Nutritional analysis of food/medicinal plants used by Haitian women to treat the syn.ptoms anemia

By

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Short Title of M.Sc Thesis of
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Analysis of plants used by Haitian women to treat anemia

ABSTRACT

Ethnobotanical and dietary questionnaires were used to assess the utilization of plants to treat the signs and symptoms of anemia by women in La Chapelle, Haiti. The usual diet of the respondents was found to be low to intermediate in iron bioavailability. The ethnobotanical questionnaire showed that most respondents (82%) used plant-based home remedies to treat anemia. *Amaranthus dubius*, *Citrus aurantium*, *Corchorus olitorius*, *Moringa oleifera*, *Phaseolus vulgaris* and *Portulaca oleracea* used in the diet and as remedies for anemia were analyzed. *Amaranthus dubius* was found to have the highest iron availability by in-vitro dialysis, 30%. The intra species variation in iron availability was influenced by storage and cooking times. The interspecies variation in iron availability was explained by the acidity of the plant species' cooked homogenate ($r=0.4168$, $p=0.007$).

RÉSUMÉ

Des questionnaires ethnobotaniques et diététiques furent administrés pour évaluer l'utilisation de plantes pour traiter les symptômes de l'anémie par les femmes de La Chapelle, Haïti. L' enquête diététique révéla que la diète des répondantes est faible à moyenne en fer bio-disponible. Le questionnaire ethnobotanique démontra que la majorité (82%) des répondantes utilisaient des remède-maisons à base de plantes pour traiter les symptômes de l'anémie. Les plantes ***Amaranthus dubius***, ***Citrus aurantium***, ***Corchorus olitorius***, ***Moringa oleifera***, ***Phaseolus vulgaris*** et ***Portulaca oleracea*** utilisées dans la diète et comme remèdes contre l'anémie furent analysées. Le plus haut taux de biodisponibilié du fer, par dialyse, fut trouvé chez *Amaranthus dubius* (30%). La variation intra-spécielle en bio-disponibilité du fer fut trouvé dépendante du temps d' entreposage et de cuisson; celle inter-spécielle, de l'acidité de l'espèce végétale cuite (r=0.4168, p=0.007).

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I. INTRODUCTION

Plants are used as both nutrient sources and therapeutic agents by humans (Johns, 1991). In their use of plants, people do not always make a distinction between food and medicine (Etkin, 1982). Food plants can contain secondary products (chemicals that are derived from the primary products carbohydrates, fats and proteins (Tyler et al. 1988)) that have physiological impact and nutrients can be administered in a therapeutic setting as medicines. Ethnobotanists researching the usefulness of medicinal plants have mainly been concerned with the secondary chemicals contained in plants of interest. On the other hand, dietary assessment procedures have focused only on ingestibles identified by the respondents as food. Therefore, some nutrients (particularly minerals) acquired through the ingestion of plant-based medicines or tonics may be overlooked (Gillies and Birkbeck, 1983). More flexibility in questionnaire design is needed to identify alternative sources of nutrients found in ingested materials. Ethnobotanists interested in the nutritional evaluation of traditional/indigenous diets are in a favorable position to assess the nutritional value of ingestible botanicals (Etkin, 1982). Empirical nutritional therapy is rarely mentioned but could be an interesting area of investigation. Koo (1984), noticed that Chinese people use foods as remedies for minor illnesses. Etkin (1982) reported the use of certain leaves as both medicine and food in an ethnobotanical study with the Hausa of Nigeria. Rouzier et al. (1986) reported the use of food plants to treat the biomedical (Western medicine) equivalent of anemia in Haiti. Many of the plants used are green leafy vegetables found also in the diet.

Wild and domesticated green leaves form an important part of the diet in developing countries where they accompany the staple foods (Ifon and Bassir, 1979). Green leafy vegetables are notable for their vitamin content (carotenoids, ascorbate and folates) but can also contain significant amounts of biologically available minerals such as iron and calcium (Rajammal and Devadas, 1979). In the high carbohydrate, low protein diet of agriculturists in developing countries, these plants also provide a source of essential and complimentary amino acids (Ogle and Grivetti, 1985). Green leafy vegetables can be a source of vitamins and minerals to a rural Haitian diet that is often nutritionally deficient.

DeMaeyer & Adiels-Tegman (1985) estimated that about 49% of women in developing countries suffer from iron deficiency anemia. A recent survey of pregnant Haitian women revealed that 89% developed folate deficiency anemia by the third trimester of pregnancy (Mulloy, 1990). The presence of vitamins and minerals, specifically folate and iron, in green vegetables used as food and/or medicine can determine their value as hematinics (increasing the number of erythrocytes and/or the hemoglobin concentration) (Steadman's Medical Dictionary, 1982). However, the nutrients in plant materials are not always available for human absorption (bioavailability). Therefore, to assess the nutritive potential of a vegetable, one must take into account its nutrients' bioavailabilities. The mineral iron is particularly sensitive to modifiers of its bioavailability. Iron depends for its absorption on an individual's iron stores, the presence of enhancers (ascorbate, citrate, organic acids) and inhibitors (tannins, phytates) for its absorption in a meal (Food and Agriculture Organization, FAO, 1988).

In this study, techniques used in nutrition, medical anthropology and ethnobotany were utilized to identify the plant-based therapies used by women to treat the symptoms of anemia in a rural Haitian community. In the first part of the study, women were interviewed to determine their knowledge of the signs and symptoms of anemia, the resources and the remedies they use to treat this illness. The nutritional usefulness of the remedies were assessed by literature review or by the in-vitro measurement of the hematinic value (iron availability) of selected plants used also in the diet. The study focused on plants used as food and medicine. Because of their dual role in the culture, such plants are more likely to be culturally important and ecologically available.

II. LITERATURE REVIEW

II.A. SELECTED BACKGROUND ON HAITI

The island of Hispaniola, of which Haiti occupies a third, is situated in the Caribbean basin. Please refer to the map of Haiti in Appendix I. Three-quarters of the country (27,750 km^2) is mountainous. The tropical climate is modulated by a dry season and a biphasic rainy season. The population of Haiti was estimated at more than six million inhabitants in 1989. Approximately 74% of Haiti's inhabitants live in rural areas (CRESDIP, 1990). Over ninety percent of Haitians are descendants of Africans, Europeans and Caribbean indigenous peoples and form a uniform ethnic group (CRESDIP, 1990). The rest of the population is comprised of recent immigrants to Haiti.

Haitians suffer from health problems that are common among populations in developing countries:

- an infant mortality rate of 94 per 1000 live births
- an average adult life expectancy of 55 years
- chronic nutritional deficiency problems e.g. nutritional anemias
- a high rate of infectious diseases due to inadequate sanitation facilities (30% of rural dwellings have access to safe water) and poor living conditions (Grant, 1991).

The modern medical coverage in Haiti is minimal: one doctor per 10,000 inhabitants on average. It is estimated that over 80% of the population relies on family and traditional medicines for their medical needs (CRESDIP, 1990).

II.B. CONCEPTS OF ANEMIA IN HAITI

In the context of nutritional anemias in Haiti, it is of interest to first assess the awareness, the concepts, the resources and the sources of treatment for the symptoms of anemia.

Haitian traditional and popular medicines are inherited from African, European and Caribbean Indian ancestral influences. Current popular medical practices encompass these medical traditions along with modern biomedicine (Hess, 1984).

Kleinman (1981) has proposed an explanatory model (EM) approach to assess the medical anthropology of an illness. Illness is defined as the patient's subjective experience and interpretation of an abnormal health situation; disease is the biophysical aspect of the health problem and sickness is the combination of disease and illness. The EM includes identifying, through informant interviews, the semantics, the articulation of the illness, its cultural definitions, etiology and treatment patterns. Each step of the anthropological inquiry is like a piece in the puzzle which reveals the cultural context and perception of illness.

This method of documenting ethnomorbidity has been used by medical anthropologists to describe a variety of illnesses (Johnson and Sargent, 1990). Judging from the prevalence of anemias in the world, it is very likely that folk illness concepts of this disease abound. But very few studies have addressed the ethnomorbidity of anemia in a particular cultural group. Rajeswari (1983) reported that, in the Suddha medicine of the Tamils of southern India, the description of the symptoms of biomedical anemia are tiredness, muscular weakness, pallor and dyspnea. The Haitian folk concepts of anemia have been documented by Delbeau, 1990 and Rouzier, 1986.

In Haiti, anemia is referred to by its symptoms: general weakness, lack of strength, dizziness (Delbeau, 1990). These symptoms are considered to be the signs of a break in the normal physiological balance. For anemia, this loss of equilibrium affects the quality and quantity of the circulating blood. Blood in popular Haitian culture is the site of the soul and the personality (Delbeau, 1990). The blood's quality and flow is highly susceptible to the emotional disposition of the individual. Menstruation is sometimes explained as a discharge of blood turned bad by anger and anxiety (Delbeau, 1990).

The causes of anemia are explained in natural, not supernatural (spiritual) terms. For these types of illnesses the therapeutic pathway is first home/familial remedies (remedies prepared from personal or familial knowledge and methods) then local healers (*Doktè fey* translated as *Leaf doctors*); and, if the illness is considered acute and severe, modern medicine. Rouzier et al (1986) reported that 86% of peasants interviewed in La Chapelle, Haiti, used home remedies as first resource to treat the symptoms of anemia. Many of the plant remedies mentioned served both as medicinal and food plants. The studies of Delbeau and Rouzier investigated on many illnesses at once. This study focused on a four illness terms related to the symptoms of anemia, in order to gather more detailed ethnomorbidity and ethnobotanical information.

II.C. ETHNOBOTANY OF GREEN LEAFY VEGETABLES

As mentioned earlier, green leafy vegetables are found in the diet and the medicine of many of the world's populations (Etkin, 1982; Booth, 1992; Johns, 1991). These can play a dual role in health and disease.

Moringa pterygosperma, is used as a vegetable and as a medicine to treat diarrhea, worms and bilious congestion by the Hausa (Etkin, 1982). This plant has been found to contain the antimicrobial principle pterygospermin. As a food *Moringa pterygosperma* provides vitamins, minerals and amino-acids; and, as a remedy, it has a microbiocidal action. Etkin argues that, as a food, *M. pterygosperma* will provide, in small quantity, its antimicrobial properties. However, Etkin did not mention that, as a medicine, *M.*

pterygosperma might also provide necessary nutrients. *M. pterygosperma* could have a dual action regardless of the context of its use. Booth (1993) went further in her conclusions on the food/medicine *Chenopodium ambrosoides* in a study done in Guatemala. *C. ambrosoides*' consumption as a food can provide a quantity of the anthelminthic ascaridole that could adversely affect the growth of intestinal worms (Booth, 1992; Booth, 1993; Johns, 1991). *Chenopodium ambrosoides* can also supplement the diet with pro-vitamin A carotenoids (Booth, 1992). Vitamin A has been found to be involved in the proper functioning of the immune system (FAO, 1988). Therefore, *Chenopodium ambrosoides*, can provide both nutrients (carotenoids) and secondary chemicals (the anthelminthic ascaridole) necessary for maintaining health and fighting diseases either as a medicine or a food (Booth, 1992; Booth, 1993). Plants used both as food and medicine are likely to have the greatest impact on human health because of their multiplicity of functions and actions and merit particular attention.

Plant leaves are revered as both utilitarian and magical in Haitian culture (Delbeau, 1990). The properties of a plant as food or medicine do not depend only on the particular species but also on the context of its use. Therefore, plants that are utilized as food for their nutritive and organoleptic properties may be used as medicines strictly for therapeutic qualities unrelated to their food dimension. The green leafy vegetables used as medicines may actually contain vitamins and minerals that constitute a nutritional therapy for anemia. Six plant species were selected for further analyses of their value as an hematinic. A literature search on the current knowledge related to the hematinic potential of these plant species was done [see Table II.2 for literature values].

Amaranthus dubius is one of the plants mentioned as therapeutic for the symptoms of anemia; it is also used as a vegetable (Rouzier, 1990). Rajammal et al. (1979) compared the efficacy of another *Amaranthus* sp. with that of iron salts supplements in a randomized controlled clinical trial with school children during eight months [Table II.1]. It was found that the *Amaranthus* sp. used was comparable in efficacy to that of an iron supplement.

Rajammal et al. (1979) did not administrate as high a dose of iron supplement as is given therapeutically (30 mg) (Gillespie, 1991). Furthermore, the bioavailability of the iron salts was not discussed. It is possible that the amounts of iron absorbed from the salts were very low compared to that of the basal diet plus amaranth. The amount of iron in the basal diet plus amaranth was not reported.

Table II.1: Result of iron supplementation trial

	Difference between Initial and Final values	
	Hemoglobin levels (g/100 ml)	Packed Cell Volume (Percent)
Basal diet : Control (7.0 mg of iron)	1.46 ± 0.09	0.8 ± 0.327
Basal diet + Amaranth (not provided)	2.04 ± 0.14*	1.8 ± 0.417
Basal diet + iron tonic *Colliron* (13 mg of iron)	1.82 ± 0.10	1.7 ± 0.540
Basal diet + Iron salts (13 mg of iron)	1.63 ± 0.11*	1.4 ± 0.340

From Rajammal et al. (1979)

*Results significantly different $p<0.05$.

Corchorus olitorius is used in Western Africa, the Middle East and Haiti as a vegetable (Chen and Saad, 1981, Latunde-dada, 1990). It is also found as a home remedy to treat the symptoms of anemia.

Moringa oleifera is an important food crop in India (Ramachandran et al., 1980). Ramachandran et al. (1980) reports that it is rich in ascorbic acid (220 mg/100 g) and essential amino-acids such as tryptophan (1.6 g/16 g nitrogen). *M. oleifera* is not often used as a food in Haiti, but it is used in remedies against anemia.

Portulaca oleracea has also been reported to contain up to 700 mg/100 g of vitamin C (T.R.A.M.I.L., 1990). This is yet another species commonly used as a green vegetable and remedy for anemia by Haitian peasants. The measurement of ascorbic acid in this plant species might have been overestimated because the pheno-indol-reduction method determination used is sensitive to other reductants in plants (Beutler, 1984). *P. oleracea* is most commonly used in combination with *Chamissoa altissima* which contains high amounts of iron (T.R.A.M.I.L., 1990). *Citrus aurantium* which is also added to some of the medicinal preparations and can provide ascorbic acid and citric acid was also analyzed for its contribution of enhancers of iron absorption. The combination of plant materials high in iron and high in ascorbic and citric acid will encourage the absorption of non-heme iron (Hallberg, 1986).

Phaseolus vulgaris' leaves are also used in Haiti as a food and as a remedy to treat anemia. Information was found on the nutrient analysis of the beans of *P. vulgaris* but no studies were found with the analysis of the leaves of this plant species (Duke, 1985).

Table II. 2 lists the information found in the literature on the plants of interest. The common names are given in Appendix IV.

Table II.2: Nutrient values of selected plants

REFERENCE	PLANT SPECIES	IRON CONTENT	IRON-AVAILABILITY (%)	ASCORBATE	FOLATE
Akoroda, 1987	*Corchorus olitorius*	4-8 mg/ 100 g	___	53-100 mg/100 g	___
Latunde-Dada, 1990	*Corchorus olitorius*	4.05 (0.11) mg/100 g	6.26 (0.14)	___	___
Latunde-Dada, 1990	*Corchorus olitorius* + 0.5 Alkaline Salt	4.05 (0.11) mg/100 g	2.87 (0.36)	___	___
Latunde-Dada, 1990	*Corchorus olitorius* +Ascorbic acid	4.05 (0.11) mg/100 g	12.3 (0.41)	___	___
Chen & Saad, 1981	*Corchorus olitorius*, raw	___	___	___	800 ug/100 g
Latunde-Dada, 1990	*Amaranthus hybridus*	5.97 (0.43) mg/100 g	10.1 (0.23)	___	___
Ramachandran et al., 1980	*Moringa oleifera*	7 mg/100 g	___	220 mg/100 g	___
Rajammal and Saroja, 1980	*Amaranthus gangeticus*	25.5 mg/100 g	___	raw :99 mg/ 100 g cooked: 39 mg/100 g	___

Numbers in parentheses are standard deviations (S.D.)

II.D. DIET AND NUTRITIONAL ANEMIAS

Although iron and folic acid are found widely distributed in foods, their deficiencies are the most common nutritional problems in the world (DeMaeyer, 1989).

II.D.1. Bioavailability of dietary iron

There are two kinds of dietary iron sources: heme and non-heme. Heme iron is bound to the protoporphyrin ring and is part of hemoglobin and myoglobin; non-heme iron is not bound to protoporphyrin and is found in different oxidation states, salts and chelates (FAO, 1988).

Heme iron which has an absorption of about 30% is found in animal or fish sources, foods which are largely inaccessible to the majority of the world's population (FAO, 1988). In industrialized countries, heme iron contributes 10-15% of the dietary iron, whereas in developing countries, its contribution is lower or negligible (FAO, 1988). Non-heme iron is found in all other sources of foods, such as cereals and vegetables, in varying degrees and sometimes as a contaminating element (iron pot, ash) or as fortification iron (FAO, 1988). Non-heme iron constitutes the major source of iron in the diet. The bioavailability of the non-heme iron found in green leafy vegetables is usually between 2-10% (FAO, 1988).

Adult requirements for absorbed iron range between 0.96 to 2.38 mg/day (FAO, 1988). For women of reproductive age the requirement for absorbed iron is 2.38 mg/day and increases to 6.3 mg/day in the third trimester of pregnancy because of iron losses in blood during menstruations or at parturition (FAO, 1988). The absorbed iron from a meal is calculated assuming that: 40% of the total iron content of animal and fish products, which represents the heme iron, is multiplied by 23% (heme iron's average bioavailability); the iron in eggs is not considered bioavailable; 60% of the total iron content of animal and fish products and all the iron of non-animal or fish products, which represents the non-heme iron contribution, is multiplied by 3 to 8% depending on the dietary intake of animal and fish products (except milk and eggs whose proteins can inhibit iron absorption) and vitamin C (Gélinas et al. 1991).

A diet that includes heme iron sources in quantities typical of those in industrialized countries can provide more than the required amount of iron (FAO, 1988; Health and Welfare Canada, 1990). Diets that are very low in or do not contain heme iron sources may or may not meet the iron requirements depending on the availability of the non-heme iron consumed. Absorption of non-heme iron depends on its chemical form and its concomitant dietary components; that is, the presence of enhancers or inhibitors of its absorption (DeMaeyer, 1989).

The recommended total iron intakes are represented according to the iron bioavailability of the diet in Table II.3 (FAO, 1988). The definitions of the diets are as follows:

- Low bioavailability diet: A diet consisting mainly of cereals, beans, roots and tubers which contain chemicals that inhibit iron absorption. It contains low amounts of meat, fish or poultry providing heme iron. This diet is also poor in fruits and vegetables containing enhancers of iron absorption such as ascorbic acid. The meals would contain less than 30g of animal or fish products or less than 25 mg of ascorbate (Monsen et al. 1978). This is a diet typical of many developing countries.
- Intermediate bioavailability diet: This diet also consists mainly of cereals, beans, roots and tubers but there is some consumption of animal and fish products and sources of vitamin C. A typical meal from this diet contains 30-90 g of animal and fish products or 25-75 mg of ascorbate (Monsen et al. 1978).
- High bioavailability diet: This diet is a diversified one containing plant and animal sources of iron and its absorption enhancers. A meal from this diet would contain more than 90 g of meat products or more than 75 mg of ascorbate (Monsen et al. 1978). Such a diet can be lowered to an intermediate bioavailability level by the daily

consumption of several cups of tea and coffee which are high in the anti-nutrient tannin.

Table II.3: Recommended iron intake mg/day

	Type of diet bioavailability (% Iron absorbed)			
Age/sex Physiological Status	Very Low (<5%)	Low (5-10%)	Intermediate (11-18%)	High (>19%)
Adult males	28	15	8	5
Adult females				
•Menstruating	59	32	16	11
•Lactating	33	17	9	6
•Menopausal	24	13	6	4

Adapted from FAO (1988)

As can be noticed from the above table, the highest iron requirements are for menstruating women because of loss of blood.

According to the FAO description, the diet of Latin Americans and Caribbeans will most likely fall into the low iron availability category due to the predominance of cereals, roots, tubers and the consumption of coffee. Hallberg et al. (1986) analyzed a Latin-American meal for iron availability. They found that a typical Latin-American meal consisting of beans, rice, maize and cauliflower, similar to that consumed in Haiti, had and iron content of 4.4 mg and an iron availability of 2.7%.

In developing countries, most diets are iron dense (iron per kilocalories) but since they fall into the category of low to intermediate bioavailability; it is useful to take into consideration their bioavailable iron nutrient density. The bioavailable nutrient density is defined as the amount of nutrient (iron) absorbed per caloric energy content of a meal. Hallberg (1981) calculated the bioavailable iron nutrient density to meet iron requirements. A bioavailable iron density of 1.1 mg Fe/1000 kcal (Western/developed country diet) multiplied by a caloric intake of 2000 kcal/day can meet the absorbed iron requirements of 90% of women (Hallberg, 1981). The typical Caribbean meal of rice and beans was found to have a bioavailable iron nutrient density of 0.18 mg iron per 1000 kcal. Therefore, for menstruating and pregnant Caribbean women, it may not be possible to absorb enough iron on a low iron bioavailability diet even when it is sufficient in energy intake (FAO, 1988).

II.D.1.a) Evaluating iron nutriture

The iron adequacy of a diet can be measured using a number of dietary tools. The most comprehensive form of dietary questionnaires is the dietary history. It is composed of a dietary journal with the types of foods, their preparation and quantities eaten over several days, a food frequency questionnaire and a usual dietary intake questionnaire (Gélinas, 1991). The dietary history gives precise information on an individual's dietary intake but is too long to assess the nutritional status of a group. The 24-hour recall can be used for individuals or groups. In this questionnaire, the food intake of the previous day is measured with the portion sizes of each food item (Gibson, 1990). For better accuracy, the 24-hour recall is usually repeated from one to seven days (Suitor, 1989). The intake of micronutrients under homeostatic control such as iron is best measured over a period of time ranging from several days to a month (Nelson et al., 1989). A 24-hour recall would, therefore, have to be repeated many times. This method of repeated dietary questionnaires is costly and is better suited for individual not group evaluations. The food frequency questionnaire asks the respondents to determine how often they use particular food items (Willet, 1990). In this questionnaire the quantities of foods can be recorded precisely or approximately. The food frequency questionnaire is best suited for an evaluation of a group's iron nutriture because it covers a longer period of time. Dietary variety is an indicator of the quality of the diet (Gélinas et al., 1991). Each food group is a good source of a number of nutrients. The greater the number of different foods one eats, the greater the likelihood of consuming different nutrients to meet nutritional requirements. Anthropometric indices can also be used to assess the nutritional status of individuals or groups. The weight and height of an individual can provide information on general nutritional status. Weight for age measurements can serve as an index of protein-energy malnutrition but are not exact because height (stature) is not taken into account (Gibson, 1990). Furthermore, the measurement of weight can also be affected by the presence of edema, ascites or tumors (Gibson, 1990).

Values obtained for weight for age, weight for height or height for age are usually compared to standards from the Metropolitan Life tables, the Canadian Table for Height and Weight or local anthropometric data. For better assessment, the anthropometric results should be compared to the appropriate reference population. The measurement of individuals can be presented as percentiles (the position of the measurement in reference to 100% of the reference population) or by standard deviation scores as compared to the median of the reference population (Gibson, 1990). A group's weight for age measurements as compared to a reference population can be represented by the use of a percentage histogram. The measurement of weight for age is usually done in children to follow growth (Gibson, 1990).

Some of the laboratory measures of iron nutriture are blood hemoglobin, serum ferritin or serum iron (Koepke, 1984). A concentration of hemoglobin in the blood of less than 12 g/dL is usually taken as indicative of anemia in women (DeMaeyer, 1985).

II.D.2. Determinants of iron availability

The absorption of dietary iron is dependent on one's physiological iron status (Magnusson et al., 1981) and the chemical composition of the meal (Bezkorovainy, 1980). The concentration of serum ferritin, indicative of stored iron resources, seems to determine the avidity of the iron-binding protein of the intestinal cells. As the concentration of ferritin in the blood is reduced, the iron absorption capacity of the individual increases (Siegenberg et al. 1991).

Iron is absorbed in its ferrous form from the slightly acidic duodenal chyme. The solubility constant of Fe^{2+} is 10^{-1}M whereas that of Fe^{3+} is 10^{-18}M (Clydesdale, 1982). Food components that can keep the chyme's pH low, reduce iron and keep it in its ferrous form (Fe^{2+}) favor iron absorption (Bezkorovainy, 1980). Other food constituents that have an affinity for the ferric form (Fe^{3+}) and chelate iron can prevent the metal's presentation and contact with the intestinal lumen for absorption. Once in contact with the intestinal lumen, the iron is absorbed by either diffusion, active transport or as a complex with its soluble chelators (Ashmead, 1985).

Nutrients that are known to facilitate or enhance iron absorption are fish or animal proteins, ascorbic acid, citric acid, and low molecular weight sugars (Kies, 1982).

II.D.2.a) Fish or Animal proteins

The presence of fish or animal proteins have been found to increase the absorption of non-heme iron from meals (Bezkorovainy, 1980). The mechanism of these proteins' action on iron has not yet been determined.

Notable exceptions are the inhibitory effects on iron absorption of milk proteins and the very low availability of egg iron (Bezkorovainy, 1980).

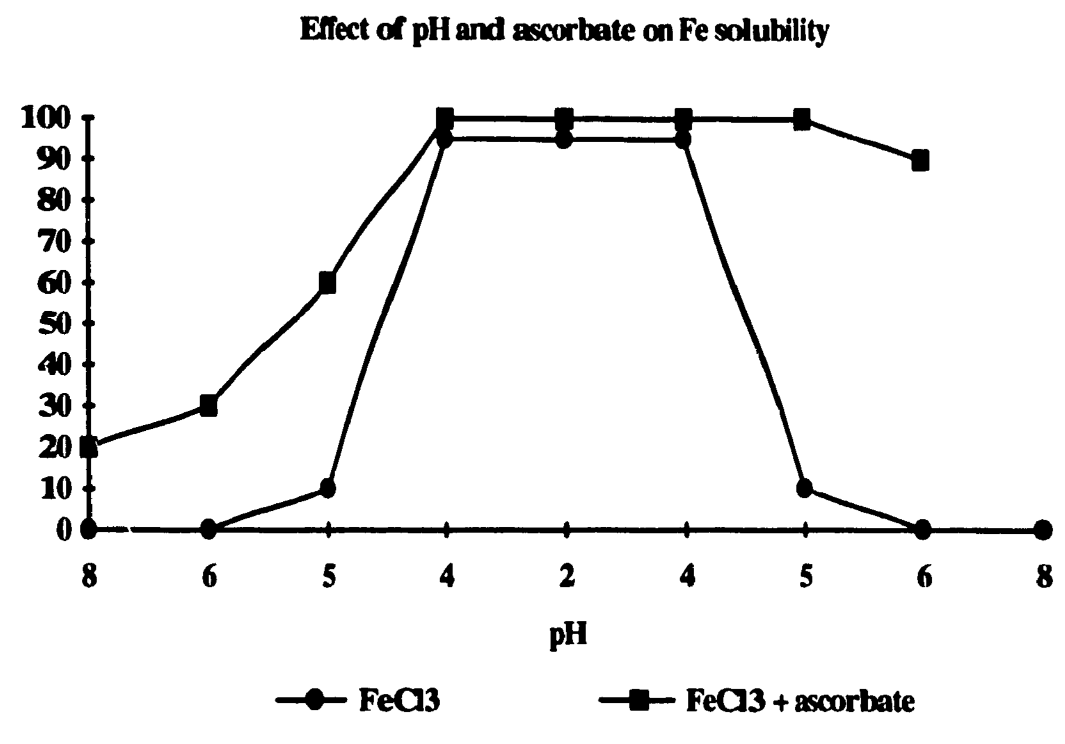
II.D.2.b) Ascorbic acid

Ascorbic acid is a major enhancer of iron absorption. Due to its acidity, it can keep the pH of the duodenal chyme low, favoring iron solubility. It reduces the ferric iron (free or bound) to the ferrous form. Ferrous iron is more soluble in the duodenal chyme than ferric iron and is, therefore, more likely to be absorbed. The effect of ascorbate on iron absorption is presented in Figure II.1. Ascorbate keeps iron in solution even at higher pH values. Ascorbic acid can also chelate ferrous iron and be absorbed with it (Monsen, 1982)

II.D.2.c) Acidity

A reduced pH keeps iron ions in solution by preventing the formation of insoluble iron hydroxide precipitates (Ashmead, 1985). When gastric production of hydrochloric acid is impaired, iron absorption decreases (Miller and Shcricker, 1982). Conrad and Schade (1968) noticed that the solubility of ferric chloride salts is pH dependent with solubility being highest between pH 2 and 4 [see Figure II.1].

Figure II.1: Effect of pH and ascorbate on iron solubility



Conrad and Schade (1968)

II.D.2.d) Other organic acids, amino-acids and carbohydrates

Ascorbate is a small organic acid. Other organic acids present in foods that have been found to positively influence iron absorption are citrate, succinate, lactate, pyruvate and amino-acids such as valine and histidine (Lee, 1982, Bezkorovainy, 1980). Carbohydrates, such as fructose and sucrose, have also been found to increase iron absorption (Lee, 1982). These small organic acids and sugars are thought to lower the intestinal pH directly or by fermentation of sugars and form soluble chelates with iron (Lee, 1982).

The most common inhibitors of iron absorption are fiber, phytates and tannins.

II.D.2.e) Fiber

Fibers are plant polysaccharides and lignins that are not completely digestible by humans (Torre et al., 1991). They are an intrinsic part of cell walls and plant structures. Fiber of plant cells is composed of hemicelluloses, cellulose, pectin and lignin. These components of dietary fiber can hinder iron absorption by adsorbing metal ions onto the fiber matrix and mediating their excretion (Torre et al., 1991). The inhibitory effect of fiber on iron absorption is thought to be mediated primarily by its phytate content.

II.D.2.f) Phytic acid

Phytic acid (hexaphosphate myoinositol) is the storage form of phosphate in most cereals, legumes and oilseeds. Phytate can chelate ferric iron, thus making it insoluble and unavailable for absorption (Nolan et al., 1987). The level of complexation of iron and phytate influence the mineral's availability. Monoferric phytate is soluble and bioavailable whereas higher complexation forms are not soluble or bioavailable (Bezkorovainy, 1980). Siegenberg et al. (1991) noticed that the inhibitory effect of phytate on iron absorption is dose-dependent.

II.D.2.g) Tannic acid

The inhibition of iron absorption by tannic acid was also found to be dose-dependent (Brune et al. 1989, Siegenberg et al., 1991, Tuntawiroon et al. 1991). Tannins are found in cereals, legumes, nuts, roots, tubers, tea and coffee. Tannic acids is the name given to a variety of polyphenols found in plants. Tannins, like phytate, also complex with ferric iron to form insoluble chelates and, thereby, decrease the availability of iron (Brune et al. 1989). Condensed tannins such as gallic acid have been found to bind iron better than uncondensed ones (Gillooly et al. 1983).

II.D.2.h) Other inhibitors

Other divalent cations such as calcium and zinc are known to compete with iron for the same ionic receptors of the brush-border cells (Ashmead et al. 1985). An example of their effect is in the decrease of iron availability of *Corchorus olitorius* to which alkaline salts were added (Latunde-Dada, 1990). This inhibition was thought to be due to the alkanilisation effect of the salts as well as their content of competing minerals. In this study, the other mineral content of the plants was not measured (Latunde-Dada, 1990). Oxalates which chelate divalent cations have also been reported to chelate iron but their effect on iron availability is not significant. They preferentially bind to calcium (Devadas and Rajammal, 1980). Specific proteins milk and egg have also been found to inhibit iron absorption (Bezkorovainy, 1980; Hurrell et al. 1988).

II.D.2.i) Food preparation

The potential effects of food preparation on iron availability have been investigated. Lee (1982) noticed that the effect of the enhancers and inhibitors of iron absorption overrides the effect of food preparation (cooking and canning) of a meal. Fermentation, however, was found to increase the iron availability by increasing the contribution of enhancers of iron absorption (acids) and decreasing its inhibitors (tannins and phytates) through enzymatic degradation (FAO, 1988).

II.D.2.j) Interaction between enhancers and inhibitors of iron absorption

There are many methods to evaluate the overall effect of enhancers and inhibitors of iron absorption in a meal. One can measure the levels of nutrients and anti-nutrients in a meal and then infer on its iron availability (Monsen, 1982). Since this method is lengthy, other methods have been devised to assess bioavailability of iron. The bioavailability of iron can be tested using rats by the hemoglobin regeneration test (Forbes et al., 1989).

Rats produce the enzyme phytase and are, therefore, insensitive to the effects of phytate on iron absorption unlike humans (Forbes et al., 1989). Iron bioavailability can be measured in vivo in humans by an Fe-radioisotope method (Hallberg and Bjorn-Rasmussen, 1972). First, a meal labeled with Fe^{55} or Fe^{59} is given. The level of the radioisotope in the blood after two weeks determines the amount of iron absorbed and incorporated into hemoglobin. Siegenberg et al. (1991) conducted an in-vivo study on a group of Indian women in South Africa. They reported that at least 30 mg of vitamin C can overcome the inhibition of phytates and polyphenols (tannins) on the iron absorption of a test meal made of cereals and varying amounts of inhibitors [Table II.4]. Studies investigating in-vivo absorption of iron offer the most reliable method of estimating iron availability. However, care should be taken that all subjects have similar amount of iron storage (serum ferritin) so that iron absorption capacities are comparable.

Table II: 4: Interaction of vitamin C, phytates and tannins in iron absorption

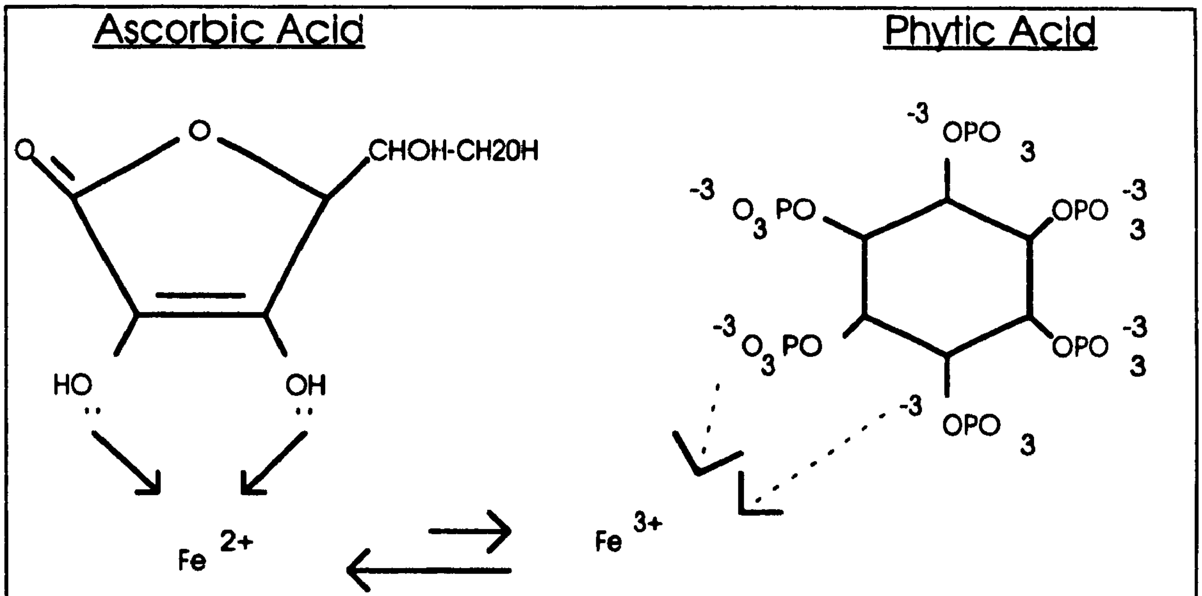
Meal	+ Inhibitor	Absorption ratio	+ Vitamin C	Absorption ratio
Maize bread	58 mg phytate	0.54	30 mg	2.08
Wheat bread	833 mg tannin	0.21	N.A.	N.A.
Wheat bread	420 mg tannin	N.A.	25 mg	2.90

Adapted from Siegenberg et al. (1991)

The iron bioavailability of a meal can be measured in vitro by a dialysable iron assay (Miller et al. 1981). A meal is homogenized and goes through in-vitro gastric and duodenal digestion. The soluble iron, available for absorption, can pass through a dialysis membrane inserted in the homogenate. The percentage of iron that is dialysable represents the meal's iron bioavailability. This method is faster and less expensive but less accurate than in-vivo methods. Gillooly et al. (1983) tested a variety of vegetables for iron availability using female subjects. The factors affecting iron availability in vegetables was found to be the levels of malic, citric and ascorbic acids as enhancers and condensed tannins as inhibitors. Phytates were not found to be determinants of iron availability in those vegetables. Absorption of iron from the vegetables ranged from 0.007 to 0.327 as compared to the reference dose absorption of ferrous sulfate whose absorption by the subjects was between 0.218 and 0.589.

There is a dynamic competition between promoting and inhibiting dietary components for the reduction and chelation of iron. In Figure II.2 vitamin C reduces the iron chelated by phytate to its ferrous form and forms a soluble chelate with Fe^{2+}.

Figure II.2: Competition between ascorbic and phytic acid.



Phytate forms an insoluble chelate with Fe^{3+} by donating some of its phosphoric electrons. Vitamin C reduces Fe^{3+} to Fe^{2+} which phytate can not bind effectively. The free soluble Fe^{2+} is now more available for intestinal absorption. Vitamin C can also form a soluble chelate with Fe^{2+} through the donation of its hydroxyl electrons. The ascorbate-iron complex can be absorbed by the intestinal lumen.

The other hematinic nutrient found in green leafy vegetables is folic acid.

II.D.3. Dietary folate

Folic acid (pteroyl glutamate) is found in foods in its mono or polyglutamate form. It is present in most foods of animal and plant origin. The best sources of folic acid are liver, leafy vegetables, fruits, pulses and yeast. The recommended intake of folic acid is 135 ug/day for adult women (Health and Welfare Canada, 1990). The anthropometric indices used to assess folate nutriture are serum and red blood cell folate concentrations. An erythrocyte folate concentration of less than 120 ng/ml is indicative of folate deficiency (Gibson, 1990).

II.D.4. Folate availability

Unlike non-heme iron, the absorption of folate is not dependent on other meal components, but similar to iron, the level of reducing agents such as ascorbic acid in the meal improves its availability by stabilizing the pteroyl moiety (Hawkes and Villota, 1989). The availability of folic acid in vegetables is variable and depends on the polyglutamination of the pteroyl moiety. Monoglutamate forms are 100% absorbed whereas heptaglutamate forms are only 50%-75% absorbed (Butterworth et al. 1969). The availability of folate forms to *Lactobacillus casei* used to measure folate levels decreases from 100 to 2.4% as the number of glutamate residues augments from four to seven (O'Connor, 1989).

Presence of folate in green leafy vegetables is significant for folate nutriture and treatment of nutritional anemias. For example, the leafy vegetable *Corchorus olitorius*, used as food and medicine in Haiti contains 800 ug/100 g of folic acid in the raw plant sample (Chen and Saad, 1981) [Table II.1]. Folic acid, however, is sensitive to heat, oxidation, extremes of pH and UV light (Hawkes & Villota, 1989). Therefore, storage, preservation and cooking procedures will affect the quantity of folate available from a food. Up to 40% of folate can be lost during storage (Chen and Saad, 1981) and up to 84% of it can be lost in the cooking water (Hawkes & Villota, 1989). Although diets in developing countries often contain leafy vegetables, their storage and preparation can result in a low intake of folic acid.

II.E. NUTRITIONAL ANEMIA AS A PUBLIC HEALTH PROBLEM

Anemia is defined as a decrease in circulating erythrocytes and blood hemoglobin, and can be caused by hemoglobinopathies like sickle cell anemia, malabsorption disorders such as achlorohydria, infections such as malaria or hookworm and nutrient deficiencies of iron, folate or vitamin B_{12} (Gillespie, 1991). The most common form of anemias in the world are those of nutrient deficiencies. The World Health Organization (WHO) estimated that approximately 20% of the world's population suffers from nutritional anemia (DeMaeyer, 1989). Iron deficiency is the major cause of nutritional anemias. The prevalence of iron deficiency anemia could as high as 60% for pregnant women in developing countries (DeMaeyer & Adiels-Tegman, 1985). Deficiency of folic acid is also a major public health problem as it affects approximately 30% of the world's population (Layrisse et al. 1988). Mulloy (1990) found that 89% of pregnant Haitian women in a cohort study developed folate deficiency anemia as indicated by megaloblastosis.

The World Health Organization has declared iron, folate and vitamin A, the micronutrients of greatest public health concern (FAO, 1988). Deficiencies of iron and folate are associated with mild to severe pathological manifestations including weakness, tachycardia, increased risk of infection and anoxia in iron deficiency, and megaloblastosis, impaired synthesis of the rapidly dividing cells of the hematopoietic system in folic acid deficiency (DeMaeyer, 1989). Specific signs and symptoms of iron deficiency anemia include general weakness, vertigo, pallor and cardiovascular distress upon exertion (Gélinas et al., 1991).

II.F. SUMMARY

It is the current mandate of the WHO to investigate and promote the use of local resources to solve public health problems (Bannerman et. al. 1983). All over the world, the majority of people resort to home or popular remedies to treat the symptoms of illnesses considered common or benign. In countries where the access to medical care is low, a higher percentage of people resort to home remedies and traditional therapies. Many of these remedies are made of plant species having a dual role in the culture as foods and medicines. These plants merit special attention because of their local importance.

The symptoms associated with nutritional anemias are found in the Haitian medical vernacular as specific illness terms. An investigation of the local knowledge of anemia in Haiti gives information on the treatments used for this illness. These remedies that often consist of green leafy vegetables, can provide a good source of hematinic nutrients. They may be the key to local solutions to the problem of nutritional anemias in Haiti.

Deficiencies of iron and folic acid cause anemia and although both are present in human diets, they do not seem to be provided in sufficient quantities to meet the physiological needs of a large proportion of women (FAO, 1988). Non-heme iron, which is the most important source of iron, has a low bioavailability and absorption is dependent upon a meal's chemical composition. Folic acid, whose availability is higher than that of iron, can be easily destroyed by cooking practices.

Of interest for this thesis is the prevalence of nutritional anemias among Haitian women. The WHO estimates that, in developing countries, 49% of adult women suffer from nutritional anemias (DeMaeyer, 1985). Chronic anemia is associated with decreased productivity and social functioning and increased susceptibility to infection. Furthermore, nutritional anemia negatively affects reproductive functions and increases health risks to the fetus and newborn of an anemic mother (Hascke and Javaid, 1991).

There have been many studies on the prevalence of nutritional anemias and many intervention programs to control iron and folate deficiency anemias (Gillespie, 1991; Mashako et al., 1991; Romslo, 1990). Very few of those have tried to place the recipients socio-cultural setting as an integral part of the program or inquired on local sources of these nutrients. The understanding of the socio-cultural setting of an illness or disease can serve as a guide for the implementation of sensible programs aimed at the control of the prevalence of nutritional anemias. Furthermore the investigation of the validity of the remedies used to treat these illnesses can be helpful in devising locally appropriate nutritional recommendations.

III. DESIGN AND METHODOLOGY

III.A. RATIONALE FOR THE PROJECT

Given the low level of biomedical coverage in Haiti, the prevalence of iron and folate deficiency anemias, and the use of family and traditional medicines in rural parts of Haiti, research on the remedies used as hematinics by the local population is of interest to public health interventionists in many respects: (1) the frequency of use of traditional remedies to treat the symptoms of anemia can reveal rural women's concern and awareness about this condition; (2) the local ethnobotany and ethnomorbidity as it applies to anemia can give health workers the necessary cultural insight to develop community health programs for the prevention of nutritional anemias which may include participation of more members of the community; (3) the plants used in familial medicine may contain hematinics. Therefore, they could be included in health promotion programs to prevent and treat nutritional anemias; (4) the promotion of effective traditional therapies is encouraged by the WHO to ensure culturally acceptable maximum medical coverage in a sustainable context (Bannerman, 1983); (5) the promotion of local nutrient sources will enhance nutritional status, broaden the food base, provide additional income (particularly for women) and improve food security by decreasing reliance on foreign imports (FAO, 1987).

III.B. STATEMENT OF PURPOSE

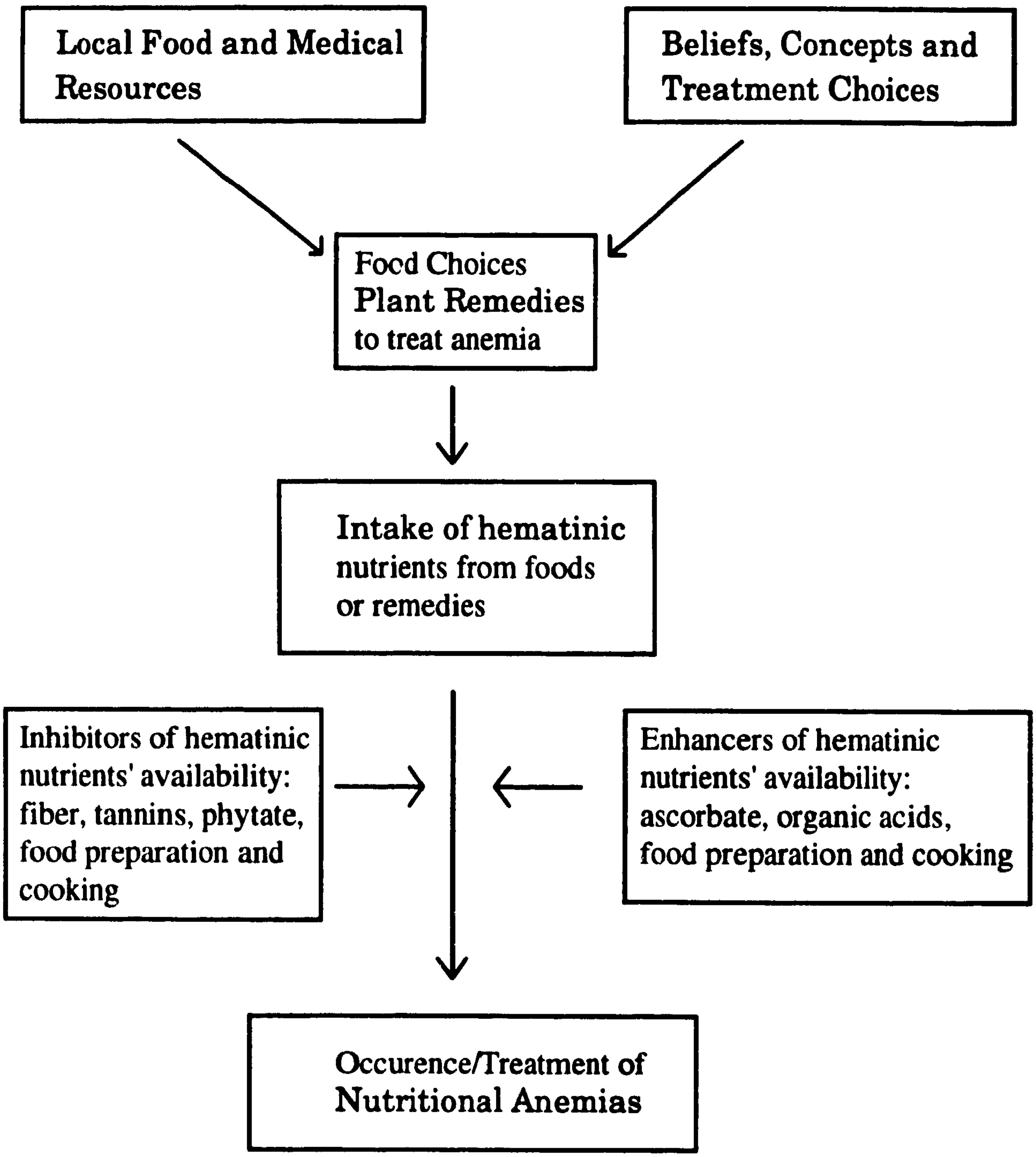
The purpose of this study was to determine the hematinic potential of selected species of green leafy vegetables used as food/medicine by a group of rural Haitian women to treat the symptoms of anemia. A conceptual framework for studying the relationship between ethnobotany, diet and illness was elaborated. The conceptual framework of the study is presented in Figure III.1, outlining the influence of the environment and culture on food and medicinal choices that, in turn, determine the presence of nutritional anemias.

III.C. OBJECTIVES

The objectives of this study were to:

1. estimate the usual composition of the diet of a group of rural Haitian women;
2. identify the ethnomorbidity terms used by rural Haitian women to describe the biomedical term anemia and its treatment procedures;
3. estimate the population proportion of women using traditional remedies to treat the symptoms of anemia;
4. identify the plant species used by these women as hematinics;
5. measure the hematinic potential of these plant species by iron availability, nutrient (vitamin C, citrate) and anti-nutrient analysis (fiber, tannins and phytate).

Figure III.1: Conceptual framework of the study



III.D. HYPOTHESES

The hypotheses were:

1. Ho: The proportion of women using traditional/home remedies is < 80%[1]

   H1: The proportion of women using traditional/home remedies is > or = 80%

2. Ho: Plant species used by a group of rural Haitian women have no hematinic potential.

   H1 : Plant species used by a group of rural Haitian women have hematinic potential.

III.E. OVERVIEW OF STUDY DESIGN

The study was divided in two parts. Part one was a descriptive field study done in La Chapelle, Haiti, where dietary, ethnomorbidity and ethnobotanical surveys were carried out. Dietary information was collected using a one-day dietary recall questionnaire. Ethnomorbidity and ethnobotanical data were collected using an illness and plant use questionnaire. For the analysis of vitamin C and iron availability, the use of fresh plant materials is necessary. Because of political instability in Haiti, the plant analyses could not be performed there. Jamaica was chosen as a site to do the plant analyses because of its similar geographical conditions (The Diagram Group, 1985), flora and its technical facilities. Part two of the study consisted of nutrient and data analyses performed at the University of the West Indies, Jamaica (U.W.I.). The analyses that did not require fresh plant materials were performed at the School of Dietetics and Human Nutrition, McGill

[1] CRESDIP (1990) estimates that over 80% of the Haitian population relies on family and traditional medicine for their medical needs. Rouzier et al (1986) reported that 86% of peasants interviewed in La Chapelle, Haiti, used home remedies as first resource to treat the symptoms of anemia.

University, Montreal, Canada. The plant analyses investigated the hematinic potential of selected plant species identified in the first part of the study.

III.F. SUMMARY OF STUDY PHASES

Stage 1. Field study

i) dietary patterns

ii) ethnomorbidity and ethnobotanical survey

iii) plant collection for identification

Stage 2: Nutrient, phytochemical analyses and data processing

i) plant collection for identification and analyses

ii) iron content, iron availability

iii) vitamin C, citrate

iv) phytate, tannins, fiber

v) data analysis

vi) interpretation of results

III.G. FIELD STUDY

III.G.1. Study area

An ethnobotanical and a dietary survey were conducted in the commune of La Chapelle, department of Artibonite, Haiti. La Chapelle was chosen because of its proximity to the capital, Port-au-Prince, and the presence of a dispensary administered by the Service Oecuménique d'Entraide (S.O.E.) a Non-Governmental Organization (N.G.O.) that has experience in ethnobotanical surveys in the area.

Haiti is located between 18° and 20° latitude North, and 72° and 74° longitude West (The Diagram Group, 1985). The commune of La Chapelle is situated in the south-east of the department of Artibonite. The region has a flat, cultivated portion that stretches along the Artibonite river and a mountainous portion where deforestation is beginning to be a problem (Rouzier, 1990). The rainy season in this region is from April to October, during which time it rains abundantly five out of seven days, with a short break in June (Rouzier, 1990). The population of La Chapelle is currently estimated at 17 000 inhabitants (Rouzier, 1990). The commune is separated into two rural sections: Martineau and the more densely populated Bossous where the research was conducted (Rouzier, 1990). A map of the region is available in Appendix II.

In terms of health-care coverage, the commune of La Chapelle is served by a S.O.E. health center. The five S.O.E. centers across Haiti work on rural development projects, porcine repopulation and community health promotion. A branch of the S.O.E. is also involved in research on traditional medicine in collaboration with the Université D'État D'Haïti and foreign members of Traditional Medicine in the Islands (T.R.A.M.I.L.).

The health center in La Chapelle is opened five days a week. A fee of ten gourdes (Haitian currency, $0.20 Cdn) is collected per consultation. The seven-member health staff is comprised of a doctor, two auxiliary nurses, a laboratory technician, a pharmaceutical assistant, a dental auxiliary and an archivist. The peripheral S.O.E. health staff consists of forty birth-attendants and ten community health agents. The S.O.E. is also involved in health education and prevention programs: prenatal and perinatal surveillance, immunization, maternal health (anemia prevention and treatment) and malnutrition surveillance. The health center estimates that 40% of the population uses its services (Dr. Cadet, personal communication).

It was noticed that almost all the villagers had a homestead garden where they cultivated some plant foods for household consumption. In the area visited, there were small cultivated lands for subsistence farming. In the village of La Chapelle, a high rate of unemployment exists because many have no access to substantial land for cultivation. Many people, therefore, go to cities to find work (personal communications with S.O.E. staff).

III.G.2. Sampling

The sampling frame was adult women of the Commune of La Chapelle department of Artibonite, Haiti. Women were chosen in this study because there are the ones most affected by nutritional anemias and, therefore, are most likely to use home remedies for this illness and to benefit from hematinic food/medicinal plants.

The sample selection was done by cluster sampling. Five clusters were randomly chosen for survey. Three were neighborhoods in the village of La Chapelle (semi-rural) and two from agricultural areas (rural). Within each cluster, the households were chosen by systematic sampling: every third house for urban areas; every second house in agricultural areas where houses were more sparse. If no one was available in the household chosen, the next household was chosen.

The sample size to estimate the population proportion using medicinal plants for the treatment of anemia was determined according to Lwanga and Lemeshow (1991). The population proportion (P) of adult women was chosen at 0.20 (Anglade, 1985); the precision on prevalence (d) was chosen at 0.20; and the confidence level (α) was chosen at 0.05. The standard deviation score at that level of confidence level was "z". The equation for sample size is: $n=z^2_{1-\alpha/2}\ P(1-P)/d^2$

The minimum sample size to estimate the population proportion using medicinal plants for the treatment of anemia was calculated to be 15 women from the area selected (all the clusters together).

A total of thirty-one women were interviewed. The interviews were conducted at the homes of the respondents. The respondents were informed of the goal of the study: to assess their dietary intake, what they know about the symptoms of anemia and what they do to treat this illness. A questionnaire written in Creole was designed to determine the respondents' neighborhood, name, age, occupation, weight, dietary intake of the previous day and their beliefs and treatment patterns for the symptoms of anemia [Appendix III].

Traditional healers referred by the respondents as *doktè fey* (*leaf doctors*) were also interviewed. The selection of these healers was done through referral by the respondents and the social coordinator of the S.O.E. The interview of local healers was done to get more information on local concepts of anemia, medicinal plants, their preparation, and prices. The cook of the S.O.E. dispensary was also interviewed as a key informant to get more information on portion sizes and preparation procedures.

A person who served as both guide and assistant was present in all but the first interview. Clearance and field support for the study was given by the S.O.E.

III.G.3. Dietary intake questionnaire

The dietary questionnaire used is in Appendix III in Creole and English. A qualitative 24-hr recall-like questionnaire was carried out with each of the respondents. The dietary intake of the previous day was asked with the approximate times, the preparation (fried, boiled) and the approximate quantities of the food items consumed. This dietary questionnaire sought to identify the dietary patterns of the respondents in terms of food groups, specific foods consumed and their preparation. Knowledge of the food items mentioned and their preparation provided insight into nutritional adequacy for the group of respondents. The lack of quantification does not allow precise conclusions on the respondents intake of macro and micronutrients.

The respondents' weight was also taken as an anthropometric indication of overall nutrition. The measurements of weight and weight for age were then compared with Canadian, American and Haitian data (Gibson, 1990; Eveleth and Tanner, 1990; Benoist, 1962).

III.G.4. Ethnobotanical questionnaire

The ethnobotanical questionnaire is contained in Appendix III in Creole and English. The ethnobotanical part of the questionnaire was adapted from the one used by the S.O.E. in their surveys (Rouzier, 1990) and that recommended by Scrimshaw and Hurtado (1987) for nutritional anthropology studies. The questionnaire was externally validated by comparing the results found in this study to those of previous studies by the S.O.E. *Feblès*, *Mank lapeti*, *Fe san vini*, and *San gate* are the ethnomorbidity terms on which information was elicited in this study. All these illness terms contain overlapping symptoms that can be linked to asthenia (general weakness) and anemia. Respondents were asked for their definition of anemia, the resources, home remedies and sources of treatment they know to treat this illness.

The plant species selected for further analysis were chosen based on these criteria:

1) the plant was mentioned by 20% or more of the respondents. This number is arbitrary because there is no definitive guidelines on informant consensus in ethnobotanical studies (Johns et al., 1990);

2) the plant species were used by less than 20% but at least 5% of the respondents and were also used as food in the community;

3) availability of the plant species for analysis in the field.

III.H. PLANTS ANALYSES

The plant specimens were identified by the botanists M. L. Rouzier (S.O.E.) and P. Lewis (U.W.I.) prior to or after the collection. The plant collection for herbaceous species was done by identifying an area of growth, then collecting all the specimens of the species of interest. If the patch was large the specimens to be picked were selected with a random numbers table. The leaves were then separated from the stems except for *Portulaca oleracea* whose stem is also consumed by the respondents. For trees, the collection was done by randomly selecting and exfoliating branches. In Haiti, plant collection was done of a few specimens of the commonly mentioned plants for identification and mounting. In Jamaica, the plants were collected mainly at the gardens of the Department of Botany on the campus of the U.W.I. for analyses. However, *Phaseolus vulgaris* was obtained from the Biotechnology Center.

A typical plant collection and preparation was as follows. Once collected, the plant species was inserted in moisture seal plastic bags and placed in a Styrofoam container kept cool by freezer packs. Within the same day the plant was taken to the laboratory. In the laboratory the plant was wiped with a dry paper towel to avoid soil and mineral contamination (Kuhnlein, 1986). All of the plant collected or random samples of it were weighed and taken for air-drying, freeze-drying, or cooking. The air-dried portions were used for the determination of moisture content, iron content, phytates and tannins. The freeze-dried portions were preserved at -80°C under nitrogen and were meant for the determination of folate and fiber. In the end, the folate content of the plants was not measured. For the iron dialysability studies, an amount of the plant, equivalent to what the respondents use, was cooked. The portions of the plant that were cooked were weighed then washed in double distilled water (iron-free) before cooking in a beaker with the appropriate amount of iron-free water. The cooked plants were then homogenized, a fraction of the homogenate was taken for iron dialysability studies, another was extracted with water for measurement of citrate, another fraction was placed in the ascorbic acid extractant [see section III.H.6.c)], fractions of the homogenate were also put in methanol for tannic acid determination. Voucher specimens of the plants were given to the McGill University Herbarium.

III.H.1. Drying procedures

The plants were placed and air dried at 60°C in a homemade plant dryer at the Chemistry Department of the University of the West Indies. For freeze drying, the plants were quick frozen at -70°C in liquid nitrogen and then placed in a Labconco freeze-dryer.

III.H.2. Moisture content

The moisture content of the plants was determined by subtracting from the fresh weight of a sample the weight of the sample dried first at 60°C then in a vacuum oven (VWR model 4710) to constant weight.

III.H.3. Iron content

The iron content was determined using the method of the Association of Official Analytical Chemists (A.O.A.C.) number 975.03 (A.O.A.C., 1990). The iron content was determined using the Perkin Elmer Atomic Absorption Spectrophotometer (AAS) model 3100. The working iron lamp was set at 18 mA current. The operating wavelength is 248.33 nm. The slit width was set at 0.2 (Boline and Schrenk, 1977).

III.H.4. Iron Availability

The iron absorbed from a meal is determined by the balance of promoters and enhancers of its absorption in the duodenal region and on the iron status of the individual. Estimation of iron availability in-vitro mimics digestive conditions. Despite the absence of the physiological modifiers, in-vitro estimation of iron availability is correlated with in-vivo iron absorption: correlation coefficient $r=0.9316$, $p<0.001$ (Schricker et al., 1981).

Iron availability of the test meals (plant homogenate) was measured by the method of Miller et al. (1981) with the modification by Hurrell et al. (1988) (Forbes et al. 1989).

All glassware used in the experiment was soaked at least 2 hours in 2M HCl to render them iron-free. A control of store-bought spinach and an internal standard of $FeCl_3$ was used. Weighed plant samples were boiled in distilled, deionized water to tenderness (an edibility criteria mentioned by the respondents). The plant being cooked was considered tender when the plant tissue was softened enough to give in when prodded with a glass rod. The plant meal was blended and acidified to pH 2 with 6N HCl. The first incubation simulates the stomach digestion: 0.5 g of pepsin was added to each test meal, the flasks containing the meals were sealed and incubated 2 hours at 37°C in a shaking water bath. Twenty-gram meal aliquots were then frozen or tested to measure the titratable acidity of the meal to pH 7.5 with 0.5N KOH. The second incubation (same temperature) simulated the conditions prevalent in the duodenum where iron absorption takes place: a Spectra-Por dialysis bag of 6-8K Molecular Weight Cut-Off (MWCO) filled with the appropriate concentration of bicarbonate as determined by the titratable acidity, was added to the meal. When the pH of the meal reached 5 (about 30 mins.), a pancreatin and bile mixture was added. Two hours later, the incubation was stopped, the dialysis membrane washed and the dialysate diluted to 25 ml. To duplicates of 5 ml of the dialysate, 2.5 ml of protein precipitant solution were added; the resulting solutions were heated 10 minutes in boiling water and centrifuged. The iron contained in the dialysate was measured by Atomic Absorption Spectrophotometry (AAS), by colorimetry or both. A colorimetric method of iron determination was used because of lack of easy access to an Atomic Absorption Spectrophotometer in Jamaica. The iron content of all the samples were eventually measured by AAS. The measurements of iron by colorimetry and AAS gave comparable results as reported by Tavenier and Hellendoorn (1969).

III.H.5. Measurement of iron by colorimetry

The method recommended by the International Committee for Standardization in Hematology (ICSH) was used to measure non-heme iron by colorimetry (ICSH, 1971). A chromagen solution made of bathophenanthroline in sodium acetate was added at a ratio of 2:1 dialysate:chromagen. After 10 minutes the absorbance was measured at 535 nm on a HP Diode array 8452A spectrophotometer.

III.H.6. Measurement of Vitamin C

Vitamin C was measured by an enzymatic method, High Pressure Liquid Chromatography (HPLC) and by fluorescence. The fluorescence method was found to be the most appropriate for the plant specimens used.

III.H.6.a) Vitamin C by enzymatic assay

This assay was done using the method of Beutlei (1984). A solution of 3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide (MTT) and 5-methylphenazinium methyl sulphate, phenazine methosulphate (PMS^{+}) is added to 200 ul of the sample. Ascorbic acid and other reducing agents in the sample reduced MTT to a formazan in the presence of PMS^{+}. In the blank reaction, the effect of ascorbic acid was selectively eliminated by adding ascorbic acid oxidase to the reaction mixture. Dehydroascorbate does not react with MTT. The MTT-formazan formed is measured by its absorbance at 578 nm HP Diode array 8452A and a Beckman DU40 spectrophotometers. The amount of ascorbic acid in solution was obtained by subtracting the absorbance of the blank reaction from that of the sample reaction. Ascorbic acid solutions were used as both controls and standards. The plant samples used were found to affect the color of the assay solution thereby hindering the spectrophotometric detection of ascorbic acid. Decolorization of the plant with charcoal provoked the oxidation of ascorbic acid which was very difficult to reduce with the recommended reducing agent dithiotreitol (Beutler, 1984). A method was found to monitor the reduction of dehydroascorbic acid by dithiotreitol with the HPLC.

III.H.6.b) Vitamin C by HPLC

Cammack et al. (1991) reported on the simultaneous determination of ascorbic and dehydroascorbic acids by HPLC. This method was used to measure vitamin C in the plant samples. The samples were extracted in 15 % metaphosphoric acid. The chromatographic eluent was 1.14 g/L of dibasic sodium phosphate with 700 ul of triethylamine. The methods recommended tributylamine but this chemical was not available at U.W.I. The use of triethylamine instead of tributylamine might have influenced the seperation of the solute. The samples were injected into a C18 Ultraspere column. Dehydroascorbic acid and ascorbic acid were detected by UV at 215 and 255 nm respectively with retention times of about 4 minutes. The best extractant for ascorbic acid in plant materials, 15% metaphosphoric acid and 8% acetic acid, had a UV absorption spectrum close to that of the vitamin; therefore, fluorescence detection was used.

III.H.6.c) Vitamin C by fluorescence

The method used was that of the Association of Official Analytical Chemists (A.O.A.C.) number 43.069 (A.O.A.C., 1990). Ascorbic acid was extracted from the plant material in a solution of 15% metaphosphoric acid and 8% acetic acid. Ascorbic acid was then oxidized and the plant extract was decolorized by the addition of acid-washed Norit. The extract was filtered. A solution of 0.5 mg/ml of o-phenelenediamine dihydrochloride was added to form a fluorophor. The base fluorescence of the sample was determined by selective elimination of the fluorophor formation with the addition of boric acid before the addition of o-phenelenediamine dihydrochloride. The fluorescence was measured at 350 nm excitation and 430 nm emission on a Perkin Elmer luminescence spectrometer LF5.

III.H.7. Measurement of Citric Acid

Citric acid was determined by an enzymatic method (Moellering, 1985). Citrate was degraded to oxaloacetate and acetate by citrate lyase. In the presence of malate and lactate dehydrogenases, oxaloacetate and its decarboxylation product pyruvate were reduced by nicotinamide adenine dinucleotide (NADH) to L-malate and L-lactate respectively. The oxidation or disappearance of NADH in the assay solution was monitored at 365 nm on a HP Diode array 8452A and a Beckman DU40 spectrophotometers. The amount of citrate in the sample was determined by subtracting the absorbance after the reduction step from that before the reduction. A citrate solution (0.4 g/L) was used as a standard in the assay.

III.H.8. Fiber content

Fiber content was evaluated in the Crampton Nutrition Laboratory, Department of Animal Science, McGill University. Neutral detergent fiber (NDF) was measured by the method of Goering and Soest (1970). The acid detergent fiber was measured by the method of van Soest (1973).

III.H.9. Measurement of Tannins

The quantification of tannins was done by protein precipitation on the dried plants (Hagerman & Butler, 1978). This method takes advantage of the protein-binding properties of tannins. The tannins from the plants were extracted with a solution of 50% methanol. The extract was added to a solution of 1 mg/ml of bovine serum albumin (BSA). After 15 minutes at room temperature, the tannin-protein complex was centrifuged down at 3600g. The pellet was then dissolved in a basic solution of sodium dodecyl sulfate. The tannins were detected by color formation of the phenolics with a ferric chloride solution. The absorbance of the complex was read on a Beckman DU40 spectrophotometer. A purified tannin solution treated as the samples was used as standard (0.025 to 5 mg/ml tannins). Black tea leaves were used as a control; their tannin content was found to be 2 mg/g dry matter (DM).

III.H.10. Measurement of Phytates

The standard procedure for the measurement of phytic acid in plant material, the iron-precipitation assay, takes advantage of its binding affinity to iron. Because of the presence of a significant amount of interfering iron and phosphates in plant leaves, a method which includes a purification and concentration step was used.

Phytic acid was measured by the method of Harland and Oberleas (1986). The phytic acid in the plant samples was extracted with 2.4% HCl solution. The incubation time was three hours at room temperature. The incubate was filtered, then diluted with H_2O. The filtrate was then applied to an anion-exchange column (AGX1-4, 100-200 mesh, chloride form). At this point the anionic inositol phosphates replace the Cl^- on the resin. The resin was washed with H_2O then 0.1M HCl to remove water soluble weak anions. The inositol phosphates were then displaced with a solution of 0.7M HCl having a stronger anionic strength. The eluate was collected into Kjeldahl digestion flasks and 0.5 ml of H_2SO_4 and 3.0 ml HNO_3 were added before wet ashing. The phosphorus content was measured by using Fiske & Subbarow's reagent as a colorimetry detection. The absorbance of the chromophore was measured at 640 nm on a Beckman DU40 spectrophotometer.

III.I. STATISTICAL ANALYSIS

The statistical analysis was performed using SPSS 5 software (Norusis, 1992). The procedures used were chi-square analysis (categorical data) and independent samples t-test (continuous data) to compare the rural and semi-rural respondents for the variables age, weight, occupation, number of meals eaten the previous day, number of different foods eaten (dietary variety), report of having suffered from anemic symptoms, resources and sources of treatment for anemic symptoms, number of iron-rich foods mentioned as good for anemic symptoms, and number of plants named as remedies. Adjustments were made for small sample size by using Fischer's exact test to compare the rural and semi-rural respondents where appropriate.

Spearman's correlation was used to detect predictors of iron dialysability (availability) in the plants. The variables were plant species, location of collection, iron, ascorbate, citrate, phytates, NDF and ADF content. One-way ANOVA and Scheffé's test for multiple comparisons were used to compare the inter-species differences in acidity and iron dialysability.

IV. RESULTS AND DISCUSSION

IV.A. COMPARABILITY OF THE GROUPS SAMPLED

The neighborhood clusters were analyzed for comparability on a number of variables by chi-square tests adjusted for the small sample size if the cells were less than 5. Some of the variables tested are presented in Table IV.1. For the variables age, dietary variety, number of iron foods mentioned, number of plants named and two of the occupations, there was no difference between the groups. The groups semi-rural and rural were dissimilar in terms of occupation: there were more cultivators in the rural area and more merchants in the semi-rural area ($p<0.05$) [Table IV.2]. There was also a difference in weight: the rural respondents were on average of lower weight than those in the semi-rural area ($p=0.025$) [Table IV.1].

Table IV.1: Selected respondents variables by rurality

Rurality	Number of Respondents	Age	Weight	Number of Foods eaten (dietary variety)	Number of iron foods mentioned	Number of Plants named
Semi-rural	17	37 (14)	58 (11)*	7 (3)	0.357 (0.842)	8 (3)
Rural	14	38 (17)	50 (7) *	8 (2)	1.000 (1.118)	10 (3)

Numbers in parentheses are (S.D.); * Results are significantly different $p<0.05$, χ^2 test

Table IV.2: Occupation of respondents by rurality

Rurality	Occupation			
	Commerce	Cultivator	Commerce & Cultivator.	Household only
Semi-rural	10 *	2 *	1	4
Rural	4 *	7 *	2	1

* Results are significantly different $p<0.05$, χ^2 test

IV.A.1. Discussion

The age of the respondents is assumed to be approximative because of the high rate of illiteracy in the area (CRESDIP, 1990).

The average weight of the respondents (as measured with the portable balance available at the S.O.E.) was 54 ± 10 kilos with a median of 53 kilos. The weight for age of the respondents was compared to data from Nutrition Canada because weight for age data was not available for Haitian women. The respondents were between 10 and 50 percentiles compared to Canadian women. Differences in nutritional and genetic background may account for the results (Jurgens et al. 1990). To control for these differences, the average weight of the respondents was compared to that of a group of Haitian women form Île de la Tortue, 49.03 ± 0.63 (Benoist, 1962). The women of La Chapelle were found to have a higher mean weight indicative of a possibly better nutritional status. The respondents' weights were then compared to the mean weight of a random sample of African-American women, 63.1 kg (Eveleth and Tanner, 1990). This group of women was chosen because they are of West-African and European descent and are assumed to be genetically similar to the Haitians; and comparatively well nourished. This comparison underlines the fact that the women of La Chapelle are on average underweight possibly because of undernourishment. The measurement of the weight of the respondents, in this study, does not allow definitive conclusions on their nutritional status.

The semi-rural and rural groups of respondents were similar for most of the variables tested. Since, the rural and semi-rural women were comparable, their answers to the rest of the questionnaire was pooled into one group. As expected, there were more rural than semi-rural women cultivators. The rural women had a non-significantly greater dietary variety but they were of significantly lower weight than the semi-rural women. This lower weight might be due to the high energy expenditure spent by rural women on farm labor. The rural women also seemed to know more plant species for the treatment of anemia. This might be due to their proximity to the plant resources. The difference in plants named, however, was not significant.

IV.B. DIETARY SURVEY

Based on the questionnaire of the previous day's diet , the staples in the diet of the respondents were rice, plantain, sweet potatoes and millet. These starchy basics were typically accompanied by wild or cultivated greens and a small quantity of salted herring or meat. Fruits were consumed irregularly throughout the day, and were preferred in the form of juice. The consumption of milk or milk products was rare [Table IV.3].

A typical dietary intake is as follows:

First meal (consumed before midday)

- boiled plantains
- fried herring
- small bun with or without a spread
- small cup of coffee

Second meal (consumed around 3 o'clock)

- a plate of millet meal with bean sauce
- meat (usually pork) in a green vegetable sauce

Third meal (consumed in the evening)

- fruits or fruit juices
- pudding with milk (wheat flour)
- bread with a spread (butter, jam)

Table IV.3: Foods eaten by the respondents

Food items	Number of reports		
	morning meal n=31	afternoon meal n=31	evening meal n=10
Starchy staples			
Rice	0	10	3
Millet	0	10	1
Corn	5	8	1
Bread, wheat	4	2	3
Sweet potatoes	3	0	
Beets	0	1	0
Meats/Alternates			
Salted herring	9	0	0
Pork	1	10	0
Beef	1	5	0
Milk (2 with pudding)	0	0	3
Butter	0	1	0
Bones	1	0	0
Goat	0	4	1
Beans	0	23	4
Misc. foods			
Soup/bouillon	5	0	0
Coffee: *Coffea arabica*	0	1	0

Table IV.3 cont.

Food items	Number of reports		
	morning meal n=31	afternoon meal n=31	evening meal n=10
Fruits/Vegetables *			
Plantain: *Musa paradisiaca*	7	1	0
Breadfruit: *Artocarpus altilis*	4	0	0
Avocado: *Persea americana*	1	0	0
Okra: *Hibiscus esculentus*	2	6	0
Citrus juice: *Citrus* sp.	2	7	2
Lychee-type fruit: *Melicoccus bijugatus*	2	0	0
Melon: *Citrullus lanatus*	1	0	0
Squash: *Cucurbita* sp.	3	0	0
Local greens ; (Amaranthaceae, Tiliaceae, Portulaccaceae and others)	3	18	1
Cucumber: *Cucumis sativus*	0	1	0
Chayote: *Sechium edule*	0	4	4
Watercress: *Rorippa nasturtium-aquaticum*	0	3	0
Cabbage: *Brassica oleracea*	0	1	0
Passion fruit: *Passiflora edulis*	0	3	0
Mango: *Mangifera indica*	0	0	1
Carrots: *Daucus carota*	0	1	0
Sugar cane: *Saccharum officinarum*	1	0	0
Ginger juice: *Zingiber officinale*	1	0	0

* The latin names are given for fruits and vegetables only.

IV.B.1. Discussion

A complete evaluation of the nutrient content of the respondents' diets was not possible due to the difficulty of assessing portion size accurately. The approximate quantities were estimated using local containers and information gathered from the S.O.E.'s cook who served as a key informant on portion size and cooking time determination.

A qualitative appraisal can be attempted by taking into consideration dietary variety (number of foods mentioned) and the relative quantities of foods the respondents reported. Over ninety percent of the respondents reported having three food groups starchy staples, fruits/vegetables, starchy staples, meats/alternates, dairy products. The approximate quantities of foods eaten revealed that the bulk of the diet consisted of starchy staples and beans. This diet is classified as a low in iron availability (FAO, 1988). Some individuals can be in the intermediate iron availability diet category because of their intake of fruits, vegetables and animal or fish protein sources that increase the absorption of dietary non-heme iron.

The dietary questionnaire shows that the respondents have a diet high in starchy staples and cereals that are low in iron and high in inhibitors of iron absorption. Since the precise quantities of foods were not measured, only a qualitative assessment of the respondents diets can be done here. The qualitative appraisal of the diet (food groups mentioned and approximate quantities) suggests an inadequate protein intake, because of the predominance of starchy foods low in protein, but the intake of vitamins and minerals may be sufficient because of the variety of fruits and vegetables eaten (Gélinas, 1991; Health and Welfare Canada, 1990).

IV.C. ETHNOBOTANICAL SURVEY

IV.C.1. Prevalence of illnesses

The ethnobotanical questioning started with asking the respondents if they had experienced the specific illness *Feblès*, *Mank lapeti*, *Fe san vini*, or *San gate*. Ninety one percent of the respondents reported having felt the illness *Feblès*.

IV.C.2. Symptomatology

The women were then asked to describe the symptoms of each illness. *Feblès* was found to be the illness term closest to the biomedical symptomatology of anemia which includes vertigo, fatigability, pallor, visual problems and amenorrhea, to name a few (Andreoli et al., 1990; Gélinas et al., 1991). The symptoms of *Feblès* as described by the respondents were, for example: dizziness, chronic fatigue, decreased physical capacity, heart palpitations, blurry vision, heavy perspiration and pallor (Table IV.4). Weak limbs and dizziness both were mentioned more than 50% of the time along with the other symptoms mentioned above. The numbers do not add up to 100% because the respondents listed several symptoms per illness term.

Table IV.4: Symptoms of anemia described by respondents

Biomedical symptoms	Symptoms reported by respondents	Percentage of report by respondents
Weakness	Weak limbs	54%
Vertigo	Dizziness	57%
	Dizziness & weakness	21%

The symptoms described for ***Mank lapeti*, *Fe san vini*** and ***San gate*** were similar to those for ***Feblès*** but some were for other symptoms which are part of their specific illness complex. For example, the plant remedies for ***Fe san vini*** may be used either to fortify the blood or to provoke menses. Therefore, the rest of the analyses is focused on the illness term *Feblès* which was found to be the best local ethnomorbidity term to describe anemia.

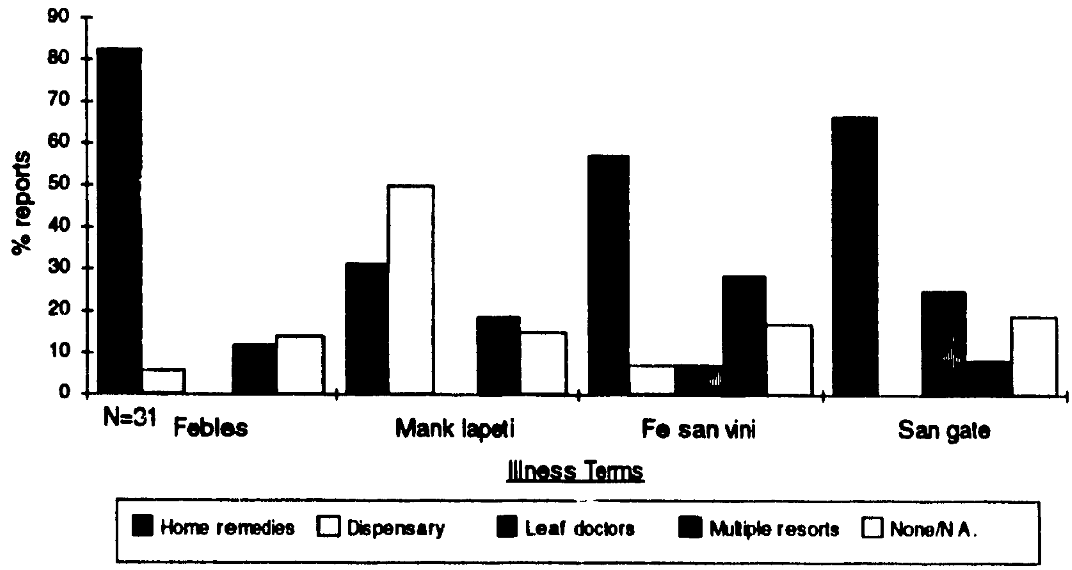
IV.C.3. Etiology

The respondents were then asked what they thought was responsible for the onset of ***Feblès***. The etiologies mentioned by the respondents were, in order: no reason/don't know, poor diet, other illnesses, fatigue, worry, pregnancy. From the respondents' descriptions of the causes of the illness, it was found that they believed the strength, quantity and health state of the blood had a direct influence on physical and cognitive ability, appetite, the quality of maternal milk, menstruation and fertility, and the general feeling of health. Some of the respondents explained that the quality of one's blood, and hence the cause of the illnesses, is affected by an altered physiological state (chronic fatigue, pregnancy), an inadequate diet and one's psychological state (anger, anxiety).

IV.C.4. Resources of treatment

The medical resources available for the people of La Chapelle are home remedies, traditional healers (leaf doctors), medical doctors at the dispensary or Houngans (voodoo priests). In figure IV.1, the respondents choices of resources are shown. It can be noticed that the majority of the women prefer to treat themselves with home remedies except for Mank lapeti. The responses do not total 100% because of multiple resorts (counted twice) by the respondents.

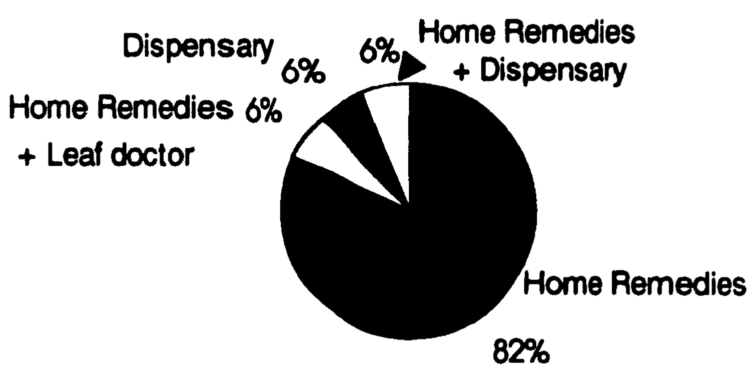
Figure IV.1: Resources for the treatment of anemic symptoms



N.A. means not available

For Feblès, a more detailed view of the responses is given in Figure IV.2. There was a predominant use of home remedies only (82%) by the respondents. The non-respondents were excluded from this figure.

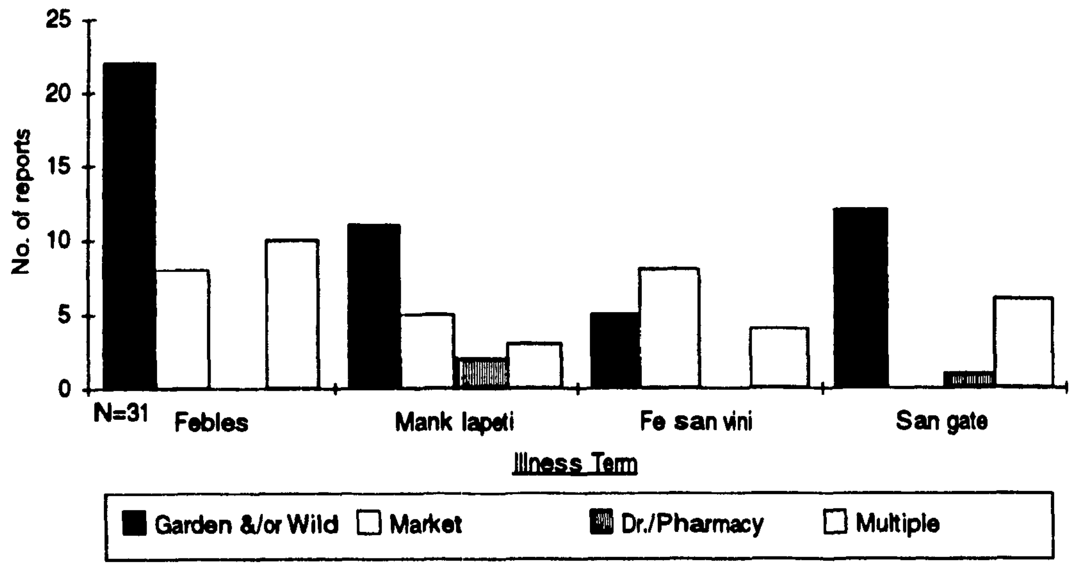
Figure IV.2: Resource for the treatment of *Feblès*



IV.C.5. Sources of treatment

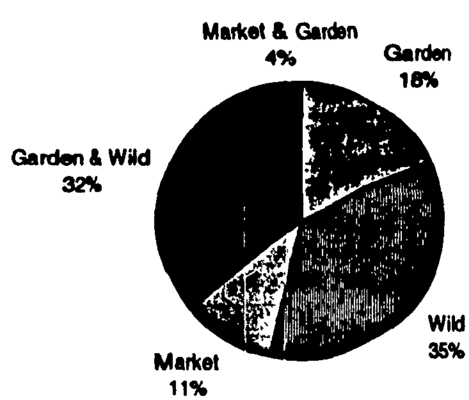
The respondents were then asked where they got the plant remedies mentioned. The treatments or remedies were obtained from the wild, a home garden, the market, the dispensary or the pharmacy [Figure IV.3]. Most remedies were obtained from the garden or wild and many people used a combination of sources of remedies. That is, some plants were bought at the market and some were harvested to be included in the same remedy.

Figure IV.3: Sources of remedies for the treatment of anemic symptoms



For *Feblès* the breakdown of the responses are in figure IV.4. Again, most of the plants were harvested from the wild (35.7%) or from the garden (17.9%).

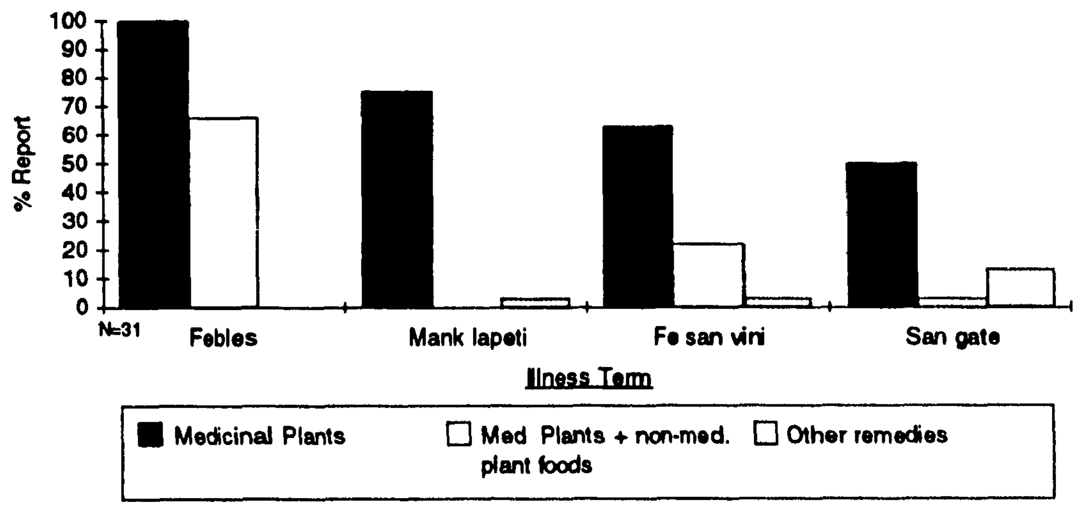
Figure IV.4: Sources of treatment for *Feblès*



IV.C.6. Home remedies

Of the home remedies used, 50 to 100% (depending on the illness questioned on) were from plant sources [Figure IV.5]. The home remedies usually were composed of plants used as medicine. Foods such as tubers or animal bones were added to some remedies. Other types of home remedies are described later in section IV.C.6.d).

Figure IV.5: Types of home remedies:



IV.C.6.a) Plant Remedies

Among the most commonly used traditional hematinic remedies [Table IV.5, Figure IV.7], over 70% were derived from food plants. Of those, the majority of plant remedies were from food plants whose fruits are used as foods, for example, the leaves of the *Persea americana* (avocado) or *Annona* sp. (soursop, bullock's heart) were used as hematinics. Six of the medicinal plants were also used interchangeably as greens or condiments in the regular diet: *Corchorus olitorius* (jew's mallow), *Rorippa nasturtium-aquaticum* (watercress), *Portulaca oleracea* (purslane), *Amaranthus dubius* (amaranth), *Daucus carota* (carrot) and *Beta vulgaris* (sugar beet). Of these, *R. nasturtium aquaticum*, *D. carota* and *B. vulgaris* are cultivated as a food crops.

Daucus carota (carrot) and *Beta vulgaris* (sugar beet). Of these, *R. nasturtium aquaticum*, *D. carota* and *B. vulgaris* are cultivated as a food crops.

A value was assigned to plants based on their use as foods and market goods. The food value was obtained from data on the respondents' usual diet. The economic value was obtained also from the usual diet and from information on Haitian commercial crops (CRESDIP, 1990). Figure IV.6 is a summary of the values of the plant species. Table IV.5 lists the most popular plants to treat anemic symptoms in alphabetical order by species name. The list of all the plants mentioned by the women and the leaf doctors is available in Appendix IV. The family, genus, species and English names were verified in Rouzier (1990), Nicolson (1991); Liogier and Martorell (1982), Mabberley (1987) and United States Department of Agriculture (1982.)

It was noticed that a number of plants used to treat the symptoms of anemia were of red color. *Hamelia patens* has bright red leaves, flowers and fruits. *Eleutherine bulbosa* has a bright red bulb from which its red dye leaks on rainy days like a stream of blood. The inside of the bark of *Haematoxylon campechianum* is also red. There seems to be an association between the color of the plant used in the remedy and the color of blood.

Figure IV.6: Summary of value of plant species

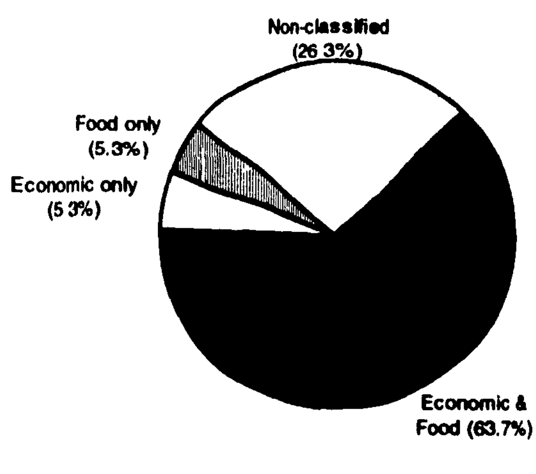
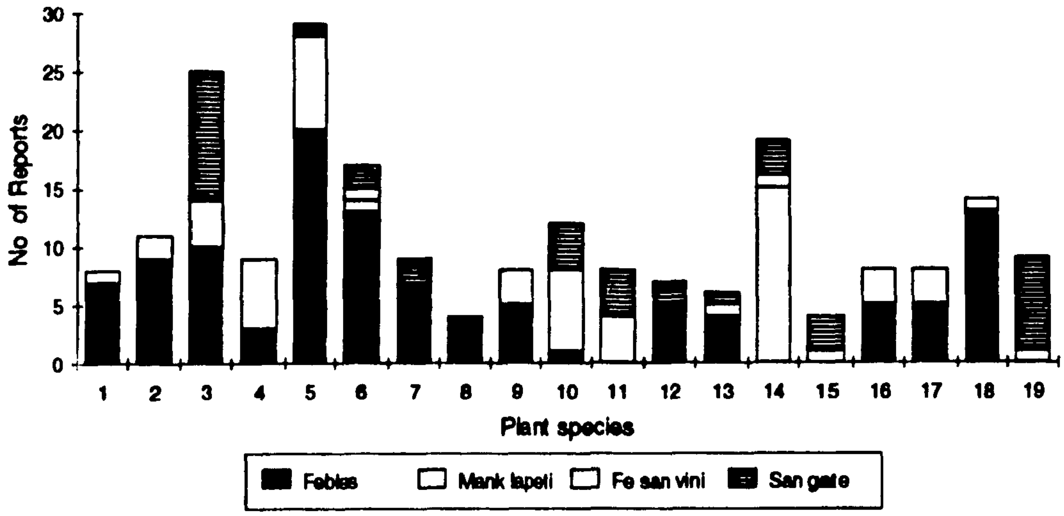


Table IV.5: Plant species most commonly used to treat the symptoms of anemia.

Number	Species	Family	Value	Common Preparation
1	*Amaranthus dubius*	Amaranthaceae	Food	Leaves: soups
2	*Annona muricata.*	Annonaceae	Economic & Food	Leaves sweet tea
3	*Annona reticulata*	Annonaceae	Economic & Food	Leaves: sweet tea
4	*Beta vulgaris*	Chenopodiaceae	Economic & Food	Root: juice
5	*Chamissoa altissima*	Amaranthaceae	Economic Food	Leaves in soups, tea
6	*Citrus aurantium*	Rutaceae	Economic & Food	Leaves: tea
7	*Corchorus olitorius*	Tiliaceae	Economic & Food	Leaves: in soups
8	*Cucurbita moschata*	Cucurbitaceae	Economic & Food	Leaves: soups
9	*Daucus carota*	Umbelliferaeae	Economic & Food	Root: juice
10	*Haematoxylum campechianum*	Fabaceae		Leaves & bark: tea
11	*Hamelia patens*	Rubiaceae		Leaves: infusion
12	*Moringa oleifera*	Moringaceae		Leaves: tea
13	*Ocimum micranthum*	Lamiaceae		Leaves: infusion
14	*Oxalis corniculata*	Oxalidaceae		Leaves: salted tea
15	*Persea americana*	Lauraceae	Economic & Food	Leaves, bark: tea
16	*Phaseolus sp.*	Fabaceae	Economic & Food	Leaves. soups
17	*Portulaca oleracea*	Portulacaceae	Economic & Food	Leaves: soups or tea
18	*Rorippa nasturtium - aquaticum*	Cruciferae	Economic & Food	Whole plant in soups
19	*Stachytarpheta jamaicensis*	Verbenaceae	Economic	Leaves: tea

Figure IV.7: Plants used to treat the symptoms of anemia per illness term



The plants species are represented by their numbers. Refer to table IV.5

IV.C.6.b) Plant associations

The plant species were almost always used in a mixture. The association of different plant species was consistent among respondents. For example, the combinations of *Chamissoa altissima* and *Rorippa nasturtium-aquaticum* was mentioned by 11 out of 31 respondents.

The most common associations were: *C. altissima + P. oleracea; C. altissima + R. nasturtium-aquaticum; A. dubius + C. olitorius + P. oleracea; A. muricata + C. aurantium.*

These plant combinations might be beneficial, neutral or detrimental in terms of their effect on a remedy's iron availability. It was not possible to test for different combinations in this study.

IV.C.6.c) Quantity used and preparation of plant remedies

The home remedies made of medicinal plants were prepared as teas or soups. Foods were added to plant-based home remedies when these were consumed in the form of a soup. The soup would consist primarily of the medicinal leaves and include tubers, bread and/or plantain. The foods used in combination with herbal remedies, not included in the soup, were citrus and passion fruit juices and milk. The quantity of plant material that was ingested to treat the symptoms of anemia varied depending on the mode of preparation. When teas were prepared, the usual amount varied from three leaves to a handful of leaves in an indeterminate volume of water. When a leaf soup or bouillon was prepared, it was estimated that the respondents used 25 to 50 g of leaves and consumed approximately three cups of the remedy per day.

The mode of preparation of each plant used as remedy was fairly consistent among respondents. Some leaves or bark were taken either as a salted or sweet tea and others added to soups or bouillons when necessary. On rare occasions the juices of the leaves were consumed. *Chamissoa altissima* or *Moringa oleifera* (Drumstick), were either eaten as vegetables or drunk as teas or infusions depending on personal preference.

IV.C.6.d) Other home remedies

There were remedies mentioned by the women that were not ingested such as the cutaneous application of coffee mixed with corn-starch to treat the rash accompanying *San gate*. Other remedies that were not of direct plant origin were dark red beverages such as grape cola. One woman explained that the cola is good for the *Feblès* because of its dark red color akin to that of blood. This association is similar to the one noticed for the plant remedies.

IV.C.6.e) Modern medications

The modern medications used were vitamin syrups containing antihistamines such as "Appetivit", antacids and antibiotics such as tetracycline.

IV.C.7. Cost of remedies

Seventy-five percent of the medicinal plants were obtained free of cost because they were harvested from the wild or gardens for use as hematinics. When bought at the local market the price range for a preparation was between G0.10 to G2.00 (one G is a fifth of the Canadian dollar). The treatments from *leaf doctors* cost between G15.00 and G35.00. The use of modern medication and vitamin supplements including iron therapy for the treatment of anemia cost between G10.00 and G53.20.

IV.C.8. Diet/food and treatment of *Feblès*

The respondents were also asked if they did anything different while taking the remedies. This question was to discover if there are practices accompanying the treatments that might affect the respondent's nutritional status such as dietary restrictions or emesis. None of the respondents mentioned dietary modifications during the treatments.

The respondents were then asked to name the foods that they knew were good for anemia (*Feblès*). The responses were, in order, milk, meat, eggs, fruits and vegetables, beans, fish. The foods mentioned most often are prestige foods that few people can afford. But, they are not necessarily foods that are rich in iron or folate such as milk or eggs (Gélinas, 1991). Interestingly, few respondents mentioned the plants used in the remedies as food plants good for treating anemic symptoms. The other plants used both as medicine/food were not mentioned either. It seems that the food plants reported as treatments are not considered beneficial for this illness outside of their medical context.

IV.C.9. Comparison with *leaf doctors*

Five *leaf doctors* were interviewed about traditional therapies to treat the illnesses *Feblès*, *Mank lapeti*, *San gate* and *Fe san vini*. The leaf doctors were considered key informants on the subject of traditional therapies. They mentioned the same plant species as the respondents for the treatment of the illness terms but many of the plants they named like *Capparis flexuosa* were not easily found in gardens or in the wild. *Capparis flexuosa* was also the only plant restricted in its use by season according to the respondents and the *leaf doctors*. The *leaf doctors* seemed to view the illness terms as related since they used more or less the same remedies for all of them. The respondents were not as consistent as the *leaf doctors* in remedies between the different illness terms, although there was largely consensus for the treatment of *Feblès*.

IV.C.10. Discussion

The women interviewed were found to be affected by and concerned with the symptoms of anemia because almost all of the women reported having suffered from it. The respondents were knowledgeable about the correct biomedical signs and symptoms of anemia through their description of the illness Feblès. It was understood that the symptoms of anemia were due to physiological changes affecting the quality of the blood.

Over 90% of the women knew and/or used home remedies that were free or relatively inexpensive compared to commercial medicines (from modern or traditional practice). This result compares to the findings of Rouzier (1990) where it was noticed that 86% of the 200 respondents (men and women) used home remedies as the first resource to treat Feblès. Despite the small sample size of this study, it was possible to detect the trend because of the high prevalence of use of home remedies. It was also found that the knowledge of which plants to use to fight anemic symptoms was not exclusive to leaf doctors. Therefore, knowledge of traditional remedies for anemic symptoms are accessible to the majority.

The respondents' sources for the home remedies was in large part from the wild or home gardens and were, therefore, free of charge. The preference of use of home remedies over commercial ones might be due to economic reasons. Furthermore, the plant remedies are more readily available as they are part of the flora or are cultivated for medicinal or food purposes.

Seventy percent of the plants used as home remedies to treat the symptoms of anemia were also dietary components. However, it was not always the plant part consumed as a food that was used in the home remedies. For example, the leaves of *Annona* sp. were used as a remedy whereas their fruits were eaten as foods. Sixty-eight percent of the plants used were found to have economic value at the local or international level. That is, they are sold at markets and are exported to obtain foreign exchange. If some of these plants are promoted as food sources, they could generate income (FAO, 1987).

It was not possible to obtain the exact amount of each plant's leaves used in the remedies. There is probably some variation between the women in the amount of plant leaves used in a remedy. From the respondents' description, it was estimated that they use about 50 g of plant leaves to prepare a remedy. The preparation method of the plants has an impact on the usefulness of the remedy as an hematinic. When the leaves of the remedy are eaten, it is assumed that the women get more nutrients than when they drink the tea. Not all of a particular nutrient can leach into the tea. The addition of other food components and the association of different plant species in the leaf soups can also increase their nutritional content.

The ethnobotanical survey pointed to several plants that would be interesting to analyze for hematinic nutrient content. A few plants that were used as remedies for Feblès and as foods in Haiti were analyzed.

IV.D. PLANT ANALYSES

The iron availability studies consist of evaluating the iron dialysability, the iron absorption promoters (ascorbic and citric acids) and inhibitors (fiber, tannic and phytic acids).

IV.D.1. Iron Content and Iron Dialysability

Table IV.6 shows the results of the iron analyses. The iron content of *Corchorus olitorius* 8.20 mg/100 g was within the range reported in the literature (Akoroda, 1987; Latunde-Dada, 1990). The iron content of *Amaranthus dubius* and *Moringa oleifera*, 14.29 and 15.98 mg/100 g respectively, were higher than previously reported (Ramachandran, 1980 CFNI, 1974). For *Portulaca oleracea* and *Phaseolus vulgaris* leaves, no values were found in the literature on iron content. However, the iron content of *Phaseolus vulgaris* was high, compared to the other plants studied, because it was grown on a soil containing EDTA at the Biotechnology Centre at U.W.I.. *P. vulgaris* was the only plant used that was not growing wild.

The iron dialysability of the control cooked spinach was found to be low (4%) as reported by Gillooly et al. (1983). The iron dialysability values for the plants analyzed ranged from 7.96% (*M. oleifera*) to almost 34.2% (*P. vulgaris*). On average, the highest value for iron dialysability was that of *A. dubius* (30%). Literature values for iron dialysability were found for *C. olitorius* (Latunde-Dada, 1990). The dialysable iron from *C. olitorius* results (8.11%) was comparable to the findings of Latunde-Dada (1990) at 6.26%. The plant species *C. olitorius*, *P. vulgaris*, *P. oleracea* were separated into two distinct groups for their iron dialysability. These intra-species variations in iron dialysability were found to be accounted for by cooking and storage times, and acidity of the plant species [section IV.D.1.a)].

Table IV.6: Iron analyses of plant species

Plant species	Total Iron mg/100g FM n=4	Percent Iron dialysable n=4	Total Iron provided mg/100 FM
A dubius	14.29 (1.40)	28.59 (6.92)	4.31 (1.03)
C olitorius	8.20 (2.61)	8.11 (0.49)	0.66 (0.06)
C. olitorius	8.20 (2.61)	30.02 (4.99)	2.46 (0.41)
M. oleifera	15.98 (0.99)	7.96 (1.45)	1.27 (0.23)
P. vulgaris	36.32 (2.82)	9.52 (0.61)	3.46 (0.22)
P. vulgaris	36.32 (2.82)	34.20 (10.30)	12.42 (3.74)
P. oleracea	8.44 (0.30)	10.07 (1.68)	0.86 (0.34)
P. oleracea	8.44 (0.30)	39.64 (15.12)	3.35 (1.28)

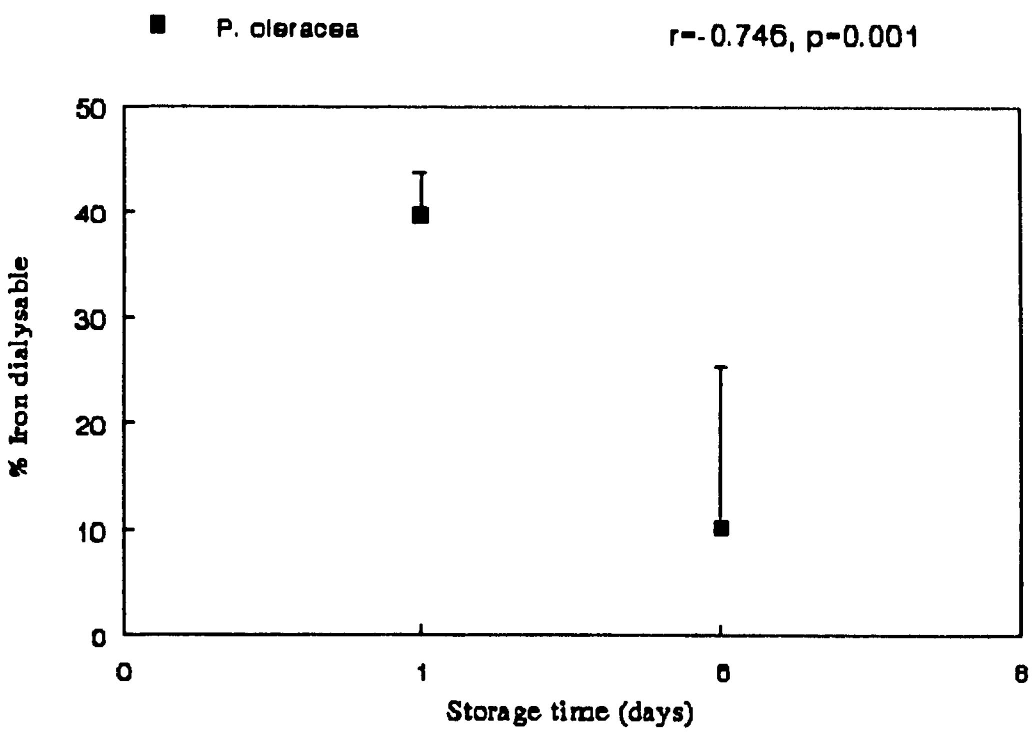
n= number of replicates
FM= Fresh Matter
Numbers in parentheses are standard deviation
Number of plant collections = 3 except for *M. oleifera* (1)

IV.D.1.a) Factors influencing iron dialysability

The variability in iron dialysability within plant species was investigated. Correlation analyses were undertaken to locate the sources of variation in iron dialysability. The correlation test used was Spearman correlation coefficient. The variables tested for were contents of ascorbate, citrate, phytate, ADF and NDF; storage time, cooking time and acidity of the meal because these could be related to the degradation of enhancers of iron absorption [section II.D.2]. For these correlations, the variables plant species and location of collection were controlled for. These correlations were not necessary for *A. dubius* and *M. oleifera* because the storage and cooking times were similar. The acidity of the plant meals was found to be consistent within plant species. But, between plant species, a difference in acidity was noticed. Therefore, the relationship between the acidity of the plant species homogenates and their iron dialysability were compared by one-way analysis of variance with Scheffé's test to detect homogeneous subsets.

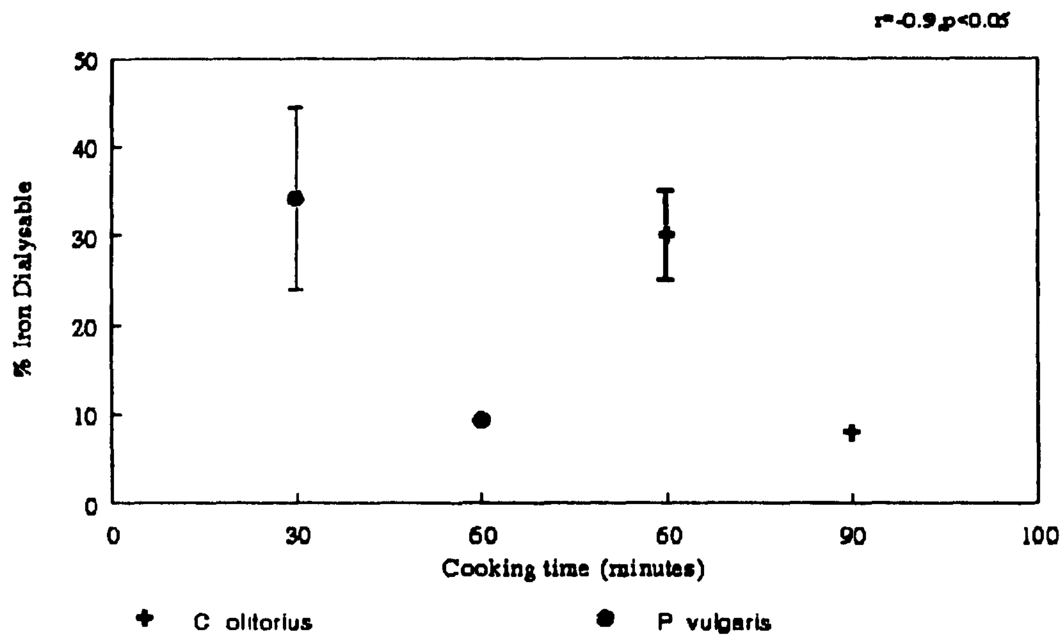
For *P. oleracea*, the decrease in iron availability is correlated with the time elapsed between the time of the plant collection and the time when the meal is prepared (r=-0.746, p=0.001) [Figure IV.8]. The iron dialysable is decreased by a third of its value within five days.

Figure IV.8: Effect of storage time on iron dialysability



For *C. olitorius* and *P. vulgaris*, it was found that the percent of iron available was related to the time of cooking (r=-0.9, p=0.001). An increase in cooking time of 30 minutes was found to produce a three-fold decrease in iron dialysability. The cooking time seems to destroy the promoters of iron absorption, such as ascorbate or other organic acids, thereby affecting iron bioavailability [Figure IV.9].

Figure IV.9: Effect of cooking time on iron dialysability



The plants were compared to each other for the effect of acidity on iron dialysability. The acidity was expressed as the titratable acidity in mEq NaHCl (higher mEq NaHCl indicates lower pH). The average acidity of plant species meals was found to be a factor in the plants species average iron dialysability ($r=0.4168$, $p=0.007$) [Figure IV.10]. *A. dubius* had, on average, the highest acidity and the highest iron dialysability. Scheffé's test for homogeneous subsets also underlines the difference in acidity between *A. dubius* and the other plants. The acidity of *A. dubius*' acidity was alone in its own subset therefore, it was significantly different from all the other plants [Table IV.7].

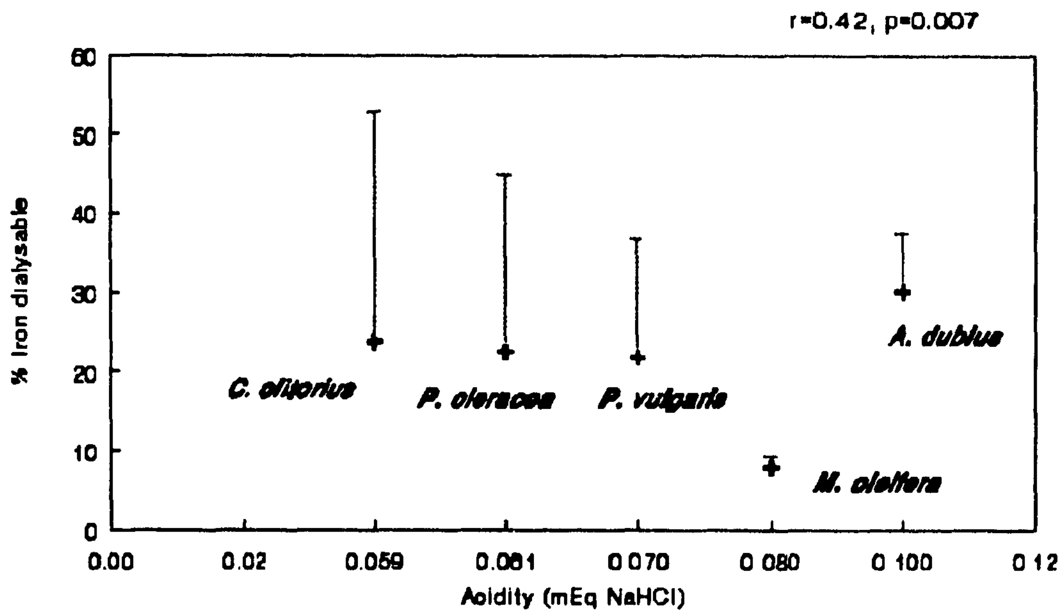
Table IV.7: Differences in acidity of the plant species.

Plant	*A. dubius*	*C. olitorius*	*P. oleracea*	*P. vulgaris*	*M. oleifera*
Mean Acidity* (mEq NaHCl)	0.100 (0.018)[a]	0.059 (0.0033)[b]	0.061 (0.014)[b]	0.070 (0.000)[b,c]	0.080 (0.000)[c]
Mean iron dialysability (%)	30.22 (7.20)	23.79 (28.95)	22.54 (22.24)	21.85 (15 01)	7.96 (1.45)

Numbers in parentheses are standard deviations

* Numbers followed by the same letter are similar in acidity

Figure IV.10: Effect of acidity on iron dialysability



IV.D.2. Ascorbate and Citrate Content

The results of the analyses of ascorbic and citric acid are in Table IV.8. Ascorbic acid could not be measured in all test meals (plant homogenates) because of difficulties encountered in its assay. It was noticed, however, that the plants *A. dubius*, *P. oleracea* and *C. olitorius* lose much of their vitamin C upon cooking. This is in accordance to literature values of losses of up to 86% of ascorbate upon cooking of *C. olitorius* (Keshrinro and Ketiku, 1979).

The citrate contents of the plant leaves analyzed was not found in the literature. The enhancing effect on iron absorption of orange juice is partly due to its citrate content of about 300 mg/100 g. Therefore, the small amounts of citrate contained in these plant species (less than 45 mg/100 g) did not likely to influence iron dialysability (Gillooly et al., 1983).

Table IV.8: Ascorbic and citric acid analyses

Plant species	Ascorbate mg/100g FM			Citrate mg/100g FM	
	Raw	Cooked	tea	Cooked	Tea
A. dubius	53.91 (0.04)	1.19 (0.13)	N/A	2.10 (2.97)	N/A
C. aurantium	N/A	N/A	1.24 (0.05)	N/A	1.77 (0.93)
C. olitorius	N/A	4.32 (1.73)	N/A	6.58 (3.87)	N/A
M. oleifera	N/A	77.13 (11.2)	1.17 (0.05)	45.14 (0.73)	16.06 (5.89)
P. vulgaris	N/A	0.59 (1.97)	N/A	N/A	N/A
P. oleracea	77.38 (28.86)	1.23 (0.00)	N/A	22.33 (5.71)	N/A

Number of plant collections=2
Number of replicates=2

IV.D.3. Fiber, Tannins and Phytates content

Table IV.9 showed the results of the analyses of fiber, tannins and phytates. The NDF and ADF content of the plant species varied greatly between plant species. The content of these two fiber subgroups were not found in the literature for the plants mentioned. The tannin content of the plants species were measured on both cooked and dried samples. The tannins could not be detected with the methods used. The detection limit was 0.125 mg/g dry matter (DM). The tannin content of the black tea leaves analyzed as controls showed a level of more than 2 mg/g DM. The phytate contents also were very low. The control of lettuce analyzed showed a phytate level of 160 mg/g DM which was similar to literature values (Alaoui and Essatara, 1985).

Table IV.9: Moisture, Fiber, Phytate and Tannin analyses

Plant species	Moisture %	ADF %	NDF %	Phytate mg/g DM	Tannin mg/g DM
A. dubius	84.89	11.30 (0.08)	22 07 (0.84)	6 23 (2.80)	<0.125
C. aurantium	N/A	N/A	N/A	N/A	N/A
C. olitorius	74.79	11.19 (0.21)	15.44 (0.02)	0.77 (0.70)	<0.125
M. oleifera	78.63	7.42 (0.42)	10.33 (0.91)	4.19 (2.60)	<0.125
P. vulgaris	87.74	19.3 (1.45)	24.80 (0.57)	0.96 (0 01)	<0.125
P. oleracea	93.17	21.35 (0.18)	32.52 (0.30)	0.66 (0.11)	<0.125

Number of plant collections = 1
Number of replicates = 2 except for moisture level (1)

IV.D.4. Discussion

The plant species analyzed were found to provide differing amounts of absorbable iron (iron dialysability) [see Table IV.6]. *Amaranthus dubius* was found to have an iron bioavailability similar to that of animal products (30%) and to provide 4 mg of absorbable iron per 100 g of cooked plant homogenate. Some of the plants used as remedies by Haitian women in La Chapelle were found to provide significant amounts of the hematinic nutrient iron.

The effect of storage, cooking time and acidity on the plant homogenates iron dialysability is relevant to the efficacy of the plant remedies. For the laboratory analyses, the plants were stored in plastic bags at 4°C and their cooking procedures were monitored. In the field, the storage and cooking conditions vary. Differences in preparation and, therefore, efficacy of the hematinic home remedies will also vary considerably. To be useful, the plants would have to be picked and cooked for less than thirty minutes within the same day. The details of storage mode and time were not gathered from the respondents. For cooking time, the respondents' answers were not precise. The criterion used for adequate cooking time was the tenderness of the plant leaves. This criterion was used in the laboratory setting and resulted in significant variations in time of cooking and iron dialysability for *C. olitorius* and *P. vulgaris*. There is, therefore, a need to determine the optimal conditions under which the plants can provide the most iron when used as remedies against anemic symptoms.

Vitamin C proved very difficult to measure in the plant samples analyzed. It was possible, however, to notice a sharp decrease in vitamin C content of *A. dubius* and *P. oleracea* upon cooking. The destruction of vitamin along with other organic acids is thought to increase the pH of the plant homogenate and, thereby, negatively influence iron dialysability.

Phytates and tannins, because of their low amounts, do not seem to play an important role in iron dialysability of the plant samples analyzed (Siegenberg et al., 1991).

The ADF and NDF fiber contents, although not negligible, were not found to be predictors of iron dialysability in the studies conducted. The binding of iron to these fiber fractions in these plant species was not significant enough for its impact to be detected.

The analyses of the plants could not be done on local specimens from La Chapelle. Rather, they were done on the plants species in Jamaica. It is acknowledged that there might be differences on plants constituents between the two regions due to climate and soil variables (Fawusi, 1983)

V. GENERAL DISCUSSION AND CONCLUSIONS

An individual's nutritional status depends on cultural traditions that determine the use of the available nutrient resources. This study outlined some cultural factors that influence hematinic nutriture in Haitian women, namely, dietary practices and the use of plant as remedies. The objectives of this study were to assess the extent of use of home remedies to treat the symptoms of anemia by a group of Haitian women and to determine the usefulness of local plant remedies to treat the symptoms of anemia.

The first hypothesis was that at least 80% of the respondents use home remedies to treat the symptoms of anemia. The second hypothesis was that some of the plant species used as treatments for anemia may have hematinic potential. To support or refute these hypotheses, the study was conducted in several stages. First, the respondents' sources of dietary iron were assessed by a dietary recall. Then their beliefs about the symptoms of anemia along with their treatment patterns was recorded through an ethnobotanical questionnaire. Finally, the hematinic potential of some of the plants mentioned to be used both as medicines to treat anemic symptoms and as foods was determined by laboratory analyses.

The diet of rural Haitian women consisted mainly of starchy staples and beans, a diet that is known to be low in available iron (Hallberg et al. 1988). The diet also included the intake of a variety of green leafy vegetables which can bring the iron availability of the diet to an intermediate level (11-18%) because of their content of iron absorption enhancers. The green leafy vegetables can also provide additional micronutrients and complementary amino-acids (FAO, 1988; Uiso, 1991). The exact quantification of individual intakes was not done, therefore, it is not possible to make strict conclusions on the macro and micro nutrient sufficiency of the respondents' diets. Nutritional anemias are known to be prevalent among Haitian women (Mulloy, 1989; DeMaeyer, 1985), therefore, it is assumed that the respondents' intake of iron and folate are below their requirements. The weight for age data of the women, although not specific, further points out to undernourishment of the women interviewed. The women were between 10 and 50 percentile of weight for age as compared to the Canadian standards. The comparison to Canadian values, however, may give a biased estimate of the respondents' overall nutritional status because of possible racial differences in anthropometric measurements. However, 84% were below the average weight of African-American women who are assumed to be well-nourished and from the same racial extraction.

The ethnobotanical questionnaire elicited answers on four illness terms: *Feblès*, *Mank lapeti*, *Fe san vini* and *San gate*. These illness terms were the ones determined from previous studies to encompass the symptoms describing anemia (Rouzier, 1990). *Feblès* was found to be the illness that matched more closely the biomedical symptomatology of anemia and the one on which the most information was provided by the respondents. Ninety-two percent of the respondents reported suffering from this illness. The existence of anemia by hematological measurements was not part of the study. It was assumed that the prevalence of iron-deficiency anemia in Haitian women is typical of that in other developing countries at approximately 49% (DeMaeyer, 1985). Drawbacks of the ethnobotanical survey were the small sample size and the lack of exact quantitation for the frequency of use and dosage of plant remedies.

The respondents described anemia as provoking general weakness and physical incapacities. Many of the women did not give a reason for the symptoms of anemia, but just as many stated poor diet as the etiology for anemic symptoms. The concepts above of anemia are probably due in part to indigenous medical traditions and to health education efforts by biomedical nurses and doctors. The respondents were found to have a cultural understanding of the etiology and the symptoms of anemia close to the biomedical model. Because of their displayed concern and knowledge, it is thought that the respondents would be receptive to public health programs to control nutritional anemias. The local concepts or definitions of anemia can be used by health care promoters to explain the laboratory results for anemia, the rationale for prevention and treatment, and the expected results of intervention measures. Using the same vocabulary as the recipients can increase their understanding and participation in programmes to control nutritional anemias. Increased community participation could increase adherence which has been found to be very low in iron supplementation programmes (Gillespie, 1991). For this study group, it can be useful to define iron deficiency as causing weak limbs and to rationalize the treatment of anemia as an improvement of the quality of the blood.

Over 80% of the respondents used home remedies as the first resource for treatment of *Feblès* and all the remedies mentioned contained plant species. The first null hypothesis was, therefore, rejected. Many of the plants mentioned (70 %) also have a food and economic value such as *Corchorus olitorius* or *Persea americana*. These plants are usually available in the wild or are cultivated in home gardens. If these plants are indeed efficacious in the prevention and treatment of nutritional anemias, the promotion of these local nutrient sources could enhance health and contribute to local economic exchanges (FAO, 1987).

Traditional healers, *leaf doctors*, were also interviewed to get more information about traditional therapies for the signs and symptoms of anemia. The knowledge of the *leaf doctors* and the lay respondents were compared. There was no difference in the description of the symptomatology of anemia between the two groups. The *leaf doctors*, mentioned the same remedies as the respondents, however; they had a larger repertoire of known plant species than the respondents.

Although many respondents mentioned a poor diet as central to the etiology for anemia, when asked what foods they know are good to treat the symptoms of anemia, few respondents mentioned again the food plant leaves used as remedies. Therefore, for the respondents, there is not necessarily a connection between the food value and the medicinal value of a plant species. There is, however, the possibility of empirical nutritional therapy through the use of home remedies. The respondents have some idea of nutritional therapy since they mentioned other foods to treat the symptoms of anemia. However, these foods are usually either starchy such as plantain or expensive prestige foods such as milk and eggs that are not rich in iron. Because of the women's understanding of the importance of diet, it would be possible to advise on dietary modifications to prevent or treat nutritional anemias. Moreover, because of the importance of leaves in Haitian culture and medicine, the use of local plants to prevent anemia can be culturally acceptable. The culturally and economically appropriate dietary modifications would be to promote the use of fruits and vegetables for their iron absorption enhancing effects and the use of food/medicinal plants such as *Amaranthus dubius* that can provide significant daily quantities of absorbable iron. Dietary modifications and plant remedies do not deliver as much iron as the commercial preparation (60 mg) but these iron tablets are not always available in developing countries and can not be considered as a long term solution (Gillespie, 1991).

This study revealed that the respondents' beliefs, treatment patterns and local resources for anemic symptoms form a cultural ecological system in which concepts of anemia, treatments and resources are interrelated and often dependent on each other. The conceptual framework of the study is based on these relationships [Figure III.1]. The agricultural circumstances of the women interviewed made plant resources available for use. The maintenance of therapeutic traditions and the scarcity of modern medical facilities meant the women were more susceptible to using traditional treatments. Since the women explain *Feblès* in natural not spiritual terms, they did not feel it necessary to resort to professional and spiritual healers. Therefore, they mostly used home remedies. The women believed that anemic symptoms are caused by physiological factors affecting the quality of the blood, therefore, they used remedies that are thought to fortify the blood. In fact, some remedies were chosen because of their red color akin to that of blood. The importance of plant leaves in Haitian culture and their field availability can explain the women's preference for leaves as remedies. The women's description of the etiology of anemic symptoms (poor diet, other illnesses, pregnancy) and the mention of foods as preventive methods points to the empirical nature of nutritional therapy by the respondents. The analysis of the plants used to treat anemic symptoms focused on their nutritional potential in terms of iron availability.

Six plant species (*Amaranthus dubius*, *Citrus aurantium*, *Corchorus olitorius*, *Moringa oleifera* and *Portulaca oleracea*) used as food and medicine were analyzed to determine their hematinic potential in terms of enhancers (ascorbate, citrate) and inhibitors (phytates, tannins, fiber) of iron absorption and iron availability. The analyses were done under laboratory conditions and, therefore, do no match exactly field conditions. Care was taken, though, to follow the respondents' explanations of preparation for the plants analyzed. In the field situation of the respondents, iron contamination is assumed to be minimal since it was observed that the respondents use aluminum, not iron, pots to cook. Contamination iron could, however, come from ashes. The values obtained for the analyses were similar to those obtained from literature values where available.

Amaranthus dubius was found to have the highest iron availability (30%). The other plant species had an iron availability between 7 and 20%. The second null hypothesis was, therefore, rejected because some of the plant species were found to be able to provide a significant amount of dietary iron. *A. dubius* was found to provide 4 mg/100 g of absorbable iron. The contents of ascorbic, citric, phytic and tannic acids and NDF and ADF were measured to evaluate the contribution of these promoters and inhibitors of iron absorption to in-vitro iron dialysability (iron availability).

Ascorbic acid determination could not be done for all test meal samples (plant homogenates), therefore, it is difficult to correlate the levels of this vitamin with iron availability. It was noticed, however, that the plants retained little vitamin C after cooking

(2-4 mg/100 g) except *Moringa oleifera* (77 mg/100 g). But, this conservation of vitamin C did not result in a higher iron availability for *M. oleifera* (7%).

The amounts of citric acid in the plants analyzed were also too low to influence iron-dialysability (Gillooly et al., 1983).

The levels of tannic and phytic acids were both very low in the plant leaves. Anti-nutrients of iron absorption are usually found in cereals, grains, coffee and tea. Therefore, it was not possible to correlate the levels of these anti-nutrients with iron dialysability. ADF and NDF were also measured because they can bind iron and prevent its absorption. No correlation was found between the plants' content of ADF, NDF and iron dialysability.

Overall, the studies of the plants' enhancers and inhibitors of iron absorption could not show their influence on iron availability because the methods of determination were either not accurate enough or the levels of enhancers and inhibitors were too low. It is believed, however, that ascorbic acid is a major player in the iron availability of these plant species. The effect of vitamin C may have been significant if it could have been monitored immediately after extraction.

The variations in iron dialysability between the plant meals was investigated. The inter-species variability was best accounted for by the acidity of the plant species' test meal ($r=0.42$, $p=0.007$). *A. dubius* was consistently more acidic and had a higher mean iron dialysability than the other plant species. The overall acidity of the plant species is due to the presence of small organic acids such as citric and ascorbic acids and sugars. The acidity of the plant species will influence the amount of soluble iron (Fe^{2+}) available for absorption. These small acids can also chelate iron and be absorbed concomitantly (Bezkorovainy, 1980). The iron dialysability of *C. olitorius*, *P. vulgaris* and *P. oleracea* was found to be very variable. The iron-dialysability was correlated to the cooking time for *C. olitorius* and *P. vulgaris* and to storage time for *P. oleracea* ($r=-0.9$, $p<0.05$, $r=-0.9$, $p<0.05$ and r=-0.76, p=0.001 respectively). These two factors appear to account for part of the intra species variability. It is believed that the storage and cooking time will result in the degradation of the enhancers of iron absorption resulting in a lowered iron dialysability. There was no mention found in the literature about the effect of storage and cooking time on iron availability in the plants, in this study, which makes this finding unique. It would be useful to obtain the exact cooking time of home remedies as used by the respondents. An optimal cooking time could be determined and included into recommendations on the use of green leafy vegetables as preventives of nutritional anemias.

This study was innovative as it investigated the medical anthropology of one illness (anemia) and followed through to the laboratory measurements of the efficacy of its treatments from a nutritional point of view. The results of this study confirm the high use of traditional plant based remedies to treat the symptoms of anemia by Haitian women and demonstrated the breadth of their knowledge in traditional medicine and botanical remedies.

The analysis of the plants revealed that some, particularly *A. dubius*, can be good sources of iron whose deficiency causes iron-deficiency anemia. It is also recognized that the plant species effects may come from secondary chemicals that could stimulate erythropoiesis or hemoglobin production that can counter iron-deficiency anemia. Only the nutritional potentials of the plant species was investigated. This study demonstrated that the length of storage, cooking and the overall acidity of a plant species are determinants of its iron availability. In this study, the cooking is shown to influence the intake of a mineral, indirectly perhaps, by possibly destroying the organic acids responsible for the facilitation of its absorption.

Further detailed research would be interesting on the anthropology of anemia in Haiti. From the dietary and ethnobotanical data gathered in this study, a new questionnaire was designed taking into account the contribution of foods and medicines, meal composition, preparation and quantity to hematinic nutrient intake (Appendix V). This questionnaire can be useful for other similar studies.

A more detailed study could lead to an integration of ethnobotany and public health. The use of plant species with hematinic potential could be recommended to prevent and treat mild cases of nutritional anemias. In cases of severe nutritional anemias, the plant remedies could be recommended along with an iron supplement. For example, the intake of A. dubius as a home remedy could provide approximately 4 mg of absorbed iron which is over twice the recommended amount per day for adult women (FAO, 1988). Intervention programmes to control nutritional anemias in Haiti or elsewhere could then integrate the recipients' knowledge, needs and their local resources to implement programs that are culturally appropriate and sustainable.

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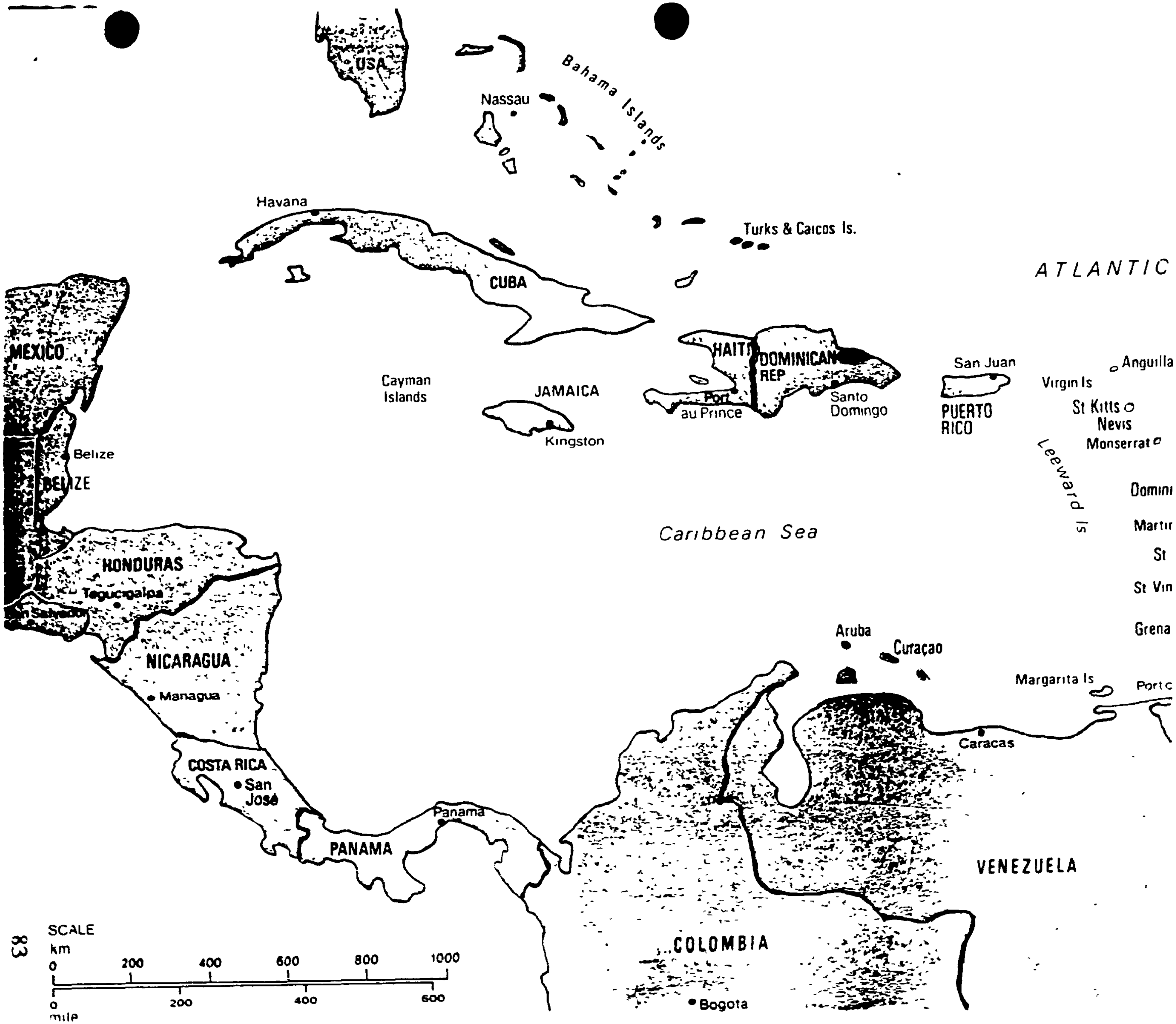
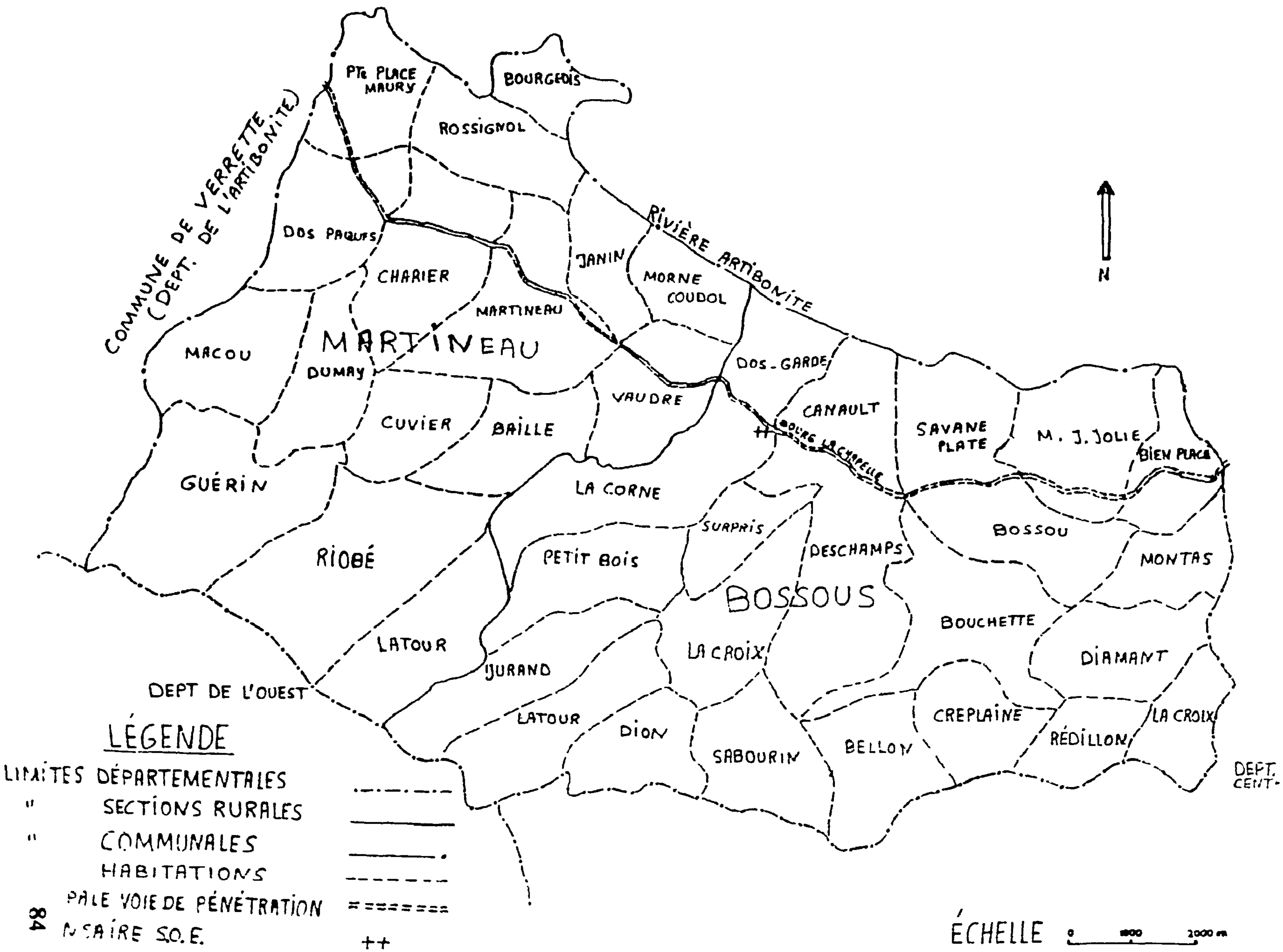
APPENDIX I: POSTER OF HAITI WITHIN CARIBBEAN REGION



APPENDIX II: MAP OF LA CHAPELLE

COMMUNE LA CHAPELLE (DEPT. DE L'ARTIBONITE)



APPENDIX III: DIETARY AND ETHNOBOTANICAL QUESTIONNAIRES

The Creole version used is followed by the English Translation

KESYONE ANKET SOU TRETMAN KEK MALADI AK REMED LAKAY

1.Non anketè a:

- Lokalite:
- Nimero sektè enimerasyon
- Dat:

2.Non moun wap kesyone a:

- Laj li:
- Okipasyon li:
- Fomasyon li:
- Ki bo li rete:
- Konbyen li pese:

KESYONE SOU KI SA NOU MANJE

M ap fe yon ti lis sou ki san nou te manje yè.

- Ki premiè bagay nou te manje nan jounen yè?
- Ki sa ou te manje aprè. Ki dezyèm bagay ou te manje? (Preparasyon)
- Eske ou te pran yon ti bagay nan jounen an, anvan dezyèm manje-a?
- Ki sa ou te manje enko?..Ou te manje deyò?..Ou pa blie anyen?
- Se sa ou abitie manje?

Lè	Manje a	Preparasyon	Mezi

KESYONE POU *FEBLÈS*

Eskc ou konn santi feblès nan kò ou?

Ki sa maladi sa a fè yon moun?

1.. 2...

3.. 4...

Ki sa ki mennen ou nan feblès sa a?

____

Ki premye kote nale lè ou santi nou gen feblès?

nou fè remèd lakay?___ nale nan yon dispansè?___

nale wè doktè fèy?___ nale kay hougan?____

Ki remèd lakay nou konnen nan fanmi-an pou feblès?

____

Kouman nou prepare remèd sa a?

____

Ki jan malad la pran remèd la-ki kantite-konbyen fwa?

____

Ki kote nou jwenn remèd sa a?

nan lakou____ nan raje_____ nan mache___ki pri li_____

kay doktè____ki pri li_____

Ki rezilta li bay?

____

Ki prekosyon pou pran lè wap pran remèd la?

____

Si ou pa jwenn remèd sa a ki lòt ou ka pran?

____

Ki la manjay nou konnen ki bon pou Feblès?

____

DIETARY QUESTIONNAIRE (translated from Creole)

FIRST PAGE:

1. Name of assistant :________________________

-Locality .______________________________

-Enumeration :________________

-Date :___________

2. Name of interviewee :________________________

-Age :____________

-Occupation :______________________________

-Education :_______________________________

-Address :_________________________________

-Weight :__________________________________

SECOND PAGE:

.I am doing a small survey on what you ate yesterday

.What is the first thing you ate yesterday? Preparation & Quantity

.What did you eat next? Preparation, quantity?

.Did you have a snack before your second meal? Preparation, quantity?

.What else did you eat? Did you eat outside your home? Preparation, quantity?

.Have you forgotten anything?

.Is this a typical day?

Time	Food	Preparation	Quantity

ETHNOBOTANICAL QUESTIONNAIRE(translated from Creole)

Questionnaire for "*Feblès*"

.Have you ever felt this illness?

.What do you feel when you have this illness?

____

.Why do you think you get this illness?

____

.What do you do when you get this illness?

Home remedies _____Dispensary ____

Leaf doctor ____ Houngan ____

.What are the home remedies you use or know that are good for that illness?

____

.How do you prepare them? (Seasonality, picking, cooking, associations)

____

.How does a sick person take this remedy? quantity? repeated dosage?

____

.Where do you find the remedies?

garden _____ wild ____ market(price) ____

leaf doctor(price) ____ dispensary(price) _____

.What result do you get from the remedies?

.What precautions do you take when you're taking these remedies? (food restrictions)

.If you don't find these ones what other ones do you use or know (go back through questionnaire)

.What foods do you know are good for "*Feblès*"?

APPENDIX IV: PLANTS USED FOR THE TREATMENT OF ANEMIC SYMPTOMS

Family	Name	Local Creole Name	English name	Uses: M=medicine F=food
Umbelliferae	*Daucus carota* L.	Kawòt	Carrot	MF
Amaranthaceae	*Amaranthus dubius* Mart.	Zepina peyi	Amaranth	MF
	Chamissoa altissima (Jacq.) H B.K.	Lyann panye		M
Anacardiaceae	*Mangifera* sp.	Mango	Mango	MF
Annonaceae	*Annona muricata* L.	Kowosòl	Soursop	MF
	Annona reticulata L.	Kachiman	Bullock's heart	MF
Apocynaceae	*Tabermontana citrifolia* L.	Bwa lèt	Milkwood	M
	Thevetia peruviana (Pers.) K. Schum.	Sezi	Milk tree	M
Asteraceae	*Eupatorium odoratum* L.	Lang chat	Bitter bush	M
	Eupatorium sp.	Kome mari		M
Boraginaceae	*Tournefortia* sp.	Chik		M
Fabaceae	*Senna occidentalis* (L.) Link	Pwa piant	Coffee senna	

Family	Name	Local Creole Name	English name	Uses M=medicine F=food
Capparidaceae	*Capparis flexuosa* L.	Montad	Caper tree	M
Chenopodiaceae	*Beta vulgaris* L.	Betrav	Beet	MF
	Chenopodium ambrosoides L.	Chemen kontra	Wormseed	M
Combretaceae	*Terminalia catappa* L	Zanmand	Sea almond	MF
Commelinaceae	*Rhoeo spathacea* (Sw.) Stearn	Bouldimas	Oyster plant	M
Crucifereae	*Lepidium virginicum* L.	Kreson danwa	Wild pepper grass	M
	Rorippa nasturtium-aquaticum (L.) Hayek	Kreson	Watercress	MF
Cucurbitaceae	*Cucurbita moschata* (Duch) Poir.	Joumou	China crookneck squash	MF
	Momordica charantia L.	Asorosi	Wild balsam apple	M
Euphorbiaceae	*Acalypha alopecuroidea* Jacq.	Degonfle		M
	Croton origanofolius Lam.	Konpany		M

Family	Name	Local Creole Name	English name	Uses: M=medicine F=food
Euphorbiaceae	*Phyllanthus amarus* Sc. & Thonn	Dèyèdo		M
Fabaceae	*Haematoxylum campechianum* L.	Kanpèch	Logwood	M
	Phaseolus sp.	Pwa	Bean	MF
	Cassia emarginata L.	Bwa kabrit		M
Flacourtiaceae	*Samyda pubescens* L.	Bwa sèk		M
Iridaceae	*Eleutherine bulbosa* (Mill.) Urb.	Sandragon		M
Lauraceae	*Persea americana* Mill.	Zaboka	Avocado	MF
Lamiaceae	*Ocimum gratissimum* L.	Atiyayo	French basilique	M
	Ocimum micranthum Willd.	Zèbaclou	Wild basil	M
Liliaceae	*Allium porum* L.	Poro	Leek	MF
	Sanseveria trifasciata Prain	Fey lèt		M

Family	Name	Local Creole Name	English name	Uses M=medicine F=food
Malvaceae	*Gossypum barbadense* L.	Koton	Coton	M
Moringaceae	*Moringa oleifera* Lam.	Doliv	Drumstick	MF
Myrtaceae	*Pimenta racemosa* (Mill.) J.W. Moore	Bwadin	Bay tree	M
Oxalidaceae	*Oxalis corniculata* L	Lapeti	Yellow sorrel	M
Palmaceae	*Cocos nuciferae* L	Kokoye	Coconut	MF
Phytolaccaceae	*Rivina humilis* L.	Laimanyen, Panzou	Cat's blood	M
Poaceae	*Cymbopogon citratus* (DC.) Stapf.	Sitwonèl	Lemon grass	M
	Zea mays L.	Mayi rouj	Red Corn	MF
Polypodiaceae	*Adiantum* sp.	Zeguy		M
Portulacaceae	*Portulaca oleracea* L	Koupye	Purslane	MF
Rubiaceae	*Coffea arabica* L.	Kafe	Coffee	MF

Family	Name	Local Creole Name	English name	Uses M=medicine F=food
Rubiaceae	*Hamelia patens* Jacq	Koray		M
Rutaceae	*Citrus aurantifolia* Swingle	Sitwon	Lemon	MF
	Citrus aurantium L.	Zoranj si	Bitter orange	MF
	Citrus sinensis Osbeck	Zorang	Orange	MF
Sapindaceae	*Melicccus bijugatus* Jacq.	Kenèp	Jamaica bullace plum	MF
Solanaceae	*Lycopersicon esculentum* Mill.	Tomat	Tomato	MF
Tiliaceae	*Corchorus olitorius* L.	Anoure, Lalo	Jew's mallow	MF
	Corchorus siliquosus L	Lalo	Broom-weed	MF
Verbenaceae	*Citharexylum fruticosum* L.	Madan Glòd	Old woman's bitter	M
	Lantana camara L.	Bonbonyen	Ramgoat leaf	M
	Lippia alba (Mill.) N. E BR.	Melis, Feblès		M
	Petitia domingensis Jacq.	Bwa dòti	Bastard stopper	M

Family	Name	Local Creole Name	English name	Uses M=medicine F=food
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl	Vèvènn	Verbena	M
Zingiberaceae	*Zingiber* sp.	jenjam	ginger	MF

APPENDIX V: NEW DIETARY AND ETHNOBOTANICAL QUESTIONNAIRE

QUESTIONNAIRE ON DIET AND HOME REMEDIES

1. Name of assistant:
2. Locality:
3. Enumeration:
4. Date:

5. Name of interviewee:
6. Address:
7. Age:

(1)15-19 (2) 20-29 (3) 30-39 (4) 40-49 (5) >50

8. Occupation:

(1) Cultivator (2) Commerce (3) Housewife (4) Other..................

9. Education:

(1) <1 year schooling (2) 5-10 year schooling (3) >10 years schooling
(4) profession:.................................

10. Height:
11. Weight:
12. Number of children:

(1) 1 (2) 2-4 (3) 4-8 (4) More........................

FOOD FREQUENCY QUESTIONNAIRE

Type	Food		Month		Week			Day			
	Name	Quantity	<1	1-3	1	2-4	5-6	1	2-3	4-5	6+
Starchy	rice										
	millet										
Meats & alt.	beef										
	pork										
Fruits	litchi										
	mango										
Vegetables	carrots										
	pussley										
Other foods	pudding										
	oil										

QUESTIONNAIRE ON REMEDIES FOR FEBLÈS

1. Non of assistant:
2. Locality:
3. Enumeration:
4. Date:

5. Name of interviewee:
6. Address:
7. Age:

(1)15-19 (2) 20-29 (3) 30-39 (4) 40-49 (5) >50

8. Occupation:

(1) Cultivator (2) Commerce (3) Housewife (4) Other..................

9. Education:

(1) <1 year schooling (2) 5-10 year schooling (3) >10 years schooling

(4) profession:..................................

10. Height:
11. Weight:
12. Number of children:

(1) 1 (2) 2-4 (3) 4-8 (4) More........................

13. Have you ever felt this illness? (1) Yes (2) No

14. What do you feel when you have this illness?

(1) ____________________ (2)____________________

(3) ____________________ (4)____________________

15. Why do you think you get this illness?

16. What is the first thing you do when you get this illness?

(1)	Home remedies	a) leaves	b) food	c) other
(2)	Dispensary	a) price	b) what did they give you?	
(3)	Leaf doctor	a) price	b) what did you get?	
(4)	Houngan	a) price	b) what did you get?	
(5)	Other place	a) price	b) what did you take?	

17. What do you feel when you take this remedy? What result do you get?

18. What precautions do you take when you're taking these remedies? Do you eat the same way?

19. What foods do you know are good for this illness?

Leaf remedies	Where found	Price	One treatment			Frequency of treatment		
			quantity	preparation	mode (how)	week	month	year