs or herbal formulations in certain grop of people and conditions or for certain period of time. These conditions include pregnancy stage, breastfeeding period, age and other medicines that might contraindicate with the herbs or formulations.
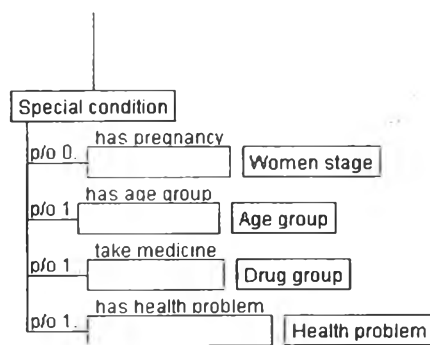
Figure 20 Special Condition Class

The list of major concepts as shown in Table 4

Table 4 THMO concept description

	Concepts	Description
1	Herb Material	Medicinal material in formulation, include plant material, animal material and mineral material
2	Taste	A property of herb material which can refer to the treatment properties
3	Tri-That	A classification of body elements according to Thai Traditional Medicine theory, contain Vata, Pitta and Kapha.
4	Formulation	A combination of herbal material in treatment of health problems
5	Use method	Methods of administration the herbal formulation in to the body according to the administration route
6	Health problem	List of health problems according to body system which include health problem in Thai Traditional Medicine Textbooks
7	Indication	Recommended uses of the formulation for treating illness
8	Adverse reaction	Adverse event related to herbs or formulations
9	Finished Product Form	The form or dosage form of products made from herbs
10	Clinical warning	Warning information of herbs or formulations

2.2 Object properties

Object properties indicates relationships between classes in the ontology. In THMO, object properties are described as shown in Table 5

Table 5 Objective properties description

	Object properties	Description
1	hasPlant	provides any of plant information which include plant botanical name, taste of plant and part of plant use as herb material
2	HasBotanicalName	Provide botanical name of plants
3	hasTaste	Provide taste information of plants
4	hasTasteMajor	Provide taste major of plants
5	hasPartofPlant	Relate Plant Material with Plant Usage. It describe part of plant which has medicinal properties
6	hasTasteEffect	Relate Taste with the Effect of Taste to Tri-That which can be describe in two type-aggravation and depletion
7	hasIndication	Relate the Formulation with the indication of the plant or formulation
8	hasRegimen	Describe the regimen of indication
9	hasAdverseReaction	Relate the Formulation with the Adverse reaction of formulation

	Object properties	Description
10	*hasDosageForm*	Relate the Formulation with the Dosage of the formulation of Thai tradition medicine
11	*hasClinicalWarning*	Relate the Formulation with the clinical warning of plant or the Formulation
12	*hasSpecialCondition*	Relate special condition with the Clinical Warning
13	*hasUseMethod*	Relate the Dosage form with the Use direction of the formulation
14	*HasAdministrationRoute*	Provide administration route information of each use method
15	*hasFormulationPreparation*	Relate the Use direction with the Formulation preparation of herbal medicine
16	*hasHealthProblem*	Provide health problem of indication
17	*hasPlantIngrdredient*	Provide plant ingredient in formulation
18	*hasPregnancy*	Provide pregnancy status with related to clinical warning
19	*hasAgeGroup*	Provide age group with related to clinical warning
20	*hasTakeMedicine*	Provide medicine which could have interaction with formulation in term of clinical warning

2.3 Data properties

The data type properties describes the value type of the classes which can be categorized including string, Boolean or number. For example, the data properties of the 'common name' and 'trade name' of the Formulation class (as in the name or trade name of the formulation) are string. The 'name' is a class with value type String. The detail of data properties of THMO describe are shown in Table 6.

Table 6 Data properties description

	Data properties	Type of Data	Description
1	*Genus*	String	Text describe genus of plant
2	*Species*	String	Text describe species of plant
3	*Plant name Author*	String	Text describe author of plant
4	*Family*	String	Text describe family of plant
5	*Formulation common name*	String	Text describe the common name of the herbal formulation
6	*Amount*	Integer	Number indicate amount of herbal material use in the herbal formulation
7	*unit*	String	Text describe unit of herbal material use in the herbal formulation

	Data properties	Type of Data	Description
8	Dose	String	Text describe the dose of herbal medicine use for treatment of illness
9	Comment	String	Text describe
10	Symptom manifestation (of adverse reaction)	String	Text describe the adverse reaction symptom manifestation of
11	Reason (of clinical warning)	String	Text describe the reason of the clinical warning in terms of precaution and contraindication
12	Instruction detail	String	Text provide more information of use direction

3. Evaluation of ontology and sematic search system application

3.1 Evaluation of ontology

The final version of ontology was obtained after the ontology schema had been evaluated by experts to test the validity of concepts, classes, subclass, object properties and relationship identification. The evaluation scores are classified as shown in Table 7

Table 7 Experts evaluation scores

Corresponding remark	Score
Strongly agree	4.50-5.00
Agree	3.50-4.49
Neutral	2.50-3.49
Disagree	1.50-2.29
Strongly agree	1.00-1.49

Two groups of experts were asked to evaluate the ontology in the following aspect:

1) validity of scope determination

2) validity of class identification

3) validity of property identification

4) Future development and reusability

3.1.1 Experts opinion on proper of scope determination

Table 8 Scope determiation evaluation

Evaluation of scope determination	Ontology experts		Traditional Doctors	
	$\bar{X}$	SD	$\bar{X}$	SD
The scope match with the information need of TTM-IS	4.50	0.71	4.33	0.47
The scope appropriate to the knowledge domain	4.50	0.71	3.83	0.37
The scope can be applied with the search system of TTM-IS	4.50	0.71	4.50	0.50
The concepts used are reasonable	4.00	0.00	4.33	0.75
The superclass is appropriate to the scope	4.50	0.71	3.83	0.37
Total	4.40	0.32	4.17	0.49
Overall satisfaction	$\bar{X}$=4.29, SD =0.48			

As shown in Table 8, all the experts agreed with the scope determination of Thai herbal medicine ontology. The total average score is 4.29 with a standard deviation of 0.48

3.1.2 Experts opinion on class identification

Table 9 Class identification evaluation

Evaluation of class identification	Ontology experts		Traditional Doctors	
	$\bar{X}$	SD	$\bar{X}$	SD
Subclasses identification are correct	3.50	0.71	3.83	0.69
The type of data properties are correct	4.00	0.00	4.83	0.37
Terminology used in ontology are appropriate	4.00	0.00	4.17	0.37
Values constraint of ontology are correct and appropriate	4.00	1.41	4.33	0.47
Total	3.88	0.53	4.29	0.48
Overall satisfaction	$\bar{X}$=4.09, SD =0.51			

As shown in Table 9, all the experts agreed with the identification of classes

and subclasses. The total average score is 4.09 with standard deviation of 0.51. The

experts also agreed with the identification of data properties, terms used in ontology

and the value constraint of the ontology.

3.1.3 Experts opinion on property identification

Table 10 Properties identification evaluation

Evaluation of property identification	Ontology experts		Traditional Doctors	
	$\bar{X}$	SD	$\bar{X}$	SD
Properties defined are related to concepts	4.50	0.71	4.17	0.69
Relationships defined for each concept is correct	4.50	0.71	4.50	0.50
Relationships have no constraint	4.00	0.00	4.50	0.50
Total	4.33	0.47	4.39	0.56
Overall satisfaction	$\bar{X}$=4.36, SD =0.52			

As shown in Table 10, all the experts agreed with property identification. The total average score is 4.36 with standard deviation of 0.52. They also agreed with relationship identification and that all relationships have no constraint.

3.1.4 Expert opinion of future development and reusability of Thai herbal medicine ontology

Table 11 Future development and reusability evaluation

Evaluation of future development and reusability	Ontology experts		Traditional Doctors	
	$\bar{X}$	SD	$\bar{X}$	SD
The ontology is reliable	4.50	0.71	4.50	0.50
The ontology can be reused and applied with other medical ontology	4.50	0.71	4.67	0.47
Total	4.50	0.71	4.58	0.49
Overall satisfaction	$\bar{X}$=4.54, SD =0.60			

As shown in Table 11, the all experts strongly agreed with future development and reusability of the ontology. The total average score is 4.54 with a standard deviation of 0.61.

3.2 Semantic search system function

This section presents an implementation of prototype of semantic search to discover relationship concepts in user query and to perform search process by using user concepts. The Semantic Ontology Search (SOS), a sematic search system application which was developed by NECTEC, was used as a user interface to perform querying and searching for herbal medicine information. The system allows users to select the searching criteria either by concepts-based query or keyword-base query.

Figure 21 Sematic Ontology Search application initial screen

The information source is a MySQL database which was developed exclusively for this study, covering diseases and herbal medicines as mentioned in chapter 3.

The initial search screen has shown in Fig.21. To start a search, the user would choose the desired concepts or that related to the question. For example, to query for herbs/formulations to treat fever, the user can select Formulation in the drop down box, choose Health Problem and then Fever respectively. The user can select other health problems in the same manner, and the system will start searching automatically. The search screen is shown in Fig.22

Figure 22 Searching screen from Semantic Ontology Search

The efficiency of the sematic search system application has not been applied in this study. This step can be perform in the future study to proof the ability of the semantic ontology search (SOS) in retrieving correct answer in the scope of the ontology for TTM-IS. This study recommend the use of frequently asked question which retrieved by TTM-IS to design the scenarios for evaluation the performance of the system according to the precision and coverage criteria suggested in Chapter 2. The scenario questions for testing the performance of THMO are shown in Table 12.

Table 12 Scenarion questions

Scenario	Questions	Related concepts in THMO
1	What is herbal formulation to treat health problems include: - Fever - Musculoskeletal problem - Gastrointestinal problem - Respiratory tract problem - Diabetes	Formulation, Health problem
2	Which herbs/ herbal formulations cannot use during pregnancy?	Clinical warning, Women stage
3	Which herbs/ herbal formulations cannot use during breast feeding?	Clinical warning, Women stage
4	What are the ingredients of herbal formulations such as: - Pet sang kat - Ya-kae-ammapreuk-ammapart (ยาแก้อัมพฤกษ์อัมพาต) - Pra-sa-ka-prao(ประสะกะเพรา)	Formulation, Plant Ingredient
5	Which are hot taste herbs?	Plant, Taste

Scenario	Questions	Related concepts in THMO
6	What are the adverse reactions of hers/herbal formulation? such as: - Bitter cucumber (มะระขี้นก) - Ginger - Thao wan prieng (เถาวัลย์เปรียง) - Sa hat thara (สหัสธารา)	Formulation, Adverse reaction
7	What are the herbs/herbal formulations should be careful while taking warfarin?	Formulation, Clinical warning
8	Which are herbs/herbal formulations for treatment of fever in children?	Formulation, Indication, Regimen, Health problem
9	What is a regimen of Turmeric for treatment of flatulence?	Indication, Regimen
10	Which are herbs/ herbal formulations can be prepared byboiling method?	Finished product form