IDRC-265e

Improving Young Child Feeding in Eastern and Southern Africa

Household-Level Food Technology

Proceedings of a workshop
held in Nairobi, Kenya,
12-16 October 1987

Proceedings

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Il existe également une édition française de cette publication.

28523

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Improving Young Child Feeding in Eastern and Southern Africa

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Cosponsored by
the International Development Research Centre,
the United Nations Children's Fund, and the
Swedish International Development Authority

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IDRC-265e

Improving young child feeding in eastern and southern Africa : household-level food technology; proceedings of a workshop held in Nairobi, Kenya, 11-16 October 1987. Ottawa, Ont., IDRC, 1988. xxi + 380 p. : ill. (Proceedings series/ IDRC)

/Feeding/, /weaning foods/, /infants/, /food technology/, /household/, /East Africa/, /Southern Africa/ - /diet/, /nutritive value/, /risk/, /malnutrition/, /food preparation/, /food hygiene/, /breast feeding/, /traditional culture/, /fermentation/, /cereals/, /conference reports/, /recommendations/.

UDC: 613.22(6) ISBN: 0-88936-516-4

A microfiche edition is available.

Abstract

The weaning period, that is the period in a young child's life when supplementary foods are introduced to complement breast milk, poses great nutritional risk to children in developing countries. By the end of the second year of life, one-third of children in eastern and southern Africa are chronically malnourished. The following factors contribute to the growth faltering commonly observed in weaning-age children: low nutrient intake, high incidence of diarrheal disease (often caused by contaminated weaning foods), and recent declines in duration and intensity of breastfeeding.

Food scientists, nutritionists, and health planners working in Africa and South Asia met in an international workshop to examine household-level food technologies that hold promise for improving nutrition of infants and young children. After reviewing current knowledge of breastfeeding and weaning practices in eastern and southern Africa, participants discussed the use in weaning diets of fermented foods and germinated flour, for both improved nutrient intake by young children and decreased risk of food contamination. Research that should be conducted into the effectiveness of the food technology was identified and its diffusion at the community level discussed.

This publication contains the proceedings, conclusions, and recommendations of the workshop. It is directed at scientists and health planners who are involved in nutrition research and developing programs to improve feeding of infants and young children in developing countries.

Résumé

Le sevrage, c'est-à-dire la période où l'on commence à donner des aliments solides à un jeune enfant en complément du lait maternel, présente de graves risques nutritionnels pour les enfants dans les pays en développement. Dès la fin de leur deuxième année, le tiers des enfants en Afrique orientale et australe souffrent de malnutrition chronique. Les facteurs suivants sont à l'origine du retard de croissance que l'on retrouve couramment chez les enfants en âge d'être sevrés : carence nutritionnelle, forte prévalence des maladies diarrhéiques (qui s'expliquent souvent par la contamination des aliments) et diminution récente de la duré et de l'intensité de l'allaitement maternel.

Des spécialistes des sciences de l'alimentation, des nutritionnistes et des planificateurs de la santé travaillant en Afrique et en Asie du Sud se sont réunis dans le cadre d'un atelier international afin d'examiner des technologies alimentaires applicables au niveau des ménages qui semblent prometteuses pour améliorer la nutrition des nourrissons et des jeunes enfants. Après avoir examiné les connaissances actuelles en matière d'allaitement au sein et les pratiques de sevrage en Afrique orientale et australe, les participants ont discuté de l'utilisation, au cours du sevrage, d'aliments fermentés et de farine germée, tant pour améliorer l'apport nutritionnel chez les jeunes enfants que pour diminuer les risques de contamination des aliments. Ils ont également discuté des recherches qu'il y aurait lieu d'entreprendre sur l'efficacité des technologies alimentaires et sur leur diffusion dans la collectivité.

Cette publication fait un compte rendu des discussions de l'atelier et présente ses conclusions et ses recommandations. Elle s'adresse aux scientifiques et aux planificateurs de la santé qui participent à des recherches en matière de nutrition et à l'élaboration de programmes visant à améliorer l'alimentation des nourrissons et des jeunes enfants dans les pays en développement.

Resumen

El período de destete, es decir, aquel período en la vida de un ni o en que se introducen en su dieta alimentos suplementarios para complementar la leche materna, representa un gran riesgo nutricional para los nin os de países en vías de desarrollo. Hacia el final de su segundo a o de vida, un tercio de los ni os en Africa oriental y del sur muestran se ales de malnutrición crónica. Los siguientes factores contribuyen al crecimiento vacilante que se observa comúnmente en los ni os que se encuentran en edad de dejar la lactancia materna: baja ingestión de nutrientes, alta incidencia de diarrea (a menudo causada por alimentos para el destete contaminados), y nuevas disminuciones en la duración e intensidad de la alimentación proveniente del pecho de la madre.

Científicos del campo de los alimentos, especialistas en nutrición y planificadores de la salud que trabajan en Africa y en el Sur de Asia se reunieron en un taller internacional para examinar las tecnologías de alimentos que se utilizan en el hogar y que prometen bunos resultados en el mejoramiento de la nutrición de lactantes y ni os peque os. Después de analizar el conocimiento que existe actualmente sobre la alimentación recibida a través del pecho de la madre y las prácticas que se utilizan para el destete en el oriente y sur de Africa, los participantes discutieron el uso en dietas para el destete de alimentos fermentados y harina germinada para que los ni os pudan ingerir nutrientes mejorados y haya una disminución en el riesgo causado por la contaminación de los alimentos. Se identificó la investigación que se debe realizar sobre la efectividad de las tecnologías de alimentos y se discutió su difusión en el seno de la comunidad.

Esta publicación contiene las actas, conclusiones y recomendaciones del taller. Está dirigida a científicos y planificadores de la salud que participan en lainvestigación nutricional y en programas de desarrollo para mejorar la alimentación de lactantes y ni os en los países en desarrollo.

CONTENTS

BULK REDUCTION OF TRADITIONAL INDIAN WEANING GRUELS

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Abstract *Amylase-rich foods (ARFs) were prepared from pearl millet (Pennisetum typhoideum), from maize, and from sorghum. Sun drying of these grains yielded ARFs of maximum amylase activity (1248 and 1855 maltose units for maize and sorghum, respectively). Roasting in a traditional iron pan lowered the amylase activity drastically. It was found, however, that roasted ARFs had a prolonged shelf life of 21 days, whereas sun-dried ARFs had a shelf life of only 7 days. Also discussed is the effect of different solids concentrations on the viscosity of the gruels. Acceptability trials were conducted to compare the mean intakes of gruels with and without ARF, by infants and by toddlers. Because the method of ARF preparation is traditional, simple, and inexpensive, it can be transferred to house-holds at the village or community level.*

In India, the first or early introductory foods for infants and toddlers are gruels made from staple flours such as rice, wheat (Triticum aestivum), bajra (Pennisetum typhoideum), maize (Zea mays), and sorghum (Sorghum vulgare) (Jelliffe 1968; ICMR 1977). The starch granules in these staple flours swell on cooking; this in turn contributes to the bulkiness or dietary bulk of these gruels, giving a low caloric density per unit volume of food consumed. Older infants (over 6 months of age) or young toddlers (13-36 months) cannot ingest sufficient amounts of such preparations to fulfill their daily energy requirements (Nicol 1971; Rutishauser 1975; Hellstrom et al. 1981; Cameron and Hofvander 1983). It is vital, therefore, that simple means be established whereby the caloric density of traditional weaning foods may be enhanced.

For the last 7 years, the Department of Foods and Nutrition of Maharaja Sayajirao (M.S.) University, Baroda, Gujarat, India, has been working extensively with fully malted multimixes made from combinations of cereals such as wheat, rice, or ragi (Eleusine coracana), of pulses such as bengal gram (Cicer arietinum) or green gram (Phaseolus aureus), and of oilseeds such as groundnut (Arachis hypogaea). When compared with their roasted counterparts, the hot paste slurries of these malted multimixes were found to have much lower viscosity or dietary bulk, higher levels of acceptability with mothers and children, and significantly higher intake levels per sitting among older infants or those used by the Nutrition Mobile Team Program, all the children toddlers. The overriding constraints with regard to the use of these malted multimixes were, however, the time, labour, and space required for their production. These factors proved to constitute a strong barrier to the transfer of the technology to the community or household (Tajuddin 1980; Gopaldas et al. 1982; Gopaldas 1984).

Malleshi and Desikachar (1982) reported that because of its high amylase content, a 5% addition of malted barley flour substantially reduced the viscosity of a 15% hot paste slurry of branded Indian weaning foods such as Nestum, Farex, Cerelac, and Balamul. In 1983, the Tanzania Food and Nutrition Centre (TFNC) reported that small quantities of germinated sorghum flour, or "power flour" (P.F.), when added to traditional African gruels made from sorghum flour, could effectively thin these viscous gruels (Mosha and Svanberg 1983).

Despite the value of the preliminary observations of Malleshi and Desikachar (1982), and of the work of the TFNC group, further research needs to be undertaken on the production and shelf life of amylase-rich food (ARF), and on the acceptability and intake, in rural and slum settings, of traditional gruels with and without ARF.

In our department, the concept of ARF has been studied in depth with respect to the foregoing parameters. In this paper, we bring together relevant data from three dissertations on the reduction of the dietary bulk in gruels made from rice (Gopaldas et al. 1986), from maize (Kapoor 1986), and from jowar (Chaudhary 1986); this reduction was effected by the addition of bajra, maize, and jowar ARFs, respectively.

Preparation of Bajra, Maize, and Jowar ARFs

As can be seen from Table 1, the optimum conditions for the development of the three ARFs were found to differ. Through a process of trial and error, we now know that steeping the grains for more than 12 h (or overnight) results in the leaching of starch. In our earlier attempts with bajra ARF, we considered "kadai" (the traditional iron frying pan) roasting and the production of a malt to be important. This was found, however, to result in greatly reduced amylase activity in the ARF (Table 2). Oven drying at 50°C conserves the amylase activity; such a procedure is not, however, feasible in village homes. In our latest studies, sun drying, in which ambient temperatures of 40 ± 2°C are attained, appears to be the most suitable technology to be transferred to village homes. Sun-dried samples have high levels of amylase activity (Table 2). In India, germination of grains is universally known and practiced, as is the sun drying of vegetables, fruit slices, etc., to prolong their shelf life. The methodologies proposed for ARF preparation - steeping, germination, and drying - are easily within the competence and understanding of any modest Indian home.

We wish to stress here the importance of the removal of all vegetative parts (rootlets and shoots) from the germinated sorghum grains before milling. Recent studies on the sprouting of sorghum have reported a marked increase in the hydrocyanic acid content of sprouts. The average amount of hydrocyanic acid (61.3 mg) obtained

Table 1. Optimum conditions for production of bajra, maize, and jowar ARFs.

Stages of production	Bajra ARF	Maize ARF	Jowar ARF
Steeping	2 h in equal volume of water	12 h in double the volume of water	12 h in double the volume of water
Germination	72 h in wet muslin cloth	96 h in wet muslin cloth	72 h in wet muslin cloth
Air drying	Until dry to touch, about 12 h	-[a]	-
Sun drying	-	Until dry to touch, about 8 h at 40 ± 2°C	Until dry to touch, about 8 h at 40 ± 2°C
Oven drying	-	Until dry to touch, about 5 h at 50°C and subsequent removal of vegetative portion	Until dry to touch, about 5 h at 50°C and subsequent removal of vegetative portion
Roasting	15 min till brown colour and malt aroma developed	-	-
Milling	To fine powder in commercial mill	To fine powder in electric mill	To fine powder in electric mill
Storage	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars	150 g of ARF in 200 gauge polythene bags, heat sealed and kept in airtight glass jars

[a] -, steps not carried out in the production of that particular ARF.

from the sprouts of 100 g of seeds (dry-weight basis) exceeds the fatal dose for an adult (Panasiuk and Bills 1984). We therefore took the precaution of removing the vegetative parts from the sorghum seeds before milling by hand abrasion. The TFNC group has been including the vegetative parts of germinated sorghum in the P.F.; in the matter of child feeding, this is of paramount importance. As with any other cereal grains, the desprouted grains can be sent to a local miller for grinding. In the case of small batches of grains, a household stone mill (one flat circular stone atop another), a metal mortar and pestle, or a flat grinding stone can be used; these are tools that are available and very frequently used in almost every Indian home.

A batch of 500 g of ARF can be kept for 1-3 weeks, under conditions of ambient temperature and relative humidity (Table 3).

Table 2. Amylolytic activity (mg maltose/g ARF) of pearl bajra, maize, and jowar ARFs.

	Roasting	Oven drying (5 h, 50°C)	Sun drying (8 h, 40 ± 2°C)
Bajra ARF	99.9	-[a]	-
Maize ARF	-	1263	1248
Jowar ARF	-	1608	1855

[a]-, steps not carried out.

Table 3. Shelf life of bajra, maize, and jowar ARFs.

		Bajra ARF (R)[a]		Maize ARF (S)		Jowar ARF (S)	
Specification	**IS/PFA specification**	**0 day**	**21st day**	**0 day**	**21st day**	**0 day**	**21st day**
Moisture content	10%	3.47	8.10	10.77	11.95	5.86	7.63
Alcoholic acidity	0.12% (as H_2SO_4)	0.026	0.042	0.036	0.0357	0.030	0.069
Peroxide value	10 mg/g	0.95	6.27	nil	nil	nil	nil
Free sugar	No specification	10.31	4.78	13.14	12.12	8.80	8.41
Bacteriological count	50000/g of ARF	29166	46500	-[b]	-	-	-

[a] R, roasted for 15 min; S, sun dried for 8 h at 40 ± 2°C.
[b] -, not carried out for that particular ARF.

During this period, there will be sufficient food for a small amount of ARF to be used daily for the thinning of gruels for two children under 3 years of age. Furthermore, a batch of 500 g of pearl millet bajra ARF, maize ARF, and sorghum ARF would cost the mother only about INR 1.15, 1.50, and 1.15, respectively (as of 1987, 13 Indian rupees [INR] = 1 United States dollar [USD]).

Shelf Life Studies

Using standard procedures (Gopaldas 1984), the shelf life of the ARFs was assessed in terms of moisture content, alcoholic acidity, peroxide value, free sugar, and bacteriological count. The ARF samples were stored in heat-sealed, 200-gauge polythene bags and were drawn on days 0, 7, 14, 21, and 28 for analysis. Table 3 gives information on values obtained on 0 day and on the last acceptable day, and shows the IS and PFA specifications for these parameters.

The data indicate that two important factors determine the shelf life of an ARF: these factors are, firstly, the fat content of the cereal used, and second, the moisture content of the ARF. The ARF from maize (with a fat content of 6%) had a poor shelf life, as indicated by its high alcoholic acidity - a measure of the degree of deterioration in the fats. Moisture is necessary for survival and multiplication of microorganisms; because of the roasting treatment applied, the ARF from bajra (a low-fat grain) had a low-moisture content and therefore a good shelf life. Currently under investigation is the possibility that the shelf life of ARF from low-fat grains can be extended by toasting sun-dried grains on a flat griddle over charcoal embers (low heat) until the grains are brittle.

Amylolytic Activity of the ARFs

Processing conditions, especially temperature, are important in determining the amylolytic activity of ARF. Amylase activity (Bernfield 1955) in ARF varies according to whether preparation is by roasting, oven drying (50°C), or sun drying (40 ± 2°C) (Table 2). The reduction in amylase activity is marked with an increase in processing temperature. Malleshi and Desikachar (1986) reported amylase activity of 150 and 170 mg maltose/g of malt for maize and jowar, respectively, germinated for 96 h and kilned at 70°C. Because our main aim was to use ARF as catalytic agents to lower the viscosity of gruels, it was desirable to obtain an ARF with maximum catalytic activity; this was achieved by sun drying, a simple and familiar procedure, followed by toasting on a flat griddle over charcoal embers; this produced an ARF with a shelf life of 2-3 weeks, and also conserved amylase activity.

Viscosity Reduction of Gruels

Gruels with a viscosity of 50,000 cP or more are dough-like; those between 10,000 and 40,000 are very thick and nonspoonable; those between 6000 and 10,000 are thick and spoonable, with drop-batter consistency; those between 3000 and 6000 are easily spoonable and of pour-batter consistency; those between 1000 and 3000 have a thick, soup-like consistency; and those less than 1000 are free-flowing liquids. The gruels were prepared as shown in Table 4. Bajra ARF was added to rice gruel (as rice cannot be germinated to prepare ARF), maize ARF to maize gruel, and jowar ARF to jowar gruel. Although a striking reduction in viscosity was obtained in the gruels to which ARF was added, the caloric content of the gruels (10% rice gruel, 15% maize gruel, 10% jowar gruel) was very low. Increasing the solids concentration to 25% increased the caloric content by 1.5 times in the case of maize gruel, and 2.5 times in the case of rice and jowar gruels. At levels of even 16% or above of solids concentration, it was not possible to reduce the viscosity of 25% rice gruel below 6800 cP with the addition of ARF; the gruel was, however, spoonable. Twenty-five percent maize and sorghum gruels with 10 and 8% ARF, respectively, had thick, soup-like consistency. Several investigators (Malleshi and Desikachar 1982; Mosha and Svanberg 1983) have reported that gruels with viscosities of 1000-3000 cP are appropriate for child feeding. Our current studies have shown that mothers prefer to feed their children with thick, spoonable gruels (2000-6000 cP) rather than with thin, free-flowing gruels (1000 cP). If, therefore, the solids concentration and the level of ARF are increased to obtain a gruel of the desired consistency, the caloric densities of these gruels will be increased proportionately.

Table 4. Optimum levels of ARF and Takadiastase required for effective thinning of gruels.

Amount of flour (g)/200 mL gruel	Water (mL)/ 200 mL gruel	ARF[a] or Takadiastase[b] (g)	Viscosity (cP)	kcal/200 mL gruel
Rice gruel 10%				
20.0	180	-	2780	-
19.0	180	0.8[a]	312	69
19.2	180	0.4[b]	325	-
Rice gruel 25%				
50.0	150	-	37200	172
42.0	150	8.0[a]	6800	-
Maize gruel 15%				
30.0	170	-	3750	-
28.5	170	1.5[a]	440	103
28.5	170	1.5[b]	1100	-
Maize gruel 25%				
50.0	150	-	30000	171
45.0	150	5.0[a]	1800	-
Jowar gruel 10%				
20.0	180	-	3100	-
19.4	180	0.6[a]	300	70
19.4	180	0.6[b]	1200	-
Jowar gruel 25%				
50.0	150	-	12000	175
46.0	150	4.0[a]	1800	-

Note: Brookfield Viscometer LVT Model No. 50 was used for viscosity measurements.

For the intake trials, porridges were prepared using cereal flour. Jaggery (unrefined brown sugar) was added at the level of 40% of the weight of flour for rice and jowar gruel, and for maize gruel at 60% level. Oil was incorporated at the 20% level. The additional effect was studied of jaggery and oil on viscosity reduction; the results are presented in Table 5. The data show that the predominant reduction in viscosity was caused by the ARF alone. Although the decrease in viscosity with the addition of jaggery and oil was not remarkable, there was a significant increase - by 200% - in caloric content. We see, therefore, that the incorporation of jaggery and oil at optimum levels not only improves the palatability of the gruels, but also markedly increases their caloric density.

Intake Studies

Gruels were prepared from rice, maize, and jowar, with and without ARF (Tables 6 and 7). Children were carefully pair-matched for age and randomly assigned either to the control or to the experimental group. The intake trials were conducted from 11:30 A.M. to noon each day, for 7 days; this generally ensured a gap of 1-1.5 h from the last home-diet feed. A serving of 100 mL of gruel (control gruel without ARF, or experimental gruel with ARF) was then offered to the subject, who was fed by his or her mother. The investigators prepared the gruel in bulk every day of the trial, at the site of feeding. Feeding time for gruel consumption was limited to 30 min. If the child finished the first serving, he was offered another 100 mL of gruel. Plate waste was measured, and the net intake/child per sitting recorded. Although the infants (6-12 months) and toddlers (13-36 months) consumed significantly higher amounts of porridge with ARF, the caloric intake was poor. Mosha and Svanberg (1983) have calculated that a child should consume 1200 mL of sorghum gruel with germinated sorghum flour (16.15 g ungerminated sorghum flour + 0.85 g germinated flour/100 mL of gruel) to meet 60% of his or her daily energy requirements (total caloric requirements = 1180 kcal). Two points have, however, arisen consistently in our intake trials: firstly, the mean gruel intake per sitting did not exceed 100 mL for infants and 150 mL for toddlers; secondly, because most of the mothers

Table 5. Reduction in viscosity of gruels on addition of jaggery and oil.

Amount of flour (g/200 mL gruel)	ARF (g)	Water (mL)	Jaggery[a] or oil[b] (g)	Viscosity (cP)	kcal/ 200 mL gruel
15% maize gruel					
30.0	-	170	-	3750	103
28.5	1.5	170	-	440	103
28.5	1.5	170	18[a]	160	172
28.5	1.5	170	18[a] + 6[b]	140	226
10% jowar gruel					
20.0	-	180	-	3100	70
19.4	0.6	180	-	300	70
19.4	0.6	180	8[a]	60	101
19.4	0.6	180	8[a] + 4[b]		137

Table 6. Composition of 100 mL rice, maize, and jowar gruel.

Flour (g)	ARF (g)	Jaggery (g)	Oil (g)	Water (mL)
Rice gruel, control (10.0)	-	4	2	90
Rice gruel, experimental (9.6)	0.4[a]	4	2	90
Maize gruel, control (15.0)	-	9	3	85
Maize gruel, experimental (14.25)	0.75[b]	9	3	85
Jowar gruel, control (10.0)	-	4	2	90
Jowar gruel, experimental (9.7)	0.3[c]	4	2	90

[a]Bajra ARF.
[b]Maize ARF.
[c]Jowar ARF.

Table 7. **Mean intake of gruels with and without ARF by infants (6-12 months) and toddlers (13-36 months).**

	Mean gruel intake (mL)		Mean calorie intake (kcal)	
Type of porridge	**Infants (n=15)**	**Toddlers (n=15)**	**Infants**	**Toddlers**
10% rice gruel, control	55.70 ± 0.96	-[a]	38	-
10% rice gruel, experimental	107.60 ± 1.10[b]	-	72[b]	-
15% maize gruel, control	42.00 ± 6.40	86.00 ± 6.50	50	97
15% maize gruel, experimental	102.00 ± 10.50[b]	156.00 ± 10.04[b]	113[b]	170[b]
10% jowar gruel, control	65.61 ± 8.45	99.28 ± 8.15	46	69
10% jowar gruel, experimental	115.28 ± 9.75[b]	186.32 ± 14.61[b]	78[b]	131[b]

[a] -, steps not carried out.
[b] Highly significant ($p \leq 0.05$).

from low socioeconomic groups in India work away from home and cook only once or twice a day, it would not be feasible to feed the children this gruel more than three times a day. The solution, therefore, would be to increase the caloric density by increasing the percentage solids concentration, and by incorporating jaggery and oil at optimum levels. A 25% gruel with ARF would provide 200 kcal/100 mL, compared with the 80 kcal provided by 10% gruels with ARF. Assuming that 100 mL is consumed twice a day, this gruel could meet a third of the child's total daily caloric requirements (ICMR 1981).

Conclusions

In selecting grains for ARF preparation, those with low fat and high starch content should be chosen. For the preparation of ARF, those methods should be employed that are simple enough for easy adaptation to the household level. Sprouts or the total vegetative parts should be removed before milling. For extended shelf life, the grains should undergo prolonged sun drying, followed by light toasting.

It should be remembered that staples such as rice and sago cannot be germinated. Gruels can, however, be prepared from these staples; ARF from other cereals or millets (such as wheat, bajra, jowar, maize, and ragi) consumed in the particular region can then be added to reduce the viscosity of the gruels. These gruels should be made as calorie-dense as possible by an increasing of the solids concentration parts should be removed before milling. For extended shelf life, the grains should undergo prolonged sun drying, followed by light toasting.

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Acknowledgments

We acknowledge the help rendered by Hemangini Gandhi, Sonia Kapoor, Ashu Chaudhary, and Suneeta Deshpande, graduate students, M.S. University, in preparing the manuscript.

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