The role of pre-mastication in the evolution of complementary feeding strategies: a bio-cultural analysis

Honors Thesis

Presented to the College of Agriculture and Life Sciences,

Division of Nutritional Sciences of Cornell University

in Partial Fulfillment of the Requirements for the Research Honors Program

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May 2007

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Acknowledgements:

This research project is guided primarily by Prof. Gretel Pelto, and in part by Prof. Jean-Pierre Habicht. I thank them for helping me to organize the project and also fostering my intellectual growth, for patient instruction and inspiring guidance. As English is my second language, Prof. Gretel Pelto contributed to editing the initial statement of the hypothesis, the Human Subjects application, the progress report and the final thesis. Without her meticulous editing and insightful interpretation, the thesis would not have the richness and depth that I hope has been achieved. I also thank Prof. Kathleen Rasmussen and Deborah Campbell (Head of English for Academic Purposes at Cornell University) for further editing of the thesis and providing valuable suggestions. Francoise Vermeylen provided invaluable instruction and assistance with the statistical analysis. Thanks to Yan Yang and his mother, and my mother for their help in pilot testing of the questionnaire. Special thanks to Jiannan Cui and Tianyu Tan at China Agriculture University, who worked with me closely to carry out the survey, and to all 104 students and their parents at China Agriculture University for participating in the survey.

Abstract

Human milk is a poor source of iron. At birth, the newborn is well endowed with iron stores, which are adequate to meet his/her needs for the first 4-6 months of infancy (WHO March 2001), and iron deficiency is rare. On the other hand, iron deficiency is prevalent among infants between 6- 12 months of age, particularly in developing countries, and iron supplementation during breastfeeding, and thereafter, is recommended, in addition to 6 months exclusive breastfeeding (WHO, 2002). If exclusively breastfed infants are becoming anemic by the time complementary foods are first being introduced, this raises a challenge to our assumptions about the nature of human bio-cultural evolution. Is the anemia of infancy normal or did usual feeding practices prevent it? As iron supplementation was not possible until recently, I hypothesized that exclusive breastfeeding was complemented by premasticated foods during our evolution as a hunting-gathering species. In other words, that iron deficiency in infancy is a recent problem in human society, which was previously prevented by premastication.

The goals of this research were to assess the prevalence of premastication in non-modern societies in order to determine whether (1) it was prevalent enough to support plausibly its role as a behavioral adaptation to prevent iron deficiency and (2) to determine whether the potentially detrimental effects of premasticated food were harmful enough to be selected against. This research involves several lines of investigation: 1) bringing together the evidence that iron deficiency is a common problem, which is now

found in many different regions of the world, 2) a cross-cultural study, using the Human Relations Area Files (HRAF) to obtain ethnographic data on the distribution and time depth of premastication in human societies, 3) a field research study in China, based on interviews conducted by University students, to examine the potential for serious under-reporting of pre-mastication in the ethnographic studies, 4) a review of the iron content of foods that are reported to be premasticated, and 5) a review of the scientific literature on the content of saliva.

In the HRAF analysis, 39 cultures out of 119 cultures (33%) that contain any information on infant feeding describe premastication as an infant feeding practice. Notably none of the ethnographies from China mention premastication. However, the field survey in China, with a sample of 104 elite college students, found that 63% (65 of 104) were fed pre-masticated food when they were infants, and those who received premasticated foods were more likely to be fed complementary foods earlier than those who did not. The survey findings support the notion that premastication tends to be under-reported in ethnographic studies. Although salvia has not been as extensively studied as breastmilk, the review of the biomedical literature suggests that it contains several potential positive substances from the perspective of infant health and fewer negative substances than are commonly assumed.

The results of the various lines of investigation suggest that pre-mastication has been a common practice in human societies, but has been significantly under-reported. The potential dangers of increased infection that pre-mastication poses for infant health have probably been less serious than the disadvantages of not engaging in pre-mastication, which is a means of giving infants iron to prevent deficiency as stores begin to drop during the first semester of life. Therefore I conclude it is probable that pre-mastication was the behavior/cultural solution to the complementary feeding challenge in human societies, that it probably prevented the level of iron deficiency, which is common today in poor societies.

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I. Introduction

Throughout human history sustaining adequate nutrition in late infancy has posed a serious challenge (Pelto et al, 2003). For all humans there comes a time when breastmilk alone is insufficient to sustain growth and meet all nutrient needs, but the child is not yet physically capable of consuming the family diet. The current international recommendation for exclusive breastfeeding is 6 months with iron supplementation during breastfeeding and thereafter (WHO, 2001). This recommendation is based on strong evidence of the protective effects of exclusive breastfeeding to prevent gastrointestinal infection and death. It is also based on evidence to show that exclusive breastfeeding for 6 months has no adverse effect on infant growth. However, human milk is a poor source of iron and zinc, which is why iron supplementation is recommended from an early age. At birth, the newborn is well endowed with iron stores, which are adequate to meet his/her needs for the first 4-6 months of infancy (WHO, 2002). After that period, as a consequence of the marginal supply of iron in usual infant diets, iron deficiency is prevalent among infants between 6-12 months of age. The prevalence of infant iron-deficiency anemia will be discussed in detail below.

The prevalent deficiency in iron and zinc among infants is a paradox from the perspective of Darwinian's evolution theory. Natural selection, operating over millions years, would have selected against deficient individuals. Perhaps our perceptions about what constitutes anemia are inaccurate and the lower levels of iron, which are so common in infants, should be regarded as normal.

If what we regard as deficiency in infants is actually normal, then so-called anemic infants should not respondent positively to supplementation. It has clearly been shown that, except in the rare condition of hemochromatosis, iron is very tightly regulated, and iron deplete individuals do not respondent to increased iron. However, research by Brown (1999) has shown that when anemic infants are given iron supplements, their hemoglobin level increases. This indicates that they were, in fact, iron deficient.

Knowing that iron depletion occurs after 6 months of age, one might decide to recommend a shorter duration of exclusive breastfeeding so that infants could obtain iron from dietary sources. The current international recommendation for exclusive breastfeeding is 6 months (WHO, 2001), which is mainly based on its protective effects against gastrointestinal infection. In as much as the mean intake of human milk provides sufficient energy and protein to meet these requirements during the first 6 months of infancy, a recommendation based on these requirements can be set at 6 months. But what about iron?

The puzzle remains and more questions need to be answered. In agricultural societies (including poor peasant communities today), paps and gruels, made from the stable grain (wheat, rice, maize) are used as complementary foods, sometimes with the addition of animal milk. These are also poor in iron. Before the rise of agriculture, in hunting-gathering societies, there were few, if any, foods that could be easily made into paps or gruels. How did families feed their young children? Premastication of food by the mother must have played an important role in providing infants with food before the infants had sufficient dentition to chew the nuts, meats and plants that made up these hunter-gatherer diets. In as much as breastfeeding was complemented by pre-masticated foods during our evolution, would this behavior have provided enough bioavailable iron to prevent iron deficiency in later infancy?

As there are no longer any groups of people who are living exclusively as hunter-gatherers, it is not possible to determine whether growth faltering and iron deficiency are prevented by pre-mastication in such societies. However, it is possible to use ethnographic data to provide some insights into where and how pre-mastication has been practiced. These sources may also provide some information on the types of foods that were pre-masticated. Studies in contemporary societies in which pre-mastication is still practiced may also provide some indication of the types of foods that are pre-chewed, but as these foods are unlikely to be significant dietary constituents, they will not provide insight into whether pre-mastication actually prevents anemia. Therefore, I used two different approaches in my honors thesis to examining the role of premastication. The first study is a cross-cultural investigation, obtaining data from ethnographic reports in the Human Relations Area Files. (The eHRAF is a cross-cultural database contains over 350,000 pages of information on all aspects of cultural and social life). The purpose of this study was to identify the breadth of premastication as an infant feeding practice. The second study was a survey of recent (but not current) feeding practices in China, as reflected in the behavior of mothers, grandmothers and other caregivers of university students some 18-22 years ago. The survey results were used as an indication of whether pre-mastication was still part of infant feeding before commercially prepared baby foods were widely available in China and whether the ethnographic reports in the HRAF files under-report premastication.

Although pre-mastication may have nutritional benefits, it may also have negative consequences for infant health if it is a source of pathogens. Some diseases are transmitted through human saliva, but many others are not. To understand what the benefits and risks of pre-mastication may have been for infant health, it is also necessary to examine the types of pathogens that are saliva-transmissible and estimate their frequency.

Iron deficiency in infancy: extent of the problem

Iron deficiency and iron-deficiency anemia are the most common and widespread nutritional disorder in the world (DeMaeyer 1985). "While the relative impact on children's health and development of iron deficiency without anemia (IDNA) remains controversial, iron-deficiency anemia during the first 2 years of life is an established cause of impairments in cognitive, mental and psychomotor development (Pollitt 1985)." (Quoted from Anne Skalicky, 2006) These impairments persist even after treatment of the deficiency.

There are no current global figures for iron deficiency, but using anemia as an indirect indicator, it can be estimated that in non-industrialized countries the majority of preschool children and pregnant women are iron deficient and at least 30-40% in industrialized countries are iron deficient (WHO database on iron-deficiency anemia). Estimation of the total prevalence of anemia per se (1990-95), based on hemoglobin levels, is 20.9% for industrialized countries and 30.1% for non-industrialized countries (WHO, 2001).

Iron deficiency and iron-deficiency anemia are prevalent among infants in their first year of age throughout the world. Factorial and balance methods have been used to estimate the iron requirements of infants. Iron requirements are estimated to be 0.5 mg/day from 0-6 months of age and 0.9 mg/day for infants 7-12 months of age (Fomon, 1993). Human milk is a poor source of iron and cannot be improved by maternal iron supplementation (WHO, 2002). Concentration of iron in human milk decreases from 0.4-0.8 mg/l in colostrum to 0.2-0.4 mg/l in mature human milk (Jensen, 1995). It is clear that the estimated iron requirements of infants cannot be met by human milk alone at any stage of infancy (WHO, 2002).

The prevalence of iron-deficiency anemia among infants and children in the United States is now relatively low, but iron deficiency remains the leading cause of anemia (Oski, 1993). Dewey (1998) found that more than 50% of infants in Hondurus and Ghana had a hemoglobin level lower than 110g/L from 2-6 mo of age. For infants with normal birth weight in Honduras and Ghana, the proportion below 110g/L Hemoglobin levels were 66% and 60%, respectively (Table 1.1). The percentage of Bangladeshi, Indonesian and Chinese 0-4 y olds with low hemoglobin levels is 82%, 38%-73%, and 23%, respectively (Table 1.2). The iron status of girls and boys in various ages in 11 European cities (Athens, Bilbao, Budapest, Dublin, Madrid, Naples, Porto, Rostole, Santiago, Umea and Vienna) is summarized in Table 1.3. From this table, one can see that the proportion of children with anemia in industrialized Europe is much lower than in non-industrialized countries. As shown in Table 1.4, in Iceland, girls have a better iron status than boys at 12 months of age, but anemia is still a problem even in this well-off Nordic country.

Table 1. 1. Percent of infants at various ages with low hemoglobin and plasma ferritin concentration in Honduras (Dewey, 1998)

	%With low Hb		%Low ferritin
Honduras (LBW)	<110g/L	<103g/L	<12ug/L
2mo	79	48	0
4mo	62	19	5
6mo	55	25	23
Honduras (NBW)			
6mo	66	29	12
Ghana			
6mo	60	36	14
12mo	70	47	52

Table 1.2.Iron status Bangladeshi, Indonesian, and Chinese 0-4 y olds (Ahmad, 1984, Soemantro, 1979, and Chen, 1984)

	Hb	Cut-off	Percent <cut-off
Ahmad, 1984	Bangladesh	110g/L	82%
Soemantro, 1979	Indonesia	110g/L	38%-73%
Chen, 1984	China	110g/L	23%

Table 1.3. Percentage of girls and boys at various ages below the cut-off point of iron status indicators in 11 European cities (Athens, Bilbao, Budapest, Dublin, Madrid, Naples, Porto, Rostole, Santiago, Umea and Vienna)

	Cut-off value	Total%	Girls%	Boys%
Anaemia	Hb<110g/L	9.7	7	11.5
Low mean corpuscularvolue	<70fl	4.6	2.3	6.7
Low serum ferritin	<10%	15.6	12.8	18
Low transferrin saturation	<10%	15	13.5	16.3
High serum transferrin receptor	>44mg/L	8.4	6.6	10
Iron deficiency		7.2	4.8	9.2
Iron-deficiency aneamia		2.3	1.3	3.1
Total		N=488	N=277	N=261

Table 1.4. Percent of infants at 12 mo of age below various indicators of iron status in Iceland (Thorsdottir, 2003)

	Cut-off	Percent<cut-off
Hb	<105 g/L	9
MCV	<74 fl	29
SF	<12 ng/ml	41
TfR	>8.5 ug/L	25

In summary, there is ample evidence that iron deficiency is a common problem in infancy throughout the world. The fact that it is so common in children by the time they reach 12 months of age, when they have usually been eating complementary foods for many months, is usually explained as a consequence of iron poor complementary foods. Because no one who reviews that data on usual complementary foods would disagree that these foods tend to be low in iron, particularly in developing countries, one can ask whether this fact alone explains the magnitude of the problem. If children have adequate iron stores at birth, they must be depleting these stores before they are able to get sufficient iron from complementary food to meet their iron requirements or one would not see the worldwide patterns of deficiency that have been documented. In fact, the decline in stores begins during the first months of life. As Butte (WHO, 2002) has so forcefully suggested, human milk alone cannot sustain iron status during infancy. The current recommendation to give iron drops in the first semester of life (and thereafter) to breastfed infants who are not receiving iron-fortified formula is intended to sustain iron status. It is conceivable that during the long course of human history, prior to the development of iron supplements, premastication played an essential role in sustaining iron status during infancy.

Perspectives on premastication

Neither the Oxford English Dictionary nor the Merriam-Webster dictionary contains an entry for "premastication" or even for "prechew." However, using "premastication" as a search term in Google Scholar produces a list of 89 references to articles in the scientific literature. A rapid review of the list shows that it is used in two completely different ways – to refer to the human activity of prechewing food or to a step in a mechanical process, as in the following: "*by heating and agitating the bitumen and rubber at above 170° C., preferably 180°-240 C C, or by subjecting the rubber to premastication before admixture...*" (Binder, 1976)

A definition of premastication can be found in the Langmaker dictionary of Neologisms, where it is defined as "the act of chewing food biologically or mechanically, often in order for it to be devoured by another." An indication of the negative view of premastication in modern society is the illustrative sentence in the Langmaker dictionary, which follows after the definition: "He premasticated the food so his girlfriend could eat it. How gross is that?"

Very little scientific research has been done on premastication. Of the 89 entries that are found in Google Scholar, 42 relate to human behavior. Only 4 studies were found in Medline and Pubmed. Most of the studies that were identified through these data base searches are concerned with premastication as a risk factor for infectious disease or its relationship to bacteria counts in food.

In an epidemiological study of risk factors for *H. pylori* among children in Burkina Faso (Taylor, 1991), maternal premastication was positively associated with risk of *H pylori*. A longitudinal study (Imong et al., 1995) examining the bacterial contamination of infant weaning foods found that premastication was significantly related to increased total bacterial and fecal coliforms count of weaning foods. However, the authors also mentioned a personal communication with Longton-Hewer, who suggested premastication added maternal IgA to the food. Thus, the authors noted IgA might offset the bacterial load transmitted. Ross (1984) suggested that the organisms from premastication would generally be of low pathogenicity.

Apart from the information on premastication in the HRAF ethnographic materials (which are described in detail in a later chapter), there are a few anthropological studies that mention premastication. In a study of the cultural determinants of population stability among a “semi-agricultural” tribe, the Havasupai of Arizona, Alvarado (1970) noted that the Havasupai introduce pre-chewed food to their babies by four months of age. Laukau (1994) noted that premastication of food was the predominant method used to prepare a baby’s food in Vava'u, Tonga Island. In a theoretical discussion on population survival, Holland (1989) suggested that premastication is a way to ensure infant survival under the most severe circumstances when milk or other digestible food is not available. He also offered the suggestion that premastication may increase the digestibility of many foods, especially starches, due to the enzymatic action of amylase (ptyalin) in the parents’ saliva. This is especially significant in light of the fact that the ability to digest complex carbohydrates develops slowly in children (Lebenthal and Heitlinger 1982). Finally, in a theoretical discussion of kissing and premastication, Wickler (241) suggested that the pleasure of mouth contact with infants is the intrinsic incentive for premastication and goes so far as to suggest that the practice of kissing derives from premastication.

In summary, there has been so little research on premastication that it is difficult to obtain much guidance from a literature review focused specifically on the subject.

II. A Cross Culture Study of Premastication

In view of the fact that it is not possible to determine whether growth faltering and iron deficiency is prevented by pre-mastication because there are no longer any groups of people who are living exclusively as hunter-gatherers, one alternative is to use ethnographic data to provide some insights into where and how pre-mastication has been practiced.

Methods

Cross Culture Studies and the Human Relations Area Files

Edward B. Tylor published the first cross-cultural study in 1889, in which he attempted to relate marital residence and the reckoning of kinship to other customs. After this initial effort, there was little cross-cultural research for the next 40 years. It took on status as a significant anthropological method beginning in the 1930s and 1940s, at the Institute of Human Relations at Yale, where George Peter Murdock invested a major effort to develop the tools for cross-cultural analysis. The primary purpose of his efforts was to establish a database of ethnographic information, which was accomplished by the development of the " Human Relations Area Files."

> The HRAF Collection of Ethnography is a unique source of information on the cultures of the world, and currently contains over 800,000 pages of indexed

information on over 370 different cultural, ethnic, religious, and national groups around the world. …The HRAF Collection of Ethnography contains mostly primary source materials—mainly published books and articles, but it also includes some unpublished manuscripts and dissertations. The files contain studies on cultures or societies in all of the regions in the world. (http://www.yale.edu/hraf/basiccc.htm , Retrieved on 2007-3-15.).

In addition to anthropology, sociologists, psychologists and other social scientists have conducted cross-cultural research using the HRAF files. To date there have been few studies to examine nutritional issues with this method. Nerlove (1974) studied the relationship between women's workload and infant feeding practices, and found that infants tend to begin receiving supplementary foods earlier in cultures in which women are more active in subsistence activities. (Nerlove, 1974). Sellen (2001) applied the cross-cultural method to examine the age for introduction of complementary foods and termination of breastfeeding in order to compare cultural patterns with current feeding recommendations. He did not use the HRAF files but created a new database composed of ethnographic reports for which data on infant feeding was sufficiently complete to permit coding of the variables he was concerned about.

Online Human Relations Area Files (eHRAF) and OCM codes

The initial HRAF collections of ethnography were distributed on microfiche. In 1993, microfiche production ended and material since then are available in electronic form only. Cultures in the microfiche and electronic versions are not covered in the same way; the electronic versions include more recent source materials and not all the older sources are retained.

eHRAF consists of selected cultures from around the world and contains information on all aspects of cultural and social life. eHRAF is a compilation of mostly descriptive documents (books, manuscripts, journal articles, dissertations) written by anthropologists, sociologists, other social scientists, travelers, and missionaries. Topics range from how the people of the culture live their daily lives, solve their conflicts, and raise their children; their religious beliefs and practices, history, etc.

Using HRAF for data collection is a relatively straightforward process. Every page in each document is indexed and assigned any number of appropriate subject category codes according to the classification scheme in the Outline of Cultural Materials (OCM) (Murdock et al. 1987). The subject codes are referred to as OCM numbers. The major advantage of the HRAF Collection of Ethnography is that it provides the investigator with the original full texts rather than with pre-coded categories (Ember, 1996). This means that an investigator can code the data according to his or her research interests.

Data Collection

We reviewed all of the data and identified every instance that mentioned or described pre-mastication that appeared in ethnographies with the OCM number "853" (infant feeding) and "862" (weaning). We also searched using different combinations of words about infant feeding practices ("Babies" and "chew"; "Babies" and "chewed"; "Babies" and "chews"; "Baby" and "chew"; "Baby" and "chews"; "Baby" and "chewed"; "Baby" and "mastication"; "Baby" and "masticates"; "Baby" and "masticate"; "Baby" and "masticated"; "Baby" and "mastication"; "Babies" and "masticates"; "Babies" and "masticate"; "Babies" and "masticated"; "Infant" and "chew"; "Infant" and "chews"; "Infant" and "chewed"; "Infants" and "chew"; "Infants" and "chewed"; "Infant" and "chews"; "Mother" and "chew"; "Mother" and "chewed"; "Mother" and "chews"; "Pre-chew"; "Pre-chews"; "Pre-chewed"; "Pre-masticated"; "Pre-masticate"; "Pre-masticates"; "Premasticates"; "Premasticated"; "Premasticates"; "Prechew"; "Prechews"; "Pre-chewed"; "Chew for"; "Chewed for"; "Chews for"). The relevant sections from documents that mentioned or contained descriptions of pre-mastication were copied and put into a database. In this database, all paragraphs under OCM code of 853 (infant feeding) and 862(weaning) that included premastication were included. In addition, information on family structure (nuclear or extended) was also recorded.

853, INFANT FEEDING

This code is described as containing information on: "Conceptions about lactation, milk, and colostrum; beliefs about sucking; initiation of suckling in newborn infants; stimulation of the flow of milk; routine of nursing (e.g., posture, intervals);

feeding problems; treatment and behavior of the nursing mother (e.g., diet, sexual abstention); communal nursing, fosterage; adjustments to death of mother; supplementary feeding (e.g., age at beginning, appropriate foods and their preparation); method of feeding (e.g., bottle, cup, spoon); etc."

862, WEANING AND FOOD TRAINING

This coded is used to include information on: "Adult beliefs, standards, and aims concerning weaning and appropriate eating habits for children; special reasons for weaning (e.g., insufficient lactation, illness or pregnancy of mother); normal age at weaning (e.g., separation from mother, ridicule, application of bitter substances to nipple); reactions of children to weaning; imposition of rules about eating; teaching of table manners; resistance of children to food training; etc."

594, NUCLEAR FAMILY

This code is used when: "Degree of emphasis on the social group consisting of a married couple and their children; exclusiveness with which this group is associated with economic, sexual, reproductive, child-rearing, and educational functions; other family functions (e.g., religious, recreational); domicile (e.g., single dwelling, apartment); family authority (e.g., matripotestal, patripotestal); family possessions; etc."

596, EXTENDED FAMILIES

This code is used to cover "Incidence of extended families; prevailing type or types (e.g., matrilocal, avunculocal, patrilocal, and bilocal extended families, fraternal joint families); size and composition; domicile (e.g., compound, single large dwelling); locus of authority; rule of succession (e.g., matrilineal, patrilineal, succession by a younger sibling); collective or individual ownership of dwelling, land, food stores, and household equipment; economic cooperation; routine activities; collective responsibility; cohesive and fissive tendencies; etc."

A coding system that establishes the variables of interest (eg. Who does the premastication; age at which pre-mastication is initiated, etc) was designed and all of the entries in the database were coded. Information about feeding and weaning are collected from paragraphs with "853" and "862" codes and family structure is determined by paragraphs with "594" and "596" codes. If a document contained no paragraphs under "594" and "596" the description of "family unit" in the culture summary was used. Minitab 14 for Windows statistical software package (Minitab Inc. State college, PA) was used to carry out all statistical analysis. Most of the statistical analyses are basic count and percentage of answer distributions and a few quartiles division.

Results

<u>Occurrence of premastication:</u>

There were a total of 155 cultures in the HRAF online database. One hundred nineteen (119) of these cultures had information on infant feeding. In 38 cultures, the discussion of feeding practices described pre-mastication. In other words, 76.8% of the cultures on HRAF online database had information on infant feeding, and 32.8% of those reported premastication as an infant feeding practice.

Descriptions of premastication in 32 out of 39 cultures were found in paragraphs with the OCM code "853"(infant feeding). Descriptions of premastication also occurred under other OCM codes, as shown in Table 2.1.

Table 2.1. Distribution of OCM codes for paragraphs containing premastication description

OCM codes	853	Others*
# of documents	42	11
# of cultures	32	7

*Others:

Document	OCM code(s) that label the paragraph
South America / Warao	856, 855, 861
Asia / Chukchee	105
North America / Blackfoot	867, 264, 888
North America / Hopi	142, 291, 302
North America / Seminole	843, 862, 761, 164, 744
Africa/San-1	842 146 862
Africa/San-4	847, 161, 855, 842, 862
Africa/San-5	461 462 512
Middle east/palestinians	825
South America / Tupinamba-3	105
North America / Copper Inuit-1	855

The 39 cultures covered all eight regions of the world, as defined by HRAF (Table 2.1 column 1). Most of them came from Asia, America and Africa regions. Middle East region and European region had only 1 culture respectively, and 2 cultures were from Middle America and the Caribbean region.

Table 2.2. Summary of cultures and regions for ethnographic data

Region	Culture	# of documents
Africa	Banyoro	1
	Igbo	2
	Maasai	2
	San	6
North America	Blackfoot	1
	Copper Inuit	2
	Hopi	2
	Iroquois	1
	Seminole	1
	Tlingit	1
	Yokuts	1
South America	Aymara	1
	Kogi	1
	Mataco	1
	Mundurucu	1
	Tupinamba	4
	Yanoama	2
	Warao	1
	Tukano	1
Asia	Alorese	2
	Badaga	1
	Chukchee	1
	Eastern Toraja	1
	Garo	1
	Ifugao	1
	Iban	1
	Kapauku	1
	Okinawans	1
	Taiwan Hokkien	1
Europe	Sammi	1
Middle east	Palestinians	1
Middle America and	Island caribbean	1

the Caribbean	Tzeltal	1
Oceania	Chuuk	3
	Manus	1
	Lau Fijians	1
	Tikopia	1
	Trobriands	1

Purpose and attitude

The purpose of premastication, as described by the ethnographers varies. They include providing nutrition, disease prevention, disease healing, and cultural and spiritual beliefs. In 31 out of 39 cultures, premastication is solely for providing foods for babies. In 4 cultures, babies and young children were given certain kind of premasticated food for a beneficial outcome that originated in religious and cultural beliefs. In two cultures, people premasticated medicine (herbs) for infants to cure disease, and in one culture, to prevent disease. Sometimes there is more than one purpose; for example, for the Garo, the purpose for premastication is both for nutrition and for a beneficial outcome related to a cultural belief (Table 2.3).

Table 2.3. Summary of the purpose for premastication

No. of Cultures	No. of Documents	Purpose
31	44	Nutrition
4	4	Religious or cultural belief
2	2	Disease healing
1	1	Disease prevention
1	1	Duel purpose (nutrition + religious or cultural belief)

The examples in which premastication are not for nutritional purpose are listed below:

Disease healing:

Example 1: Culture: Banyoro (Africa)

"The nurse usually chewed the herbs to be administered or moistened them with her own saliva and spat them from her mouth into that of the infant." (Roscoe, 1923)

Example 2: Culture: Maasai (Africa)

"…The plant is chewed as a loosening agent for coughs. Moreover, the mother gives the baby afflicted with feverish bronchial catarrh the extract obtained by her from chewing a small piece of the pungent root, mixed with milk, to drink…" (Merker, 1910)

Disease prevention:

Example: Culture: Tzeltal (Middle America and the Caribbean)

"…Alternatively the mother chews some chili herself and then puts a small piece of masticated chili in the baby's mouth. If this were not done, then the child would grow up having frequent stomach aches…" (Stross, 1970)

Beneficial outcomes that are rooted in cultural or religious belief:

Example 1: Culture: Igbo (Africa)

"…any kinsman who is known as an orator will chew a few grains of alligator pepper, spit the mixture on his right forefinger, and insert it into the infant's mouth beneath the tongue, rubbing it on the genioglossi and exhorting the child to become an orator…" (Henderson, 1966)

Example 2: Culture: Badaga (Asia)

"… mendicants were given consecrated pieces of banana mixed with crude sugar. These they chewed a little, then spat into the hands or mouths of devotees, who ate this or fed it to their children because it was believed to cure all diseases…" (Hockings, 1982)

Example 3. Culture: Blackfood (North America)

"…This would be some special old lady—one with a lot of power to doctor or put up Sun Dances. She would chew my meat and then give it to me to swallow. This was a blessing for me, just like getting part of her life. Whenever we had any spare change we were taught to give it to old people like that." (Hungry Wolf, 1980)

Example 4: Culture: Palestinians (Middle east)

"The Mohammedans cherish the idea that the love and devotion of Christ to his mother was all due to the date-fruits…Children were brought to the Prophet and he prayed for blessings on them and he chewed dates, and then rubbed them on the roof of their mouths." (Granqvist, 1947)

Duel purpose:

Culture: Garo (Asia)

"The mother premasticates the first solid food for the child…(foods and description of feeding)… Mothers even feel that they must soon start to give the babies a taste of chili peppers, or else they will never be able to eat them properly…" (Burling, 1963)

Attitudes about premastication are rarely reported in the ethnographic data. We believe that people hold positive or at least neutral attitudes to premastication if it is integrated in their infant feeding culture. In the cases where premastication is performed for spiritual or cultural beliefs, the attitudes are generally positive. There are only three negative comments. In the first the ethnographer, not the people themselves, is the source of the negative comment. Among the San, the comments reflect concern that even premastication cannot overcome the challenge of feeding two infants at the same time.

Example 1. Culture: Banyoro (Africa)

"…In this way the child often contracted other diseases, especially venereal diseases, from which so many of these women suffer…" (Roscoe, 1923)

Example 2. Culture: San (Africa)

"…The !Kung have no milk from cows or goats and no cereals to feed an infant, and they say that even if they supplement the feeding by chewing their tough meat, harsh roots, and nuts and feed the infant premasticated food from their own mouths (we have seen them do this), they cannot successfully feed two infants this way. Neither thrives, both may die…" (Marshall, 1976)

Example 3. Culture: San (Africa)

"…An infant cannot thrive on their harsh foods, they say, even though they chew the food and put it into the infants' mouths, and the mother cannot support two entirely with her milk…" (Marshall, 1965)

Breastfeeding and complementary feeding

In most of the cultures, mother start breastfeeding as soon as breastmilk comes in and breastfeeding remains the predominant method of infant feeding for at least the first two or three months.

Breastfeeding, but not exclusive breastfeeding, is carried out for a long time. The median age of weaning is 2.5 y with a minimum of 10mo and maximum of 6 y. Non-breastmilk liquids are reported to be introduced at an early age. Some examples of frequently given non-breastmilk liquids are sugar cane juice, cow and goat's milk, coconut milk, water, herb water, butter water, honey, and etc. (Table 2.4)

Table 2.4. Non-breastmilk liquids and the number of cultures introducing them to infants

Non-breastmilk liquid	Number of cultures
Water	11
Cow milk	8
Sugar cane juice	8
Coconut milk	3
Juice	2
Tea	2
Honey	2
Condensed milk	1
Panela water	1
Butter water	1
Herb water	1
Malanga soup	1
Platano broth	1
Goat's milk	1
Meat broth	1
Quail soup	1
Platano broth	1
Unfermented maize beer	1

In some of the descriptions the ethnographers make a distinction between foods that are given to infants by pre-masticating them and foods that are given without premastication. However, it is often not possible to make ascertain whether a particular solid food was premasticated or not. Thus, in table 2.5, solid foods are divided into two group: 1) definitely premasticated and 2) non-identified solid foods.

Table 2.5. Summary of definitely premasticated foods and non-identified solid foods

Definitely premasticated foods		Non-identified solid foods	
Food	# of cultures	Food	# of cultures
Meat	11	Meat	2
Fish	4	Fish	1
Taro	3	Taro	2
Corn/maize	3	Corn/maize	4
Yam	1	Yam	2
Banana	6	Banana	5
Rice	4	Rice	3
Sweet potatoes	3	Sweet potatoes	1
Papaya	1	Papaya	1
Pepper/chili	2	Pepper/chili	1
Breadfruit	1	Breadfruit	2
Bread	1	Bread	1
Peach	1	Peach	1
Coconut flesh	1	Coconut flesh	1
Tapioca	1	Potato	1
Bean	1	Cassava	1
Cake	1	Cornstarch	1
Seal or caribou meat	1	Boiled pork fat	1
Dried fish	2	Vegetable gruel	1
Pungent root	1	Millet	1
Nuts	2	Manioc	3
Herb	1	Rye meal	1
Veldkost	1	Semolina	1
Root	1	Mango	2
Berry	1	Orange	1
Reindeer tongue	1	Tortillas	1
Date	1	Acorn gruel	1
Watermelon	1	Papaw	1
Piki	1	Loboe pap (lagenaria vulgaris)	1
Grain	1	Ocas	1
Fruit	1	Acu (brown barley meal)	1
Flour	1	Curcuma	1
Ocumo	1	Coconut palm leaf shoot	1
Ubi	1	Cigarette	1
Linu gaw	1	Outer skin of betel nut	1
Pisang	1		
Cantaloupe	1		

Meat is reported to be premasticated for babies in almost one third of the cultures (Table 2.5). Other premasticated foods include plant roots, grain, various fruit and vegetable gruel, fish, nuts and etc. The most common non-premasticated solid foods among cultures are banana, taro, maize and meat. The median age of introducing premasticated foods and non-identified solid foods is 6mo and 5.5 mo respectively. Premasticated foods were introduced as early as 1 mo and at 18 mo the latest (Table 2.6).

Table 2.6. Ages of first introduction of premasticated foods and non-identified solids food

(a). Ages of first introduction of premasticated foods

Introduction of premasticated foods (mo)	# of reported cultures	Statistics	
1	2	Minimum	1 mo
3	2	1st quartile	3 mo
4	1	Median	6 mo
6	3	3rd quartile	12 mo
9	1	Maximum	18 mo
12	3	Mean	7.93mo
18	1	Number	14

(b). Ages of first introduction of non-identified solid foods

Introduction of non-identified solid foods (mo)	# of reported cultures	Statistics	
1	2	Minimum	1 mo
2	1	1st quartile	2.75 mo
3	2	Median	5.5 mo
4	1	3rd quartile	8.25mo
6	2	Maximum	54 mo
5	1	Mean	8.79mo
8	2	Number	14
9	1		
13	1		
54	1		

In Table 2.7, common premasticated foods are summarized into groups as follows: Carbohydrates, vegetables, animal foods and nuts.

Table 2.7. Summary of premasticated foods reported in HRAF in groups

Carbohydrates:	Animal Foods
Beans Cake Boiled corn Young yams Yuca Roasted half ripe plantains Banana mixed with crude sugar Sweet potatoes Potato Papaya Cassava Rice Sugar cane juice	Meat Meat broth Seal or caribou meat Fish Dried Fish Vegetables: Alligator pepper Pungent root Breadfruit Nuts: Nuts Mongongo nuts

In 25 out of 30 cultures, the mother is reported to be responsible premasticating food for her baby. In a few cultures, fathers, grandparents and siblings also premasticate food for the child (Table 2.8).

Table 2.8. People who premasticated food for babies or feed babies

People who premasticated food	Number of cultures (total =30 cultures)
Mother	25
Father	1
Grandparents	3
Siblings	3
Others	8

People who feed babies	Number of cultures (total= 29 cultures)
Mother	29
Father	2
Grandparents	4
Siblings	4
Others	9

Twenty-five cultures in our sample are composed of extended families and 11 are composed of nuclear families, the remaining three cultures either lack of information or have both extended and nuclear families. Although more premastication happens in extended families (25 societies) than nuclear families (11 societies), we cannot conclude that extended family are more likely to premasticate food for babies because extended families are so much more common in the world's cultures in general.

Discussion

Cross-cultural methods have many problems that can affect the ability of researchers to test hypotheses definitively. For example Harris (1968) pointed out that not all ethnographies are of equal quality and selecting a sample to analyze based on quality may introduce other biases. On the other hand, Naroll (referenced in Levinson and Ember, 1996) suggested that researchers should rate ethnographies for certain qualities, such as the author's command of the native language and time spent in the field. The effects of putting this suggestion into practice were empirically tested by Levinson and Ember (1996), who found that it had very little effect on the results of testing numerous anthropological hypotheses.

A primary issue for the use of the HRAF files to address my thesis hypothesis is the lack of information in the ethnographies. Unlike survey results, ethnographic data reports information on infant feeding with different degrees of detail. For each variable we examined, the number of cultures with information is listed in Table 2.9. For example, data from at least one culture is missing for all variables except for the purpose of premastication. Another extreme example is that in only one culture is there information on when children no longer receive premasticated food. In spite of the "missing data" problem, I decided to use the HRAF files because they are widely accepted as a representative sample of the cultures of the world.

Table 2.9. The number of cultures with information for each variable

Timing variables

Variable examined	# of cultures with information
Start of breastfeeding	11
Stop of breastfeeding	21
Start of non-breastmilk liquid	10 (4 cases at early age but no specific age)
Start of non-premasticated solid foods	13
Start of premasticated food	13
Stop of premasticated food	1

Food variables

Variable examined	# of cultures with information
Premasticated food	35
Non pre-masticated solids	21
Non breastmilk liquid	23
Preparation of food	14

Other variables

Variable examined	# of cultures with information
Purpose of premastication	39
Who premasticated for babies?	30
Who fed babies?	29

Another serious issue for the use of the HRAF files to address my thesis hypothesis is underreporting of premastication: 76.8% of the cultures on HRAF online database have information on infant feeding, and 32.8% of those that have information report premastication as an infant feeding practice. Is this proportion actually true? In general the level of detail in descriptions of how babies are fed is poor (Pelto et al, 2003). Given the lack of attention to specifics of infant feeding practice, we hypothesize that premastication is underreported in the ethnographic literature.

To test the hypothesis that premasticated is under-reported, we turned to a specific cultural group – the Han majority in Mainland China, which is represented by a number of studies in different regions of China in the HRAF database. There are no Han groups in eHRAF samples so we had to use the microfiche database

There are 8 groups of Han majority in Mainland China (discussed in 124 documents) in the HRAF: North China, Northwest China, Central China, East China, Southwest China, South China, and Inner Mongolia. Eleven out of the 124 documents have paragraphs with OCM subject code of "853-infant feeding," which includes 7 of the 8 cultures. As shown in Table 2.10 not a single description of premastication is found in these cultures.

Table 2.10. Han majority cultures in Mainland China in eHRAF

	Cultures	# of documents	# of documents under OCM "853"	# of documents have information on premastication
AF1	China	80	4	0
AF12	North China	8	1	0
AF13	Northwest China	3	1	0
AF14	Central China	2	1	0
AF15	East China	3	0	0
AF16	Southwest China	7	1	0
AF17	South China	8	1	0
AH6	Inner Mongolia	13	2	0

If we believe that premastication is not under-reported in the ethnographic reports, we would have to conclude that there is no premastication in Mainland China. However, I know from personal observation that premastication is practiced. As a Chinese, I have seen people premasticate food for babies in my hometown, and I also know that I received premasticated food from my mother (who is a cardiologist) and my grandmother. To provide some indication of the degree of underreporting, we decided to undertake a study of the infant feeding practices that were experienced by Chinese college students. The rationale for the study sample and the results are presented in the next chapter.

If one assumes that premastication is significantly under-reported in ethnographic reports, the results of this study, nonetheless, provide clear evidence about the nature and importance of premastication as an infant feeding strategy:

1. It occurs in all parts of the world, particularly in the regions where traditional subsistence systems survived into modern times.
2. It is reported from different types of food systems, from hunter-gatherers to peasant agriculturists.
3. It is reported in different types of family social organizational systems (using family type as an indication of organization)
4. The foods that are premasticated are often good sources of iron (see Section V).
5. There is variation in the age of introduction of premasticated foods, with 43% of societies reporting it prior to 6 months.
6. The primary, stated motivation for premastication is to provide foods to babies before they are able to chew.
7. The mother, who is also breastfeeding her infant, is the primary source of the premasticated foods.

In summary, the cross-cultural survey cannot, by the nature of its limitations, provide definitive evidence to address the basic hypothesis that premastication prevented anemia in infancy. It can, and has, provided evidence that it was commonly practiced in different types of societies and environments. Its occurrence in such widely different cultural traditions and environments indicates that it was not a unique invention of a particular cultural group, which then spread to neighboring societies. The results of the study encourage us to explore further.

III. A field research study in China

The primary purpose of the survey in China was to provide information that would be helpful for assessing the extent of under-reporting of premastication in the ethnographic literature. Because I was aware of premastication as a cultural practice that survives in contemporary China, I felt that it would be instructive to compare on infant feeding in China, the reports in the HRAF files on Chinese societies, and reported practices in a survey that was specifically designed to obtain information on premastication.

College students were chosen for several reasons: (1) as a recent former student in an elite university in Beijing, I felt it would be possible to invite my fellow students to participate in an informal study, and that the data could be collected in a timely fashion; (2) the students in my former university come from all parts of China (not just Beijing) so that one could get a broad picture; (3) I expected that many of the students came from well-educated families whose feeding practices 20 years ago would represent acceptable "modern" practices, and who would be least likely to practice premastication. Clearly a volunteer sample of college students is not a random sample, but we reasoned that if we found that it was reported at all by this group, it is probably practiced by other social groups in China. Because premastication is generally discouraged by physicians and nurses, we felt it was necessary to embed questions about this practice within a larger set of questions about infant feeding. As a consequence, we obtained data not only about premastication, but also about other aspects of infant feeding. The results on premastication are presented in Chapter III and the results on other aspects of the survey are in the Appendix.

The following paragraphs provide an overview of the types of recent studies on infant feeding in China and the context of infant feeding practices.

Rapid economic development in China in the past two decades has brought about a great improvement in living conditions of the population. The increasing availability of pre-prepared, manufactured foods has caused major dietary changes throughout China. The use of breastmilk substitutes has been a subject of concern and scrutiny from the lay public as well as the medical and nutritional community and has led to policies to limit the advertising of formula (SinoCast China Business Daily News, 2004). However, much less attention has been given to describing and understanding the changes that are occurring with respect to complementary feeding.

In a recent paper Wang, (2005) examined feeding practices in 105 counties of rural China. The results showed that breastfeeding was very common, but exclusive breastfeeding was quite low. The likelihood of breastfeeding was higher in rural areas than in urban communities. The percentage of breastfed rural babies was 98.2% and the percentage in each of 28 provinces was above 95%, while the same statistics in urban mothers was only 73%. In contrast to the data on initiation of breastfeeding, in a sample of children older than 4 months, the percentage of exclusive breastfeeding in the first 4 months after birth was much lower in rural areas, at 24%, while in their urban counterparts it was 52%. Among urban and rural children 6-24 month old, the proportion of caregivers who began complementary feeding at the recommended time was only 36%. In the rest, it occurs either earlier or later. Among children older than 6 months, about 75% had been given meat from the beginning of receiving complementary foods, and 50% had been given meat weekly.

Another cross-sectional survey of feeding practices in 6-12 month old infants was conducted in urban areas of Beijing to identify biological and social constraints on optimal feeding practices in the first year of life (Li et al, 2003). The investigators reported the median age for solid/semisolid food introduction was 4 months, ranging from 2 to 8 months of age. In 76% of the infants, the introduction of semisolid food occurred between 4 and 6 months of age. Semisolid food were introduced on a daily basis at < 4 months in 19.3% of the infants. The investigators concluded that the majority of infants in urban Beijing were fed in accordance with the national and international recommendations. However, this conclusion ignored the WHO recommendation for exclusive breastfeeding to 6 months because 55.8% of the sample was receiving foods by 3 months of age. Rice cereal, rice, porridge and dumplings were the staple solid/semisolid foods most frequently mentioned. Other frequently introduced solid/semisolid foods were egg, meat, vegetables, and fruit. Maternal education level, employment status and antenatal nonexclusive breast-feeding plans were positively correlated with early introduction of semisolid and solid foods.

He et al (2001) studied the growth and feeding practices of infants 4 to 8 month old in Southern China. In the city, the mean Z-scores of weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ) of infants were above the National Center for Health Statistics (NCHS) reference median at 4 months. By 8 months, WAZ and WHZ, but not HAZ scores, were below the NCHS reference median. Rural infants were lighter and shorter than the NCHS reference at 4 months. Prevalence of breastfeeding was 65% at 4 months and 44% at 8 months for urban infants, but 99% of the rural infants were being breastfed at 4 months. Rural infants were fed less commercial baby cereals, high-protein foods, and fruits, but more homemade cereals than urban infants. The attained size of the 4 months old urban infants was positively associated with the amount of breast feeding, and intakes of fruits, and vitamin supplements, but negatively associated with formula, rice porridge, and glucose drinks. Body weight of the 4-month rural infants was negatively associated with the use of formula and glucose drinks. By 8 months, the growth of the urban infants was associated positively with the reported intake of fruits, high-protein foods, and vitamins supplements, but negatively with home made cereals and Chinese herbs. The association with herbs may reflect the fact that herbs are used for healing illness and infants who received more herbal preparations may have been sick.

Adequate quality of the complementary food diet is crucial for normal growth of infants. Studies on current feeding practices give very limited information on specific foods, the ages at which these are started, and the overall quality/diversity of the complementary diet. For example, protein sources other than egg and meat are rarely reported in studies of complementary feeding in China, but must certainly be used. In addition to what is fed, the behaviors that are associated with complementary feeding (issues of where, when and how babies are fed) are rarely described. For example, stir-frying carrots with oil can greatly increase the absorption of fat-soluble Vitamin A compared with boiling them, and iron availability significant increases if meat is consumed with other Vitamin C rich food, but almost no study mentions the preparation methods of complementary food or the overall dietary diversity of complementary foods. Most importantly with respect to our specific interest in premastication, this practice is not mentioned in any of the studies I reviewed.

From the studies I reviewed it is apparent that there is a difference in infant feeding practices between rural and urban areas, while no large differences are found from North China to South China. These differences give us an opportunity to study the biological and social constraints on optimal feeding practices. Maternal education level, employment, and antenatal nonexclusive breast-feeding plans have been shown to correlate with inappropriate feeding practices (Li, 2003). However, the role of caretakers and the effect of family structure on infant feeding are often ignored. Family structure in rural China is often complex, with multiple generations and lateral relatives living under the same roof, while families in the city are usually in small family units of two or three. Also, the feeding practices of the previous generation influence and interact with current conditions. When grandparents play an active role in young childcare, as is often the case in China, generational influences are likely to be particularly strong. Thus, it is important to understand the "evolution" of practices across generations.

In general, there is little available information describing Chinese complementary feeding practices during the 1980s, which is the period when the respondents in my study were being fed. This was undoubtedly a period of rapid transition in feeding practices because of the powerful economic development and marketing changes that were taking place then in China. As infant care behaviors (including feeding behaviors) are embedded in cultural/historical as well as social contexts, it is important to understand these contexts. Knowing that rural infants are fed less commercial baby cereals, high-protein foods, and fruits, but more homemade cereals than urban infants (He, 2001), it is important to explore the social and historical reasons that underlie these differences further. A thorough description of commercial infant food usage and availability is crucial for understanding the "evolution" of infant feeding practice in the past two decades.

In the published literature on infant feeding in China there is no mention of premastication. There is also no discussion about many other aspects of feeding behavior, such as food preparation and who feeds infants. From this literature we cannot conclude that premastication does not occur. In fact, the information that many infants are receiving meat from the age of 3 months suggests that it probably does occur, unless families are using other means to prepare the meat for their young infants. The likelihood that all of the meat being reported in the surveys is from commercially prepared, pureed products is low. However, this cannot be definitely concluded from the available information. The results of recent studies in which practices are linked to maternal education, place of residence, work status and feeding intentions have implications for the analysis of my survey data. Although it is not the primary purpose of the study, I will examine some of the social dimensions that affect feeding practices, which will be included in the appendix of the thesis.

Methods

Subjects and sampling

At the present time, there are over 1040 public institutions of higher learning in China, with an additional 323 scientific research institutes offering postgraduate programs. In addition, there are approximately 1282 private colleges and universities in operation, but only 43 of these institutions are currently authorized to award diplomas. China Agricultural University (CAU) is a leading agricultural education and research institution in Beijing, China, offering a wide range of subjects in agriculture, biology, engineering, veterinary medicine, economics, management, humanities and social science, etc. CAU is a national key university and directly subordinate to the Ministry of Education, P. R. China. Now, CAU is one of first national key universities to qualify for the State 211 Project[1]. In 2002, China Agriculture University ranked 23 out of all the universities in China.

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[1] "211 Project": 100 Chinese universities affiliated with the Education Ministry of China that have been carefully selected and will be given first priority for development in the 21st century.

Most of the participants of this study were students who matriculated in the College of Biological Sciences in China Agriculture University in 2003, and a few of them are students in the College of Agronomy and Biotechnology. As a whole, these students represent a special group whose intellectual and physical accomplishments are far above the average for their age group in China.

In this study, I asked young adults (students at China Agricultural University) to interview their parents and/or grandparents, with the focus on how he or she (the interviewer) was fed when he/she was an infant. I recruited student interviewers from friends and students who were part of my network when I was a student at CAU. A random sample is not necessary for this study, and the biases of volunteer reports do not seriously affect the goal of developing a preliminary, qualitative description of feeding practices of 20 years ago.

Questionnaire development

Items in the questionnaire were selected after a review of breastfeeding/complementary feeding literature, from suggestions made by Professor Gretel H. Pelto. The questionnaire was developed and modified through an interaction between my mother and me.

The questionnaire was pilot tested with a Cornell undergraduate and his mother, who is a faculty member at Cornell. The pilot interview was conducted in my presence and detailed notes were taken. Decisions about face and content validity were based on feedback from the pilot process.

Data collection

The interviews were conducted by telephone (in most cases) because students at CAU come from all over the country and usually return home only for holidays. If a student returned home during the period of data collection, the interview was conducted face-to-face. Informed consent forms were used to ensure the protection of human subjects.

Definition of terms in the questionnaires

- Exclusive breastfeeding: Children had mother's milk and didn't receive any other liquids.
- Complementary foods: including home-prepared flour/rice foods, meats, vegetables, commercial child food, fruits, soups, eggs and other foods.
- Length of breastfeeding: The reported ages of cessation of breastfeeding were used as the length of breastfeeding.
- Dietary diversity score (DDS): Dietary Diversity Score is calculated from Q14 (In this question, interviewees were asked to evaluate the frequency of five main complementary food groups that were given when babies were 8 and 12 months old.) The frequency was converted to a "1-5 scale" (very frequently=5, frequently=4,

sometimes=3, less frequently=2, not given=1). The sum of the number scale at both ages is the dietary diversity score. DDS reflects both the variety and the frequency (amount) of complementary food.

- Dietary variety score (DVS): DVS is derived from Q5 and Q7, which are open-ended questions asking about the complementary foods given at the very beginning of complementary feeding and when more variety of complementary foods was given. Every food item mentioned by the interviewee is counted as "1" and the number of all food items mentioned at both questions is the DVS.
- Frequency of premastication (FPM): FPM is derived from Q21 (How frequently pre-masticated foods were given). The results are converted to a "0-4 number scale" (very often=4, often=3, sometimes=2, rarely=1, never=0).
- Major cities: From an online statistics report (http://www.mongabay.com/igapo/China.htm), the ten largest cities with the largest urban population are Shanghai, Beijing, Tianjin, Wuhan , Shenyang, Guangzhou , Harbin, Chongqing, Chendu and Hongkong. Therefore, children who were born in these cities were put into the major cities group. The major cities group turned out to consist of only four municipalities—Beijing, Tianjin, Shanghai, and Chongqing.
- Non-major cities: In this study, the cities other than Beijing, Tianjin, Shanghai and Chongqing were coded as non-major cities.

Data Analysis

Minitab 14 for Windows statistical software package (Minitab Inc. State college, PA) was used to carry out all statistical analysis, mainly regression analysis and chi-square tests. Frequencies were calculated and the chi-square test was used to examine the frequency or count differences between groups. In a few questionnaires, respondents misunderstood the meaning of complementary feeding and family food. Thus, if complementary feeding was not started by 12 mo or family food was not given by 3 y old, these items are treated as missing data.

Results

Sample Characteristics

120 copies of questionnaires were distributed and 104 were returned and used for this analysis. The pilot test was not included. The interviewers ranged in age from 20 to 24 year old, of which 54 were female and 50 were male students. As the university recruited students from all over the country, the 104 samples represented 27 out of 34 provinces, autonomous regions, and municipalities. The region where most students came from was Beijing, which had 10 students. Our sample did not include students from Nignxia Hui, Xinjiang Uigur, Qinghai, or Tibet.

The respondents were 90 female and 14 males, of which 89 were mothers of the interviewers, 14 were fathers and 1 was the grandmother of the interviewers. The median age of respondents was 48 year old.

The education levels of respondents were very high. Only 4 out of 104 respondents had not received any education. Nearly 32% of respondents had received a college level education or above, another 38% had received a high-school-level education. The education level of respondents was far beyond the average of their age group in China. Therefore, the participants in this study were not representative of all educational levels in the country.

At the time of the child's birth, 23 mothers had no outside job, while 79 were employed full time outside the home; 52 out of 77 (67.5%) working mothers had a maternal leave equal to or less than 3 months, 17 mothers (24%) had a maternal leave of 4-6 months, and only 7 (9%) mothers had a maternal leave of 6-12 months.

Table 3.1. Birthplace of interviewers

Place	Number	Percent of Total
Beijing	10	9.6%
Hubei	7	6.7%
Hebei	6	5.8%
Liaoning	6	5.8%
Anhui	6	5.8%
Shandong	6	5.8%
Heilongjiang	5	4.8%
Zhejiang	5	4.8%
Henan	5	4.8%
Tianjin	4	3.8%
Inner Mongolia	4	3.8%
Jilin	4	3.8%
Jiangsu	4	3.8%
Sichuan	4	3.8%
Chongqing	3	2.9%
Shanxi	3	2.9%
Sanxi	3	2.9%
Jiangxi	2	1.9%
Guangdong	2	1.9%
Shanghai	1	1.0%
Guangxi Zhuang	1	1.0%
Fujian	1	1.0%
Hunan	1	1.0%
Hainan	1	1.0%
Guizhou	1	1.0%
Yunnan	1	1.0%
Gansu	1	1.0%
Tibet	0	0%
Ningxia Hui	0	0%
Xinjiang Uigur	0	0%
Qinghai	0	0%
Missing	7	6.7%

Table 3.2. Demographic Characteristics of Interviewees (Parents/grandparents)

	Number	Percent of Total
	AGE (104)	
36-40 y	1	1.0%
41-45 y	16	15.4%
46-50 y	62	59.6%
51-55 y	19	18.3%
56-60 y	2	1.92%
Missing	4	3.85%
	EDUCATION (total 104)	
None	4	3.8%
Less than 5 y	10	9.6%
5-9 y	18	17.3%
9-12 y	39	37.5%
College or above	33	31.7%
	GENDER (total 104)	
Female	90	86.5%
Male	14	13.5%
	RELATIONSHIP TO INTERVIEWERS (104)	
Mother	89	85.6%
Father	14	13.5%
Grandmother	1	1.0%

Pre-mastication as a method of complementary feeding

Premastication was a very common way to prepare tough complementary foods. Only 39 out of 104 respondents reported never gave premasticated food to the infant. Of those families who reported premastication, 21.5% said they used this practice “often” or "very often." The most frequently premasticated foods were meat, followed by rice and grain, other "tough foods" and nuts.

The start of premastication ranged from 1 month to 24 months with a median of 8 months. The end of premastication ranged from 5 months to 48 months with a median of 24 months. The median age of starting premastication was two months after the introduction of complementary feeding, but the median age at which premastication was ended coincided with the age of starting a full family diet.

There was no relationship between the age of which complementary foods were introduced and whether or not premasticated foods were given ($p>0.05$). The average dietary diversity score and dietary variety score were about the same regardless of premastication. (Table 3.3. and Table 3.4.).

Table 3.3. The association of premastication and the age of introduction of complementary food by month

Complementary feeding	Pre-mastication		
Age of introduction	Yes	No	Total
1 mo	4	1	5
2 mo	2	1	3
3 mo	11	7	18
4 mo	8	4	12
5 mo	2	2	4
6 mo	9	10	19
7 mo	4	0	4
8 mo	5	3	8
10 mo	2	1	3
12 mo	5	4	9
18 mo	3	1	4
24 mo	2	2	4
36 mo	1	1	2
Missing	7	2	9
Total		39	104

Table 3.4. The association of premastication and DDS and DVS

	DDS	DVS
Premastication	Mean/ Standard Dev.	Mean/ Standard Dev.
Yes	30.3/9.4	4.17/2.7
No	30.4/8.9	4.13/1.9

Table 3.5 shows that the likelihood of premastication is not related to whether the babies lived in nuclear or extended families (p=0.57). However, as shown in Table 3.6

and 3.7, babies had a higher likelihood of receiving premasticated food if someone other than the parents were involve in their feeding (p=0.002). The frequency of premastication is lower in families where only parents fed their babies (p=0.024).

Table 3.5. The association of premastication with family structure (nuclear versus extended family)

	Nuclear family	Extended family	All
Premastication	25	37	32
No premastication	11	21	62
All	36	58	94

Results — Pearson Chi-Square = 0.316, DF = 1, P-Value = 0.574
Likelihood Ratio Chi-Square = 0.318, DF = 1, P-Value = 0.573

Table 3.6. The association of premastication with who fed the infant (Parents only versus parents and others)

	Parents only	Parents and other people	All
No premastication	21	17	38
Premastication	16	49	65
All	37	66	103

Results — Pearson Chi-Square = 9.786, DF = 1, P-Value = 0.002
Likelihood Ratio Chi-Square = 9.705, DF = 1, P-Value = 0.002

Table 3.7. The association of frequency of premastication with who fed the infant (parents only versus parents and others)

	Never	Rarely	Sometimes	Often	Very often	All
Parents only	21	6	8	2	0	37
Parents and other people	17	14	23	8	4	66
All	38	20	31	10	4	103

Results Pearson Chi-Square = 11.202, DF = 4, P-Value = 0.024
Likelihood Ratio Chi-Square = 12.408, DF = 4, P-Value = 0.015

In Table 3.8 it appears that longer breastfeeding is inversely related to the frequency of premastication. However, regression analysis of breastfeeding length vs. frequency of premastication found no relationship between these two (p=0.708).

Table 3.8. Association of breastfeeding length with the frequency of premastication

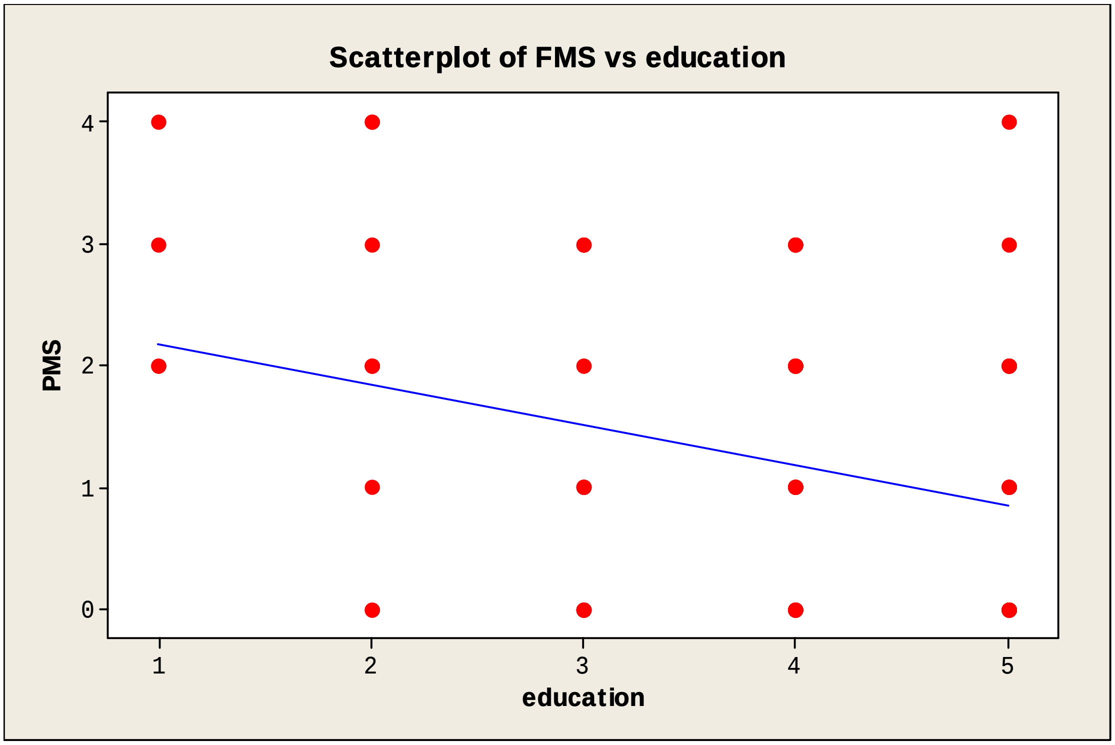
Breastfeeding length	Frequency of premastication (FPM)
1st quartile	2.33
2nd quartile	1.90
3rd quartile	1.36
4th quartile	1.29

In Table 3.9 and Figure 3.10 we see that there is a trend in which those with more education were less likely to premasticate foods for their babies. A regression analysis shows this relationship is highly significant (p=0.000).

Table 3.9. The association of education of interviewees with the frequency of premastication

Education of interviewee	Frequency of premastication
1	2.75
2	2.00
3	1.00
4	1.28
5	0.88

Figure 3.10. Scatter plot of education and frequency of premastication



The regression equation is

PMS = 2.50 - 0.331 education

S = 1.11531 R-Sq = 9.7% R-Sq(adj) = 8.8% p=0.000

A diversity of complementary food items was reported. The premasticated foods included grain and rice, meat and dried meat, nuts, vegetables, dumplings, and eggs (Table 3.11)

Table 3.11. Summary of premasticated foods reported in China's survey in groups

Carbohydrates: Steamed bread Biscuit Potato Corn bread Millet Rice Porridge Noodles Animal Foods: Eggs Meat Dried meat Fish Dried fish Meat soup	Vegetables: Potato Vegetable soup Fruits: Apple Orange Tomato Tangerine Others: Nuts Walnuts Peanuts Cod fish oil Dumplings

To understand the trajectory of infant feeding, we pinpointed five transitional ages in the course of infant feeding. These five points are the length of breastfeeding, age of starting complementary feeding, starting and stopping pre-masticated food and starting a full family diet. The ages of starting and stopping premastication are grouped into 4 categories—very early, early, middle, late (Table 3.12 and 3.13.) Each category was assigned a score between "1-4" with "1" for group of very early and "4" for group of late.

Chi-square tests were used to examine whether there is an association between categories of premastication and similar categories of other variables. The results show that introduction or cession of premasticated food was not related to the length of breastfeeding, introduction of complementary food or family food (p>0.05).

Table 3.12. Age of starting pre-masticated food grouped by very early, early, middle and late

	Start of pre-mastication	Number/ percentage out of 20
Very early	1-4 mo	4/ 20%
Early	5-8 mo	7/ 35%
Middle	9-18 mo	7/ 35%
Late	> 18 mo	2/ 10%

Table 3.13. Age of stopping pre-masticated food grouped by very early, early, middle and late

	End of pre-mastication	Number/ percentage out of 31
Very early	5-10 mo	3/ 8%
Early	11-18 mo	12/ 38.7%
Middle	19-30mo	11/ 35.5%
Late	> 30 mo	5/ 16.1%

Discussion

The findings provided striking confirmation that premastication was under-reported in the HRAF files. Although none of the ethnographies from China mentioned premastication, we found that it was practiced by a majority of families in a sample that would be least likely to have premasticated food for their babies. It was very unlikely that the discrepancy for China was unique to that country, particularly in view of the fact that nearly all of the China cultures (7 of 8) reported data under the "infant feeding" OCM numbers.

In addition to confirming the basic hypothesis concerning under-reporting in the files, the results provide important information about the nature of premastication practices among well-educated families two decades ago. These include:

1. As an infant feeding practice, it happened in all parts of China, in major and smaller cities so it was not only a "provincial" practice.
2. It was a very common way to introduce complementary solid foods.
3. It was practiced in both nuclear and extended families, so it was not limited to older generation grandparents.
4. It was more likely to occur if people other than parents were involved in infant feeding. (This might reflect differences in the types of foods being prepared in the family and general attention to food. See the appendix.)
5. Parents with more education were less likely to premasticate foods for their babies.
6. The foods that were premasticated are often good sources of iron (see Section IV).
7. The mother, who was also breastfeeding her infant, was the primary source of the premasticated foods.

The finding that maternal education level was inversely related to the likelihood of premastication may be explained by the following: physicians and nurses generally discourage premastication (This is also our reason for imbedding premastication questions in a larger set of questions about infant feeding). One potential explanation is that parents with more education tend to have more exposure to health information from physicians and nurses. Thus, they are more concerned about the hygiene of infant foods are less likely to premasticate food for their babies.

There is a trend, although not statistically significant, for length of breastfeeding to be inversely related to the frequency of premastication. This might be explained by an effort of mothers to maximize their breastfeeding duration if few complementary foods are available.

The finding that the average dietary diversity score and dietary variety score are about the same regardless of premastication runs counter to our expectation about the role of premastication in improving dietary diversity. However, this may be explained by the following: First, the dietary variety score is derived from an open-ended question, which is the count of food items the respondents mentioned. It is likely that respondents only listed the most frequently given food items instead of all foods. Second, some respondents gave specific food items while others gave food categories. For example, contrast "beef stew" and "finely cut lamb" versus "meat." The latter is only counted once even, whereas beef stew and lamb would count as two items. Third, for the dietary diversity score, there is a decrease in infant formula or milk as infants grow bigger that may offset the increasing diversity of adult food, such as meat and vegetables. Therefore, due to the ambiguity of the responses and other factors, the finding that premastication does not increase dietary diversity is difficult to interpret.

Premastication was not shown to be related to other feeding transition patterns. It is important to note that failing to find an association does not mean there is no association. With small sample sizes one must have large differences to show statistical significance and some statistical tests that would have been appropriate (such as chi-square) could not be used because the expected cell count was too small.

A review of the types of foods that were premasticated indicates their role as sources of iron in infant and young child diets. Chapter IV examines this in more detail.

IV. The plausibility of the premastication hypothesis: benefits and risks

The evidence from the China's survey strongly suggests underreporting of premastication in the ethnographic database. If premastication has been a normal aspect of infant feeding practice during the long course of human history before the development of iron supplements, it is conceivable that it played an important role in sustaining iron status during infancy.

Iron deficiency is a common problem in infancy throughout the world. The fact that it is so common in children by the time they reach 12 months of age, when they have typically been eating complementary foods for many months, is usually explained as a consequence of iron-poor complementary foods. Because no one who reviews the data on usual complementary foods would disagree that these foods tend to be low in iron, particularly in developing countries, one can ask whether this fact alone explains the magnitude of the problem. So are the foods that have been reported to be premasticated good sources of iron? Is premastication a practice that enhances population survival, as some of suggested, or, as many others believe, does it have negative consequences? Are there any beneficial effects apart from iron? To examine these questions, the iron content of premasticated food and the magnitude and severity of saliva-transmitted disease will be examined in the next two sections.

Iron content of premasticated foods

The plausibility of the hypothesis that premastication contributes iron to the diet of infants that they would not otherwise receive depends on what foods are premasticated. Below are two examples to illustrate how the data are reported. Table 4.1 shows a sampling of the foods that are reported in the ethnographies.

Table 4.1. Summary of premasticated foods reported in HRAF in groups (same as Table 2.7.)

<u>Carbohydrates:</u> Beans Cake Boiled corn Young yams Yuca Roasted half ripe plantains Banana mixed with crude sugar Sweet potatoes Potato Papaya Cassava Rice Sugar cane juice	<u>Animal Foods</u> Meat Meat broth Seal or caribou meat Fish Dried Fish <u>Vegetables:</u> Alligator pepper Pungent root Breadfruit <u>Nuts:</u> Nuts Mongongo nuts

Example 1: Culture: Kung San (Africa)

“The! Kung have no milk from cows or goats and no cereals to feed an infant, and they.... [feed] ... by chewing their tough meat, harsh roots, and nuts and feed the infant premasticated food from their own mouths” (Marshall, 1976)

Example 2: Culture: Garo (Asia)

“…with a banana leaf beside her containing food which she chews mouthful by mouthful, before spitting it into her hand and placing it in the baby's mouth.... Gradually she tries feeding the baby meat, dried fish, and *all the other Garo foods” (*Burling, 1963)

In my survey in China, a diversity of complementary food items was reported. The premasticated foods included grain and rice, meat and dried meat, nuts, vegetables, dumplings, and eggs.

Table 4.2. Summary of premasticated foods reported in China's survey (same as Table 3.11.)

Carbohydrates: Steamed bread Biscuit Potato Corn bread Millet Rice Porridge Noodles Animal Foods: Eggs Meat Dried meat Fish Dried fish Meat soup	Vegetables: Potato Vegetable soup Fruits: Apple Orange Tomato Tangerine Others: Nuts Walnuts Peanuts Cod fish oil Dumplings

Table 4.3 shows the iron and zinc content for some of the foods that appear in the ethnographic studies and in my studies.

Table 4.3. Iron and Zinc composition of selected premasticated food from ethnographic data and China survey results (from USDA Nutrient Data Laboratory)

Food	Iron (mg/100g)	Zinc (mg/100g)
Peanuts	1.52	3.28
Nuts, walnuts, black, dried	3.12	3.37
Beef, cured, dried	2.90	3.97
Pork, cooked	1.10	2.90
Dried pork (double above)	2.20	5.80
Vegetables and dumplings and beef	0.47	0.33
Pork, fresh, variety meats and by-products, liver,	17.92	6.72
Egg, whole, cooked, hard-boiled	1.19	1.05
Rice, white, medium-grain, cooked	1.49	0.42
Corn flour, whole-grain, yellow	2.38	1.73
Rice noodles, cooked	0.14	0.25
Wheat flours, bread	0.90	0.85
Millet, cooked	0.63	0.91
Bread, cornbread, dry mix, prepared	1.90	0.63

Research on saliva

Saliva is composed of a variety of electrolytes, including sodium, potassium, calcium, magnesium, bicarbonate, and phosphates. Also found in saliva are immunoglobulins, proteins, enzymes, mucins, and nitrogenous products, such as urea and ammonia (Sue, 2001)

According to Sue (2001), salivary function is organized into 5 major categories that serve to maintain oral health and create an appropriate ecologic balance: (1) lubrication and protection, (2) buffering action and clearance, (3) maintenance of tooth integrity, (4) antibacterial activity, and (5) taste and digestion. As the first three functions mainly concern oral and dental health, they are less likely to cause any benefit or risk for infants through premastication, Sue discussed the last two functions as in the following two paragraphs:

> "Saliva can enhance taste and assist digestion. The hypotonicity of saliva enhances the capacity to taste salty foods. This enhanced tasting capability depends on the presence of protein and gustin, which bind zinc (Roth, 1981). Saliva has an early role in total digestion by beginning the breakdown of starch with amylase, a major component of parotid saliva that initially dissolves sugar (Moss, 1995). This is especially significant in light of the fact that the ability to digest complex carbohydrates develops slowly in children (Lebenthal and Heitlinger 1982) Lingual lipase, a salivary enzyme, also initiates fat digestion (Valdez, 1991). More importantly, mucus serves to lubricate the food bolus, which aids in swallowing.
>
> Concerning the antibacterial action of saliva, immunologic contents of saliva include secretory IgA, IgG, and IgM. Nonimmunologic salivary contents include several proteins, mucins, peptides, and enzymes. IgA, which is active on mucosal surfaces, also acts to neutralize viruses, serves as an antibody to bacterial antigens, and works to aggregate or clump bacteria, thus inhibiting bacterial attachment to host tissues. (Dowd, 1993) Additionally, proteins, such as glycoproteins, statherins, agglutinins, histadine-rich proteins, and proline-rich proteins, are involved in aggregating bacteria. Very importantly, this "clumping"

process reduces the ability of bacteria to adhere to hard or soft tissue intra-oral surfaces and thereby controls bacterial, fungal, and viral colonization (Mandel, 1989)."

The clumping process may help to explain why oral transmission of human immunodeficiency virus (HIV) by the millions of HIV-infected individuals is a rare event, even when infected blood and exudate are present. The saliva of viremic individuals usually contains only noninfectious components of HIV, indicating virus breakdown. Hypotonic disruption may be a major mechanism by which saliva kills infected mononuclear leukocytes and prevents their attachment to mucosal epithelial cells and production of infectious HIV, thereby preventing transmission (Baron, et al. 1999).

A number of recent studies have shown that saliva contains multiple growth factors that can enhance the body's repair mechanisms after tissue injury. Epidermal growth factor (EGF) provides cytoprotection against irritants, enhances healing of gastroduodenal ulceration, and decreases the permeability of the esophageal mucosa to hydrogen ions (Denny, 1991). EGF may play a role in maintaining the integrity of gut mucosa. Swallowed saliva is also believed to protect the esophagus by neutralizing refluxed acid to aid in the restoration of the esophageal pH toward an alkaline state (Kavita, 1999).

Saliva clearly has many beneficial roles, but it also has a negative side: some diseases such as HIV, HHV-8 and TTV are transmitted through human saliva. Therefore, to assess the potential risks and benefits of premastication in human evolutionary history, it is also necessary to examine the types of pathogens that are saliva-transmissible and estimate their frequency.

A recent study demonstrated the presence of *H. pylori* positive polymerase chain reaction (PCR) in maternal saliva and in the water in which children's soothers (pacifiers) were stored, suggesting a plausible route of mother to child oral transmission (Sinha, 2001). Another study found that 82% of the children born to mothers infected with *H. pylori* also became infected, compared to only14% of children with infection when their mothers were seronegative. However, other studies have not demonstrated an association between maternal and infant infection. As suggested by Bassily (1999), a possible explanation for the conflicting results is that maternal seropositivity is only a surrogate marker for true risk factors, such as maternal premastication of food, family density or poor hygienic conditions. Additional research is thus required to determine how maternal-infant transmission occurs.

In highly endemic areas of the human herpesvirus 8 (HHV-8), as Central Africa, viral transmission occurs mainly from mother to child and between siblings (Brayfield, 2003). Saliva seems to play a major role in the viral transmission, and may be a reservoir for HHV-8. Human herpesvirus 6 (HHV-6) is a B-herpesvirus with two variants: HHV-6A and HHV-6B. HHV-6B is the major causal pathogen of exanthem subitum, a predominantly benign exanthematous disease of infants, which occasionally has central nervous system complications. Infection with HHV-6 is common in the general population, and the virus mainly seems to be transmitted from mother to infant via saliva (Yamanishi, 2000)

In a recent report two babies who were found to be TT virus-DNA positive at three months of age had low sequence homology with their mothers, which suggests feces or saliva drops may be the source of TT virus (Bagaglio, 2002) Streptococcus mutans and Streptococcus sobrinus are the main microorganisms associated with caries in humans. These are transmitted in early childhood from mother to infant, mostly by saliva (Berkowitz, 1981). Hepatitus B virus has been found in impetiginous exudates and saliva, albeit at concentrations lower than in blood. According to Gregory (2001) the sources of HBV transmission in household settings includes contact with dermatologic lesions and premastication of food.

In a longitudinal study by Imong and colleagues (1995), the investigators examined the bacterial contamination of infant weaning foods and found that premastication was significantly related to increased bacterial content of weaning foods. The authors suggest that the diseases that could be introduced through premastication could include, among others, leprosy and tubercle mycobacterium, hemolytic streptococci, and respiratory tract viruses. A finding of increased bacterial count without any further specification of its nature does not tell us whether there is a greater risk of infection. Moreover, they present no rationale for their list of specific diseases or any evidence that these were present in their samples. However the authors do mention the possibility that IgA in saliva might offset the bacteria load.

It is very likely that pathogenic organisms can be transferred from mothers and other family members to infants through saliva, but this transfer may also be important as a mechanism to produce immunological responses in infants. What is not clear from the literature is the extent to which saliva exposure produces frank disease in infants and the severity of disease acquired in this fashion.

It is interesting to compare salvia to breastmilk from the perspective of disease transmission. Table 4.4. presents a summary, drawn from a review of the literature on disease agents in breastmilk to complement the information presented above.

Table 4.4. Saliva and breastmilk transmitted disease/viruses

Breastmilk transmitted	Saliva transmitted
Serotype Panama infection	Streptococcus mutans
Human cytomegalovirus (HCMV)	Streptococcus sobrinus
E. coli, other GNR	Hepatitis G virus (HGV)
Mastitis/Staphylococcus aureus	HHV-8
Mycobacterium tuberculosis	Helicobacter pylori
Group B spreptococci	
Listeria monocytogenes	
Coxiella burnetii	Transmitted both by breastmilk and saliva
Cytomegalovirus	
Hepatitis C	TT-virus
HTLV-I& II	HHV-6
Herpes simplex virus	HIV
Rubella	Hepatitis B
Varicella Zoster virus	
Epstein-Barr virus	
HHV-7	
Brucellosis[1]	
Toxoplamosis (parasites)	

Conclusions

The overview of iron content in premasticated foods shows that many of them are good to excellent sources of iron. It is likely that the practice of premastication provided infants with foods that are generally higher in available iron than traditional "weaning foods," the soft gruels and paps made from starches and grains.

Apart from its role in nutrition, premastication may play other positive roles in infant health. Saliva contains many important substances for healthy functioning. I was not able to identify any research on whether and how these substances function when they are transmitted from mothers to their infants. Are the positive features actually functional in infants? The scientific literature does not provide detailed information on the types of specific antibodies that are found in saliva. Does maternal to infant transfer of saliva convey specific antibody protection, as is the case for breastmilk? Again, I was not able to find answers to this question. If the positive characteristics of saliva are sustained in the infant, then premastication, like kissing, may be an important mechanism for supporting infant health. In summary, the potential beneficial effects are important, but understudied.

The scientific literature also provides evidence of the potential for premastication to be a source of disease, which is also understudied. Most importantly, the literature does not provide sufficient information to permit an estimate of the trade-offs between positive and negative features.

Summary

Infant iron deficiency anemia is a common problem throughout the world that is related to but not limited to the low iron content in breastmilk and in conventional complementary foods. It was hypothesized that exclusive breastfeeding was complemented by premasticated foods during our evolution as a hunting-gathering species. In other words, that iron deficiency in infancy is a recent problem in human society, which was previously prevented by premastication.

This cross-cultural study provided evidence that premastication was commonly practiced in different types of societies and environments, particularly in the regions where traditional subsistence systems survived into modern times. Its occurrence in such widely different cultural traditions and environments indicates that it was not a unique invention of a particular cultural group, which then spread to neighboring societies.

As is shown in the study of elite university students in China, premastication as an infant feeding practice happened in all parts of China, in major and smaller cities so it was not only a “provincial” practice. It was not limited to the older generation although it was more likely to happen if people other than parents were involved in infant feeding. Unlike the survey results, a review of cultures in the Han majority in China from the complete HRAF database found no description of premastication, which confirmed that the occurrence of premastication was severely under-reported in the HRAF files. It is probable that in the past most cultures practiced premastication.

In both the HRAF study and China's study, mothers were reported to be the primary source of the premasticated foods. The overview of iron content in premasticated foods shows that many of them are good to excellent sources of iron. There is evidence that in some, but probably not all, of the societies that practiced premastication, foods were introduced to infants before six months of age. This may help replenish infant's iron pool in a timely manner. There is also evidence that this practice continued through the second semester of infancy and probably longer. Given the diversity of foods that have been reported to be premasticated and the inclusion of animal source foods in these reports, it is likely that the practice of premastication provided infants with foods that are generally higher in available iron than traditional "weaning foods," the soft gruels and paps made from starches and grains. In summary, the review of the ethnographic literatures and the study of this practices in families of elite university students in China have shown that it is possible that premastication has been a source of iron in infant diets.

Apart from its role in nutrition, premastication may play other positive roles in infant health. Whether maternal to infant transfer of saliva conveys specific antibody protection or whether these substances are actually functional in infants need to be further studied. If the positive characteristics of saliva are sustained in the infant, then premastication, like kissing, may be an important mechanism for supporting infant health. The scientific literature also provides evidence of the potential for premastication to be a source of diseases. On balance, it appears that the risks of premastication are no greater than the risks of breastfeeding. However, the HIV transmission through saliva may be dangerous enough that premastication will not and should not be practiced for any reason in the HIV epidemic areas.

Taken together, these considerations suggest that further research is warranted to examine the hypothesis that premastication has been a significant bio-cultural adaptation to prevent iron-deficiency anemia in infancy. It is conceivable that during the long course of human history, prior to the development of iron supplements, premastication played an essential role in sustaining iron status during infancy.

Appendix

Infant feeding practices 20 years ago: Other results from the university student survey

Apart from the results on premastication, the survey provided a great deal of additional information on how the students in the sample were fed when they were infants and young children. These results provide further information on the feeding context within which premastication occurred.

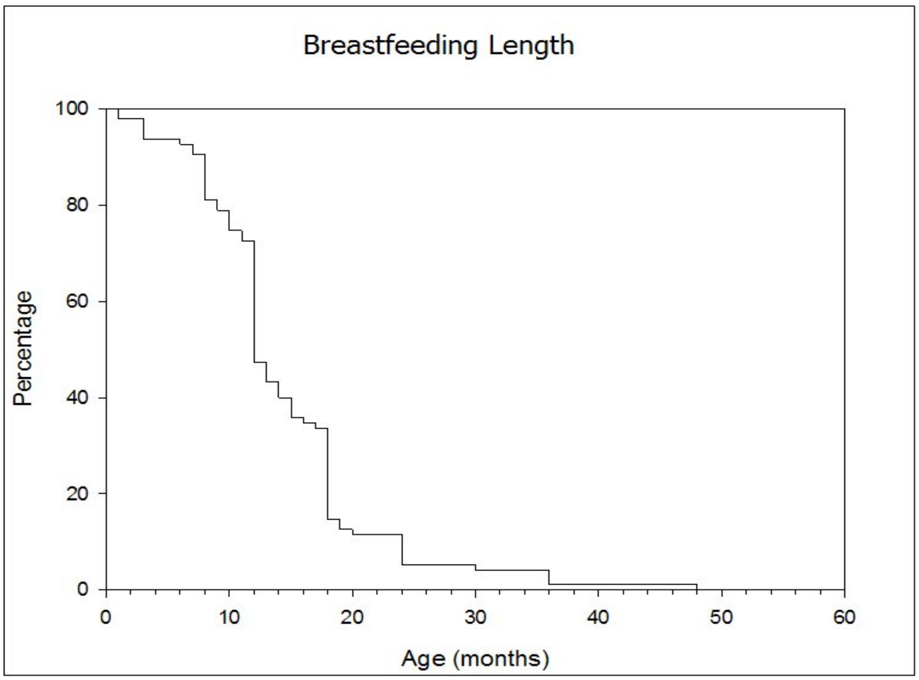
Breastfeeding

Virtually all of the children were breastfed: 102 of the 104 children. The two mothers who did not breastfeed said that this was due to lack of breastmilk. Seventy two percent of the mothers started breastfeeding within the first day of their children's birth, another 25% started within the first week, and all started within first month. The majority of mothers, 75 out of 101 mothers reported that they never used a bottle to feed their babies. The numbers of respondents answering "rarely", "sometimes", "often" and "very often" to bottle-feeding are 5, 13, 2 and 3 respectively.

The length of breastfeeding ranges from 1 month to 48 months with a median of 12 months. Among the children who had had mother's milk, the percentages of infants weaned by the first, sixth, 12th and 24th months were 2.1%, 7.4%, 52.3%, and 95.8%

respectively. Nearly half of children older than one year were still being breastfed (Figure App.1)

Figure App.1. Proportion of breastfeeding duration by months



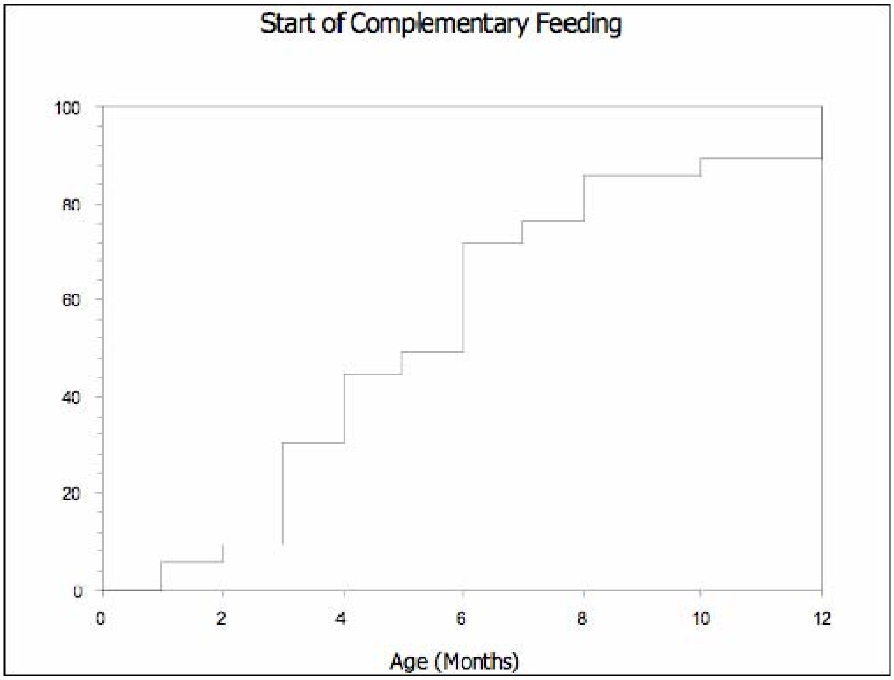
At 8 months the number of times per day that women recalled feeding their infants had a median value of 3, while the median frequency of breastfeeding at 1 year was 2 times a day. The difference was significant using a Mann-Whitney U test (p=0.0000).

To examine the influence of place of residence we compared the age at which breastfeeding ceased for children in the major cities compared to the non-major cities.[2], Mothers in the large urban areas (major cities) cities weaned their babies earlier ($p<0.026$).

Complementary feeding

The introduction of complementary feeding ranged from the first month to the twelfth month after birth with a median of 6 months. The percentages of infants started complementary foods by the first, third, sixth, ninth and twelfth months were 5.2%, 39.2%, 57.04%, 68.4% and 87.5% (Figure App.2).

Figure App.2 Proportions of infants starting a complementary diet by months



The first food introduced to babies included: sugar water (n=10), water (n=11), milk powder (n=7), cow's milk or goat's milk (n=3) and vegetables (n=1). The most commonly used complementary foods were rice and other grains, porridge and boiled or steamed eggs. The respondents also frequently mentioned milk powder, vegetables and fruit juice, meat powder, fish powder, and all kinds of soup. Although eggs were the most frequently mentioned animal source food, meat or fish powder were also commonly given. Other secondary protein sources included bean curd and animal livers.

Concerning the preparation of complementary foods, 73.7% of the infant foods were prepared separately from the family diet, and the time for preparation ranged from 10 minutes to over an hour, with a median of 26-30 minutes. The main preparation methods for complementary food were boiling, steaming and brewing, and occasionally stir-frying, sautéing and frying. Tough foods were prepared by cutting finely, mashing, squeezing, soften or blend with hot water and by pre-mastication.

As shown in Table App.3, 34.0% of the infants at 8 months old received complementary food less than 4 times a day while 68.6% of the infants at 12 months old received complementary food fewer than 5 times a day.

Table App.3. Frequency of complementary feeding per day

	8 months	12 months
Less than 3 times	35	17
3-4 times	40	53
5-7 times	25	29
> or =8 times	3	3
Missing	1	2
Total	104	104

The frequency of complementary feeding at 8 months old compared to 1 year of age approaches statistical significance ($p=0.059$) and it is likely that this difference would be significant in a larger sample.

From Table App.4, we see that at the age of 8 months, over 80% of babies received a comprehensive complementary diet that included grains, fruits and vegetables, fish, meat and poultry. When babies reached 12 months old, the percentage of all categories of complementary foods increased, except for infant formula, which had a decrease of 2.9%. The food group that increased most was meat, fish and poultry. The table indicates that babies were fed more fruit than vegetables at 8 months old, but more vegetables than fruits at 12 months.

Table App.4. Complementary foods at the age of 8 months and 12 months

At 8 months

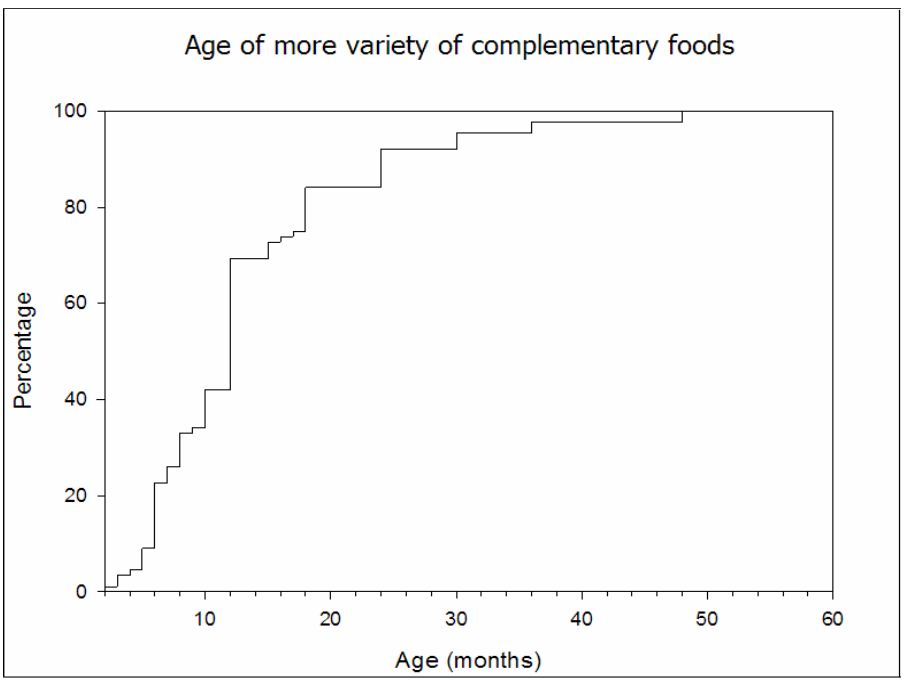
Food given	Number of families	Percent of total (104)
Grains	92	88.5%
Fruits& Vegetables	91	87.5%
Meat, fish and poultry	84	80.8%
Diary	71	68.3%
Infant formula	68	65.4%

At 12 months

Food given	Number of families	Percent of total (104)
Grains	97	93.3%
Fruits& Vegetables	92	88.5%
Meat, fish and poultry	94	90.4%
Diary	73	70.2%
Infant formula	65	62.5%

We asked mothers at what age their child began to receive a greater variety of foods. The responses ranged from 2 months to 48 months with a median of 12 months. The percentages of infants receiving more variety of complementary foods by the 4th, 7th and 11th months were 4.1%, 26.1% and 42.0%, respectively. As Table App4 shows that cooked grains and porridges remained the dominant complementary food between 8 and 12 months. There was a great increase in vegetables and fruits, while milk powder and animal milk decreased. Meat and meat powder became the main source of protein, followed by eggs, and fish and fish powder. Boiling and steaming remained the predominant cooking method while stir-fried foods were more frequently introduced (Figure 4.5). It is important to note that there is no definition for “more variety” in the questionnaire; the answers for this question were therefore very subjective.

Figure App.5. Proportions of infants eating a more various complementary diet by months



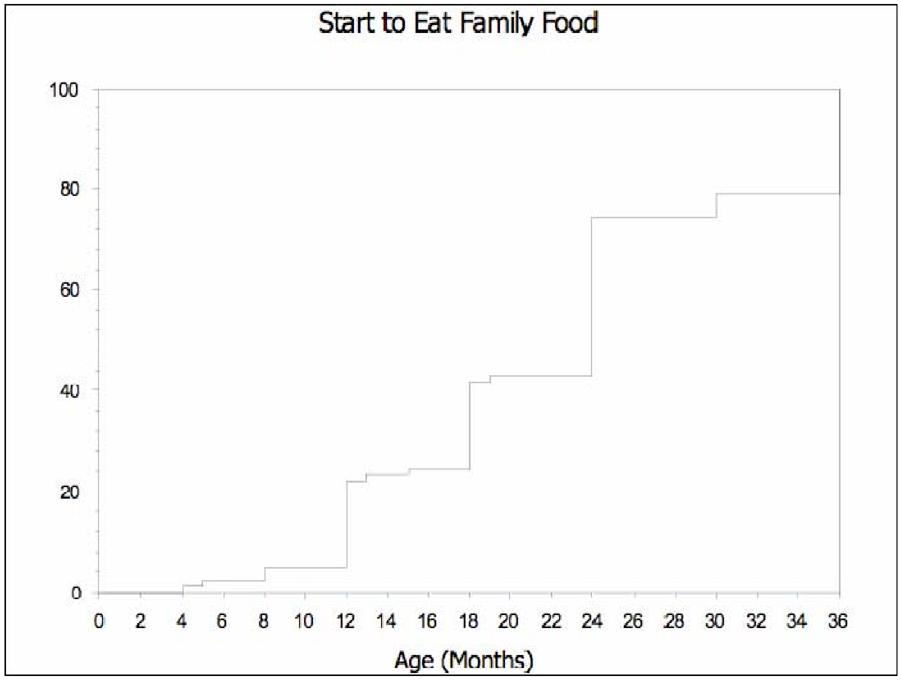
The data in Table App.6 are presented to examine the relationship between duration of breastfeeding and diversity in the diet. (The method for calculating dietary diversity is described in the methods section of the previous chapter) From Table App.6, we see there is a pattern: the shorter the duration of breastfeeding, the more diverse the complementary diets are.

Table App.6. Association of breastfeeding duration with DDS and DVS

Breastfeeding length	Ave DDS	Ave DVS
1st quartile	32.71	4.542
2nd quartile	32.38	3.538
3rd quartile	28.58	4.387
4th quartile	25.36	3.500

With the gain in chewing ability and increasing age, children started to have a full family diet. The reported age of starting family foods ranged from 4 months to 36 months with a median of 24 months. Over 20% of the babies had started a full family diet by 12 months and 69.7% by the end of 2 year (Figure App.7).

Figure. App.7. Proportions of infants beginning to eat a full family diet by months



Commercial infant foods as part of complementary foods

Sixty one percent of the infants were given commercial infant foods. The two main reasons that were given by the respondents who did not buy commercial infant foods were: (1) limited availability, and (2) limited money to buy the foods. In addition, 6 respondents expressed distrust of commercial infant foods and 2 others didn't think commercial infant foods were necessary because they had enough breastmilk. These two had breastmilk substitutes in mind when they answered that question.

The most common commercial infant foods reported by the respondents were milk powder, followed by candy and jelly, and grain cereal. The most frequently given commercial infant foods were milk powder and grain cereal.

Concerning the price of commercial infant food, most respondents thought they were relatively expensive. The percentages of people who found it “cheap”, “reasonable”, “expensive” and “very expensive” were 13.7%, 24.2%, 48.4% and 13.7% respectively. Meanwhile, the self-reported family income level shows that 32.4% were from low-income families, 64.7% were from middle-income and 2.9% were from high-income. For percent of family income spent on foods: 58.7% of the families spent less than 10% of their family income on food, 32.6%, 6.3% and 2.1% of the families spent 11-30%, 31-60% and above 60% of income on infant food, respectively.

Intra-culture variation in feeding practices in relation to social factors

Intra-culture variation in infant feeding practices need to be discussed. Specifically I examined how social conditions (family structure, mother’s education, income level and major city vs. rural city) related to feeding behaviors.

(1) Breastfeeding length and mothers’ education

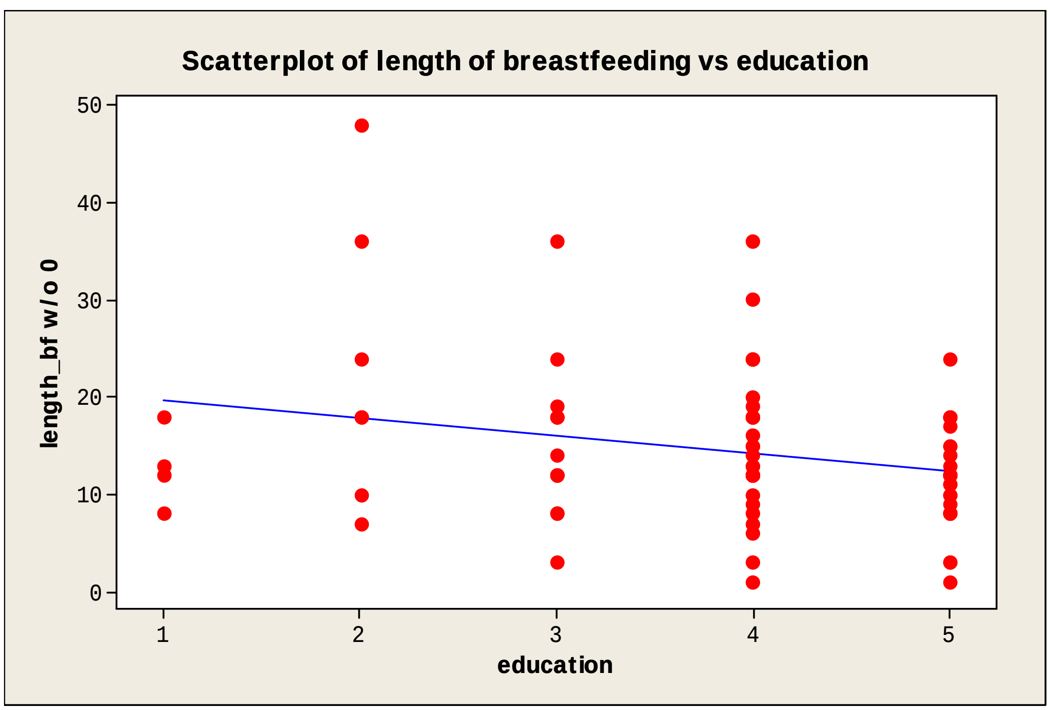
In Table 4.8, we see that mothers with the least education tended to breastfeed their babies for a longer time than mothers with more education (Regression analysis P=

0.000). This trend was more obvious towards the fourth quartile of breastfeeding length (Figure App.9).

Table App.8. The association of breastfeeding duration with interviewee's education level

Breastfeeding Duration	Ave interviewees' education
1st quartile	4.042
2nd quartile	4.077
3rd quartile	3.742
4th quartile	3.429

Figure App.9 Scatter plot of breastfeeding duration and education



The regression equation is

```
Length of breastfeeding = 21.4 - 1.79 education

S = 7.34053   R-Sq = 6.8%   R-Sq(adj) = 5.8%
```

(2) Family structure and Dietary Diversity

Concerning infant's dietary diversity (Table App.10), extended families have an average dietary diversity score of 32.1 compared with 27.2 of nuclear families, and an average dietary variety score of 4.3 compared with 4.1 for nuclear families.

Table App.10. Average DDS and DVS of different family structure groups

Family structure		Ave. DDS	Ave. DVS
Nuclear		27.2	4.1
Extended		32.1	4.3
	Maternal	32.4	4.4
	Paternal	32.1	4.2
Other		29.6	4.3

The Mann Whitney U tests result shows that the dietary diversity scores in extended families are significantly higher than in nuclear families ($p=0.04$). However, the dietary variety scores are not significantly different between nuclear and extended families.

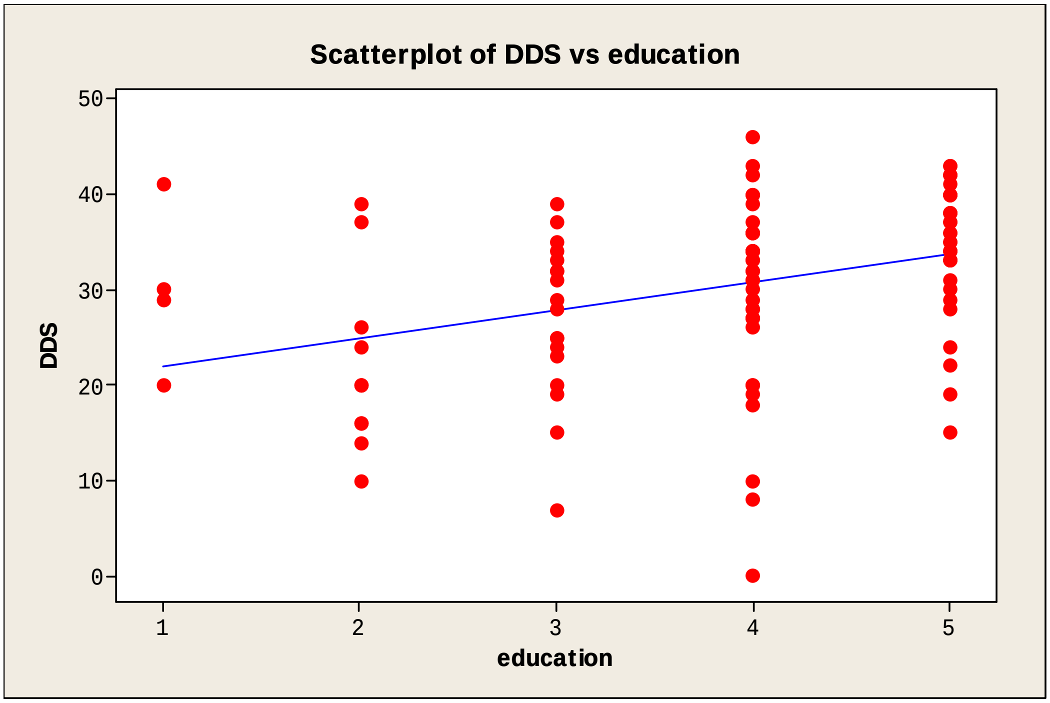
(3) Education and dietary diversity

An interesting pattern is shown in Table App.11, in which there is a significant trend towards increased dietary diversity with higher education. However, parents with no education are an exception to this trend. On the dietary diversity score they resemble parents with high school education, and on dietary variety the average score is between middle school and high school educated mothers. Regression analysis shows the association between education and dietary diversity is significant (p=0.001). (Figure App.12)

Table App.11. Average DDS and DVS of different education groups

Education of interviewee	Ave Dietary Diversity Score	Ave DVS
None	30.0	3.75
Primary school level	22.2	2.20
Middle school level	27.1	3.22
High school level	30.3	4.49
College and above	34.6	4.91

Figure App.12. Scatter plot of education and Dietary Diversity Score




```
The regression equation is

DDS = 19.0 + 2.94 education

S = 8.63549   R-Sq = 12.4%   R-Sq(adj) = 11.5% p=0.001
```

Infant feeding trajectory

To help understand the trajectory of infant feeding, we pinpointed five transitional ages in the course of infant feeding. These five points are the duration of breastfeeding, age of starting complementary feeding, starting and stopping pre-masticated food and starting a full family diet. For each time point, ages are grouped into 4 or 5 categories—very early mature, early mature, middle mature, late mature and very late mature. Each category was assigned a score between “1-5” with “1” for group of very early mature and “5” for group of very late mature.

Chi-square tests are used to examine whether there is an association between these new variables and other social factors. For example, we are interested in whether children who are early maturers in complementary food will start an early full family diet, or whether they are more likely to receive premasticated food than later maturing children. Tables App.13 -App.15, (and Tables 3.12, 3.13 in the previous chapter) show the distributions of these variables in different groups.

The Chi-square results indicate that these variables are not related to each other, nor are they related to the likelihood of premastication, level of education, dietary variety or family structure ($p > 0.05$).

Table App.13. Duration of breastfeeding grouped by very early, early, middle and late

	Breastfeeding duration	Number/percentage out of a total of 93
Very early	1-6 mon	7/7.53%
Early	7-12 mon	43/46.2%
Middle	13-18 mon	31/33.3%
Late	> or = 19 mon	12/12.9%

Table App.14. Age of introducing complementary food grouped by very early, early, middle and late

	Age of introducing complementary food	Number/ percentage out of a total of 97
Very early	1-3 mon	38/39.18%
Early	4-6 mon	27/27.84%
Middle	7-9 mon	11/11.34%
Late	10-12 mon	21/21.65%

Table App.15 Age of starting a full family diet grouped by very early, early, middle and late

	Age of starting a full family diet	Number/ percentage out of a total of 86
Very early	< or = 1y	19/22.1%
Early	13-18 mon	17/19.8%
Middle	19-24 mon	28/32.6%
Late	25-36 mon	22/25.6%

Discussion

Breastfeeding and Exclusive breastfeeding

Breastfeeding is an unparalleled way of providing nutrients for the healthy growth and development of infants; it is also integrated in the reproductive process with important implications for the health of mothers. To meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods, with breastfeeding continuing, ideally for up to two years of age or beyond.

In our sample, breastfeeding was nearly universal (98.1%). The percentage of exclusive breastfeeding for the first 4 months was 60.0%. This dropped to 35.8% by 6 months. Thus, one can see that complementary foods were introduced to the majority of infants before 6 months of age. Breastfeeding was clearly valued by these mothers, as evidenced by the nearly universal initiation and the duration (time to weaning) and the fact that bottle-feeding was not practiced. Without further study of the circumstances it was impossible to say, on the basis of these data, how feasible it would have been for them to practice breastfeeding to six months, as is now recommended but was not at the time.

Problems with complementary feeding

Examined in relation to current recommendations, or in relation to the earlier recommendation of starting complementary foods between 4 and 6 months, the children in this sample were given complementary food either earlier or later. The percentage of complementary feeding at the recommended time was only 19.6 %. A total of 39.2% of children were younger than 4 months had been already given complementary food, while one third of the children at 7 months old, or even older, had not been given any other food at all.

With respect to frequency of feeding complementary foods the WHO recommendations are:

6-12 months: 3 times a day, if breastfed
5 times a day, if not breastfed
12-24 months: 5 times a day

In our study, 35.6% of the infants at 8 months old received complementary food less than 3 times a day while 68.6% of the infants at 12 months old received complementary food fewer than 5 times a day. Without data on their anthropometric status, we could not say whether the children were deficient. Given their academic success, there was certainly no indication of functional deficits as a consequence of the early feeding practices they experienced.

Previous studies in China found that, the two main complementary foods in rural areas were cereal porridge and wheat flour (Zeitlin &Ahmed 1995; Wang et al. 2002) and poor variety was common. In contrast, in this sample, over 80% of babies were receiving a complex diet that included grains, fruits and vegetables, fish, meat and poultry. By one year of age foods from the animal protein group had increased the most. This finding probably reflected both the higher education levels and higher economic levels of the families.

There were interesting inter-relationships between dietary diversity, education, urbanism and length of breastfeeding. The finding that higher education of the mother was associated with greater diversity might be explained by the following: first, better education led to a better job and higher income level. With more money, parents could afford more variety of foods, especially expensive foods such as meats, eggs and fruits. Second, parents with better education might have more nutrition knowledge and be more likely to make an effort to provide a balanced various diet for their babies. The odd finding concerning the higher diversity mean for the "no education" group may simply be an artifact of the very small number of respondents in that group.

Better educated mothers, with their greater economic means, also breastfed for a shorter period of time, but made up for the loss of nutrients from breastmilk by providing their infants with a more diverse diet. In less well off, less educated families, mothers relied to a greater degree on breastmilk to support their infants' growth. The role of economic factors in the complementary feeding diet was reinforced by the finding that about 40% of the families spent a significant portion of their income on feeding their babies.

The finding that mothers in the largest cities breastfed for a shorter period of time was probably related to the factors above. But it also reflected the social environment in which they lived. In many parts of the world urban mothers stopped breastfeeding very early, much earlier than was reported by the mothers in our study. Nonetheless the various pressures that lead to cessation of breastfeeding when women are pursuing urban lifestyles is still apparent here.

When mothers were asked how much their infants liked the complementary foods they were being fed, there was no difference in their assessments at 8 compared to 12 months. This finding suggested that the decrease in breastfeeding and concomitant increase in dietary diversity was not due to infants' preferences, but to their mothers' decisions.

The finding that extended families fed infants a more diverse diet than nuclear families requires further interviewing to identify its origins. One explanation is that the majority of extended families were comprised of working parents (the mothers and fathers of the interviewers) and their parents. If grandmothers and grandfathers are at home while their sons or daughters are away at work, they may devote more time to food buying and cooking than is the case in a small nuclear family in which both husband and wife are working, as well as taking care of an infant when they return home. Greater attention to the meal may well result in increased diversity, including greater diversity for the infant. A second explanation, not in contradiction to the first, is that in a bigger family there is a greater variety of foods in the home in order to cater to everyone's preferences, and this in turn, may lead to a greater variety of foods being offered to the infant.

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