Selecting an Appropriate Baby Formula Milk and Baby Cereal Food Using Fuzzy Logic

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Abstract:
Infant Formula milk and Infant cereal based formula food is an important factor for a mother to decide. A working mother or a mother who is medically unfit to breastfeed her baby, she has to substitute that with formula milk and formula cereal food to ensure her childs overall growth. It is very necessary to select a good formula milk and formula based cereal food for a Mother. Selection of a bad formula milk and a bad formula based cereal food can cause many diseases in infants such as middle ear infections, eczema, gastrointestinal infections etc. A good formula based product is decided by many factors and percentages of those factors in that product such as total carbohydrate, vitamins, minerals, protein etc. This paper is written with an intention to help a mother select a perfect formula product for her bundle of joy according to her babies health and digestion capability using fuzzy logic.

Keywords: vitamins, minerals, protein, fuzzy logic.

1. Introduction
The right kind of formula milk is very important for the overall growth of the baby and babies brain development. Selecting a right kind of formula milk and right kind of cereal based milk product depends on many factors such as proper quantity of vitamins, minerals, fats etc. in proper percentage. In market there are so many formula milk and cereal based formula food, makes very difficult to decide for a mother to choose the best one. This work is done to make the task of a mother easier using fuzzy logic.

2. Introduction to concept of fuzzy logic
Computers are very good in crunching numbers. Computers are good in solving deterministic problems. We human beings solve many indeterministic problem in everyday life, for example,
1. Healthy person....a person can be termed healthy depending on many factors such as the body temperature, blood sugar, blood pressure. Only depending on the body temperature, a person cannot be termed as healthy. So this is a indeterministic condition.
2. Depressed person...a person may be depresed for various reasons again the degree of depression may be variable.
3. Milk is sweet....the milk is sweet depends on the number of sugar cubes we are adding and the person who is having the milk. Some person can find the milk sweet even with one cube, some with two cubes.

So, there are many such situations in everyday life which are not definite that are solved by human beings. To make the computer also to solve indeterministic cases fuzzy logic is used.

FOR A LONG PERIOD
1. Dinasaurs ruled the earth for a long period (ABOUT MILLIONS OF YEARS SA Y).
2. It has not rained for a long period (say for 6 months).
3. I had to wait for the doctor for a long period (about 6 hours).

This a long period has different interpretations and meaning in different statements. The computer can be made to understand the different interpretation of a long period using FUZZY LOGIC.

3. FUZZY SETS
Defining Fuzzy Sets

In mathematics a set, by definition, is a collection of things that belong to some definition. Any item either belongs to that set or does not belong to that set. Let us look at another example; the set of tall men. We shall say that people taller than or equal to 6 feet are tall. This set can be represented graphically as follow

The function shown above describes the membership of the ‘tall’ set, you are either in it or you are not in it. This sharp edged membership functions works nicely for binary operations and mathematics, but it does not work as nicely in describing the real world. The membership function makes no distinction between somebody who is 6’1” and someone who is 7’1”, they are both simply tall. Clearly there is a significant difference between the two heights. The other side of this lack of distinction is the difference between a 5’11” and 6’ man. This is only a difference of one inch, however this membership function just says one is tall and the other is not tall.
The fuzzy set approach to the set of tall men provides a much better representation of the tallness of a person. The set, shown below, is defined by a continuously inclining membership function.

The membership function defines the fuzzy set for the possible values underneath of it on the horizontal axis. The vertical axis, on a scale of 0 to 1, provides the membership value of the height in the fuzzy set. So for the two people shown above the first person has a membership of 0.3 and so is not very tall. The second person has a membership of 0.95 and so he is definitely tall. He does not, however, belong to the set of tall men in the way that bivalent sets work; he has a high degree of membership in the fuzzy set of tall men.

### Defining Fuzzy Sets Mathematically

Fuzzy sets were first proposed by Lofti A. Zadeh in his 1965 paper entitled none other than: *Fuzzy Sets*. This paper laid the foundation for all fuzzy logic that followed by mathematically defining fuzzy sets and their properties. The definition of a fuzzy set then, from Zadeh’s paper is:

Let $X$ be a space of points, with a generic element of $X$ denoted by $x$. Thus $X = \{x\}$.

A fuzzy set $A$ in $X$ is characterized by a membership function $f_A(x)$ which associates with each point in $X$ a real number in the interval $[0, 1]$, with the values of $f_A(x)$ at $x$ representing the "grade of membership" of $x$ in $A$. Thus, the nearer the value of $f_A(x)$ to unity, the higher the grade of membership of $x$ in $A$.

This definition of a fuzzy set is like a superset of the definition of a set in the ordinary sense of the term. The grades of membership of 0 and 1 correspond to the two possibilities of truth and false in an ordinary set. The ordinary boolean operators that are used to combine sets will no longer apply; we know that 1 AND 1 is 1, but what is 0.7 AND 0.3? This will be covered in the fuzzy operations section.

Membership functions for fuzzy sets can be defined in any number of ways as long as they follow the rules of the definition of a fuzzy set. The shape of the membership function used defines the fuzzy set and so the decision on which type to use is dependant on the purpose. The membership function choice is the subjective aspect of fuzzy logic, it allows the desired values to be interpreted appropriately. The most common membership functions are shown below:

### 3.1 Fuzzy Explanation

As explained earlier Fuzzy Logic is used where situation is indeterministic. Fuzzy Logic is used where we want the computer to act like a human being. In our present work we want to find the best formula milk and a cereal based formula milk product, this is dependent on many factors like fats, carbohydrate, minerals, vitamins, etc and in what percentages they are present in that product, we want the computer to act in a human way, so, fuzzy logic is used.

The essential characteristics of fuzzy logic as founded by ZaderLotfi are as follows.

- In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
- In fuzzy logic everything is a matter of degree.
- Any logical system can be fuzzified.
- In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently, fuzzy constraint on a collection of variables.
- Inference is viewed as a process of propagation of elastic constraints.

### 3.2 Fuzzy Sets

- Uncertainty
  - When $A$ is a fuzzy set and $x$ is a relevant object, the proposition “$x$ is a member of $A$” is not necessarily either true or false. It may be true only to some degree, the degree to which $x$ is actually a member of $A$.
  - For example: the weather today
    - Sunny: If we define any cloud cover of 25% or less is sunny.
    - This means that a cloud cover of 26% is not sunny?
    - “Vagueness” should be introduced.

- The crisp set v.s. the fuzzy set
  - The crisp set is defined in such a way as to partition the individuals in some given universe of discourse into two groups: members and nonmembers.
  - However, many classification concepts do not exhibit this characteristic.
● For example, the set of tall people, expensive cars, or sunny days.
○ A fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in the fuzzy set.
● For example: a fuzzy set representing our concept of sunny might assign a degree of membership of 1 to a cloud cover of 0%, 0.8 to a cloud cover of 20%, 0.4 to a cloud cover of 30%, and 0 to a cloud cover of 75%.

4. PROCESS OF SELECTING A GOOD FORMULA MILK AND A GOOD CEREAL BASED MILK

Infant foods are very sensitive food product available in market. Since these replace mother’s milk or add on to the diet of infant for his/her proper growth, these products are necessary to meet the required quality and safety standards. In recent past many cases of adulteration have been reported, for example adulteration of Melamine in infant foods in China.

The main parameters for which different brands of infant food was tested were, Protein, Fat, Carbohydrate, Vitamins, Minerals, Organoleptic Properties and Micro-biological requirements. Since infant foods replace the mother milk, these are expected to be rich in protein, fat and micronutrients like vitamins and minerals. Organoleptic properties of the infant foods also play an important role in the acceptance of particular product.

Sensory Tests
sensory tests for colour, appearance, flavour/odour, taste and after taste feel to observe the organolaptic properties of these infant foods, because a new born baby also react to these properties of foods which matter for its acceptance.

Breast feeding universally recommended
Breast feeding is universally regarded as the most appropriate form of nourishing the infant. However, when breast feeding is not possible, reliance has to be placed upon alternate sources of nutrients for infant feeding. It is imperative that infant milk substitutes should be properly formulated so that nutritional requirements for optimal growth are met adequately, and that is minimum of physiological stress on the developing organs and enzymatic system of the infant. It is equally important to promote correct feeding practices, so that appropriate use of the infant milk substitute could be made for protecting the health of the infant.

Packaging of baby foods
Baby foods should be packed in hermetically sealed, clean and sound containers or in a flexible pack made from film or combination of any of the substrates made of bo-ard paper, polyethylene, polyester, metallised films or Aluminium foil so as to protect it from deterioration. In case plastic material is used for flexible packaging, only food grade plastic shall be used.

Baby foods free of starch
Starch is a polysaccharide carbohydrate. As an additive for food processing, food starches are typically used as thickeners and stabilizers in food products. As per the Indian Standards, it should be absent in baby foods. Our test found all the brands to be starch free.

All infant food contained minerals as per the requirements
A mineral is a naturally occurring solid chemical substance formed through biogeochemical processes, having characteristic chemical composition, highly ordered atomic structure, and specific physical properties. We tested different categories of baby food for the minerals named Iron, Calcium, Phosphorous, Iodine, Sodium, Potassium, Chloride, Magnesium, Copper, Manganese, Zinc & Selenium. All the brands of baby foods met the requirements prescribed in Indian Standards.

Infant formula supplies vitamins
A vitamin is an organic compound required as a nutrient in tiny amounts by an organism. We tested all categories of baby food for the vitamins named Vitamin A, Vitamin D, Thiamine, Niacin, Riboflavin, Vitamin B6, Vitamin B12, Folic Acid, Panthenothenic Acid, Biotin, Vitamin C, Vitamin k, Nicotinic Acid & Vitamin E. All the brands met the requirements prescribed in Indian Standard for Vitamin Content.

Total Protein
Protein is an essential nutrient in diet. They play an important role in the cellular maintenance, growth, and functioning of the human body. As per the Indian Standards, Protein in Follow-up Formula – Complementary Foods should be between the range of 13.5 to 24.7 g/100g. In Infant Milk Substitutes, it should not be less than 12g/100g. In the Processed Cereal Based Complementary Foods, it should be minimum 15g/100g and in Milk-Cereal Based Complementary Foods, It should not be less than 12 g/100g.

Milk/Total Fat
Fat component adds richness of flavour, contributes to a smooth texture. As per the Standards, it should be in the range of between 18.0 to 27.7 g/100g in Follow-up Formula – Complementary Foods. In Infant Milk Substitutes, it should not be less than 18g/100g and in Milk- Cereal Based Complementary Foods it should not be less than 7.5 g/100g. All the brands we tested have met the minimum requirement prescribed in Indian Standards.

Solubility
Solubility is the property of a solid substance in liquid to form a homogeneous solution of the solute in the solvent. As per the Indian Standard, Solubility percentage of Follow-up Formula – Complementary Foods & Infant Milk Substitutes should be minimum 98.5% by mass. All the brands we tested met the requirement for solubility.

Total Carbohydrate
Carbohydrate is the source of energy. The requirement for carbohydrate content is only for the category of Processed Cereal Based Complementary Foods & Milk-Cereal Based Complementary Foods. As per the Standard, it should not be less than 55g/100g. All the brands met the minimum requirement.

Aflatoxin
Aflatoxin is a kind of toxin or poison produced by the mold Aspergillus flavus. When animals or humans consume these compounds, they may produce severe undesirable health effects. The requirement for Aflatoxin is only for the category of Processed Cereal Based Complementary Foods and it was not detected, hence tested brands got full weightage.
Sensory Tests
This is very important parameter where subjective Panel tests were conducted based on their critical examination and opinion since consumer is very critical on selection of product from retail stores that makes that brand most acceptable/least acceptable in respect of price. During this test, we determine the overall organoleptic (sensory) quality of the product in term of consumption. We conducted the sensory tests against colour & appearance, odour/flavour, taste and after taste feel. These tests were conducted in the lab involving panel members under the supervision of trained experts.

Microbiological Tests
Microbiological contamination is a very serious issue for food products. Microorganisms are responsible for many foods borne disease. We conducted this test for Bacterial count, Coliform count, Staphylococcus aurous, Salmonella, Shigella, E. coli and Teast & Mould. The entire range of microorganisms we tested were found either absent or within the permissible limit.

Heavy Metals
All brands of baby foods for the presence of heavy metals as Lead, Arsenic, Tin, Cadmium and Copper. All the brands of all categories of baby foods were found within the required limit prescribed in Indian Standards.

5. Conclusions
In this paper fuzzy logic has been used to get the best baby formula milk and cereal based milk product. On the basis of the factors mentioned above such as fat, minerals, vitamins, starch, carbohydrate, aflatoxin, etc, giving it as input helps us in getting a perfect formula milk and cereal based formula milk product.

MATLAB/Fuzzy Logic Toolbox has been used to materialize this study.

References