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Proposal to combat malnutrition in India . . .

. . . with a grain of FORTIFIED salt

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☐ WITH THE beginnings of a recognition in many parts of the developing world that malnutrition can be an inhibiting factor in national development, policy leaders in these countries are looking for means to combat malnutrition quickly, efficiently and inexpensively.

Approaches leaned on heavily in the past—particularly nutrition education for mothers and children—are for the first time being questioned by impatient decision makers. Without denying the long run importance of such education-oriented programs, they correctly appreciate the considerable financial and manpower resources needed and the time involved to make them work.

At the same time, the very problems faced in attempting to change eating habits have suggested the fortification approach—an approach which relies on traditional staples to provide needed protein, vitamins and minerals.

Canons for fortifications

The fortification spectrum offers an attractive variety of possibilities. Bread, wheat flour, rice, dairy products and oils have all been used as fortification carriers. In India, the Government has already set in motion several programs and initiated considerable research to explore the relative potential of these carriers.

These carriers are being evaluated on the basis of a fairly well defined checklist: Is the carrier consumed by a sizeable portion of the population? Is it sufficiently inexpensive to permit consumption by the low income vulnerable groups in greatest need of these nutrients? Is the carrier processed centrally in units large enough to permit controlled fortification? Does the food offer a distribution mechanism capable of covering large geographic areas? Will the carrier allow for fortification without affecting its taste, odor or appearance? Will it permit further processing or cooking without loses? Will it be consumed in relatively constant amounts (so that levels can be accurately calculated)? And finally, can it be fortified without significant alteration of its economics?

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Limitations of cereal fortification

Measured against these criteria, the common food carriers mentioned above show certain shortcomings. The bulk of Indian cereals are home ground or processed in small wheat *chukkis* or rice hullers. Since 80% of the people in India live in 500,000 villages, this rules out controlled fortification.

Wheat ground by roller flour mills (total capacity 4 million tons or one fourth of the total wheat availability) is, like bread, now limited to distribution in urban areas, although it reaches the lowest income urban dwellers. Rice may be further limited as a carrier because of the traditional Indian practice of lengthy cooking in an excess of water. The water is subsequently discarded with any nutrients which have been added in the form of coated or simulated premix kernels.

Indian shortening, called *vanaspati,* although presently fortified with vitamins A and D, may lose as much as 50–75% of these nutrients during cooking. Dairy products are still out of the reach of the lower income Indians, although toning with vegetable protein may permit a major increase in availability.

Awareness of these shortcomings, fortunately, did not limit research or the planning of national programs to use these carriers in India. It did, however, motivate a broader examination of additional carrier possibilities and led to the present consideration of salt.

Salt for all seasons

The first cursory examination of salt production and utilization in India revealed at once its extraordinary potential as a carrier of nutrients. Everyone uses salt (1). Those not part of the monetized economy barter for salt. And salt production is relatively centralized. The Indian production of 4.8 millon tons per year (2) is limited to fewer than 200 salt works. Roughly half of this production takes place at 24 large works, most of which are located in the single state of Gujarat. The distribution of salt can be at least partially controlled by the Central Salt Department and by the regulatory mechanisms of the State Governments. Nutritionally, salt is an attractive carrier because it is used consistently throughout the year. The quality of a rural Indian's diet can vary considerably, depending on seasonal crop availability. Nutrients via salt can offer insurance during the low-quality periods. Most important, salt is consumed in relatively constant quantities by all Indians, urban and rural, rich and poor, vegetarian and non-vegetarian.

Salt as a carrier is not a new concept. In many countries salt has been iodized to combat goiter. In India, salt produced for the sub-Himalayan goiter belt must, by law, be iodized. This program has reduced incidence of goiter in children in Kangra Valley (Himachal Pradesh) from 38% in 1956 to 3% currently. It was this concept and the results which led, in the last few years, to thought and discussion of extending the salt fortification principle beyond iodization. The Central Food Technological Research Institute (CFTRI), in Mysore, and the Central Salt and Marine Chemicals Research Institute (CSMCRI), in Bhavnagar, began to look into calcium fortification. CSMCRI also carried out preliminary research on iron fortification. Meanwhile, the idea of research on salt fortification with lysine was proposed by the Director of the Nutrition Research Laboratories, Hyderabad.

While it is still too early to predict the outcome, a few factors emerge which will be central to consideration of a salt fortification program.

Fortifying during crystallization

Salt lends itself to two broad fortification techniques. One is conventional dry-mixing or spray-mixing in a screw conveyor located at the bagging site. This is the technique which has been used for iodization at India's large public sector salt works. The second technique takes advantage of the salt manufacturing process itself.

In India virtually all salt (99.9%) is solar evaporated. The process is simply one of evaporating sea water in successive man-made condenser pans or reservoirs until the sea salt separates and crystallizes.

From research carried out thus far, it appears possible to add nutrients during this crystallization process itself. In the final "crystallizer" pan a layer of salt about one inch thick is allowed to form on the bottom, after which powdered nutrients can be sprinkled and allowed to settle on the salt. The pans are then stirred with rakes to distribute the powder as uniformly as possible.

The continuing crystallization of salt traps the nutrient particles within the salt crystals until a two inch salt layer is harvested. The salt consistency is then suggestive of a sandwich: layers of pure salt on the bottom and top covering a middle layer of salt containing the fortifying agent. During harvesting, the nutrient-bearing layer becomes mixed with the other layers, producing a blend.

From a technical and logistical point of view the nutrient easiest to add is calcium. During an intermediate stage in the crystallization process, calcium sulfate, present in sea salt at a level of roughly 3–5%, precipitates out. This calcium, if cleaned and finely ground, can be reintroduced to the salt during the final evaporation stage described above in a form easily absorbed by the human system.

Iron might also be added to the salt in the same manner. The need is for an iron salt which will be easily absorbed physiologically and which will not discolor the salt. Preliminary tests indicate that iron pyrophosphate may be appropriate. If this proves feasible, a major impact could be made against one of India's most serious nutritional deficiencies.

Vitamins are not stable in salt unless encapsulated in gelatin. In this form vitamins A and D are now used to fortify salt produced for animal feed in the U.S.

Experiments with lysine as a fortifier disclose a number of areas requiring further research. One relates to its stability in the presence of salt and/or the impurities in the salt. (Several samples of lysine-fortified salt developed a pungent odor during storage tests.) A second is the possibility of separation during storage and transport. The particle size of lysine (which would almost surely have to be dry-mixed with the salt, or sprayed onto it) is so much smaller than coarse Indian salt that some separation would probably be inevitable. This separation could be minimized by grinding the salt, but the average Indian actually prefers unground salt; the finely ground salt, he fears, may be adulterated. The Indian Government has, in fact, reported cases in which iodized salt has been rejected because of the partial grinding which precedes the iodization.

A third concern of lysine research is the possibility of lysine losses during Indian style cooking. This is a critical issue because virtually all Indian salt is added to food during cooking rather than as table salt. Finally, since the lysine is not being used to upgrade the protein quality of the salt (which has no protein content) but rather is simply being carried by the salt to upgrade the quality of the diet as a whole, it must be determined that salt fortification does, in fact, produce the desired results in a variety of Indian diets.

Fortification levels

This leads to the matter of fortification levels. A determination of levels cannot be treated in isolation. Fortification at levels which are desirable nutritionally, may be impossible to bring about technologically. Nonetheless a few figures should be set forth here as being nutritionally optimal.

In the case of calcium, 5% calcium sulfate (assuming 23% Ca) would supply an adult with 173 mg per day or over one third of his daily calcium requirement on the basis of an average salt consumption of 15 g per day. With iron the optimum level nutritionally would be 500 ppm Fe. For an iron salt containing 20% iron, the amount of the iron salt to be added comes to 0.25% of the total salt. This would give an adult 7.5 mg of iron per day, again over one third of his daily requirement and in a form more readily absorbed than iron from fruits and vegetables.

Indian nutritionists have been discussing the addition of lysine at levels of up to 5%. For an Indian child consuming 6 g of salt per day, fortification at 5% would mean an intake of 300 mg of lysine or enough to meet all but the worst cases of lysine deficiency. The complication in setting lysine requirements is that they vary significantly depending on the cereal base and the amount of pulses consumed. This may require the establishment of different lysine levels for different regions of the country.

Fortification economics

Finally, we come to the economics of salt fortification. The cost of salt in India is extremely low relative to world prices. The wholesale price of salt at the source of production comes to roughly Rs. 35 ($4.70) per ton. The price paid by the urban consumer is considerably higher, Rs. 150–250 (up to $30) per ton depending upon the extent of handling and freight, but still only a fraction of the cost of salt in the West.

This low price reflects the simplicity of the salt manufacturing process and the low cost of labor. It has remained low, interestingly, because of the political significance attached to this commodity since Gandhi's famous "march to the sea" in 1930 to protest the British Salt Laws (3).

Calcium fortification should not increase the cost significantly. The calcium sulfate that replaces 5% of the salt is no more expensive than the salt; to this would be added minor labor costs for washing and grinding the calcium sulfate and physically adding it to the salt. Iron fortification will, most likely, add approximately 10% to the cost of salt, assuming an iron salt costing Rs. 10 (about $1) per kilogram.

Fortification with lysine presents a more complex economic problem. Unlike calcium and iron, lysine is not produced in India. While some of this might be available now under bilateral and multilateral assistance programs, imports could eventually require a considerable foreign exchange outflow. Lysine, although one of the least expensive of the amino acids in synthetic form, still costs on the world market about $1 per pound. (Production of the massive amounts needed for a nation-wide program may eventually lower this price.) The addition of lysine to salt at say a 5% level would increase the ingredient cost of the fortified salt four times.

The economics of lysine fortification can and perhaps should be viewed another way. The cost of salt itself is so low that the average Indian adult spends only Rs. 1.5 (20¢) per year on salt. Even if this were multiplied by 4, the resulting cost would be well within the reach of even the lowest income groups. Such an increase might be initially supported by a government subsidy which could be gradually reduced and eventually eliminated as incomes rise.

Looked at from another vantage point, lysine, or any nutrient for that matter, will cost the same regardless of the food to which it is added. Should X units of lysine be considered necessary as a supplement to the diet of the average Indian, these X units would cost Y rupees regardless of the food with which they were mixed. The fact that these X units raise the price of a low-cost item like salt by a higher percentage than they raise the price of a higher priced foodgrain should not in itself argue against the fortification of the salt if, in fact, the salt is otherwise a more desirable carrier.

The cost of eliminating deficiencies

By fortifying a commodity such as salt, consumed by the entire populace in relatively constant amounts, it becomes possible to think in terms of *totally eliminating deficiencies*—a hitherto unimaginable prospect. With such a vehicle it also becomes possible for governments to calculate with some accuracy the *cost* of eliminating these deficiencies—and to weigh these costs against other governmental investments.

For example, *Vitamin A*, if added at a level of 100 I.U. per gram of salt could provide roughly ½ of an individual's daily Vitamin A requirement. To fortify all salt used for Indian human consumption (roughly 3 million tons), 300 trillion I.U. of Vitamin A would be required. This would cost Rs. 20 crore ($26.6 million) per year or 1/100 of the Government of India budget, plus the cost of dry mixing equipment needed.

If *iron* were added as discussed, and if for some reason the price of salt could not be raised the 5–10% to absorb the cost, fortification at 500 ppm would require an annual governmental expenditure of Rs. 3 crore ($4 million), or one fifth of the funds set aside annually for nutrition in the Indian Fourth Five Year Plan.

The promise of salt

Overall, while there is still work to be done and information to be collected, salt fortification emerges as a particularly attractive means of quickly combatting certain forms of malnutrition. Such a program will require a working combination of resourceful scientists and creative policy makers. Given this, calcium fortification could be introduced almost immediately, iron within a year, perhaps lysine and vitamins not long afterwards. Should these efforts prove successful, India's government will have made a unique and significant contribution to her people and possibly to others well beyond her borders.

NOTES:

(1) The importance of salt in Indian culture is reflected in the saying in the northern state of Uttar Pradesh: "If you throw salt on the ground, in the next life you will have to pick it up with your eyes."

(2) Of this, 2.8 million tons are used for human consumption; 1.5 million tons go for industrial usage (chemical manufacture, food preservation, soaps, oils, dyes, leather, textiles, glass etc.); and 0.5 million tons are exported, primarily to Japan. One relatively accurate index of economic development might be the ratio between salt used for industrial purposes and that directly consumed by the populace.

(3) In an effort to enforce their salt tax in India, the British decreed it an offense to manufacture salt independently or to purchase or be in the possession of contraband salt. To carry away natural salt deposits from the seashore was also a violation of the law. Gandhi's 200 mile, 24 day, march to the sea ended when he picked up a handful of salt to symbolize the protest. The simple act triggered nationwide action. The Indian Congress Party organized the illegal sale of salt. This led to the arrest of Gandhi, Nehru and most other prominent Indian leaders. In all, the British took in 100,000 political prisoners for breaking the Salt Law, 40,000 of them during the first month. Censorship was imposed. Numerous Indians working in government positions resigned. The Salt March is regarded as one of the most significant and influential of Gandhi's non-violent actions.