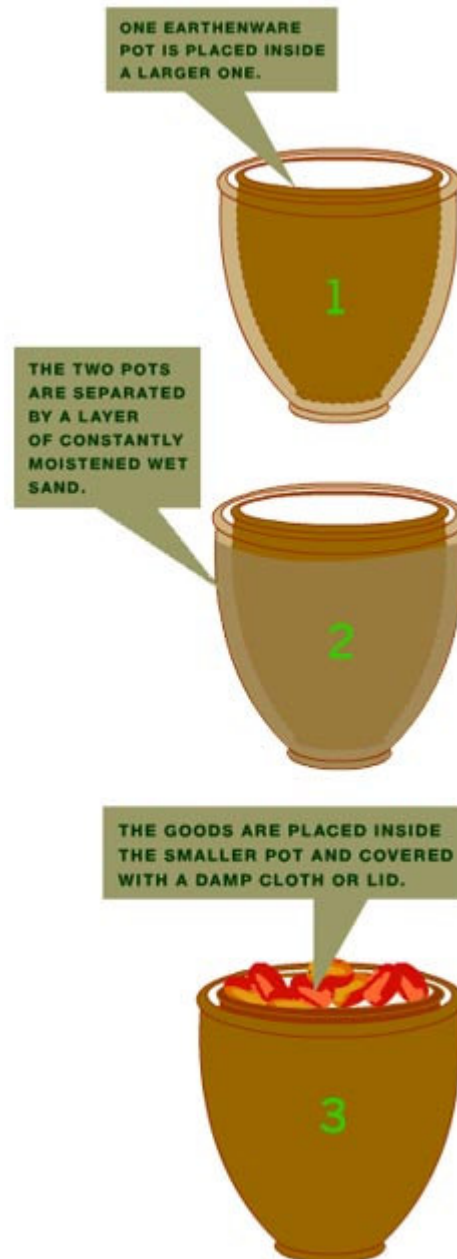


Here's how it works.

You take two earthen pots, both being the same shape but different sizes, and put one within the other. Then, fill the space between the two pots with sand before pouring water into the same cavity to make the sand wet. Then, place food items into the inner pot, and cover with a lid or damp cloth. You only need to ensure the pot-in-pot refrigerator is kept in a dry, well-ventilated space; the laws of thermodynamics does the rest. As the moisture in the sand evaporates, it draws heat away from the inner pot, cooling its contents. The only maintenance required is the addition of more water, around twice a day.



Development of a low-cost cooler to preserve perishable foods in countries with arid climates



Mohammed Bah Abba has recently been awarded the Rolex Award for Enterprise for his role in the refinement of an ancient technology to meet the needs of modern life in Nigeria. Mohammed Bah Abba took the traditional pot-in-pot cooler and adapted it. The principles of the technology are very simple. When heated by the sun, water contained in wet sand between two jars evaporates, cooling the contents of the inner pot. A range of traditional fruits and vegetables such as spinach, tomatoes, onions and other perishable goods can all be preserved for longer periods.

Introduction

Northern Nigeria is an impoverished region where people in rural communities eke out a living from subsistence farming. There is no electricity, therefore refrigeration is not possible. As a result, perishable foods spoil within days. The loss of foods is not only wasteful, it poses food safety hazards and loss of potential income for farmers who are forced to sell immediately after harvest.

In northern Nigeria, the art of pottery is deeply rooted in African culture.

Traditionally, all manner of vessels, from cooking pots to wardrobes, are moulded from clay, but today they have largely been replaced by aluminium containers. Mohammed Bah Abba grew up in a family of pot-makers and was therefore familiar with working with clay. His idea of making a low cost fruit and vegetable cooler grew from his interest in traditional simple technology and his desire to help the rural poor of northern Nigeria.

The technology

The innovative cooling system that Abba developed in 1995 consists of two earthenware pots of different diameters, one placed inside the other. The space between the pots is filled with wet sand that is kept constantly moist, thereby keeping both pots damp. Fruit, vegetables and other items such as soft drinks are put in the smaller inner pot, which is covered with a damp cloth and left in a very dry, ventilated place. The water contained in the sand between the two pots evaporates towards the outer surface of the larger pot where the drier outside air is circulating. The evaporation process causes a drop in temperature of several degrees, cooling

the inner container and extending the shelf-life of the perishable food inside.

Abba carried out several trials with the pot, consistently refining the invention over a two year period. He found that aubergines would stay fresh for 27 days instead of three, tomatoes and peppers lasted for up to three weeks and African spinach, which spoils after one day in the intense tropical heat, remained edible for 12 days.

After several refinements to the prototype pot, Abba was satisfied with the invention and then went about making it available to local rural communities. He employed some of the local unemployed pot makers to produce an initial batch of 5000 pots. These cost about US\$0.30 per cooler to produce. These pots were distributed, free of charge, to five villages in Jigawa, northern Nigeria. Later, in 1999, Abba built additional pot-making facilities and produced a further 7000 pots that were supplied to another 12 local villages. Abba estimates that almost three quarters of rural families in Jigawa are now using his cooling device.

Impacts of the pot-in-pot cooler on rural lives

There are several beneficiaries and benefits of the new pot-cooler:

- Farmers can control the selling of their produce, selling on demand rather than rush-selling to avoid spoilage. They can therefore command higher prices for their goods
- Young girls who would traditionally have to sell the family produce on a daily basis, can now reduce this to once per week and as a result have more time available to attend school. The number of girls enrolling in primary schools is rising
- Married women can sell food from their homes and therefore reduce their dependency on husbands as the sole providers
- Fresh fruits and vegetables are available for longer periods, thereby increasing the variety of the diet
- Improved food storage facilities means that there are fewer outbreaks of food-related illnesses and disease
- Pot making generates significant rural employment opportunities, thereby

keywords

Storage, low-cost refrigeration, food spoilage, evaporative cooling, fruit and vegetables



Nigeria

Africa

slowing the pace of rural exodus to the cities.

Following the resounding success of the cooler-pot in Jigawa State, Abba will soon start to distribute the cooler in the four neighbouring States. One of the biggest obstacles he is trying to overcome is educating the villagers about the new technology. To do this he has devised an educational campaign tailored to village life and the illiterate population. He has made a video recording of the cooler pot, that he plays on a cloth screen with a portable projector and generator. He shows the video in the evening since that

is when farmers return from the fields and are keen to watch an entertaining presentation.

Abba has recently started to sell the pots at US\$0.40 per pair, which is US\$0.10 higher than the original production cost. He uses the profit to further develop and expand production. His aim is to export the pot cooler to other hot, dry countries where cold food storage is a problem.

This extract is taken from the article – the Winners of the *Ninth Rolex Awards for Enterprise*, which can be found on the internet at <http://www.rolexawards.com/laureates/home.html>



MOHAMMED BAH ABBA

Manufacture and supply an innovative earthenware cooling system to preserve perishable foods in developing countries with arid climates

Northern Nigeria is an impoverished region where people in rural communities eke out a living from subsistence farming. With no electricity, and therefore no refrigeration, perishable foods spoil within days. Such spoilage causes disease and loss of income for needy farmers, who are forced to sell their produce daily. Nigerian teacher Mohammed Bah Abba was motivated by his concern for the rural poor and by his interest in indigenous African technology to seek a practical, local solution to these problems. His extremely simple and inexpensive earthenware “Pot-in-Pot” cooling device is starting to revolutionise lives in this semi-desert area.

The art of pottery is deeply rooted in African culture. In northern Nigeria, earthenware pots have been used since ancient times as cooking and water storage vessels, coffins, wardrobes and banks. Today, these clay pots are almost extinct, replaced by aluminium containers and more modern methods of burying the dead, storing clothes and saving money.

Born into a family of earthen pot makers and raised in the rural north, Mohammed Bah Abba was from an early age familiar with the various practical and symbolic uses of traditional clay pots. As a child he learned the rudiments of pottery making and was struck by how the clay figures he moulded were water retentive and remained intact even when dry, unlike items made from other soils. Subsequently studying biology, chemistry and geology at school, Abba unravelled the technical puzzle that led him years later to create the “Pot-in-Pot Preservation/Cooling System”.

The 36-year-old teacher has been selected as a Rolex Laureate for this ingenious technique that requires no external energy supply to preserve fruit, vegetables and other perishables in hot, arid climates. The Pot-in-Pot cooling system, a kind of “desert refrigerator”, helps subsistence farmers in northern Nigeria by reducing food spoilage and waste and thus increasing their income and limiting the health hazards of decaying foods. “I invented the Pot-in-Pot system to help the development of the rural poor in a cost effective, participatory and sustainable way,” says Abba.

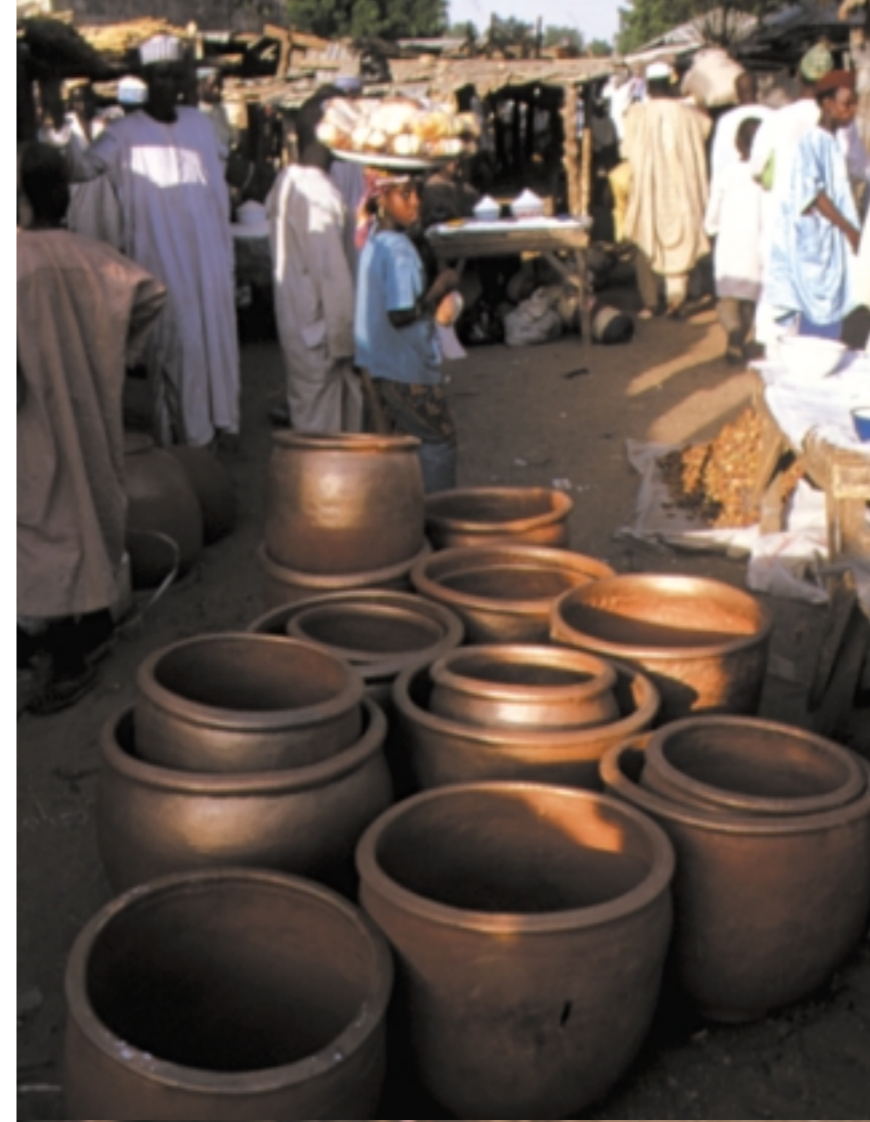
Semi-desert scrubland, subsistence farmers and lack of electricity

To understand the relevance of Abba’s Rolex Award-winning project, it is necessary to look at the geography of northern Nigeria and the restricted lives led by the people. This region is primarily a semi-desert scrubland inhabited by a large, mostly agriculture-based population, the majority of whom live in abject poverty.

Polygamy is a dominant feature of the family structure, and women, living in purdah, are confined to their homes and seriously disadvantaged in terms of health care, education and employment opportunities. Young girls are particularly enslaved because they are forced to go out each day and quickly sell food that would otherwise perish, in order to add to the meagre family income.

Fundamental to the Pot-in-Pot project is the lack of electricity in most of the northern rural communities, for without electricity there can be no refrigeration. Even in towns and cities the power

Adapting an ancient technique to modern life, Rolex Laureate Mohammed Bah Abba has refined the “Pot-in-Pot” method of preserving fresh food by storing it in double-walled clay jars such as these seen in a Nigerian marketplace. Water contained in wet sand between the jars evaporates in desert heat, cooling the contents and preserving them for days. The method applies to such staple crops as spinach, tomatoes, onions and other perishables. The Pot-in-Pot could revolutionise life in rural Nigeria, where farmers are forced either to use or sell their crops the moment they are harvested.



supply is erratic, with some areas experiencing total blackouts for several weeks. Most of the urban poor cannot even afford refrigerators.

In the context of an economically drained nation facing severe communication, transport and utility problems, Abba responded to his country's need for managers and set out to try and help improve the ailing economy. He began by studying management sciences at Ahmadu Bello University in the town of Zaria. Equipped with a Bachelor of Science degree in business administration, he became a lecturer at the College of Business and Management Studies at Jigawa State Polytechnic in Dutse in 1990, at the same time heading the college's Student Industrial Work Experience Scheme. When not teaching, Abba serves as a consultant to the regional United Nations Development Programme (UNDP) in Jigawa, organising community activities and giving seminars. A staunch supporter of women's rights, he is also a consultant with the state's Ministry for Women Affairs and Social Mobilization.

These consultancies have brought Abba in close contact with rural communities, where he has observed the extreme hardships suffered by subsistence farmers and their families. "Through these observations, I became motivated to revitalise earthen pot usage and extend the life of perishable foods," he adds.

Raised in a family of traditional pot makers, Abba learned the trade as a boy in northern Nigeria before attending school and becoming a teacher in the south. Years later he returned home and recognised the need for an inexpensive method of preserving food. He hired and supervised skilled pot makers to produce thousands of the double-walled jars at his own expense.

By 1999 Abba had expanded his annual production of Pot-in-Pots to 7,000 jars, and he continued to distribute them free to rural families. He hopes that within five years the jars will be in use throughout northern Nigeria. He describes his Rolex Award as "highly timely" and envisions a day when the Pot-in-Pot will benefit other countries with similar hot, dry climates.

Vegetables, fruit and drinks cooled by a simple evaporation process

The innovative cooling system that Abba developed in 1995 consists of two earthenware pots of different diameters, one placed inside the other. The space between the two pots is filled with wet sand that is kept constantly moist, thereby keeping both pots damp. Fruit, vegetables and other items such as soft drinks are put in the smaller inner pot, which is covered with a damp cloth and left in a very dry, ventilated place. The phenomenon that occurs is based on a simple principle of physics: The water contained in the sand between the two pots evaporates towards the outer surface of the larger pot where the drier outside air is circulating. By virtue of the laws of thermodynamics, the evaporation process automatically causes a drop in temperature of several degrees, cooling the inner container, destroying harmful microorganisms and preserving the perishable foods inside.

Abba's first trials proved successful. Eggplants, for example, stayed fresh for 27 days instead of three, and tomatoes and peppers lasted for three weeks or more. African spinach, which usually spoils after a day, remained edible after 12 days in the Pot-in-Pot storage.

The enterprising teacher persistently refined his invention for two years between 1995 and 1997. He then tapped into the large unemployed local workforce and hired skilled pot makers to mass



produce the first batch of 5,000 Pot-in-Pots. Manufacturing these devices at his own expense for 30 US cents each, he began distributing them for free to five villages in Jigawa. For this initial phase of his project, he received limited financial backing from his brother and assistance in the form of transportation, fuel and labour from the UNDP, the regional government, a local women's development group and the Jigawa State Polytechnic.

In 1999, Abba built additional pot-making factories and supplied another dozen local villages with 7,000 pots, again at his expense. He estimates that three-quarters of the rural families in Jigawa are now using his cooling device.

An invention that helps women and girls particularly

The impact of the Pot-in-Pot on individuals' lives is overwhelming. "Farmers are now able to sell on demand rather than 'rush sell' because of spoilage," says Abba, "and income levels have noticeably risen. Married women also have an important stake in the process, as they can sell food from their homes and overcome their age-old dependency on their husbands as the sole providers." In turn, and perhaps most significantly for the advancement of the female population, Abba's invention liberates girls from having to hawk food each day. Instead, they are now free to attend school, and the number of girls enrolling in village primary schools is rising.

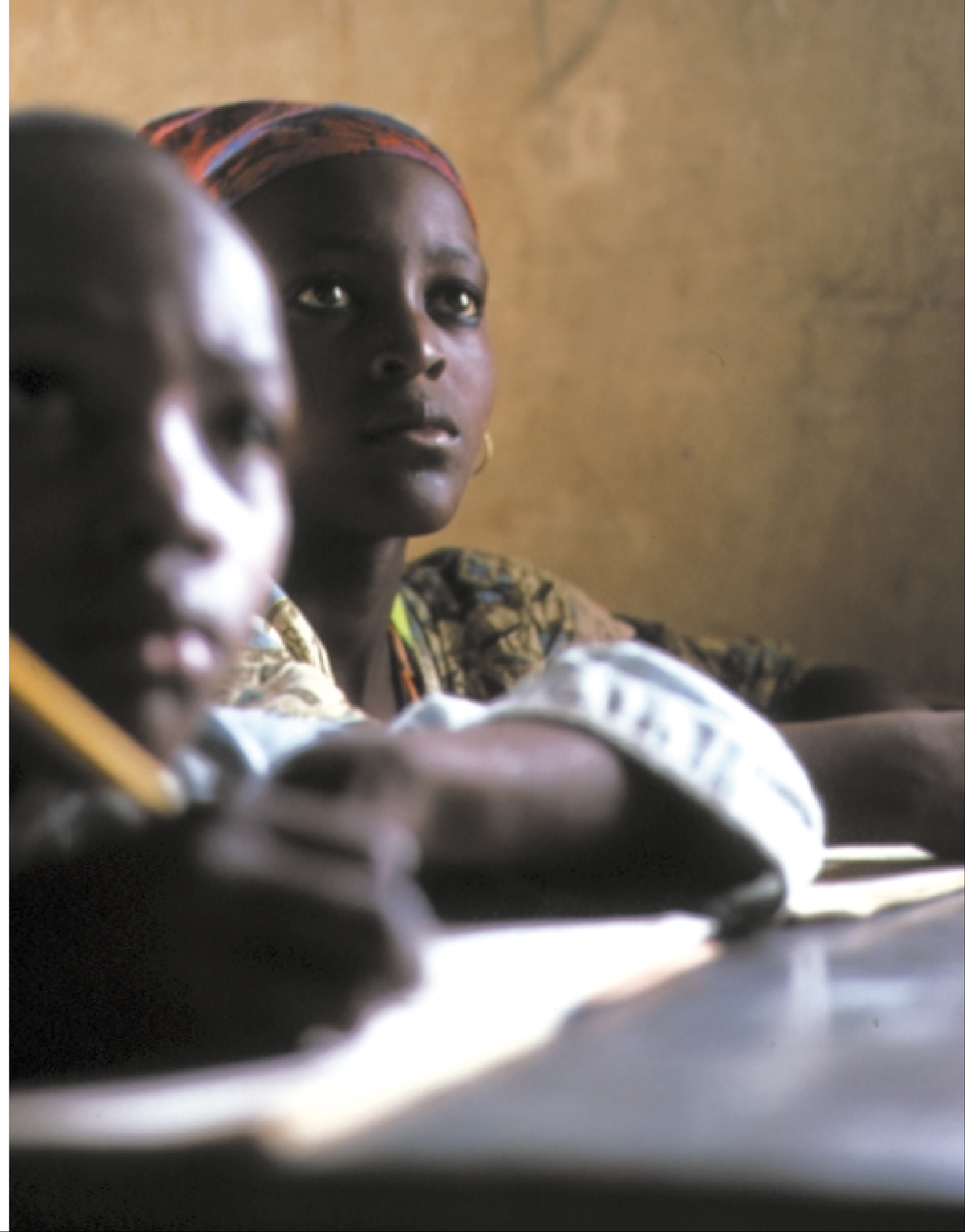
These factors, coupled with the effect that the Pot-in-Pot has had in stemming disease and slowing the pace of the rural exodus to cities, are what, in Abba's words, "make the Pot-in-Pot a tangible and exciting solution to a severe local problem".

Encouraged by these positive results, Abba will soon begin distributing the cooling devices to the four Nigerian states bordering Jigawa, starting with Yobe. However, looking at his experience over the past five years, he understands that one of the biggest obstacles is educating the villagers about this simple technology.

As training workshops and the use of "criers", village PR men, were only moderately successful, Abba has devised an educational campaign tailored to village life and the illiterate population. The innovative campaign features a video-recorded play by local actors who dramatise the benefits of the desert refrigerator. Abba has begun showing the video in villages using a makeshift cloth screen and a portable projector and generator. "Nightfall is best," he comments, "because this is when farmers head home and are keen to watch an entertaining presentation."

Abba has recently begun to sell his pots at 40 US cents a pair, 10 cents higher than the original production cost. While the proceeds will help finance manufacturing and distribution costs, he looks to the "very timely" Rolex Award to further his expansion plans. He estimates that it will take five years to cover the whole of northern Nigeria and hopes one day to export the Pot-in-Pot to other hot, dry countries facing similar problems.

Among major beneficiaries of the Pot-in-Pot are young Nigerian farm girls such as the two opposite, whose traditional task was to hawk their families' produce at daily markets. "Now," says Abba, "local farmers can sell on demand rather than 'rush sell,' and their daughters at last can attend school. Married women also benefit, for now they can sell food from their own homes and reduce their age-old dependency on their husbands as the sole providers. In fact, everyone benefits, for the reduction of waste and spoilage among crops has raised the average family income wherever Pot-in-Pots are used."



A further exciting option that the Rolex Laureate is considering is setting up a centre connected to the Internet to exchange information on traditional rural technology.

Well known for his dedication, Abba is also praised for his concern with the social and economic development of his fellow Nigerians. “Mr Abba cares for the progress of society in general,” says Mrs Hadiza Abdulwahab, president of the local Society for Women Empowerment and Development. The permanent secretary of the State Ministry of Women Affairs and Social Mobilization, Mrs Rabi Umar, concurs. She believes that Abba has been “selfless and tireless” in his efforts to make his project succeed. Summing up his work, she says: “The Pot-in-Pot project is the first to use simple cultural solutions to address the primary needs of the rural northern Nigerian population, for whom the basic necessities of life are nearly non-existent.”

Rural Nigerian women listen as Abba describes how the Pot-in-pot functions. The enterprising teacher has enlisted women’s help in educating others to benefits of the device. Recently he produced a video of a play by local actors dramatising the uses of his “desert refrigerator”.

“Mohammed Bah Abba’s idea of an earthenware cooling system... has a thousand social consequences for human health, employment of the young, especially women, and general well-being.”

“Abba’s project impressed me a great deal because of its apparent simplicity, yet it was highly innovative and pragmatic. He observed how difficult life was for the people of his rural community, as vegetables and fruit perished very quickly and affected their livelihoods. This is a marvellous example of how the innovation and spirit of enterprise of one man can affect positively the quality of life of a whole community.”

Dr Kanwaljit Soin

“Oftentimes the simpler a device, the greater its impact. Clearly, Mohammed Bah Abba’s 30-cent “Pot-in-Pot” cooling system can dramatically improve sanitation, a balanced diet, and quality of life for the poor rural population of Nigeria.”

Mr Gilbert M. Grosvenor

“There is no technology like apparently simple technology. The invention of the button and the stirrup changed the world. Mohammed Bah Abba’s idea of an earthenware cooling system may not change the world, but it could certainly change the local economy in Nigeria and other countries with a similar environment. It has a thousand social consequences for human health, employment of the young, especially women, and general well-being.”

Sir Crispin Tickell

“In a region like Africa, or in any other torrid climate, the idea of the “Pot-in-Pot” may improve a millennial way of life, without any revolutionary technological traumas. In this way the local people’s life patterns will be respected, thanks to Mohammed Bah Abba’s ingenious idea.”

Dr Giancarlo Ligabue

“This is a wonderfully simple and ingenious project, the flow-on benefits to the villages will be enormous. It really fulfils the conditions of the Rolex Awards of being truly enterprising and truly benefiting many people.”

Prof. Adrienne E. Clark



STORING INSULIN IN A CLAY POT IN THE DESERT CAUSES NO LOSS OF ACTIVITY: A PRELIMINARY REPORT

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Munirah Al Taweel, MBBCh; Adnan Abozenadah, MBBCh; Tariq Nasser, MBBCh;
Nabil Richi, MD; Ibrahim Hashim, PhD; Gerald Tevaarwerk, MD

The biological activity of insulin, like any protein, is affected if stored at extremes of temperature. The older, acidic form of insulin required refrigeration at 2 to 8°C, but the newer neutral formulation is much more stable at room temperature (15-30°C).^{1,2} Manufacturers recommend storing insulin under cool, shaded conditions, neither of which is available in the desert, where temperatures frequently exceed 40°C, thus constituting a major problem for diabetic patients. The possibility of adverse side effects due to heat-induced breakdown of products must also be considered. The purpose of our study was to demonstrate the possible effect on the bioactivity of insulin, following storage in a *zeer*, a semiporous clay pot containing water, in desert conditions. The small amounts of water that slowly seep through the walls of the *zeer* evaporate, using up heat, thereby cooling the remaining water. This principle is widely used in the Middle East to cool drinking water in such containers.

Materials and Methods

Eight physicians, aged 25-60 years of age (median age 45 years), volunteered and gave informed consent to participate in the experiment. All were healthy individuals free of any systemic diseases, and not on medications. They were allocated to the trial using a block design, which allowed partial double-blinding. Block 1 consisted of the four males and block 2 of the four females. For block 1, pre-storage insulin was used as the standard (reference) at the start of the experiment, thereby precluding blinding of both subjects and experimentors. For block 2, the reference insulin was that stored in a refrigerator at 4°C. For block 2, both the reference and *zeer* insulins were available at the same time, and their order of use was randomized using a coin toss. Both subjects and experimentors were blinded to the allocation in block 2.

Insulin Storage Condition

Neutral human insulin used was stored in a refrigerator at 4°C or in a *zeer*. This is a clay pot that is unglazed, enabling water to slowly seep through the wall and evaporate, thus lowering the temperature of the remaining water. The *zeer* used in the experiment had an internal diameter of 30 centimeters and a height of 30 centimeters. A glass jar was partially filled with desert sand and put in the center of the *zeer*. A water bath was created by adding water outside the jar to the same level as that of the sand in the glass jar. Water was added to the mark (topped up) daily from a larger storage *zeer*. The *zeer* was closed with a clay lid and kept in the shade. An exact replica of the *zeer*, but without water, was also used to store insulin and record temperatures. Additional bottles of insulin were kept outside in the shade, in the bathroom of an air-conditioned house and in a refrigerator. A small amount of insulin (10 units) was removed twice daily from each insulin vial to simulate actual usage conditions. Temperature readings were taken on 12 separate occasions during the six-week storage period (Table 1).

Insulin Sensitivity Test

The protocol of Tevaarwerk and Hudson, which consists of withdrawing a baseline blood sample in fasting subjects, followed by the intravenous injection of 0.1 unit of regular insulin per kilogram body weight, was used.³ Blood was then taken every 5 minutes for a period of 30 minutes following the injection.

Blood Glucose Measurements

Blood samples were collected in fluoride oxalate tubes. Plasma glucose levels were determined, using an Ektachem 500 Chemistry Analyser (Ortho-Clinical Diagnostics, Rochester, USA), according to the manufacturer's instructions. Imprecision (co-efficient of variation) ranged from 2.8% at 1.9 mmol/L and 2.4% at 5.1 mmol/L.

Data Handling and Statistics

The slopes of the fall in plasma glucose levels were determined, using a computerized "best fit" method (SPSS Statistical Program).⁴ The differences in the slopes for

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each individual were then calculated and the mean and standard error of the mean (SEM) determined for the group as a whole. Student's *t*-test for paired groups was used to assess the statistical significance of the difference between the slopes of the glucose values.⁵ As any observed difference in bioactivity might theoretically go in either direction, the two-tailed test was used.

Diabetic Patients' Trial

Two diabetic patients using regular (clear) and NPH/Isophane (cloudy) insulins mixed just prior to use stored the insulin they were using during a two-month period in a *zeer*, while living in a tent in the desert during July and August.

Results

The mean of the temperature measurements in the *zeer* was 26.6°C and the mean of the outside temperature was 38.3°C. It was 34.6°C in the dry *zeer*, and 35.3°C in an insulin vial stored in the shade (Table 1). There was no

TABLE 1. *Temperatures (°C) under various storage conditions.*

Date	Time	Outside temp.	Insulin vial	Dry <i>zeer</i>	Insulin <i>zeer</i>	Bath-room	Fridge	Water <i>zeer</i>
18 June 98	12:00	43	37	34	26	25	4	25
26 June 98	07:00	29	31	30	25	25	4	25
26 June 98	12:00	38	33	32	27	26	4	27
02 July 98	12:00	40	36	34	26	27	4	26
03 July 98	12:00	39	38	37	27	27	4	27
07 July 98	07:00	42	39	38	27	27	4	28
10 July 98	12:00	38	37	36	27	26	4	27
12 July 98	07:00	37	33	32	27	26	4	27
12 July 98	12:00	42	39	39	27	27	4	27
19 July 98	07:00	37	32	35	26	27	4	27
19 July 98	12:00	41	37	37	27	27	4	27
20 July 98	07:00	34	31	31	27	27	4	27
Mean		38.3	35.3	34.6	26.6	26.4	4	26.7

TABLE 2. *Rate of fall in blood glucose (mmol/L/min) following IV insulin.*

Subject	Before storage	After storage in refrigerator	After storage in <i>zeer</i>	Difference
1	0.258	–	0.254	0.004
2	0.216	–	0.180	0.036
3	0.176	–	0.129	0.047
4	0.139	–	0.176	–0.037
5	–	0.300	0.250	0.050
6	–	0.198	0.179	0.019
7	–	0.186	0.146	0.040
8	–	0.230	0.220	0.010
Mean±SD	0.197±0.040	0.228±0.037	0.192±0.037	0.021±0.02
SEM				0.003

SEM=standard error of the mean.

change in color or appearance of the insulins. The mean age of the eight study subjects was 45 years (range 24-60), and half were males. None of the subjects experienced any effects other than those due to hypoglycemia. The mean fall in plasma glucose levels following reference insulin was 0.213 mmol/L/min, whereas it was 0.192 mmol/L/min following the *zeer*-stored insulin (Table 2). The mean difference was 0.0211 mmol/L/min. This represents 9.9% less fall in glucose in the *zeer*-stored insulin. The ratio of the mean difference divided by the standard error of the mean gave a test statistic of $t=2.052$ with 7 degrees of freedom. As the critical ratio to be reached for the two-tailed test at the 95% confidence level was 2.37, the null hypothesis was not rejected.^{4,5} That is to say, the observed difference in the rate of decline of glucose following insulin stored in a *zeer*, and that before storage or being stored in a refrigerator, was not statistically significant.

The two patients who stored the insulin they were using in a *zeer* while living in a tent in the desert reported no changes in the appearance of the insulin, nor were there any local or general side effects. There were no noticeable changes in diabetic control.

Discussion

The results obtained in our study show that the glucose-lowering effect of insulin stored in a *zeer* in desert conditions was 9.9% less than the reference insulin, a difference that was not statistically significant. Although the number of subjects in this report was small, using paired samples increased both the precision and power of the test by decreasing the effect of variance. Thus, the difference shown is probably clinically insignificant. This is in spite of outside temperatures of up to 43°C. The lack of apparent change in color and turbidity, and the absence of adverse effects in the subjects following the injection of insulin, either intravenously or subcutaneously, attests to the safety of this method of storing insulin in the desert.

The lack of adverse effect on either the regular or NPH/Isophane insulin used by the two diabetic patients indicates that the above observations may be extended to both types of insulin and to its subcutaneous use.

The principle of cooling in a *zeer* or similar devices is the fact that for water to evaporate, latent heat is required. This is obtained from both the surrounding atmosphere and the water that is evaporating. It is defined as the energy absorbed or released by a substance during a change in its physical state that occurs without a change in temperature.⁶ It is in effect, the heat of vaporization, that is, the heat carried away by the evaporating water molecules. This may be observed in nature by panting animals losing heat from the surface of the tongue, and the principle has been used in most observed societies to cool substance such as food and drink. In the Arabic world, the device is called a *zeer*, or when used to cool drinking

water, it is referred to as a *koolah*. Such devices can be used anywhere where the temperature is high and water is available. The temperatures observed (Table 1) attest to its efficacy as a cooler.

Our results are in agreement with those observed under laboratory conditions.^{1,2,7,8} At 25°C, intact vials of both the older acidic form¹ and the newer neutral formulation² were stable for several months. However, at 37°C, Pingel and Volund⁷ found a loss of bioactivity of 5% over five months. A recent report from Ethiopia on the use of insulin by patients who stored their insulin in various ways found no differences in fasting blood glucose levels and glycohemoglobin values in those using insulin exposed to higher temperatures, although hyperglycemic symptoms were less frequent in patients using refrigerator storage.⁹ Our results were obtained under somewhat different circumstances, in that each insulin bottle was exposed to outside air and insulin removed twice daily during the six-week storage period, and in the patients, during a two-month period. Our results and those obtained by others under laboratory conditions^{1,2,7,8} do not support the need for the storage recommendations of some insulin manufacturers,^{8,10,11} which recommend storage at temperatures of between 2 and 8°C, and suggest that the insulin may then only be used for up to one month.

The results of our experiment show that insulin kept in a *zeer* in the desert for up to six weeks does not show any significant deterioration in bioactivity or any adverse effects, and may thus safely be used. Although the effect of temperature on insulin activity has previously been studied, this does not appear to have been translated into practical suggestions for insulin storage under desert conditions. Refrigeration is available in some settings but this is not the case in most instances. As *zeers* or similar devices are readily available in most parts of the world,

they may be recommended for insulin storage purposes for up to six weeks and probably longer.

Our study concludes that storing insulin in a *zeer* in the desert for up to six weeks does not cause any significant deterioration in its bioactivity and safety. These results are preliminary and require confirmation in a larger trial. Nevertheless, they hold the promise of providing a simple and readily available method of insulin storage in the desert.

Acknowledgements

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