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USE OF CASSAVA FLOUR AS ENERGY SOURCE FOR WEANING FOODS

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INTRODUCTION

In the past twenty years in Congo, cassava-based weaning gruels have been progressively replaced by gruels from fermented corn dough, especially in the urban areas *(1)*.
Prepared by a restricted number of women, these fermented corn dough have low nutritive value becauses of losses during preparation and are sold at high prices which make it difficult for mothers to feed their infants for a long time *(2)*. Gruels traditionally prepared from fermented cassava flour or dough are still used by 20% of mothers, but they are very poor in nutrients such as protein and amino acids.
In addition, given the high swelling capacity of their starch, gruèls from both fermented cassava and corn are prepared 'at low concentrations in order to obtain acceptable consistency for the infant *(2)*. These low concentrations result in very low energy density (average of 60 Kcal/100g of gruel).

All these factors outlined above are responsible for poor weaning practices, which in turn lead to relatively high prevalence of protein-energy malnutrition (20.5% of children less than -2 SD of NCHS reference for height-for-age) *(3,4,5)*.

We therefore undertook a series of research work in order to propose weaning foods with the following characteristics:
- wholesomeness (microbiologically clean, toxin-free and antinutrient-free);
- easy accessibility (availability, low cost and ease of preparation);
- adequate complementation with natural sources of proteins, minerals and vitamins;
- high energy density close to 120 Kcal/100g of gruel, value which is considered adequate for children up to 2 years old because of their small stomach volume *(6,7)*;
- proper fluid consistency acceptable to the infant.

For weaning foods prepared from appropriate mixtures of local raw or semi-processed foods, the real problem lies with obtaining both the last two characteristics in order to reduce what is known as "dietary bulk" *(8,9,10)*.

In this paper we present results on studies aimed at comparing the behaviour of starch from cassava (the most available staple in Congo), rice and corn during the preparation of gruels and at developing processing schemes which can be operated at household level and in cottage industries to solve the problem of dietary bulk.

MATERIALS AND METHODS

1. Materials.

Market samples (Brazzaville) of cassava, rice, corn, soyabean and kidney bean were ground into flour of 0.5mm sieve size in a hammer mill. Samples were ground in the following form: retted and dried cassava slices, whole corn grains, cargo rice, dehulled and toasted soyabean and kidney bean. Amylase-rich flour was prepared from a malted local variety of red sorghum. Malting was carried out as follows *(11,12)*: sorghum grains were cleaned, steeped in water for 24 hours, spread on a humid cloth, let to germinate in the dark for 48 hours, sun-dried for 3 days, rubbed with the hand and blown to remove vegetative parts and ground in a hammer mill.
BAN, an industrial alpha-amylase of bacterial origin was obtained from NOVO NORDISK BIOINDUSTRIE S.A. Its activity as specified by the manufacturer was 800 KNU/g, where a KNU is defined as the amount of enzyme required to hydrolyse 5.26g of soluble starch in 1h at 37°C and pH 5.6.

2. Methods.

Gruels were prepared by cooking suspensions of known weights of flour in 250ml of water on a hot plate for 5mn, after reaching 85°C. They were cooled down at room temperature to 45°C, and viscosity measurements were made using a thermostatic (45°C) HAAKE VT500 rotatory viscometer with a SV-DIN spindle at 64.5 rpm. At the same time, 100g aliquots of gruels were taken for flow-rate determination using a KINEMATICA polivisc at 40-42°C and for time interval of 30s.
Meanwhile, 10g aliquots of gruels were also taken for dry matter determination.

Gruels prepared from a reference cereal-based commercial infant formula (cerelac from NESTLE) was used for comparison.

RESULTS

1. Untreated gruels.

It is shown (figure 1) that for viscosity values between 0.5 and 3.5 Pa.s (considered as acceptable for infants between 4 and 12 months) the concentration of gruels from cassava, rice and corn are comparable. However, for the same viscosity, gruels from cassava have a higher flow-rate than those of rice and corn (figure 2). Consequently, one notices a significant difference in flow-rate of these gruels (figure 3) for the acceptable range 20 to 120 mm/30s. This makes it possible to feed the infant with cassava gruel of slightly higher concentration than rice or corn gruel. In fact, average concentration of cassava-based gruels in Congo is significantly higher ($P<0.05$) than that of corn-based gruels (15.7 and 14.5 g DW/100 g, respectively) *(2)*.

But the highest acceptable concentration is still twice less than that of the reference commercial infant formula. Hence, the need to develop processing schemes for infant food preparation applicable in developing countries.

2. Processes applicable at household level.

Research carried out in the the past 10 years have shown that it is possible to improve the energy density of cereal-based gruels by the addition of plant amylase sources (especially flour from malted cereals) *(10,13,14,15,16)* and/or by fermentation *(17,18,19)*. We therefore tried to do the same for gruels from cassava *(20,21)*.

With respect to fermentation, we noticed, like Mlingi *(18)*, that the retting time and procedure do not cause a noticeable change in viscosity of cassava gruels. In fact, at a concentration of 10g DW/100g of gruel, the viscosity values are 1.92, 1.82, 1.94 and 1.74 Pa.s, respectively, for gruels from unfermented roots, 2-day retted roots, 6-day retted roots and air-fermented roots (grated mash of roots in a porous synthetic bag for 3 days). Hence, retting permits detoxication of cassava roots but does not improve the energy density of gruels therefrom.

On the contrary, the addition of 1 part of flour from malted sorghum to 9 parts of retted cassava flour reduces the viscosity of gruels considerably (figure 4), thus permitting the preparation of gruels twice concentrated and of acceptable consistency. It can be remarked that cassava starch is more susceptible to amylase treatment than corn starch, given that for a viscosity value of 2 Pa.s the concentration increases from 11.0 g DW/100 g for untreated cassava gruel to 22.5 g DW/100 g for gruel treated with sorghum amylase, compared to corresponding values of 11.0 and 13.5 g DW/100g for corn-based gruels (figure 5).
In addition, we compared different ways of preparing gruels from cassava/sorghum (9:1, w:w) in view of selecting those leading to the greatest reduction of viscosity. Instead of the procedure described in methods, the cassava flour was first homogenized in a little volume of cold water, poured into boiling water, let to stand at ambient temperature for 5mn and then cooked for 5mn. In this case, the viscosity reading changed from 5.38 to 1.10 Pa.s for a concentration of 28 gDM/100 g of gruel.

Considering the above, it is possible to obtain gruels with optimum energy density from cassava flour by the use of mimimum amount of malted sorghum flour and an appropriate preparation procedure. Such small quantities of malted sorghum flour can be conveniently prepared in households, even though malting is considered to be a time-consuming process *(22)*.

3. Processes for cottage industries.

Preliminary work in our ORSTOM laboratory in Montpellier showed that it is possible to reduce the water-holding capacity of cassava starch by moderate acid hydrolysis *(23)*. Experiments under various time (24 to 72h), acidity (0.15 to 0.30 N Hcl) and temperature (55 to 60°C) conditions revealed that a cassava flour/water mixture (2:3, w:w) can be hydolyzed into a dough which, on reconstitution (after drying), gives an energy dense gruel of acceptable consistency. Although this process is simple and requires inexpensive equipment its application in cottage industries demands well-trained personel. Besides it is not yet authorized for infant food manufacture. Reasons why we looked for alternative enzymatic procedure with less constraint than that involving the use of plant amylase sources.

Among the wide range of industrially produced food-standard alpha-amylases we chose BAN, an enzyme of *Bacillus subtilis* origin, commercialised in microgranular form, and with optimum activity at pH 6.0 and temperature 72°C.
Figure 6 shows that the addition of moderate amount of BAN to gruels (29 KNU/100g DW) increases the concentration of gruels from the various flours with no apparent change in consistency. The concentration increase is higher for cassava than for rice or corn gruels. At the viscosity level of 2 Pa.s, for example (figure 7), the concentration of cassava gruel is twice that of corn (32 against 16 g DW/100 g).
Additionnal work to define the conditions for using BAN showed that *(24)*:
- the efficiency of the enzyme depends on the source of protein chosen to complement cassava flour (figure 8), given that it is necessary to add twice the amount of enzyme to cassava/kidney bean mixture (62:38, w:w) than to cassava/soyabean mixture (71:29, w:w) to obtain gruels of comparable viscosity;
- its activity is independent of the pH of gruels for values between 5.5 and 9.0 (pH range of half of the locally produced cassava flour in Congo), but drops drastically to zero below or above this range (figure 9);
- the efficiency of the enzyme is slightly affected by the heating rate, considering that the viscosity of cassava/soyabean gruel of concentration 30 g DW/100 g changes from 1.0 to 2.0 Pa.s only for a change of heating rate from 3 to 10°C/min (figure 10);
- 5 minutes of cooking (above 85°C) is enough to inactivate the enzyme and stop further hydrolysis which could lead to excessive liquefaction of gruel during cooling;
- the activity of the enzyme after its addition to the flour stays the same after 5 months of storage in a plastic bag at ambient condition.

The addition of BAN to cassava-based weaning flour produced at cottage industry level seems, therefore, to be an appropriate process for dietary bulk reduction. The enzyme is cheap (25000 KNU per US $), the process does not impose any special constraint (except the use of precision balance and flour with appropriate pH), and the preparation of gruels therefrom can be easily accomplished by mothers.

CONCLUSION

Because of the properties of its starch, flour from cassava roots, devoid of cyanogenic glycosides by retting, and complemented with adequate plant protein sources (soyabean or kidney bean) could constitute an excellent weaning food for developing countries. At the moment, the best procedures to reduce dietary bulk seem to be the addition of appropriate alpha-amylase sources: malted cereal flour at the household level; industrial food-grade enzyme at the cottage industry level.
But another solution would be fermentation under conditions favoring the action of amylolytic microflora. Research effort should be made in this direction.

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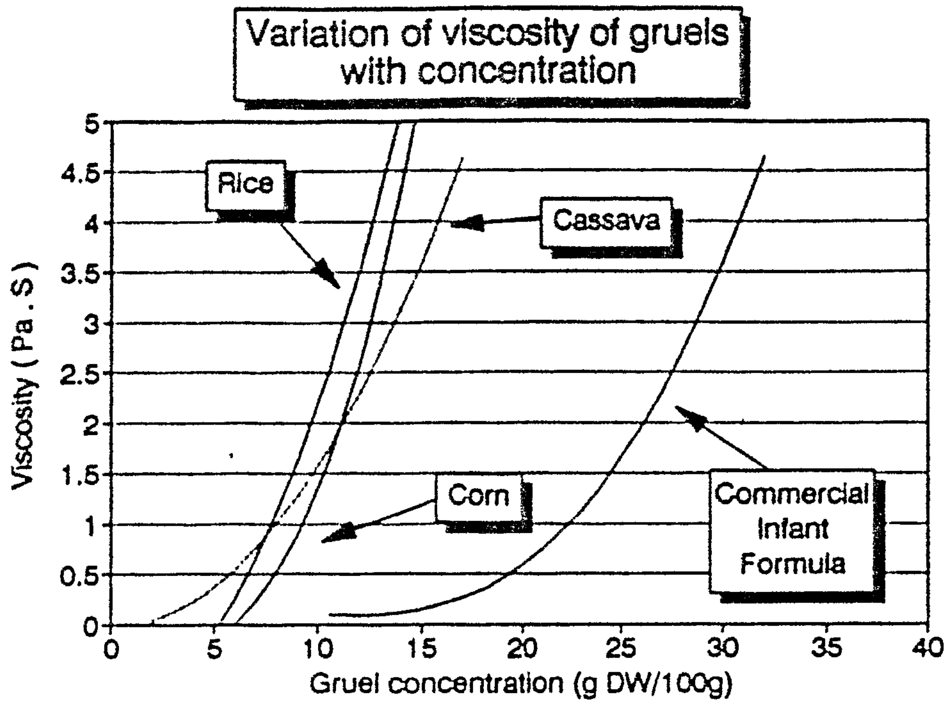
FIGURE 1:



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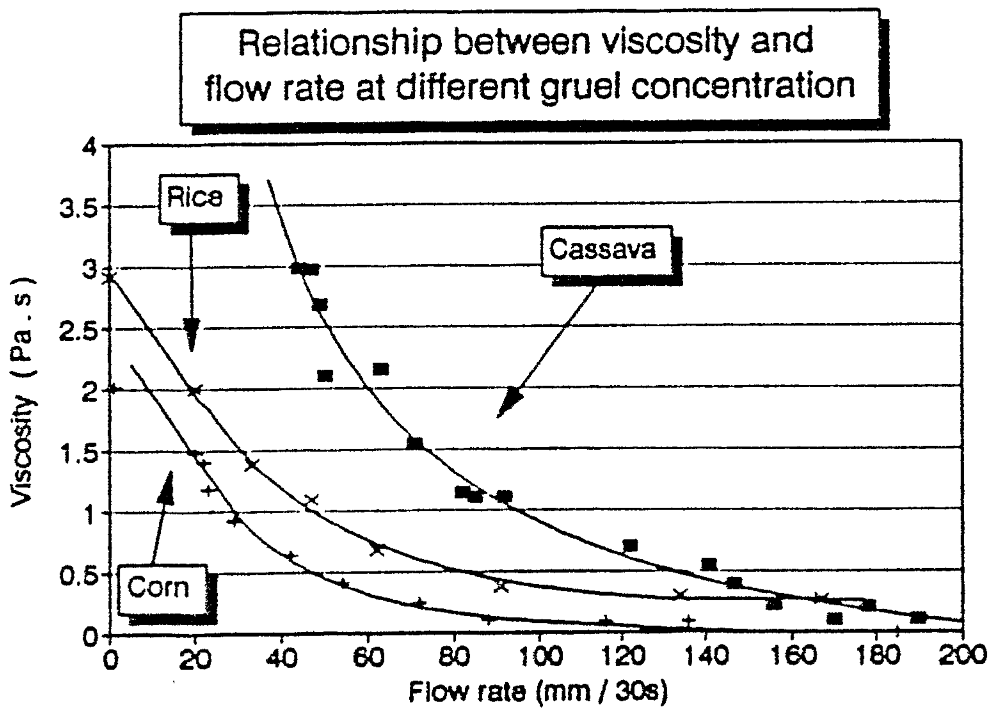

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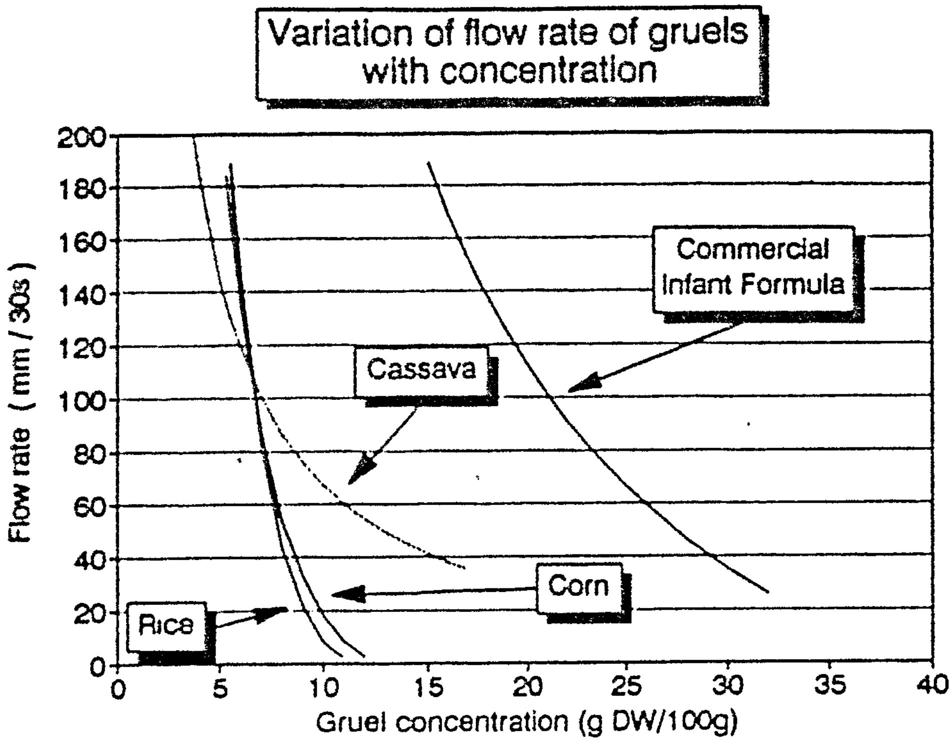

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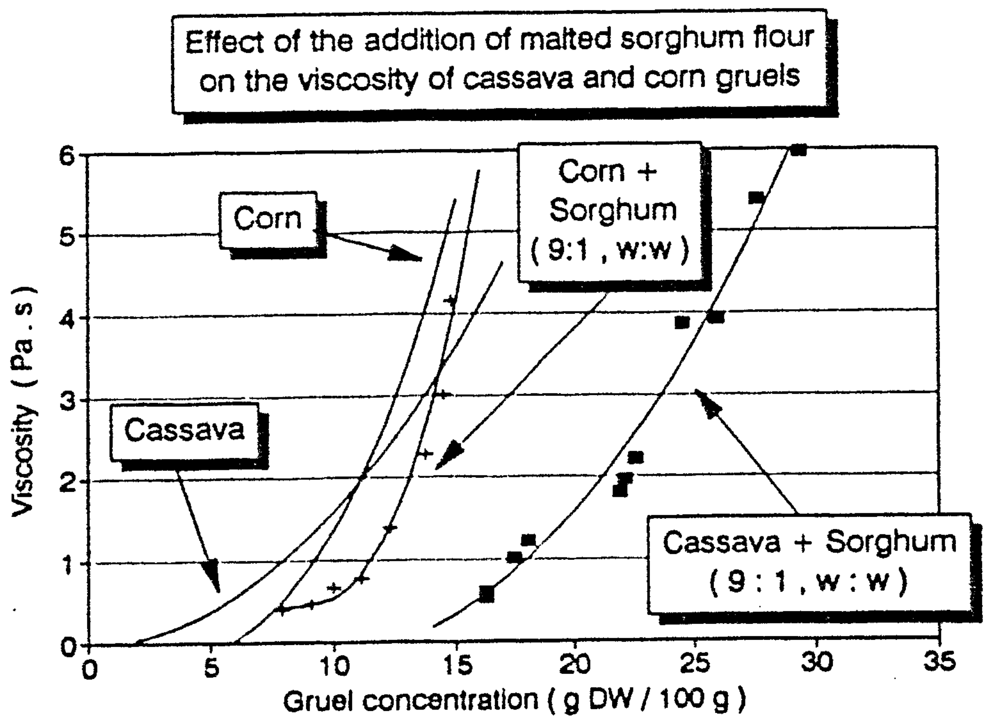

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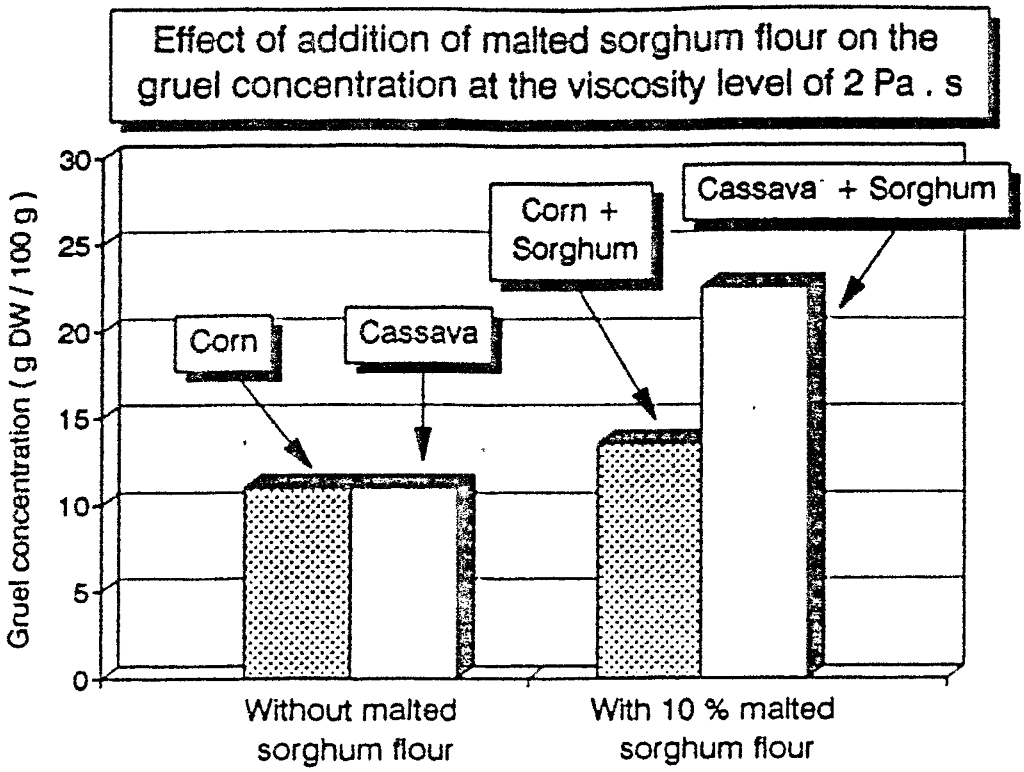

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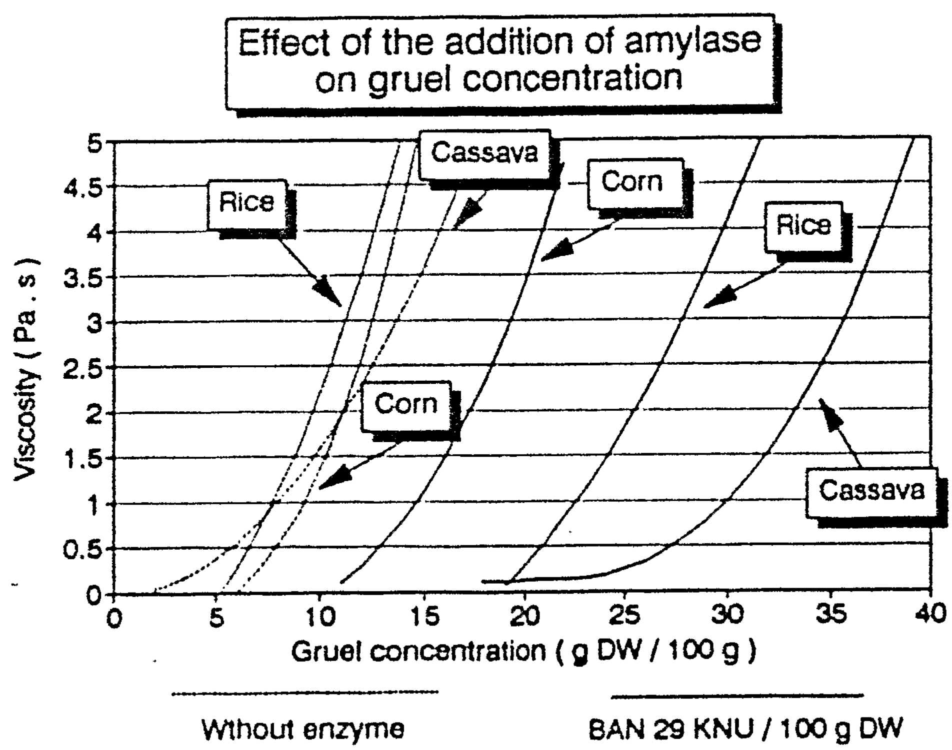

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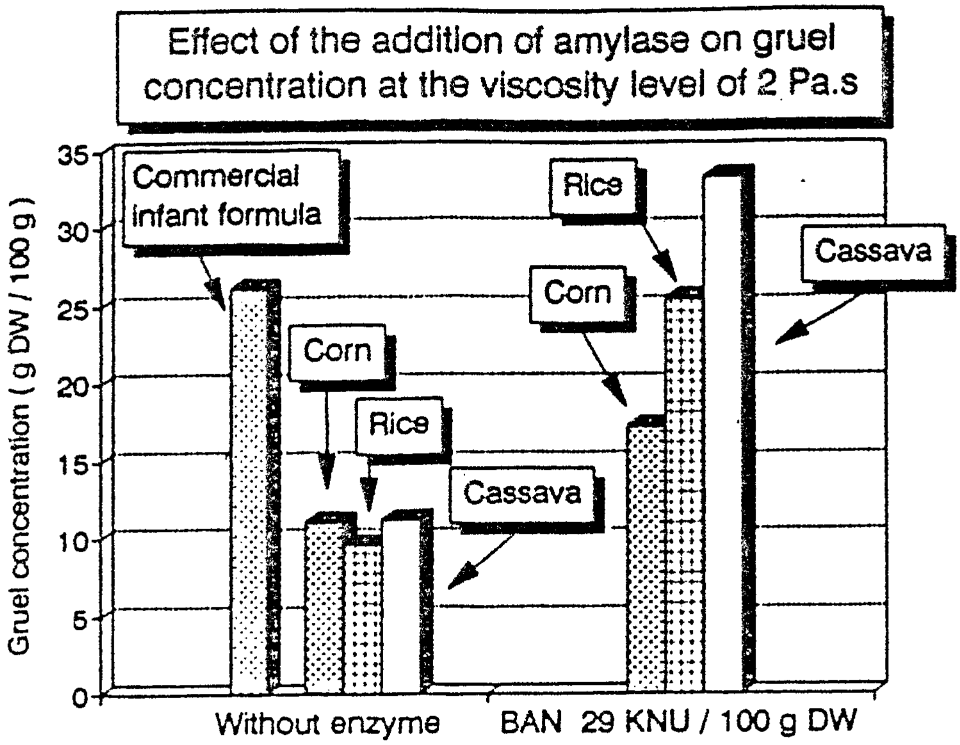

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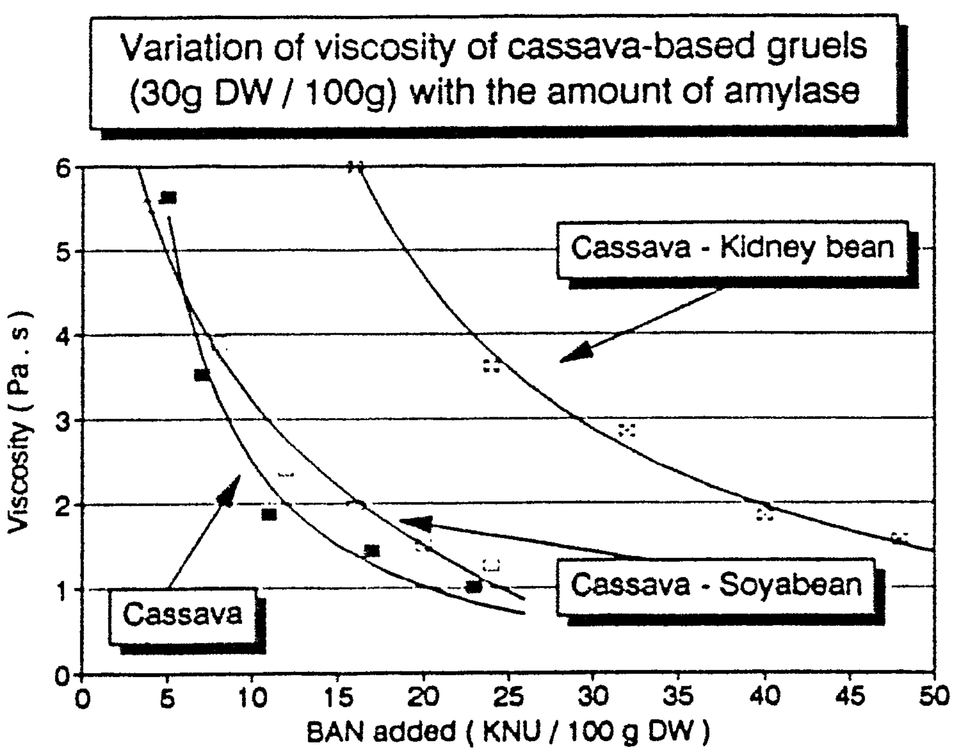
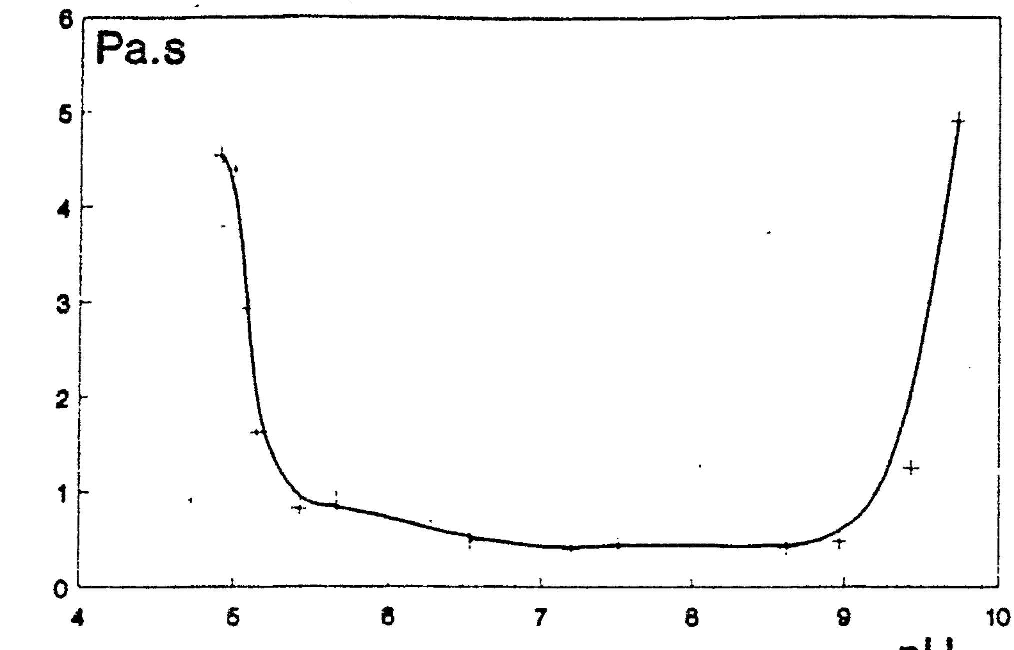


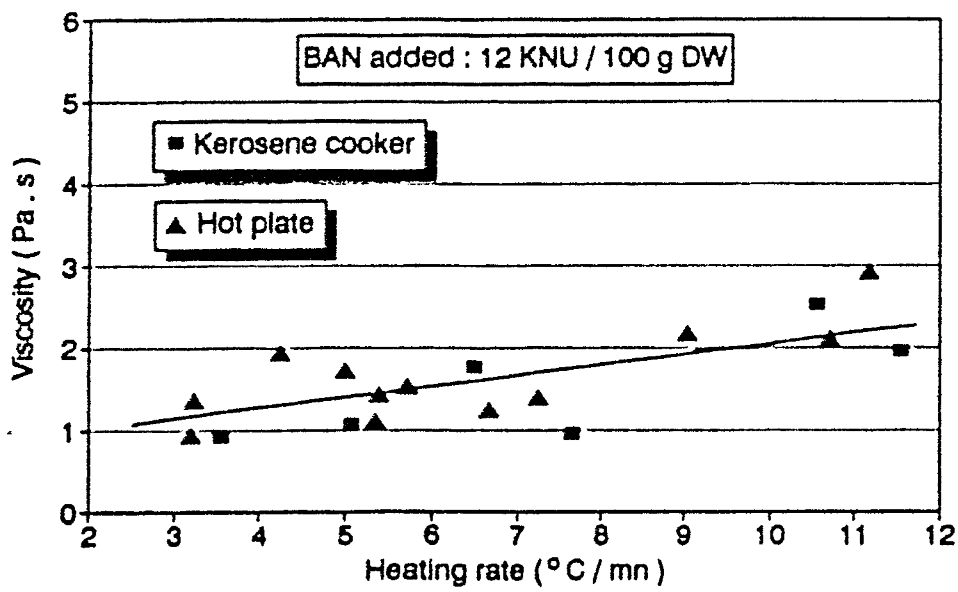
FIGURE 9: VARIATION OF GRUEL VISCOSITY WITH pH OF CASSAVA FLOUR



Cassava gruel prepared at the concentration of 30g DW/100 g

FIGURE 10:

Variation of viscosity of Cassava / Soyabean /Amylase gruel (30g DW / 100g) with the heating rate between 65 and 85° C



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