EFFECT OF FEEDING *MORINGA OLEIFERA* LEAF MEAL ON THE GROWTH PERFORMANCE OF *OREOCHROMIS NILOTICUS* FRY.

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Key words: *Moringa oleifera*, heat treatment, fishmeal replacement, growth performance.

Abstract

The study was conducted to determine the suitability of heat-treated M. oleifera leaves as a protein source for Oreochromis niloticus fry. Four experimental diets were used; Diet A had 5 % boiled moringa and 95 % frymeal; Diet B contained 10 % boiled moringa and 90 % fry meal; Diet C had 5 % steamed moringa and 95 % frymeal and Diet D contained 10 % steamed moringa and 90 % frymeal. Diet E was the control diet containing fishmeal. A standard 24-day fry feeding trial was carried out in 10 fry tanks with each tank stocked with 15 000 fry. The growth rate, feed conversion ration and protein efficiency ratio of fry fed the five diets were similar. The body weight gain ranged from 0.012 to 0.014 g/d for fry fed boiled moringa and the control diets. Fry fed diets C, D and E had higher FCR values of 1.1, 1.1 and 1.0, respectively, compared to those on diets A and B (1.2 and 1.3, respectively). Fry fed steamed diets had better growth performance than those on boiled diets although the differences were not significant. It is concluded that steam-heated moringa leaf meal can be used to substitute 10 % of dietary protein in Nile tilapia fry without significant reduction in growth performance.

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INTRODUCTION

The Nile tilapia (*Oreochromis niloticus*) was one of the first fish species cultured

and is still the most widely cultured species of tilapia in Africa. Positive aquacultural characteristics of tilapia species include their tolerance to poor water quality and the fact that they eat a wide range of natural food. Of the total world production of fish, which amounted to 112.30 million tonnes in 1995, 18.97 % came from the aquaculture sector while the rest came from the captured fishery [1]. Most of the increase in fish production is expected to come from aquaculture, which is currently the fastest growing food production sector of the world [2].

In aquaculture systems the increasing price of feed is considered one of the most important factors that limit profitability, caused mainly by the cost of fishmeal used as a primary source of protein [3; 4]. As a result, there is a need to search for alternative protein sources for aquaculture diets. The high cost and fluctuating quality of imported fish meal have led to the need to identify alternative protein sources for use in fish feed formulations [5]. The identification and utilization of non-conventional and lesser-utilized plant protein sources to replace fishmeal, either partially or totally in practical fry diets has been an area of focus in aquaculture nutrition [6]. Earlier studies have shown that, *Moringa oleifera* is a promising protein source for inclusion in fish diets at low levels [7].

Plant proteins are cheap and readily available, but have some antinutritional factors that limit their use as aquaculture feeds. These limitations could be successfully overcome by different methods of heat treatment [5; 8]. The objective of the study was to determine the effects of heat-treated moringa supplemented diets on the growth performance of the Nile tilapia (*Oreochromis niloticus*) fry.

MATERIALS AND METHODS

Experimental Animals

O. niloticus fry with average body weight (ABW) of 0.01 g were taken from Lake Harvest hatchery. The collection and transportation of the fry was done as recommended

[9]. They were taken to the experimental tanks in the early hours of the day from 0500 to
0700 hr.

Fry tanks and fry stocking

A total of ten fry tanks were used and each treatment diet was randomly allocated to two fry tanks. Water in the fry tanks was continuously exchanged throughout the
experiment that lasted for 24 days. A compressor was used to supply oxygen into fry tanks
via air stones and this ensured adequate dissolved oxygen to be above 80 % saturation.
Each individual experimental tank with the volume of 3.16 m^3 was stocked with 15 000
fry. The fry were weighed at the beginning and progressively at weekly intervals. No feed
was given on the weighing days to prevent stress.
299

Processing of moringa leaves and diet preparation

M. olifera leaves were taken from Lake Harvest forestry unit and were dried under shed.
After drying, some of the leaves were either heat treated by boiling or steam heating at a
temperature of between 60 ° C - 80 ° C for 15 minutes. Steam heating and boiling was
meant to minimize or deactivate the antinutritive factors such as tannins, phytic acid and
saponins that inhibit the digestion of plant proteins in Nile Tilapia. After the heat
treatments the leaves were allowed to dry under shed before being milled through a 0.01
mm screen.
Four isonitrogenous diets were formulated to have 450 g/kg DM of crude protein (CP). Diets A and C were composed of 5 % boiled and 5 % steamed moringa leaves, respectively, whilst 95 % by mass was fry meal. Diets B and D were composed of 10 %
boiled and 10 % steamed moringa leaf meals, respectively, whilst 90 % by mass was the
fry meal. The standard fry meal, Diet E, which contained no moringa leaf meal, served as
a control and had fishmeal as a protein source.

Feeding

The fry were fed a daily ration at a rate of 15 % of bodyweight. The daily ration

was divided into eight feedings per day at an hourly interval from 0800 hours to 1500
hours.

Data collection

The fry in each tank were weighed weekly in order to assess their growth performance. A Tefal electronic digital scale was used to measure weights of fry per week.

The fish fry were weighed and returned into their respective fry tanks. No feed was
offered during sampling days. Salt was added to fry tanks at a rate of 5 mg/l after sampling
to prevent stress, which would have caused high mortalities.

Growth performance were analyzed in terms of total body weight gain (BWG), average
daily gain (ADG), feed offered (FO), feed conversion ratio (FCR), protein efficiency ratio
(PER) and survival percentages. The following formulae as described [10]:

BWG (g) = Final body weight - Initial body weight

ADG (g/d) = BWG/21 days

FO = Total dry feed offered (g)

FCR = Total dry feed offered (g)/ Live body weight gain (g)

PER = Wet body weight gain (g)/Crude protein fed (g)

Laboratory analysis

The diets were used were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), Ash, Ca, P and energy content using the standard procedures [11].

Statistical analysis

The growth performance was analysed using the one-way analysis of variance (ANOVA) using Minitab Version 12.1.

RESULTS

Chemical composition of diets

The chemical composition of the diets is presented in Table 1. The diets had CP content of that ranged from 46.4 to 46.9 % CP. The crude fibre of the diets that contained
moringa leaves was high, ranging from 2.95 to 4.17 % as compared to that of fry meal of
1.97 %. The ash content of diet A and C was higher as compared with other diets as shown
in Table 1. The calcium and phosphorus concentration in the diets was not different. The
energy content of the five diets ranged from 8.2 to 12.5MJ/kg.

Table 1: Proximate composition of experimental diets (% on DM basis)

Constituent [1]	**Diet A**	**Diet B**	**Diet C**	**Diet D**	**Diet E**
Dry matter	87.9	89.9	88.1	89.6	90.00

Crude protein 46.5 46.4 46.7 46.4 46.9
Crude fibre 3.44 4.17 2.95 3.32 1.97
Ash content 17.27 13.37 18.57 11.03 11.12
Calcium 2.42 2.68 2.48 2.49 2.41
Phosphorus 1.42 1.5 1.76 1.14 1.07
M.E (MJ/Kg) 10.7 9.8 8.2 12.3 12.5
ıDiet A contains 5% boiled moringa leaves and 95% fry meal
Diet B contains 10% boiled moringa leaves and 90% fry meal
Diet C contains 5% steamed moringa leaves and 95% fry meal
Diet D contains 10% steamed moringa leaves and 90% fry meal
Diet E contains fry meal only

Feed intake, growth performance and feed utilization

The growth performance and feed utilization in terms of body weight gain (BWG), average daily gain (ADG), feed conversion ratio (FCR) and protein efficiency ratio (PER)
are presented in Table 2. There was no rejection of feed until the end of the experiment
and the acceptability of the diets was similar. No mortality or any signs of disease were
observed in any of the dietary groups during the study period.
There was no significant difference ($P > 0.05$) on total body weight gain and average daily gain of the fry fed the five diets. Fry on diets C, D and E produced the best
FCR and PER as compared to all other diets, but this did not differ significantly ($P >$
0.05). In general, among the five diets, fry fed diets containing steamed moringa leaves
showed better growth performance in terms of final body weight, gain in body weight,
FCR and PER than those fed boiled moringa leaves.
301

Table 2: Growth performance and nutrient utilization of tilapia fed different experimental
diets.

Parameters	**Diet A**	**Diet B**	**Diet C**	**Diet D**	**Diet E**
IBW (g)	0.01	0.01	0.01	0.01	0.01
FBW (g)	0.261	0.253	0.279	0.288	0.298
BWG (g)	0.251	0.243	0.269	0.278	0.288
ADG (g/d)	0.012	0.012	0.013	0.013	0.014
FO (g)	3074	3074	3074	3074	3074
FCR	1.2	1.3	1.1	1.1	1.0
PER	1.8	1.7	1.9	2.0	2.0

IBW = initial body weight, FBW = final body weight, BWG = body weight gain, ADG =

Average daily gain, FO = Feed offered, FCR = Feed conversion ration, PER = Protein
efficiency ratio

DISCUSSION

The crude protein content of the experimental diets used in this study was within the range used in a previous study [3]. Protein is very important in fish growth and thus
crucial ingredient in fish diets. A comparison between the amino acid composition of the
raw and extracted moringa leaves to that of soybean revealed an almost identical composition of essential amino acids. The proximate analysis of the experimental diets
showed that the crude protein was ranging from 45.4 % to 46.9 %. This range is within
Lake Harvest requirements for the growth of fry which ranges from 45 % to 47 % CP.

The diet which contained 10% steamed moringa leaves (Diet D) showed the
highest growth performance as compared to all other formulated diets, except for the fry
meal (Control diet) although the differences were not statistically different. In terms of
growth rate, fish which received the diet which contained 5 % steamed moringa (Diet C)
had low growth rate as compared to diet D. This is contrary to the previous study [12]
which showed that higher inclusion levels of moringa leaves in fish meal had an impact on
lowering the growth performance because of the presence of antinutrients such as phenols,
tannins, phytates and saponins. This present study indicate that a 10 % inclusion level of
moringa in fry meal yielded good growth performance possibly because the antinutritrients
such as phenols, tannins, phytates and saponins were could have been inactivated by steam
heating [13]. This could have resulted in the reduction of palatability-reducing factors.

Heat treatment methods employed might have increased the digestibility of
proteins and other dietary components such as starch related compounds leading to high
FCR and PER in fish fed with diets C and D. The reduction in antinutrients by processing

techniques such as soaking, drying and heat treatment on plant-based fish ingredients have
resulted in better palatability, increased feed digestibility and growth in fish [10; 13].
Generally steam heating reduces loss of soluble nutrients from moringa leaves since that
process does not involve a solvent media to dissolve the nutrients. Apart from that,
steaming employed in this study might have resulted in little protein being denaturated
302
thus making more quality protein been made available in steamed leaves than boiled
leaves.
Boiling breaks cell components like cell walls and cell membranes of plants cells.
Some of the nutrients within the cells of boiled moringa leaves were lost to boiling water
during the heat treatment process. The soluble cell components such as soluble proteins
and glucose molecules might have dissolved in water during boiling. This could have
caused the reduction of essential amino acids (EAA) in diet A and diet B. Boiling might
have caused the inactivation of antinutrients such as saponins, phytates, phenols and
tannins that bind some quality proteins and inhibit digestion in fish. Apart from breaking
the cell components; boiling induces the precipitation of polyphenolic and other
phytochemical compounds which might have depressed the growth of fish receiving feed
with boiled moringa leaves. Boiling also induces the formation of colloidal starches as a
result this reduces the amount of available glycoproteins to fish [13].
Boiling and steaming showed no significant effect on the crude fibre content but it
was within Lake Harvest requirements for the growth of fish; except for diet B that had a
higher crude fibre content of 4.17 %. This might have contributed to the lowest growth
rate of fish fed with diet B. It has been shown that fibre can bind nutrients like fats,

proteins and essential minerals, and reduce their bioavailability [10; 12]. Dietary fibres apparently influence the movement of nutrients along the gastrointestinal tract and significantly affect nutrient absorption.

CONCLUSION

The results of this study indicate that up to 10% inclusion of steam heated moringa leaves can be recommended for *Nile tilapia*. In view of the favorable amino acid profile of moringa leaves and their wide and ready availability throughout the tropics and subtropics, moringa can be considered as a potential feed component with high nutritive value for *Nile tilapia*.

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304

MILK PRODUCTION FROM LACTATING HOLSTEIN COWS FED CEREAL-TREE FORAGE LEGUME SILAGES.

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Key words: Silage, *Acacia boliviana, Leucaena leucocephala*, Milk yield, Milk composition.

Abstract

Trees are important throughout the world because of the services and products they provide to humankind. Use of tree leaf meals in feeding livestock adds value to trees at household level. The objective of this study was to assess the nutritive value of A. boliviana and L. leucocephala-maize silages as partial substitutes for commercial dairy meal in lactating Holstein dairy cows. The tree forage legumes were ensiled together with maize in a 50:50 ratio (w/w). The ensilage was carried out in plastic bags for seven weeks. The crude protein content of the maize-legume silages ranged from 176 to 209 g/kg DM and was greater than that of maize silage, 71 g/kg DM. The neutral detergent fibre content of the silages was not significantly different with values of 608, 658 and 603 g/kg DM for bagged maize, maize-leucaena and maize-acacia silages, respectively. The modified acid detergent fibre content of maize-leucaena silage of 357 g/kg DM was higher compared to that of bagged maize, 304 g/kg DM, and maize-acacia, 319 g/kg DM silages which themselves did not differ. The milk yield was higher in cows fed mixed maize-acacia, 15.7 kg/d, and maize silages, 17.0 kg/d, compared to animals on mixed maize-leucaena silage, 14.1 kg/d. However the milk composition in terms of butterfat, lactose, protein and total solids was not different across the treatment diets. It is concluded that mixed silages can be used to partially replace commercial feed supplements without loss in milk yield or quality.

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INTRODUCTION

In the tropics and sub-tropics there is a general shortage of natural grazing during the dry season resulting in high use of commercial feeds in livestock production during this period. The lack of all year round supply of high quality on-farm forages is one of the

major limiting factors to improved milk yield in the tropics [1]. In the smallholder dairy sector of Zimbabwe commercial feeds account for over 60 % of the total production costs [2]. In this regard dairy producers would benefit if the amounts of commercial feeds were reduced in their feeding systems without a decline in yield and quality of milk. Traditionally silage has been made from cereals and grasses whilst legume silages have some potential [3]. The cereal silages are rich in energy but low in protein whilst the converse is true for legume silages [4]. The protein content of the maize silage can be improved significantly by ensiling it together with tree forage legumes [5]. The objective of this study was to assess the nutritive value of *A. boliviana* and *L. leucocephala*–maize silages as partial substitutes for commercial dairy meal in lactating Holstein dairy cows.

305

MATERIALS AND METHODS

Crops and harvesting

The forage-tree legumes (FTLs) used in this experiment were *Acacia boliviana* (Acacia) and *Leucaena leucocephala* (Leucaena) and the material used came from coppices of the 1999 harvests. The coppices were cut 0.7 m high when more than 25 % of the coppices were at flowering stage. The leaves were stripped by hand from the branches and twigs. A long season white maize variety, SC709, was used. The crop was managed in line with a commercial maize crop in terms of fertilizer application and weeding as well as pest and disease control. The maize was harvested a medium-dough stage. Hand harvesting was used and a motorised chuff cutter was used to chop the maize into pieces of ± 15 cm long.

Ensilage process

Ensilage was done in 50 kg plastic bag silos [5]. Five kilograms of freshly chopped maize was thoroughly hand mixed with five kilograms of the respective freshly cut leaves of the forage tree legume (FTL). The mixed forages were then packed in the plastic bags

and compacted by hand to exclude as much air as possible and then tied by a string ensuring air-tightness. The material was left to incubate in a room for seven weeks before samples were taken for laboratory analyses. At the same time, maize from the same crop was ensiled in a bunker silo. This silage provided the basal diet for the trial animals.

Samples preparation

Samples of freshly milled maize and mixed maize-legume material were taken for laboratory analyses. After a seven-week incubation period three bags of each of the respective silages were randomly selected, opened and thoroughly mixed before three twokilogram samples were taken for laboratory analyses.

Ration formulation

Individual animal rations were formulated to give an overall CP content of 130 g/kg DM and energy concentration of 11.0 MJ/kg ME. The bunker silage provided the basal diet for the experimental animals. A commercial lactating meal (19.6 % CP and 13 MJ/kg ME) was used to balance the rations for overall CP and energy content. The diets consisted of 10 kg treatment silage, 20 kg of basal maize silage (from the bunker) and 6.5 to 10.5 kg of a commercial lactating meal (19.6 % CP and 13 MJ/kg ME).

Animals and treatment allocation

Twelve Holstein cows with a mean of 610 ± 71 kg live weight and all in midlactation (days in milk 166 ± 27) were used in the study. The animals were arranged into four groups of three animals each according to parity. The three cows in each group were randomly allocated to one of the three treatment silages namely maize (control), maizeleucaena and maize-acacia. All the experimental animals were then randomly allocated to individual feeding troughs in the feeding shed.

Feeding management

The cows were given three meals per day at 06:00, 12:00 and 17:00 hours for a period of 21 days of which 14 days were for adaptation followed by seven days of data collection. The meal was mixed with the silage to prevent excessive selection against the roughages. The apparent intake was calculated as the difference between the amount

offered and the refusals for each meal. The animals were given access to water in-between meals every day. Daily milk yields were recorded during the morning and evening milking sessions.

Milk samples

Milk sampling was done twice per week during morning and afternoon milking sessions. Twenty millilitre samples were collected into sample bottles with a Bromopol (2-bromo, 2-nitropraine, 1,3 Diol + Natamycine) preservative tablet to prevent any spoilage before chemical analysis.

Laboratory analyses

All samples were milled through 1.5 mm screen before analysis. The parameters analysed on the fresh material and the silages included oven dry matter (DM), neutral detergent fibre (NDF), modified acid detergent fibre (MADF), crude protein (CP) and ash.

All analyses were done in duplicate. The DM in fresh forages and silages were determined in a forced air oven at 60 ° C for 48 h. The CP content was determined by the Kjeldahl method. The NDF and MADF were assessed using standard procedures [6]. Energy in the forages was estimated from the MADF values according to the following formula: ME (MJ/kg) = 0.16D (where D is the estimated digestibility of the forage calculated from the MADF value from the formula; Digestibility (D) = 99.43 - 1.17*MADF). The milk samples were analysed for butter fat (BF), lactose, protein, and total solids by a Bently 2000 infrared milk analyser.

Statistical analysis

The data on parameters for nutrient content was analysed using the Statistical Analysis Systems (SAS) [7] analysis of variance (ANOVA) procedures for a completely randomised design as represented by the model below. Tukeys method was used to separate the means.

$R_{ij} = \mu + T_i + e_{ij}$

Where: R_{ij} = response variable (e.g. dry matter, crude protein),

μ = Overall mean,

T_i = treatment effect (i = 1, 2, 3),

e_{ij} = random error.

In the feeding trial the general linear model procedure of SAS, for repeated measurements in a completely randomized block design was used for the analyses of DMI,
milk yield and milk composition data. The following model was used:

$R_{ijk} = \mu + P_i + T_j + e_{ijk}$

Where: R_{ijk} = response variable (DMI, milk yield, protein, butterfat, lactose etc)
μ = overall mean,
P_i = effect due to parity (i = 1, 2, 3 or 4),
T_j = treatment effect (j = 1, 2 or 3),
e_{ijk} = random error.
The differences among the means were assessed by Tukeys method.
307

RESULTS

Nutritional composition of the silages

The NDF content of the silages were not different but they were all significantly different from that of the meal ($P < 0.05$) as indicated in Table 1. Bagged maize silage and
mixed maize-acacia silage had similar MADF values of 304.4 and 318.6 g/kg DM, respectively. The bunker maize silage and the maize-leucaena silage had significantly
higher MADF values of 353.5 and 357.4 g/kg DM, respectively, compared to the other
silages. The bagged maize silage had the highest D-value followed by the, mixed maizeacacia
silage, bunker maize silage and the mixed maize-leucaena silage. The estimated D value of the bagged maize silage was significantly different from that of the maizeleucaena
and the bunker maize silage ($P < 0.05$) but similar to that of the maize-acacia silage. The maize-acacia silage was not significantly ($P > 0.05$) different from that of the
bunker silage and the mixed maize-leucaena silage. The same trend was found with the
estimated metabolizable energy values.
The CP content of maize- acacia was the highest whilst the bunker maize silage had the lowest. The ash content was highest ($P < 0.05$) in the mixed maize-leucaena silage
followed by the bagged maize silage and then the lactating meal with similar levels to
those of the bunker silage and the mixed maize-acacia silage.

Table 1: The nutrient content of the silages .

Bagged maize silage

Maize--
Leucaena
silage
Maize--
Acacia
silage
Standard
Error of
means
DM (g/kg)
271a
276a
339a
12.3
CP (g/kg) 71.2c 176.0b 208.7a 0.5
NDF (g/kg) 608.2a 658.4a 602.6a 17.5
MADF (g/kg) 304.4b 357.4a 318.6b 4.4
ME (MJ/kg) 10.21b 9.22c 9.95bc 0.1
Ash (g/kg) 6.6ab 7.4a 5.6b 0.2
Digestibility (%) 63.8 b 57.6 c 62.2 bc 1.5
abcValues with different superscripts in a row are significantly different (P<0.05)

Dry matter intake

The dry matter intake (DMI) levels of the silages are shown in Table 2. The cows given mixed maize-acacia and maize silage had higher intake levels than those fed the mixed maize-leucaena silage (P < 0.05).

Milk yield and quality

The milk yield (Table 2) was higher (P < 0.05) in cows fed mixed maize-acacia and maize silages compared to animals on mixed maize-leucaena silage. However, the milk composition in terms of butterfat, lactose, protein and total solids was not different (P > 0.05) across the treatment diets.

Table 2: DM intake, milk yield and milk composition from animals fed mixed cereal-legume silages.

Maize
silage
(control)
Maize-
Leucaena
silage

Maizeacacia
silage
Standard
error of
means
DMI (kg/100 kg live
weight)
3.30a
3.11b
3.31a
-
Daily milk yield (kg) 17.02a 14.06b 15.7a 0.69
Butterfat (%) 3.59 a 3.72 a 3.57 a 0.11
Protein (%) 3.36 a 3.44 a 3.45 a 0.05
Lactose (%) 4.58 a 4.57 a 4.48 a 0.04
Total solids (%) 12.47 a 12.74 a 12.48a 0.16
abValues with different superscripts across the rows are significantly different at P<0.05

DISCUSSION

Nutritional composition of the silages

The CP of the mixed silages that ranged from 170 to 210 g/kg DM is comparable to that of commercial dairy feeds and this gives them the advantage over the maize silage
that had a CP content of 68 g/kg DM. These findings are similar to those in an earlier
study [5] although the values in this study were slightly higher. However, the efficiency of
utilisation of the CP in the mixed silages is not guaranteed due to the perceived interference from the polyphenolic compounds. In view of the interference from the
polyphenolic compounds, the feeding value of mixed silage can best be judged from the
performance of animals in a practical feeding trial. CP content and the availability of the
protein in any livestock feed is quite important in that it has a bearing on the supplementary requirements, if any, for this expensive nutrient.
The NDF levels of the mixed maize-FTLs are within the range for some forage silages in the tropics. For example, guinea grass silage in Sri-Lanka had 69.9 - 71.9 NDF
[1], napier grass silage in Thailand had 64.2 - 70.2 NDF [8]. The MADF of forages and
silages should be within the 220 - 500 g/kg DM range [9]. The lower the MADF the

higher the energy level in a forage or silage. The levels found in this study are within this
range and this indicates that the mixed maize-FTL silages have a potential to replace the
silage from traditional crops such as maize and sorghum if other factors are ideal. It is
important to note though that the NDF and MADF levels are dependent on the maturity
stage of any given forage since they are essentially indicating the levels of cell wall
components mainly the cellulose, hemicellulose and lignin (for NDF) and cellulose and
lignin (for MADF).
Similarly the DM and CP of silage all depend on the type and stage of maturity of the crops at the time of ensiling in addition to the methodology of harvesting and
technique of ensiling. It is generally known that feeds with high fibre content have low
digestibility and hence are of poor quality. The MADF of the bagged maize silage and that
of the mixed maize-acacia were similar and so were those of the bunker maize silage and
that of the mixed maize-leucaena silage but they were all within the 22-50 % range
suggesting that the quality is acceptable. If NDF is considered, the picture is different,
with all the four silages having similar content. In this regard MADF seems a better

parameter to indicate the potential digestibility of a given silage than NDF. The MADF
was used to calculate the estimated digestibility values (D-value) for each silage. The
digestibilities of all the silages are slightly higher than those reported in literature. The
variation could be due to the differences in maturity of the various crops at the time of
ensiling, with better digestibilities being found in young forage material. After the
laboratory work there is need to confirm the estimated feeding value (the D-value) of the
mixed silages through proper feeding trials.
The ash content of the mixed silages was comparable to that of the maize silage

and the lactating meal. Mixed maize-leucaena silage had a significantly higher level of the
ash than the lactating meal and other silages used in this study. This suggests that there
may be no need to add commercial mineral supplements if the mixed silages are used.
However there is need to analyse the ash for the quantities of calcium, phosphorus, iron,
magnesium and other minerals required by lactating cows in order to ascertain the sufficiency from the silages.

Dry Matter Intake

There was no significant difference between the DMI of maize-acacia (3.31 kg/100 kg liveweight) and the maize silage (3.30 gkg/100 kg liveweight). This demonstrates the
potential of the mixed maize-acacia silage as a source of protein in dairy cattle feeding.
DMI is an important parameter in assessing the nutritive value of a feed or forage. The CP
content of a feed influences the DMI of that feed because it tends to improve the palatability. However the CP content alone can not be responsible for high DMI because
the energy content of the feed also plays an important role since animals eat to satisfy
energy requirements [10]. The DMI reflected the influence of NDF, MADF and digestibility levels in the experimental treatment silages. The low DMI of the maizeleucaena
silage could have been due to high fibre levels resulting in the rumen fill effect.
It is quite interesting to note that the DMI seems to have been influenced by the fermentation quality of the silages. Generally, it is believed that if forage has high levels of
total phenolics its intake may be low. In this study mixed maize-acacia had the highest
levels of total phenolics but its dry matter intake was similar to the control that had the
lowest levels of phenolics. The reason could be that even the levels detected in the maizeacacia
silage might not have been enough to exert significant negative effects on DMI. This is supported by earlier studies [11; 12], which showed that low levels of tannins (20 -
40g extractable CTs/kg DM) may in fact be beneficial by reducing protein degradation in

the rumen and increase amino acid absorption from the small intestines without depressing
fibre digestion and voluntary food intake.

Milk yield and quality

Milk yield and quality are influenced by stage of lactation, parity, animal size and
the body condition at calving within the same breed in addition to the type of feed and
level of feeding. It is a fact that rations that stimulate high milk yield will depress butterfat
and increase total solids content. Good levels of feeding tend to stimulate high milk yields
and lactose but depress BF, protein and minerals. Conversely under feeding results in high
BF, protein and minerals and low milk yield and lactose [9]. In this study maize silage had
milk yields similar to that of the maize-acacia silage and this indicates that the mixed
silage has the potential to replace the maize silage without affecting yields. However the
potential of the mixed silages cannot be guaranteed as this depends on the prevailing
economic situation. Low DMI levels seem to have affected the milk yield from the maizeleucaena
silage. Milk yields from animals supplemented with *L. leucocephala* hay were
higher than those from animals fed *Acacia angustissima* and *Calliandra calothyrsus* 310
supplements [13]. These findings seem to suggest that the processing done prior to feeding
the animals influence the performance of forages. In any case it has been found that sun or
oven or freeze drying have varying effects on tannin levels [14; 13] and this has an effect
on dry matter intake and subsequently the milk output.

There were no differences in the quality of milk across the treatments although studies [15] suggested that milk yield and composition in dairy cows might be influenced
by the source of roughage. The data generated in the present study seem to be in agreement with the conclusions made that the dairy cow can maintain similar milk yield
despite marked differences in the type of end products arising from carbohydrate and

protein digestion [16]. Similar studies [17] using mixed maize-red clover silage and lucerne silage reported that the mixed silage increased milk yield compared to the maize silage alone (control) but lucerne silage was out performed by the control. The same authors also reported that the legumes compared to the maize silage lowered milk fat and protein levels. The varying results indicate that there is need for more research into the subject of mixed silages and their influences on milk yield and composition in given environments. This is important since the quality of milk has an influence on processing milk into milk products. Long-term studies are needed to determine the effects of mixed forages on udder development and the subsequent milk yields.

CONCLUSION

Mixed silages of good quality can be produced and used to partially replace commercial feed supplements without loss in milk yield or quality. However, there is need to ascertain the trend with low yielding dairy cows especially crossbreeds cows where there is potential to completely replace the commercial feeds with mixed FTLs and increase profits.

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ALFALFA YIELD UNDER SUBSURFACE DRIP IRRIGATION APPLYING SECONDARY DOMESTIC EFFLUENT

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Key words: alfalfa, lateral spacing , secondary domestic effluent, sprinkler irrigation,
subsurface drip irrigation, water use efficiency

Abstract
*Scarcity of fresh high-quality water has heightened the importance of wastewater reuse in
dry regions together with improving its efficiency by using the most effective irrigation
method. In this study, field experiments were conducted during two years on the commercial farm of Revivim and Mashabay-Sade Farm (RMF) southeast of the City of Beer-Sheva, Israel. The response of alfalfa (Medicago sativa) to secondary effluent*

application was examined. Subsurface Drip Irrigation (SDI) system was compared with conventional sprinkler irrigation. In the SDI the emitters were installed at 20 and 40 cm below the soil surface and lateral spacing was 100, 150 and 200 cm. In an adjacent field alfalfa was cultivated and sprinkle-irrigated. The amounts of effluent applied were around 12,000 m3/ha during summer and 5,000 m3/ha during winter for both sprinkler irrigation and SDI system. The results of dry weight yields of SDI showed higher yields (from 3% to 25%) than sprinkled-irrigated. The average Water Use Efficiency (WUE) indicate the highest mean value of WUE of up to 1.7 t/ML (tone per mega liter of water) for alfalfa in SDI plots. This shows that SDI system under the examined conditions of RMF, have best alfalfa yield when properly designed and managed.

INTRODUCTION

In many places throughout the world, the utilization of treated wastewater for irrigation is becoming acceptable. However, wastewater contains a variety of excreted organisms and pathogens that pose risk to the humans [1], [2] and [3]. The factors influencing the transmission of diseases by irrigation are: the degree of wastewater treatment, the crop type and the harvesting practices used (e.g. human consumption or not, consumption after cooking or not, animal consumption fresh or sun-dried, etc), the degree of contact with the treated wastewater and the irrigation method.

The intense use of effluent for irrigation has attracted public awareness of environmental pollution and the impact on water quality [4], [5] and [6]. This was mainly due to the fact that sprinkler irrigation was the primary application method associated with microorganism distribution in the air. With the advent of advanced innovative technology, on-surface drip irrigation (ODI) and subsurface drip irrigation (SDI) have become the preferred methods. In the SDI method the laterals and drippers are buried below the soil surface in the vicinity of crop root zone [7]. SDI method allows precise application of

water, nutrients and other agro-chemicals directly to the root zone of the plants. The depth
and placement of subsurface drip lines is determined by the soil composition and the crop
needs. An efficient installation together with frequent irrigation provides continuous root
zone wetting.

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The purpose of this work is to evaluate SDI system for growing alfalfa with treated
domestic wastewater over the conventional sprinkler irrigation system in terms of yield
production and water use efficincy. The ultimate goal is to come up with recommendation
for SDI implemenation for alflafa irrigation.

MATERIALS AND METHODS

Experimental Site

Field experiments were conducted on the commercial farm of two community farms (Kibbutzim), Revivim and Mashabay-Sade farms (RMF). The field is located a few
kilometers southeast of the City of Beer-Sheva, Israel. Mean annual precipitation is around
200 mm, mainly received from November to March. Mean maximum temperatures reach 33^0C during July and August and decrease to a mean minimum of 4^0C during January. The
soil moisture content by weight of the silt loam soil derived from loess at field capacity
was about 16% and the volumetric dry weight of the soil was about 1.55 g/cm^3.

Crop Planting

The total area for the SDI plots was about 2,900 m^2 and according to the treatments
was divided into two blocks. In each block six treatments were defined. The area for each
replication was 240 m^2 (40 m long and 6 m wide). Alfalfa (*Medicago sativa*) was cultivated by the use of SDI system with emitter depths of 20 and 40 cm below the soil
surface, and lateral delivery pipe spacing of 100, 150 and 200 cm depending on the
treatment as shown in Table 1. Emitters on lateral spacing was 100 cm and flow rate of 4
l/hr was used during irrigation.

In an adjacent field, alfalfa was irrigated by sprinklers. The sprinkled field was divided into two sub-sections of about 500 m^2 each to facilitate two different harvest timings. The alfalfa in one of the sprinkled sub-sections was harvested at the same age as the SDI system while the other was cut at maturation (when flowering reached about 50%) as conventional agricultural practices. Alfalfa was planted in the month of November at a seeding rate of 40 kg/ha. Prior to planting the field was ploughed, disked twice and cultivated with a roller. To stimulate germination, 20 mm of effluent (200 m^3/ha) was applied by sprinkler irrigation since the initial soil water contents were not adequate [7].

The experimental field was fertilized at the beginning of experiment with urea (40% N) at a rate of 75 kg/ha.

Table 1: Lateral spacing and emitter depths (cm) in different treatments for SDI system experimental plot

Treatment number	Lateral spacing (cm)	Emitter depth (cm)
1	100	20
2	100	40
3	150	20
4	150	40
5	200	20
6	200	40

314

Effluent Source

Almost all raw domestic wastewater from the City of Beer Sheva is diverted to the treatment plant. The wastewater plant consists of four settling ponds, two facultative ponds, two maturation ponds and an effluent reservoir with capacity of about 500,000 m^3.

Daily raw sewage inflow was approximately 10,000 m^3/day and retention time for the wastewater (in the ponds only) varied from 12 to 20 days. The effluent was pumped from

the reservoir and applied for irrigation. Total five day biological oxygen demand (BOD_5) of incoming raw sewage was about 215 mg/l. Prior to application, the effluent was filtered through a series of net screen filters to diminish emitter clogging. Concentrations of various constituents in the effluent are listed in Table 2.

Effluent Application

The SDI plots were irrigated twice a week with a locally developed crop coefficients based on evaporation measurements taken from an adjacent class "A" pan [8]. About 1,200 mm of effluent were applied during the summer and 500 mm applied during the winter. The sprinkled plots were irrigated every 10 to 14 days, similar to conventional practice in the region. Total amount of effluent applied per year for all treatments were similar during the

Table 2: Constituent concentration range of the effluent applied as irrigation water on the RMF for the 1st Year and 2nd Year of experiment

S/No	Constituent	1st Year Concentration (mg/l)	2nd Year Concentration (mg/l)
1	Total COD	281-426	199-436
2	Ammonia	33-47	29-64
3	PO_4	22-42	32-39
4	Na	218-263	227
5	Ca	95-105	82
6	Mg	36-41	49
7	K	28-33	20
8	TSS	90-121	60-149

experimental period of two years (Figure 1). Effluent application during the winter season was adjusted to precipitation rates and events. Total amount of effluent applied during the first year and second year of experiment were between 1,310 and 1,480 mm, respectively. Total precipitation during the related periods was 197 and 116 mm, respectively.

RESULTS AND DISCUSSION

Yield

The alfalfa yield obtained in one of the sprinkled sub-sections was harvested at the same age as the SDI system. Two sub-samples for the yield assessment were taken for each harvest, from a sampling area of 21 m^2. A similar sampling area was taken in the sprinkle-irrigated portion of the experiment. The fresh samples were oven dried and used for yield analysis. The samples were dried for about 48 hours at 70 ^{0}C to obtain dry weight. The dry weight yields obtained at the same age in SDI and sprinkler system were compared as presented in Figure 2.

315

(Values with similar letters for the data are not different according to Post Hoc test at 5% significance). The results show that in the first year of experiment in all treatments of SDI, the yield of alfalfa was 11%-25% higher than the yields obtained from sprinkler irrigated system. In the second year of experiment all treatments of SDI showed higher yields (from 3% to 9%) than sprinkled-irrigated except when the lateral spacing was 200 cm where yield was 5% less.

In general, the yields of the two experimental years indicate higher yields of alfalfa in all SDI treatments than sprinkler irrigation system when the lateral spacing was 100 cm and 150 cm. The highest yield was obtained when emitter depth was 40 cm with lateral spacing of 100 cm in the first year and 150 cm in the second year of experiment.

Figure 1: Effluent received by alfalfa on RMF for the 1st Year and 2nd Year of experiment

Water Use Efficiency

Water Use Efficiency was compared not only for the yields harvested at the same age as SDI in the sprinkler plot but also the plot harvested at maturation (50% flowering).

Water Use Efficiency, WUE (t/ML), was calculated by the amount of alfalfa produced (tones/ha) per mega liter (ML/ha) of irrigation water applied [9].

Water applied (ML/ha)

WUE(t /ML) = Yield (tonnes)/ha

The *WUE* for two experimental years are presented in Table 3. The results show that in the first year of the experiment all SDI treatments had *WUE* values that were higher than those obtained from sprinkler irrigated system (Table 3). Alfalfa harvested at maturation in the sprinkler irrigated sub-section produced the lowest *WUE* of all treatments as well as in the second year. In the second year of the experiment all treatments of SDI showed higher *WUE* values than sprinkled-irrigated except treatment number 5 and 6 where the lateral spacing was 200 cm. In general, the average *WUE* of the two experimental years indicate higher *WUE* of alfalfa in all SDI treatments than sprinkler irrigation system as indicated by mean value of *WUE* (Table 3).

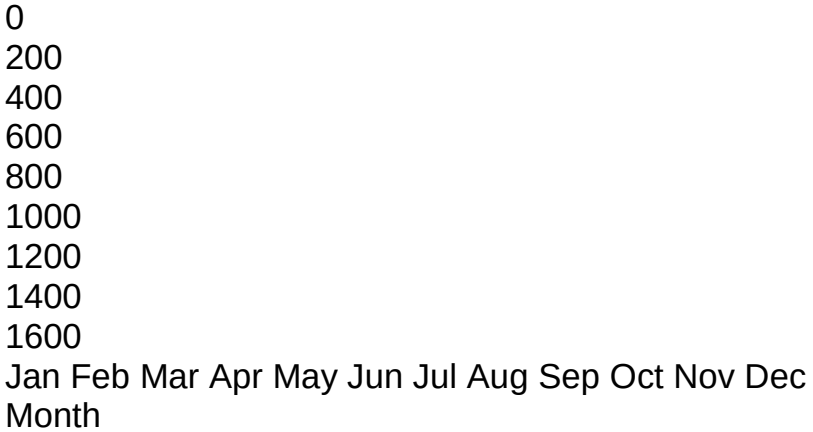

Figure 2: Alfalfa yield response to different parameters (lateral spacing and emitter depth) of SDI system comparing to conventional sprinkle irrigation. [a) and b) first and second years of experiment respectively].

Table 3: Annual WUE (t/ML) of alfalfa for the 1st Year and 2nd Year of experiment

Water Use Efficiency, (t/ML)	
Treatment Number	

Lateral
spacing (cm)
Emitter
depth (cm)
First Year Second Year 2 years Mean
1 100 20 1.57 1.36 1.47 ± 0.15
2 100 40 1.70 1.37 1.53 ± 0.23
3 150 20 1.60 1.36 1.48 ± 0.17
4 150 40 1.61 1.45 1.53 ± 0.11
5 200 20 1.49 1.32 1.41 ± 0.12
6 200 40 1.58 1.26 1.42 ± 0.23

Sprinkler

1.35 1.33 1.34 ± 0.01
Sprinkler (50% flowering) 1.31 1.25 1.28 ± 0.04

Treatment number 2 with lateral spacing of 100 cm and lateral (emitter) depth of 40 cm produced the highest value of *WUE* in the first year of experiment while treatment
number 4 with lateral spacing 150 cm and lateral depths of 40 cm indicated highest value
of *WUE* in the second year. In general the highest average value of *WUE* of 1.7 t/ML was
obtained in treatment number 2. The average *WUE* in the sprinkle-irrigated that were

15000
17500
20000
22500
25000
27500
Yield 2369725565241842429122529237412040 3
20cm40cm20cm40cm20cm40cm
100cm150cm200cm
Emitter depth
Lateral spacing
Sprinklers
Yield, kg/ha
ab
c
abcbc
a
abc
15000
17500
20000
22500
25000
Yield 2170821836217772307621060201512115 0
20cm40cm20cm40cm20cm40cm
100cm150cm200cm
Emitter depth
Lateral spacing
Sprinklers
Yield, kg/ha
bbcb
c
ab
a

b)

a)

harvested at the same age as SDI was 1.34 ± 0.01 t/ML while that at maturation (50% flowering) produced only 1.28 ± 0.04 t/ML of dry weight. The extra yields obtained under SDI are due to two main outcomes: (i) the yield per cut under SDI was higher than under sprinkler irrigation due to the earlier maturation in the drip plots, and (ii) there was at least one additional harvest per year in the drip plots as compared to the sprinkled plots.

Conclusions

A field study with SDI of alfalfa was compared with sprinkler irrigation of alfalfa showed that treated wastewater can be effectively and economically applied through a SDI system. The SDI systems offer many technological and agronomical advantages. Additional benefits are gained with the convenience of field cultivation in the SDI system.

The followings are the outcomes of this study:

1. The best alfalfa yields were obtained from SDI system at a trickle lateral depth of 40 cm and when the lateral spacing is 100 cm and 150 cm. This shows that SDI system have the best yield of alfalfa when properly designed and managed compared to sprinkler irrigation system.
2. The results also showed that when lateral spacing was 200 cm the SDI system produced less yield compared to sprinkler irrigation. Therefore, depending on the soil type and kind of crop, the SDI system installation and use parameters have to be studied thoroughly for better efficiency when SDI is to be used.
3. The average water use efficiency show that SDI system has higher water use efficiency than sprinkler system when properly designed and managed.

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SMALLSCALE PALM OIL PROCESS IMPROVEMENT FOR PORVERTY ALLEVIATION AND NATIONAL DEVELOPMENT

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Keywords: Oil palm, Palm oil, *kaizen*, moisture content, impurities, free fatty acids
(FFA), yield

Abstract

What makes oil palm development more strategic and economically sound is that there exist enormous opportunities globally for palm oil and products from it. Currently, there is an estimated external market for 2.6 million tonnes of crude oil and allied products from Ghana and West Africa but only 800,000 tonnes is produced annually in the sub-region. Indeed, there are even greater long-term opportunities in oleo chemicals and paints and as bio-fuel because of the rising cost of fossil fuels. Thus this study sought to improve yield and quality of palm oil produced by using 10 palm oil mills for the initial background study and subsequently 4 of the studied mills were chosen for the validation phase in the Ashanti Region of Ghana. The results showed that moisture content, impurities and FFA were poor and could be improved considerably by training the stakeholders. The yield of palm oil could also be improved considerably following recommended procedures to improve returns with minimal layout changes costing next to nothing. The quality and quantity gains improved access to the market which was hitherto not the case. Oil recovery from the sludge for the local soap industry did boost the incomes of millers. The main difficulty at the mills was the mountains of palm nuts crying to be processed into palm kernel oil. The outcome of this work could be replicated in oil palm producing countries on the continent to improve the livelihood of the poor and accelerate national development.

Introduction

The current population of Ghana is estimated at 22 million based on the 2000 population census. Ghana currently produces about 100,000 tonnes of palm oil annually but her annual requirement is estimated at about 240,000 tonnes. There is therefore a

deficit of 140,000 tonnes which is imported at great cost to the nation. The nation can
therefore save up to about $200 million in terms of import substitution alone by producing
her palm oil requirements since conditions for doing so are right. Ghana with her peaceful
environment and democratic credentials see herself as the gateway to the sub-region with
many international agencies relocating their offices to the country. The economic
integration of the 15-member Economic Community of West African States (ECOWAS)
is progressing satisfactorily. This promises a market of some 250 million people. There is
also a deficit of 1.8 million tonnes of crude palm oil in the sub region.
Ghana is a West African country lying along the Gulf of Guinea between latitude
40° 44’ N and 11° 11’ N, and longitude 3° 15’ W and 1° 12’ E. It is bound on the east by
Republic of Togo, on the west by La Cote d’ Ivoire and the north by Burkina Faso. Kumasi
is the capital of the Ashanti Region of Ghana. Ghana is predominantly an agricultural
country with about 50.7% of the working population working in agro-industry which
accounts for approximately 42% of her GDP. The government of Ghana has also
320
encouraged the development of non-traditional industries over the past decade in order to
diversify the country’ s export base.
Crude Palm Oil (CPO) is extracted from the mesocarp which in turn can be further
refined. The refined oil and fat is used in industrial production of non-dairy creams, ice
cream powder, salad additives and fat spread. It is used as substitute in the formulation of
soaps, detergents, margarines and baking fats. Palm oil is also a rich source of vitamins A,
D and E which are indispensable in the pharmaceutical industry. The fibre is used in mills
(boilers) as fuel and for stuffing car seats and mattresses. The list of products cannot be
complete without reference to the nut which comprises a shell and a kernel. The shell of
the palm nut is used as fuel and as activated carbon for bleaching purposes. This product is
in high demand on the international market. The kernel is a rich source of lauric acid, a

vital ingredient for the soap, cosmetic and confectionary industry.
What makes oil palm development more strategic and economically sound is the fact that there exist in Ghana, West Africa, the rest of Africa and the world at large enormous opportunities for palm oil and products processed from it. It is currently estimated that there is an external market for 2.6 million tonnes of crude oil and allied products from Ghana and the sub-region but only 800,000 tonnes is produced annually in the sub-region (PSI, 2003). Indeed, there are even greater long-term opportunities in oleo chemicals and paints. Others are researching into its use as a bio-fuel because of the rising cost of fossil fuels. For example, the energy content of industrial diesel oil per tonne is 42.3 GJ and that of palm oil is comparable of value 41.0 GJ. There is scope for the use of the waste for the generation of electricity from boilers or biogas plants. A wealth of technical know-how also abounds locally to be tapped for this industry.
The peak season for harvesting palm fruits in Ghana is from January to June. The period from July to October is regarded as the mid-season and the lean season is from October to December. During the lean season, production of palm oil is cut down due to a drop in the supply of raw materials. This is being addressed by breeders and also putting much larger areas under cultivation. There is also the need to ensure that seedlings of the *tenera* variety is produced and sold to farmers for cultivation since it gives the highest yield in terms of fresh fruit bunches and oil. Farmers are also being taught the correct lining and pegging techniques to maximise production on farms. In order to overcome the problem of shortage of fruits for processors, the government of Ghana is pursuing an aggressive policy to add 20,000 ha of oil palm plantations per year for the next five years.

Materials and Methods

The palm oil process involves a point where harvested bunches are received at the

factory or mill and these may be loaded into cages in a factory setting or stripped at an association mill. The bunches are then taken through, sterilisation, threshing or stripping, digestion, pressing for the palm oil, separation of the fibre from the nuts, clarification of the oil, storage of the oil and disposal of the sludge. Each of these stages was monitored to ascertain the losses occurring. The layout of each factory and mill visited was also measured as part of the study. The quality of fruits/bunches used in the preparation were also assessed. Most of the measurements entailed some level of weighing either using normal scales or in the case of bigger factories, weighing bridges. Samples of the oil were taken for laboratory analysis of the free fatty acids content, moisture content and impurities.

Results and Discussions

321

Table 1-3 show the studied mills in the Ashanti Region, the areas under oil palm production and employment offered especially to women respectively. During the main season a lot of casual employment is offered to inhabitants in the areas of manual stripping of the fruits, fetching water, separating of fibre from nuts, provision of firewood and vending of food. Where no casual labour is provided, the association members assist themselves with free labour known as '*nnoboa*' locally to contain cost and maximise profits. The mill at Amaning is the only one wholly controlled by women.

The availability of a company farm may help but it is not a necessary condition for starting an oil mill in Ghana. All the mills are located in areas with oil palm plantations owned by individuals. The desirable fruits are ***tenera*** which contains 21-24% oil. Unfortunately the traditional varieties are still in the system since millers buy fruits with different varieties which are difficult to differentiate just from the looks as shown in Table 4.

The capacity of the cooperative mills is just a tonne per hour. Those of the

factories were between 2-13t/h. The sources of funding for the factories/mills were
individual member shares, bank loans and the district assemblies. The Rural banks have
been assisting in the development of these rural enterprises. Technoserve, an NGO (Non-
Governmental Organisation), has also been assisting the mills with technical expertise.
Palm oil processing is a lucrative business. The cost of the fruit per tonne is about $70 but
crude palm oil sells for about $1000/t, the kernel oil for $1087/t and the shells could sell
for $136/t. The cost of machinery, water, labour and other incidentals need to be factored
into the cost though.

Table 1: Location of Studied Oil Mills

Name of Oil Mill	**Location**	**District**	**Distance from Kumasi (km)**
1 Antoakrom	Antoakrom	Amansie West	55
2 Sekyere East Oil Mill Limited	Asokore	Sekyere East	55
3 Pease Oil Palm Association	Pease	Bosumtwi-Atwima-Kwanwoma	32
4 Ntinanko Cooperative Oil Palm Farmers Society Limited	Ntinanko	Amansie East	44
5 Ayokoa (Sir Speedy)	Ayokoa	Adansi North	82
6 Afotom Oil Palm Processing and Marketing Society Limited	Afotom	Offinso	45
7 Amaning Women's Association	Amaning	Offinso	65
8 Adansi Oil Mills Limited	Dompoase	Adansi North	63
9 Juaben Oil Mills Limited	Juaben	Ejisu-Juaben	50
10 Anwiankwanta Oil Mills Limited	Anwiankwanta	Amansie East	35

322

Table 2: Production of Oil Palm in Ashanti Region (2005)

No.	Districts	Area under Cultivation (ha)	Production of Fresh Fruit Bunches (t)
1	Ejisu Juaben	4,163	14,986.8
2	Asante Akim North	1,821	6,555.6
3	Asante AkimSouth	3,902	14,047.2
4	Sekyere East	3,122	11,239.2
5	Sekyere West	1,301	4,683.6
6	Ejura Sekyedumase	520	1,872
7	Kwabre	1,821	6,555.6
8	Efigya Sekyere	1,821	6,555.6
9	Offinso	3,643	13,114.8
10	Ahafo Ano South	3,122	11,239.2
11	Ahafo Ano North	3,122	11,239.2
12	Atwima Nwabiagya	3,122	11,239.2
13	Atwima Mponua	3,122	11,239.2
14	Amansie East	3,122	11,239.2
15	Amansie West	2,081	7,491.6
16	Amansie Central	3,122	11,239.2
17	Adanse South	3,643	13,114.8
18	Adanse North	3,643	13,114.8
19	Obuasi Municipality	1,041	3,747.6
20	BAK	1,041	3,747.6
21	KMA	0	0
	Total	52,295	188,262

323

Table 3: Employee breakdown of oil mills

Name of Oil Mill	Actual Employees				
	Male	Female	Managerial	Casuals	Total
1 Antoakrom	12	21	1	100	134
2 Sekyere East	5	145	-	150	300
3 Pease	1	14	-	-	15
4 Ntinanko	12	26	7	-	45
5 Ayokoa (Sir Speedy)	6	2	2	6	16
6 Afotom	4	15	-	10	29
7 Amaning	3	11	-	5	19
8 Adansi	18	1	4	3	26
9 Juaben	125	125	6	251	557
10 Anwiankwanta	24	2	2	6	34

Fruits were kept for too long at the association mills. A maximum period of 3-5 days is recommended to prevent deterioration and higher FFA’s in the oil. Sterilisation is

also done for too long and with too much water at a lower temperature which is not optimal for the efficiency of oil yield. There is temperature loss during digestion and pressing because of the sheer distances between sterilisation and digestion. Clarification temperatures at the association mills also needed some fine-tuning.

Table 4: Raw material base of oil mills

Name of Oil Mill	Size of company farm (ha)	Type of fruits used (%) Tenera	Dura
1 Antoakrom	230	80	20
2 Sekyere East	Nil	60	40
3 Pease	Nil	90	10
4 Ntinanko	4.5	90	10
5 Ayokoa (Sir Speedy)	50	90	10
6 Afotom	Nil	100	Nil
7 Amaning	Nil	100	Nil
8 Adansi	Nil	90	10
9 Juaben	175	70	30
10 Anwiankwanta	Nil	80	20

Apart from the free fatty acids content at the factories which were within the recommended average of 5-5.5 %, all the others were just too high. To target the international market, FFA will have to come down to about 2-3 %. This will mean processing the fruits in far fewer days than is currently the case. Currently, fruits are stored for up to 14 days at some places. This does not include the period harvested bunches are kept in the farm. They are piled up and some are stored in fertiliser sacks in the open.

These generate a lot of heat leading to faster deterioration, mouldiness and bruising which cause higher free fatty acids. Storage is slightly better at Ntinanko and Asokore where fresh fruit bunches (FFB's) are stored on wooden platforms.

The standard for impurities is 0.045 %. Unfortunately, the dirt content is way too high but better at the factories. Much of this is due to poor storage of bunches and lack of patience to allow settlement before skimming-off the oil. The introduction of filters at the cooperatives will be helpful. The pressing of oil from the pulp present a problem of nuts in

the fibre which is a limitation on how much pressure can be exerted. Pressures of 200kPa
324
are exerted by the presses at the factories. In the case of manual screw presses, the
pressures are up to 22 kPa which is woefully inadequate.
The yield of *tenera* is high in the range of 22-24 % (Poku, 2002). This is the preferred fruit for palm oil production. Unfortunately, there is this tradition of not
destroying economic crops during land preparation. Also squirrels and other animals
disperse the palm fruits to all sorts of places. Wild *dura* fruits are also harvested for
consumption and sale. Some farmers also produce their own seedlings and some unscrupulous people produce seedlings to cash in on the booming seedlings business. No
wonder a lot of *dura* is available in all the production centres studied. There is the need to
intensify education on seedling production and sale. Certified seedling producers must be
encouraged and farmers made aware through agricultural extension officers. Finally,
buyers of bunches and fruits can be trained to decipher this problem since most mills do
not own their own farms. Subsequent studies focussed on the small scale millers because
of their many problems and lack of assistance in their activities.
It is recommended that the oven and digester distance should be at a maximum distance of 10 m. This will reduce the carrying of fruits for longer distances which resulted
in severe temperature drops to affect the yield of palm oil in the old production techniques
studied. The digester and press must similarly be close to prevent further temperature
drop. The sum total of these modifications minimised the drudgery associated with the
process and more importantly ensured high enough temperatures in the digested mash
during pressing to improve yield.
The other problem is the use of inefficient local ovens by essentially placing three
stones to form a tripod for the sterilisation/clarification/drying tanks. This led to a lot of

smoke in the environment. It is recommended that more efficient ovens should be built
with bricks to deal with the unhealthy smoky environments. If improved ovens are built,
then the distances between the digester and steriliser could even be closer. The
improvements kept temperatures of digested material above 70oC which is a pre-requisite
for keeping the palm oil in a liquid state to optimise yield. The digester and press were
equally close, thus the temperature of the fibre and nuts after pressing was even around
70oC. Boiled fruits were also not heaped before digestion but were carried in reasonable
bits straight to the digester after sterilisation.

Table 5: Analysis of quality/ yield of Palm oil under old and improved processing methods

Location of Mill Type of Processing				
		Afotom	**Antoakrom**	**Ntinanko**	**Pease**
Oil Left in	Old Method	24.01 (2.31)	18.81 (1.02)	20.20 (0.97)	21.83 (0.68)
Fibre (%)	New Method	6.21 (0.86)	5.48 (0.82)	6.23 (1.37)	5.28 (0.70)
Impurities (%)	Old Method	8.82 (1.14)	7.21 (2.01)	8.21 (1.18)	8.66 (0.88)
	New Method	1.50 (0.88)	2.00 (0.56)	1.78 (0.64)	1.41 (0.52)
Moisture	Old Method	1.21 (0.28)	1.10 (0.32)	1.05 (0.17)	1.02 (0.16)
Content (%)	New Method	0.33 (0.10)	0.35 (0.09)	0.30 (0.11)	0.30 (0.10)
Free Fatty	Old Method	10.56 (2.00)	11.38 (1.84)	10.43 (2.02)	9.49 (1.56)
Acids (%)	New Method	6.41 (0.76)	6.30 (0.72)	6.65 (0.73)	6.41 (0.76)
Yield	Old Method	8.18 (0.84)	10.36 (1.20)	9.77 (2.93)	9.27 (2.64)
(Theoretical Yield is 22-24) %					
	New Method	18.94 (0.98)	17.16 (3.52)	19.31 (0.57)	19.21 (1.01)

Standard Deviation in Parenthesis

The level of impurities reduced substantially simply by pre-washing before boil and also using cleaner containers at all stages. Skimming of the oil layer after clarification
must minimise some of the sludge getting in with the oil to be dried. This was the cause of
too many particles after the drying process. The technique of skimming of particles after
drying must also be improved. By drying until all the bubbles died down, the moisture

contents were brought within recommended standards as shown in Table 5 for all the
mills. The drying process must be carried out in about 30 minutes. The fire temperature
must be managed to keep drying temperature around 120-130oC like Antoakrom in Figure
1. Drying to high temperatures as at Afotom in Figure 1 wasted time and energy and also
destroyed the quality of oil. The volatile components of the palm oil vaporised at higher
temperatures to destroy its quality.

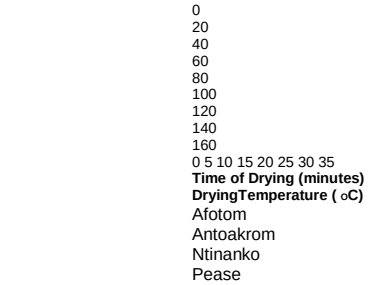

Figure 1: Correlation of drying time with temperature

The FFA of palm oil produced (see Table 5) using the new procedures improved.
The yield of palm oil nearly doubled in most cases. This clearly shows that by following
the improved methods, millers stand to gain a lot financially. It is the result of not leaving
fruits to rot and keeping temperatures very high up to pressing. The extension of the effort
arms for manual presses and changing of oil in hydraulic presses to the correct hydraulic
oil contributed to this.

Fruits must well-covered to ensure boiling temperature of at least 100oC. It is better to add about 45% of the material volume of the fruits as water. Where there are no
weighing scales, a third of the tank to be filled with fruits for sterilisation must be filled
with water and covered tightly with no heaping.

The effort arms of the manual presses were extended with galvanised iron pipes to the length of the existing effort arm by about 0.5-1.0 m each side to improve pressing and
minimise human effort. An attempt to use bamboo for the extension failed, but more
mature bamboo could serve the purpose. Heaping of mashed pulp in the basket for pressing was avoided to prevent pressed oil from falling back into the fibre and nuts to

reduce yield. Pressing was gently done to avoid spillage onto the floor and was continued
until no more material oozed out. The cake was ejected afterwards and immediately separated manually into fibre and nuts. When enough fibre to fill the cage of the press was
obtained, a final pressing was recommended.
The efficiency of extraction improved tremendously from 65% to over 100% in the areas studied with the improvement techniques and also as shown in the low level of oil
left in the fibre in Table 5. There is a limitation on how much oil can be squeezed given
the pressure available and the presence of concretions in the form of nuts. No matter the
pressure, some oil will still stick to the fibre.

The sludge was never thrown away after clarification. It was poured into a 200 litre
oil drum (45 gallons) or a reasonably sized container, covered and left for 1-4 days (Kyei-
Baffour and Manu, 2007). It is better to avoid longer periods to prevent decay and the
emission of offensive odour. A new oil layer appeared on the sludge afterwards, and this
was skimmed into a drying container. An equal quantity of clean water was added to the
oil skimmed and dried. The quality of this oil is low. It is therefore not palatable or edible
so it is best sold to the local soap industry. This can also boost the incomes of millers.
Finally, the sludge must be disposed off in pits dug for the purpose not into natural drains
or water ways. The water in the sludge will infiltrate into the soil. When the pit is full, it
should be covered with soil to control the stench, flies and scavengers and also to ensure a
relatively clean environment.

Conclusions and Recommendations

Serious education is needed to ensure that only certified seedlings of *tenera* are grown in Ghana to optimise palm oil yield. Storage and the general environmental conditions of mills must be improved. Capacity must be improved to minimise the storage
of fruits for longer periods. There is the need to train all association type millers to

improve on their efficiencies. The factories will need to rehabilitate sensors for monitoring temperatures and pressures as well as all valves and filters. The disposal of sludge is not currently acceptable and serious research is needed to deal with the problem. Millers must be encouraged to go into palm kernel oil production to prevent waste and increase their incomes. The duration of storage of bunches and fruits need to be kept to a minimum of 3-5 days since rotten fruits at the association mill when boiled led to a lot of oil losses through the sterilisation water and higher FFA's in the palm oil produced. Over-sterilisation must be avoided. Boiling with too much water for over 2 hours is not good. At the factories, the quality of steam is important since this affects the extraction rate, the quality of oil and the efficiency of the machinery. Trapped air in the steriliser happens because of the lack of automatic air vents at the factories studied. This can lead to longer than required sterilisation period because the air forms a barrier to sterilisation. Steam temperature and pressure at the factories of 140$_o$C and 300kPa respectively were the recommended standard.

Inadequate sterilisation leads to poor threshing leading to the loss of oil to bunches. However, the clearance between the inner cylinder of the digester and the beating arms had problems leading to lots of undigested fruits and subsequently longer digestion time for all the mills. Pressures and temperatures were controlled at the factories during pressing. Excess pressure could break the nuts and affect the quality of palm oil. Pressures exerted by manual presses were too small at the association mills.

Acknowledgement

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327

Phenotypic Characterization of goats raised under traditional husbandry systems in Bugesera and Nyagatare Districts of Rwanda

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Key words: Rwanda, Goats, Indigenous, Phenotypic characterization

Abstract

Phenotypic characterization is a simple, non-invasive, inexpensive technology that can be utilized in mapping out an inventory of characters peculiar to a group of animals. A random sample of 487 non-descript village goats in Bugesera and Nyagatare were characterized according to their phenotypic characteristics. Three age categories, based on dentition, were examined: milk, young, and adults. Parameters assessed included face, back, and rump profiles, presence of beards and toggles,, tail, and ear lengths, coat color and pattern, presence of horns, live weight, heart girth, wither height, body and back lengths. Overall, 77.2% of goats sampled had a flat face while 22.8% had concave faces. More than ninety eight percent (98.4%) had flat backs with 1.6% having a hollow back. All the goats in the study had a sloping rump. Only 6% had beards. About fourteen percent (13.5%) had toggles averaging 3.4 cm in length. Average horn length varied from 4.3± 0.2 cm in the milk category to 8.0 ±-0.1 cm in the mature goats. Horn diameter varied from 3.3 +/0. cm in the kids to 8.6 +/-0.2 cm in adults respectively. The mean tail length ranged from 9.6(+/-0.1 to 12.0 +/-0.1 cm for the same age categories as above.

Average mean ear length ranged from 10.3 (+/-0.1) to 11.5(+/-0.09) (milk-adults). There was no significant difference (P > 0.05) from one dentition category to another. The predominant coat color was the uniform multi-colored coat pattern. The mean live weight (kgs) recorded were 13.1 (+/-3.3) (kids), 25.5 (+/-0.7) (young), and 33.3 (+/-0.5) (mature goats). Mean heart girth (cm) recorded was 54.4 (+/-0.5) (Milk), 67.0 (+/-0.5) (Young), and 74.0 (+/-0.4) (mature goats). Our results show that goats in the study are predominantly not the East African Small type, but rather, are an improvement from the typical East African Small. Implications of the present findings on goat breeding and productivity in Rwanda are discussed.

Background and Justification

In Rwanda, it has been estimated that there are approximately 1,379,895 goats in the country (12). Goats are a very valuable genetic resource that is suited for low-input agricultural production systems. They require low inputs and are easy to manage, making them suitable for the resource poor rural households (1). The abilities to reduce their metabolism, efficiently use water, minimize nitrogen requirements, and efficiently digest high-fiber forage are among the desired adaptive features of goats (7, 19, 14, 11). These characteristics enable them to continue providing milk and meat even when cattle have succumbed to drought (16). On account of their adaptability, goats can survive on woody browses and infrequent watering during droughts, and after drought, their high reproductive rate and short generation interval enable their owners to recover quickly and

economically (9, 15). Other valuable attributes of goats include provision of food (9), fibre (18), income generation (18), and creation of employment (9), for poor rural families, especially women and children. They can be sold to attain immediate cash assets for poor

goat holders, helping them improve livestock and crop farming and financing social events
(14). Last but not least, the value of goats for the use of the vast areas of natural
mountainous and hilly regions where crop production is less practicable should not be
overlooked (9).
Despite their multiple roles and economic importance, information collected by the
Food and Agriculture Organization (FAO) of the United Nations indicates that
approximately 30% of the world's farm animal breeds inclusive of goats are at risk of
extinction (FAO, 1999). The major threat has come from animal breeding practices that
have emphasized productivity and specialization, and by so doing, promoted prevalence of
a relatively small number of breeds at the expense of locally adapted, but less productive
native breeds. Unfortunately, once animal genetic diversity has been lost, it cannot be
replaced. Unlike breeds from temperate regions, most of the available goat genetic
resources in Rwanda have undergone natural selection (8,6). As a result, the reproduction
performance and production of most tropical goat breeds are both low. To improve this
situation, native goats should be selected for their abilities to produce and reproduce
efficiently and survive in the environments in which they are kept (3). Breed
characterization should thus be prioritized, if we are to select superior animals.
Characterization means the distillation of all knowledge which contributes to the
reliable prediction of genetic performance of an animal genetic resource in a defined
environment and provides a basis for distinguishing between different animal genetic
resources and for assessing available diversity. It thus includes a clear definition of the
genetic attributes of an animal genetic resource and the environments to which it is
adapted or known to be partially or not adapted to at all. It also include the
population size

of the animal genetic resource, its physical description, adaptations, uses, prevalent breeding systems, population trends, predominant production systems, description of environment in which it is predominantly found, indications of performance levels (milk, meat, growth, reproduction, egg, fibre, traction etc.), genetic parameters of the performance traits and information on genetic distinctiveness of the animal genetic resource and its evolutionary relationship with other genetic resources in the species (8, 6)

Phenotypic breed characterization is an essential, initial step in breed identification (4). However, very little effort has been made towards characterization of indigenous goat breeds in Rwanda. The lack of information on characterization of a genetic resource may lead to the underutilization of that resource, its replacement, and dilution through crossbreeding despite their local adaptation to prevailing environmental constraints.

Therefore, assessment of genetic variability in domestic animals is an important issue to preserve genetic resources and maintain future breeding options in order to satisfy the demands of changeable markets (10). Unplanned and indiscriminate breeding among native stocks is directly or indirectly responsible for the dilution of Rwandan livestock germplasm. Hence, identification and characterization of the goat breeds in Rwanda is a must to identify our genetic resources and also to prioritize breeds for conservation.

Characterization of animal genetic resources promotes continuing use and conservation of indigenous livestock, which are usually more productive than exotics under low levels of input. Given that most of the goats in Rwanda are in the resource-poor rural households, promotion of breeds that thrive under low input systems is envisaged to result in increased farmers' incomes and food security. Presently, Rwanda does not have a complete inventory of the indigenous goat breed resources nor a basic description of many

of the current species. It is therefore important to obtain an inventory of domestic animal
329
genetic resources in general and goats in particular, and to characterize these resources at
the phenotypic and genotypic levels. In this endeavor, physical or morphological characteristics can be particularly useful in the classification of populations, strains, or
breeds within a species (21). The objective of this study was therefore, to make an
inventory of phenotypic characteristics of and genetic diversity among indigenous goat
breeds in Nyagatare and Bugesera districts of Rwanda. The information so generated will
be used in determining their relationships which may thereafter be useful as potential
predictors of performance traits.

Material and Methods

Sites of study

The two site chosen for characterization exercise were Tabagwe and Kamabuye sectors in Nyagatare and Bugesera districts respectively because these sectors are known
for keeping purely indigenous breeds. The type of climate experienced in both sites is
equatorial and are found in the low altitude zones of the Eastern and South-Eastern parts
of the country respectively. The approximate distance between the two districts is 261 km.
The study area is located 30’ 30o- 30o 25’ East and 20 05’- 20 30’ South and an altitude of
1400 m a.s.l with average temperature 25o C in wet season and 30o C in dry season and
relative humidity of 74% . The rainfall received is a moderate bimodal, fairly well
distributed within the year, with the short rains (Season A) falling between September and
December, while, the long rains extends from March through May (Season B).
The most popular goat production system is semi-intensive where tethering the goats close to the homesteads or some take them to graze freely in communal areas beginning at about 9.00am to mid day, then they are brought home and either kept in
sheds/pens or tethered on pegs and they are supplied with twigs, banana leaves, peels,

potato vines, leaves etc. till at about 4.00pm. They are normally taken back to the grazing area, where they are tethered till 6.30 to 7.00pm. Banana leaves and pseudo-stems are cut and fed to the animals in the sheds at resting time at mid day when the ambient temperatures are high outside. Supplementation with agro-industrial by-products and other sources of supplements is rather uncommon within the farming systems. The local goats have been adapted to the environment and bear tremendous resistance to a good number of diseases prevalent in the region. Common diseases in the area include helminthiasis and contagious pustular dermatitis. Generally disease control is done on an *ad hoc* basis. The lack of effective disease control measures has been attributed to inefficient veterinary services and lack of awareness by farmers who rely on use of indigenous technical knowledge. Few farmers keep bucks for breeding. Normally nearly all born male kids are castrated when less than three month of age for improved meat quality. As a result, the farmer keeping a buck, whenever, other farmers bring does for mating they pay for that service and the price varies between 0.4- 0.6 US dollars

Data collection

Data on a random sample of 238 and 249 goats was collected from Nyagatare and Bugesera districts respectively. The goats were categorized by dentition ranging from young animals with no permanently ruptured teeth (milk teeth) to those with four pairs permanently ruptured teeth (Full Dentition). This is because farmers seldom keep birth records, so to determine various stages of growth, dentition was found to be the most appropriate. Goats without any permanently ruptured teeth were classified as milk goats while those with one or two permanently ruptured teeth were grouped together and referred to as young and those with three or four permanently ruptured teeth were considered as the mature category. All goats were weighted using a spring balance after

ascertaining their dentition. Measurements were recorded using a tape measure in cm.
These included; heart girth, wither height, body length and back length from the base of
the neck to the root of the tail. Tail, ear type and their lengths were also recorded. Horn
orientation, its length, and diameter at the base were also noted. Presence of toggles, their
length and if single which side they occur was also recorded.

Data Analysis

Data was analyzed with SAS using the general linear models. ANOVA for live
weight and linear measurements was carried out to determine the fixed effects of dentition,
coat color, origin, and their interactions. Least square means were computed for all the
tested factors. Coefficients of correlation between the measured parameters were
computed for the various dentition categories in Nyagatare and Bugesera districts to
determine linear associations. Stepwise regression models of body weight as the
dependent variable with linear measurements as the independent variables for milk, young
and mature categories of goats in both districts was determined. This was done to find the
most suitable models showing relationships between live weight and linear measurement
of heart girth, withers height, back length, and body length for various dentition
categories. Proportion of live weight to heart girth, withers height, back length, and body
length was calculated for the various dentition categories to determine the trends of these
associations. Other linear proportion that was considered were heart girth with withers
height and back length for various dentition groups.

Results

Three age categories (based on dentition) were examined: milk, young, and adults.
Parameter assessed included face, back, and rump profiles, presence of beards and
toggles, horn, tail, and ear lengths, coat color and pattern, presence of horns, live weight,
heart girth, wither height, body and back lengths. The predominant coat color was the
uniform multi-colored coat pattern. Overall, 77.2% of goats sampled had a flat face while

22.8% had concave faces. More than ninety eight percent (98.4%) had flat backs with
1.6% having a hollow back. All the goats in the study had a sloping rump. Only 6 % had
beards. About fourteen percent (13.5%) had toggles averaging 3.4 cm in length.
Polledness was observed in 8.9 % and 4% of goats in Nyagatare and Bugesera districts,
respectively. The horn length and diameter varied from 3.4 cm to 8.8 cm and 4.3 cm to 8.3
cm respectively from milk to mature groups. Average horn length varied from 4.3(+/- 0.2)
in the milk category to 8.0 (+/-0.1) in the mature goats. Horn diameter varied from 3.3
(+/0.1) cm in the kids to 8.6 (±0.2) in adults respectively. Fifty one percent (51%) of the
horns shape was straight and the orientation of 67.9% being backwards. The mean tail
length ranged from 9.6 (+/-0.1) to 12.0 (+/-0.1) for the same age categories as above. Tail
length did not differ with age category. Average mean ear length ranged from 10.3 (+/-0.1)
to 11.5(+/-0.09) (milk-adults). There was significant difference ($P < 0.05$) in ear length
from one dentition category to another. The mean live weight (kgs) recorded were 13.1
(+/-3.3) (kids), 25.5 (+/-0.7) (Young), and 33.3 (+/-0.5) (mature goats). Goats with
black/brown coat coloration were the heaviest followed by black/white and uniform black
(Table 2). Heart girth increased as dentition category increased but the difference between
consecutive categories reduced progressively. Mean heart girth (cm) recorded was 54.4
(+/-0.5) (Milk), 67.0 (+/-0.5) (Young), and 74.0 (+/-0.4) (mature goats). A similar trend
was observed for wither height, back length and body length. Just like weight,
black/brown goats had larger linear measurements. Within the dentition groups the
proportion of live weight to linear measurements (heart girth, wither height, body length
and back length reduces progressively (Table 1). Live weight was significantly correlated

with heart girth (P < 0.01). There was strong indication that heart girth is a good predictor
for live weight as it appears in all dentition categories.

Table 1. Linear measurement and live weight for the different age-groups of goats in Nyagatare and Bugesera Districts, Rwanda.

Dentition	**Weight (Kg)**	**Heart Girth (cm)**	**Wither height (cm)**	**Body Length (cm)**	**Back length (cm)**	**Tail length (cm)**	**Ear length (cm)**	**Horn length (cm)**	**Horn diameter (cm)**	**Toggle length (cm)**
Milk	13.1± 0.3	54.4 ± 0.5	49.3 ±0.5	46 ±0.5	44.1 ± 0.4	9.6 ± 0.1				

10.3
± 0.1
3.3
± 0.15
4.3
± 0.2
3.3
± 0.3
Young 25.5
± 0.7
67
±0.5
59.6
± 0.4
57
± 0.5
55.3
± 0.4
11.1
± 0.12
11
± 0.1
6.7
± 0.1
6.8
± 0.1
3.36
± 0.17
Mature 33.3
± 0.5
74
± 0.4
63.1
± 0.4
62
± 0.3
59.2
± 0.3
12
± 0.10
11.5
± 0.09
8.6

± 0.2
8
± 0.1
3.7
± 0.2

Table 2. Live weight and linear measurements of the different colors of Goats in Bugesera and Nyagatare Sectors (mean + SE of mean)

Coats Color	Live weight	Heart Girth	Wither Height	Back Length	Body length
Black	25.22 ± 0.73	66.20 ± 0.74	57.81± 0.59	53.49± 0.60	55.42± 63
Black/white	25.32± 0.91	66.07± 0.78	58.03± 0.60	53.25± 0.64	55.12± 0.67
Brown	21.50± 2.99	65.30 ± 3.05	55.60 ± 2.73	52.90± 2.10	53.50± 2.51
Black/ Brown	28.28± 1.70	69.40 ±1.62	59.80± 1.37	55.57± 1.20	57.33± 1.41
White	21.00±2.60	62.00±2.77	55.11± 2.16	49.78 ±2.48	54.67± 3.11
Ikivuzo (mixes of black and white)	21.64 ±2.20	61.56± 2.57	55.40 ±1.70	52.52± 2.10	54.04± 2.21
Black/Ikivuzo	24.72±1.97	65.85± 2.28	58.63± 1.98	54.26 ± 2.14	55.93±2.23

Discussion

The World Watch List for Domestic Animal Diversity [WWL-DAD] prepared by the Food and Agriculture Organization of the United Nations (FAO) in 1993, and which has since been revised two times (1995 and 2000), has defined a breed as: either a homogenous, sub-specific group of domestic livestock with definable and identifiable external characteristics that enable it to be separated by visual appraisal from other similarly defined groups within the same species, or a homogenous group for which geographical separation from phenotypically similar groups has led to general acceptance of its separate identity. The colour ranges recorded in this study is in line with other observations on East African Goats, which is described as ranging from pure white to pure black with various intermixes of roan and speckled brown (20). However, horn length in the pure East African goats is reported to range from 2.5-20 cm in length(20) whereas our findings were that horn length ranged from 4-8 cm. Our findings showed great variation in

all characteristics studied in relation to those of known breeds hence little could be said about the breeds under study. However, while little is known about the actual breeds of goats in these study sites, differences in their horn shapes indicate that two or more breeds could have been present.

Based on coloration, and all other phenotypic characteristics studied, it appears all the indigenous goats under study belong to the Small East African goat type. 'Indigenous goat' is the collective term used for all varieties of native East Africa goat breeds.

However, it is almost impossible to classify a group of goats into different populations using phenotypic characters commonly used to describe goat breeds (coat colour, horns, physical body measurements and productive traits) (2), because there is considerable variability within and among the populations. As a result, it is difficult to combine different characters in order to have a useful tool for assigning individuals to their source populations. Elsewhere, attempts have been made to assign specific breed names according to the geographical areas in which they occur, or the names of breeds and types were taken over from the nations or tribes that own them (8). However, this classification system does not accommodate thousands of indigenous goats found outside these specific locations, hence it has not been well accepted.

Discrimination among individuals is essential for effective and proper management of livestock breeds for conservation, especially for Rwandese breeds which are not adequately characterized even at phenotypic level and have no pedigree information. To overcome this, microsatellites can be used to determine the genetic differences between closely related goat populations thereby paving the way for assignment of anonymous individuals to their source populations. Though no definite breeds were identified,

phenotypic characterization is an essential, initial step in breed identification, which should be followed by in-depth genetic characterization of indigenous goat breeds. A lack of information on genetic resource characteristics may lead to the underutilization, replacement, and dilution through crossbreeding of local goat breeds, despite their local adaptation to environmental constraints.

The presence of toggles in 13.5% of the goats studied contrasts with observations of (17) who recorded toggle presence of between 68% and 98% in Spanish goats. Polledness was observed in 8.9% and 4% of goats in Nyagatare and Bugesera districts, respectively. The low prevalence of Polledness can be explained by the fact that the hop allele which is present in both sexes determines the presence of horns and is dominant over the Ho+ which when homozygous, determines the presence of horns in both male and females (17). The Hop+ allele is generally therefore, of low frequency in East African goats.

Overall, present findings indicate that the indigenous goats of Rwanda vary in horn and coat types, colour, ear length, and size, and are mostly of medium size. Variation in size between goat types is attributable to environmental extremes. Nevertheless, the local breeds of goats are well adapted to their varied natural environments. This might have influenced the phenotypic characteristics observed herein. Similar observations were reported (13) in Botswana. Heart girth increased as dentition category increased but the difference between consecutive categories reduced progressively. This was the same for wither height, back length and body length (Table 1). The mean live weights and linear measurements for various coat colors observed (Table 2), shows that goats with black/brown coat coloration were the heaviest followed by black/white and uniform black.

Black/brown goats, similarly exhibited larger linear measurements. When we consider live

weight as a proportion of linear measurements we find that for all the linear measurements
the proportions reduce as the age of goats increases for each measurement. This could be
due to morphological changes as result of tissue accumulation relative to linear growth as
the animal gets older.
It was also observed that within the dentition groups the proportion of live weight
to heart girth, wither height, body length, and back length reduces progressively. However,
when we consider wither height as proportion of heart girth measurements, constant
proportions for all dentition categories for heart girth with wither height and back length
are observed. This indicates that there is a proportionate increase of linear measurements
as the goats' age. As has been observed by various authors live weight associates
333
significantly ($P<0.01$) with heart girth and therefore heart girth could be a reliable
indicator for live weight, particularly in circumstances where a weighing balance is
unavailable. The association reduces as the animals get older. Similar trends are also
observed for other linear measurements exhibiting stronger association. These
observations are in agreement with those of (20).

Conclusion

Goats from the two regions of Rwanda differ in various linear measurements and
live weights. Thus there is need to plan to harmonize the classification criteria such that
the various strains, landraces and breeds of goats can clearly be identified to plan for an
appropriate selection, methodology leading to improvement and thereafter conservation of
some of these unique indigenous genetic materials. The characterization exercise forms
the beginning of identifying the different heterogeneous goat strains located in the various
localities nationwide that constitute previously uncharacterized populations.

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Trends in Earthen Construction for Rural Shelter in Zimbabwe: The case of Tsholotsho in Matabeleland North Province

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Abstract

Historically, earth and other local materials have been in dominant use in construction for both rural and urban housing in Zimbabwe. The Matabeleland Provinces in the Southern part of Zimbabwe are no exceptions. With advances in technology and noticeable improvement in living standards, people popularly tend towards a set of building materials, albeit for the purpose of securing more durability and modernity. However, the adequacy and effectiveness of these materials, in terms of affordability and sustainability in rural housing remains below expectations. The use of non-traditional materials is prevalent and the provision of affordable housing is still a major challenge in rural Zimbabwe.

This paper seeks to examine the trends in earthen construction, for housing in the Matabeleland region and specifically, Tsholotsho. It also seeks to explore the potentials for improved, affordable and sustainable earthen construction for shelter housing in

Zimbabwe. Alongside, the paper addresses some of the inherent psychological factors militating against the promotion of earthen construction in general.

Introduction

In the history of human settlement development, communities have largely been concerned with locally available materials and their appropriateness to the climatic conditions and other threats. Thus shelter has evolved from olden day caves to the modern structures we have today, where the use, comfort, social customs, convenience and status are some of the factors that influence the choice of materials and construction techniques.

Traditional building materials in rural Zimbabwe include adobe, timber, stone, thatch and other related locally available materials. However these are used with little or no scientific input, leading to their faster deterioration. Hence the shift from these appropriate building materials to the non-traditional materials. The communities desire to construct durable structures and reduce maintenance. Notably, these materials except clay bricks are 'imported', and their prices are beyond the reach of many. Their manufacturing processes and transportation consumes lots of energy. Further more environmental concerns inform the reduction of materials like timber and fired brick as deforestation in the district has risen to alarming levels. Thus the use of non-traditional materials such as steel, cement, plastic floor tiles, aluminium roofing sheets, etc easily proved inadequate. A study carried out in South Africa showed that traditional construction materials and methods were more cost effective than the conventional [3]. Despite these factors, the

popularity of non-traditional building materials continues to grow in Zimbabwe, thus enhancing the ability of families to develop and own houses. Almost everyone sufficiently eligible to own a house is a victim of this negative trend. This paper embodies the outcome

of a research carried out in Matabeleland to identify trends in earthen construction with
focus on the promotion of sustainable earthen construction. The objectives of the research
are essentially to promote earthen materials in rural housing and to investigate the aspects
of further exploitation of the potentials of earthen construction in Tsholotsho District.
Recently, earthen construction has gained some recognition in the first world, where various scientific mechanisms are being applied in an effort to improve its durability, aesthetics and cost effectiveness. Regionally, there are research efforts
underway in Botswana, South Africa and Zimbabwe to establish a framework for developing performance-based codes. The use of performance-based codes would certainly preserve earthen building materials and methods in Southern Africa [3]. Ngowi
[7] has also done some work on improving the traditional earth construction in Botswana.
In South Africa, research on earthen construction dates back to 1950. Currently research is
being undertaken on the subject by the University of the Free State (Bloemfontein), by the
Peninsula Technikon (Bellville) and the Namibian Clay House Project (Windhoek and Otjiwarongo, Namibia). The University of the Witwatersrand and Hydraform Africa have
achieved reasonable success in the use of earth and waste materials such as the ‘sludge’
precipitated at the water treatment plants for the production of masonry elements [6]. In
2003 the International Centre for Science and Technology an institution within the
framework of the United Nations Development Organization (ICS-UNIDO) initiated a project on strengthening the capacity of Mozambique in the production of cost-effective
building materials based on local clay resources.
In Zimbabwe, the Scientific and Industrial Research and Development Centre (SIRDC) through its Building Technology Institute (BTI) has perfected and promoted
rammed earth Technology in Zimbabwe. BTI built rammed earth structures at their premises (1997), in Insiza district (2003), and in Mutoko (2003) and launched a National
Pilot Project with the Ministry of Science and Technology. BTI in conjunction with the

Standard Association of Zimbabwe (SAZ) also developed standards for rammed earth construction. SIRDC and Practical Action worked on the promotion of stabilized soil
blocks as well. In another initiative sponsored by the Department for International
Development (DIFD), BTI identified Kalahari sand, river sand and cement as potential
materials for stabilized soil brick production for blair latrine construction in Tsholotsho
and Lupane Districts where the geological formations are the predominantly unstable
Kalahari sands [8]. These are some attempts to promote sustainable use of earthen construction in Zimbabwe.

Although much has been done in the development of earthen construction technology locally and internationally, the innovative earthen materials ideal to ease shelter problem
have remained largely unimplemented as a result of a number of challenges. These include
but not limited to stigma and perception, social status, psychological mindset, poor
marketing of earthen products, ineffective dissemination of research results and the gap
between supply and demand. It is therefore vital to address these challenges, which have
affected the promotion of earthen materials in Zimbabwe.

Features and Retrospective Issues of Study Area

The study was carried out in Tsholotsho District in the Matabeleland North Province. The District is administratively divided into 20 Wards, and each Ward into six
Villages (Fig.1).

337

Fig. 1. Location of study area showing the subdivisions of the Wards

The housing situation in Tsholotsho is below acceptable standards for a contemporary
rural community. The province has poverty levels averaging 81.1% [2]. It is a general a
generally drought prone area. Settlement patterns in Tsholotsho are generally linear or
clustered. Generally, the settlement is divided into residential, arable and grazing blocks.

A homestead in the District normally consists of an area made up of 4-8 shelter units.

These units include: separate main house for the parents/family head, girls' house, boys' house, other relatives' houses as well as the kitchen. Normally, new units are erected as the need arises. The need factors include: family expansion and rebuilding old dilapidated units. Granaries for storing maize and other grains are built closer to the kitchen. A typical homestead in Tsholotsho is shown in Fig.2.

In history, shelter construction can be traced to the eighteenth century when the Ndebele settled into the area, now western Zimbabwe. They migrated after they broke away from the Zulus and headed north from South Africa. The original dwelling type was the Zulu bee hive structure with no distinction between the wall and the roof (Fig.2).

Fig. 2. Typical homestead Fig. 3. Traditional bees hive housing. Source [4]

By evolution in time, the houses acquired the form with distinct separation between the walls and roof. Walls are made of straight poles with mud infills. These materials soon gave way to sun-dried bricks (adobe) and hand made in-situ bricks (cob). Figure 4. indicates the separation of walls and roof. Colourful clays are then used on both walls to give a unique decorative finish. These three earthen construction methods co-exist even today. Thatching using grass was, and is still the dominant roofing material. In earthen walls, the roof is supported by a central wooden post and a ring of poles (columns). The crossbeam technique was introduced by the Europeans around 1930. Here, a ring of poles

with connecting horizontal poles at the top replaces the central structural support system as illustrated in Figure 5. This technique was later adopted in the modern building methods and marks a remarkable deviation from the traditional method.

Fig 4. Roof supported by the walls Fig 5. Cross beam technique of supports

In Tsholotsho where there was a high degree of social cohesion and housing construction,

the act of shelter building was a major community event in which all able bodied men and women participated [5]. The actual construction work was a culmination of several weeks of assembling of the materials, etc and preparation of the building site. At the end the participants were treated to food and local beer party. This enhanced the continuity of indigenous knowledge in traditional building practices and environmental conservation.

Earthen Construction Practices and the Factors of Change

Until the establishment of the Ministry of Rural Housing and Social Amenities in 2005, there was no Government arm that dealt specifically with rural housing. Although this development is commendable, it is worrying some that the schedule of materials for their model homestead specifies non-traditional materials. Initiatives from other organisations like the Non Governmental Organisations (NGOs) have been restricted to relief and disaster management projects with none addressing the issue of earthen construction materials in their housing programmes. Earthen construction in rural areas is not regulated by any codes, standards or building by laws. The absence of bye-laws and standards has led to a range of sizes of plots, building heights, spaces, material specifications, etc. On the other hand, it encourages creativity and diversity in earthen construction.

There are environmental, geographic, social, cultural and economic factors that influence the design and construction of rural houses and hence the trends in earthen construction. In Tsholotsho, the choice of materials and techniques is attributed to the following: climate, aesthetics, tradition, durability, cost, external influence, source of procurement, government policy, income levels, agricultural practices, diversity of geology etc.

Wall thicknesses vary depending on shelter type and adobe blocks. The walls rest directly on the ground, as there are no formal foundations. Rectangular houses are now the

most common type because they can easily be partitioned. The circle is the prime shape
for kitchens. The superstructure was found to be of adobe, cob, and pole and dagga. Floors
were done by ramming in an appropriate quantity of earth after the removal of top soil.
This incremental beating of mud results in floors as durable as cement. Earthen floor
finishes are a product of an earthen mix and cow dung and are smoothed with the regularly
339
shaped coal blocks. In Tsholotsho high quality thatch roofing increases the life span of the
earthen walls.
There are no earthen roofs. As this is a generally dry area with an average rainfall between
400mm and 450mm per annum, the buildings have small overhangs. There is also no
evidence of longer overhangs on the windward side to protect walls from wind driven
rains, neither are there wind breakers nor buffers on the windward side.
Traditionally, the community has a good building maintenance culture. This is
done at least once a year during the dry season i.e. between April and October. Normally,
plastering, plinthing and re-roofing are the main tasks. Earthen plaster is normally applied
externally for waterproofing and internally for appearance and to even out the wall
surfaces. It is a common practice to retouch the plastering of the internal wall of granaries.
There are little or no extensions to the existing buildings save for internal partitioning.
Families either put new buildings or demolish existing ones to create space for a new
structure. Three Wards, namely 13, 18 and 20 were selected for case studies. The criteria
for their selection are: Ward 13 is a flood prone area; Ward 18 is one of the first areas to
be inhabited in this District; Ward 20 is a former commercial farming zone and now a
resettled area. In the Villages in the later Ward, save for Dhlula Villages were occupied
under the government fast track resettlement programme between 1998 and 2002. Dhlula

was set up by ex-farm workers when the previous owner moved out of the country in the early eighties.

Ward 13 Villages

These are Villages along the Gwayi Riverbanks, the main river in the District. As such, they are affected by floods due to the seasonal bursting of the riverbanks during heavy rains. The most severe was the Cyclone Eline induced floods in 2000 and river floods in 2001. Although flash floods occur anywhere in the district, villages in the Gwayi River flood plain have been the most affected especially as was the case in 2005. Floodwater destroys homes, household property, livestock and other important utilities, which suffer extensive structural damage. When people have lost their homes to such natural calamity, only local materials are available for reconstruction. Relief agencies through the Civil Protection Unit (CPU) can only assist in rescuing operations, and provision of relief labour and temporary shelter. In the ensuing scenario the victims have to respond to the situation at a very short space of time using locally available materials mainly in their raw state. Normally the fastest construction techniques are employed, resulting in structures with low durability, unable to withstand the next seasonal floods.

Consequently, adobe, grass and wood remain the main building materials in the Ward.

Despite the frequency of floods in the area, the communities have not been pro-active in developing technologies/strategies for post flood construction. Thus flooding, speed of construction, availability of materials, external influence and rising incomes are the major factors affecting the trends in earthen construction in this Ward.

Ward 18 Villages

The political situation before independence and the civil strife between 1980 and 1987 led to the slow rate of socio-economic development of this area. Driven out by poverty, unequal opportunities and political unrest, economically active members of the

community trekked to South Africa and Botswana as refugees. The males (mainly craftsmen) were more mobile during the civil disturbances. The resultant attrition of the
expert builders created unwanted gap in continuity of building culture and led to low
340
quality shelter construction outputs. Unfortunately, the migration trend has persisted with
negative impacts on continuity of sustainable building practices.
Today, Tsholotsho's wealthy sons and daughters in diaspora especially in South Africa give Ward 18 a comparative advantage in infrastructure development over neighboring districts such as Lupane, Hwange and Bubi. Equally true is the rapid disappearance of the local architectural milieu and building practices in favour of
diasporian practices in non-traditional materials. Consequently, foreign influence, higher
aspirations and rising incomes led to a revolutionary transformation of the architectural
landscape of this Ward. Today, more and more people find appealing the use of nontraditional
materials and technology to the detriment of appropriate local materials.
However not all families have members who earn their livelihoods outside the country.
There are still a lot of people who are unemployed who channel their meager resources to
their housing needs. They hire out their labour locally for their livelihoods. Their success
is solely on fate and chance. This has led to the stratification of the communities in terms
of the haves and the have nots. These factors have brought negative trends in shelter
development using earthen construction technology. Regularly shaped adobe bricks are
the most common type of earthen materials in this area. Deforestation has led to reduced
use of pole and dagga. Due to the increasing distance to locations of colourful clays,
decorators are opting to use low quality mud and other materials.
In a bid to increase the durability, reduce frequent maintenance and improve appearance, there has been an increased use of impervious/waterproof plasters on external
walls, cement mortar and plaster on floors and walls. Although this approach improves the

outlook, the plasters often delaminate within two years after application because of weak
bonding. This also justifies the use of non-traditional materials eg: cement mortar, for the
repairs of earthen structures. The tendency towards application of non-traditional materials
on earthen construction is a pertinent issue of concern requiring conserted research for
optimization.

Ward 20 Villages

The resettled farmers in this Ward were all originally from different communities within the District. Local materials are available in abundance. However, owing to the
shortage of skilled builders, the output quality is poor. Besides, villagers walk up to 10km
to fetch water for building purposes. Therefore the scarcity of water contributes to the poor
quality of the earthen products. Thus the bricks soon exhibit cracks and other defects. In
addition, the high speed of construction affects the durability of the structures. The use of
pole and dagga has become the most common earthen construction method. Naturally, the
newly resettled farmers need to build many structures to establish their homesteads. These
include kraals, houses, perimeter walls and external works. Normally, developments in a
homestead are incremental. Building works are normally done during the period of May to
October. Except in some special circumstances, only family labour will be available in this
period as most households are preoccupied with their pressing commitments.

The prevalent building material used in the Ward is sun dried earth bricks. The moulds are cut from disused five litre cooking oil containers. The pole and dagga technique is not refined and produces irregularly shaped walls. Lack of adequate infill on
walls has lead to frequent maintenance as the infill falls away in rainy season. Floors in
this area are also earthen. Rendering and painting are practiced here but time constraints
have led to fewer houses being rendered.

Trends and Impacts

The desire to build shelter with less frequent maintenance has brought about understandable paradigm shift in shelter construction amongst the communities. It has certainly resulted in a changed architectural milieu. Foreign influence and sub-contracting has brought about the weakening of strong family ties. Developments in earthen technologies have resulted in a discernible level of expertise on traditional practices.

Arguably, this has improved family incomes and diversified source of their livelihoods.

However much of the familiar archi-forms are fast disappearing in the process. Although burnt bricks are the prime choice at the moment and locally produced in the District, its production entails the use of wood resulting in deforestation and environmental degradation. In spite of the fact that cement stabilized earth blocks are growing in popularity within the district, their rate of use is limited by the hyper inflationary state of the economy and a very erratic supply of cement since 1997. High-pressure compaction machines like the Cinva Ram and the Amandla Press have been promoted by BTI. The dependence syndrome created by the NGOs has made it difficult for many families to acquire these machines.

Government policy for shelter and infrastructure provision for rural communities based on new concepts and materials has a further discouraging impact on the communities who see their indigenous houses as inferior [7]. It further strengthens their perception that traditional earthen houses do not qualify for modern life conditions. There is therefore a need to urge the Ministry of Rural Housing and Social Amenities to reappraise the current rural housing policy with a view to popularizing innovative materials and technologies.

Conclusion

On the strength of its affordability, abundance and availability, earthen materials will continue to be of fundamental importance in rural housing and as one of the main building materials for rural as well as urban communities in the near future, despite the

attendant social stigma and the apparent popularity of non-traditional materials. Naturally,
earthen houses provide an environment compatible with the life style, social, and cultural
values, economic and physical needs of the rural communities. Doubtless, earthen materials remain the tested and true for human settlement development. From the evaluation of the case studies, it is evident that geographic, physical and climatic
conditions in the district affect the layout and choice of earthen construction systems. The
prevailing conditions with regards to rising incomes, external influence, migration etc.,
have led to a high rate of social changes and consequently favour the use of non-traditional
building materials. Culture and tradition, natural disasters, database of traditional building
skills, poverty, speed of construction, availability of labour were the main reasons for
continued use of traditional earthen practices. In the cost analysis factor for earthen
construction, the procurement/hiring of compacting equipment and stabilizers should be
inclusive. As the cultural, physical, social and even psychological needs change with time,
earthen construction must be developed to move with them. Thus from the findings of this
research there is a valid case for promoting indigenous earthen dwellings through improved and appropriate earthen construction techniques.
The communities of Tsholotsho and rural Zimbabwe in general should not abandon locally available material, but new technologies must be designed to enhance their quality
and durability as sustainable technology is crucial for shelter delivery in Zimbabwe. This
342
will not only help in sustainable rural development but also have long-term positive
impact on the well being of rural Tsholotsho communities.

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DEVELOPMENT OF QUALITY CEREAL BASED COMPOSITE FLOUR FOR NUTRITIONALLY VULNERABLE CHILDREN USING LOCALLY AVAILABLE RAW MATERIAL

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Key words: Cereal based composite flour, Quality Protein maize, Soybean, Orange fleshed sweet potatoes, nutritional composition

Abstract
Quality protein maize (QPM) based composite flour for nutritionally vulnerable groups
was developed using QPM, soybean and orange fleshed sweet potatoes (Caceapedo variety). Single flours of QPM was prepared by soaking the grains into cold water at
ambient temperature for 24 hours, drained and then milled into flour using a conventional

milling machine. Soybean flour was prepared by roasting the grains and milling them also using a conventional milling machine. Orange fleshed sweet potatoes (OFSP) were prepared by washing, peeling, cutting, soaking in sodium metabisulfite solution for three hours and milling. Single flours were mixed in different proportions. Prepared gruels using different composite flours with traditional methods were subjected to sensory evaluation by 15 testing panellists. Panellists scored the gruels made with 55 g of QPM, 35g of soybean and 10g of OFSP as the more testing than other nine tested gruels. The preferred composite flour and the red sorghum flour taken from Butare market were subjected to nutritional analysis using ISAR chemistry laboratory for comparison. Results showed that the protein concentrations were higher in the composite flour than in the sorghum flour normally used for gruels preparation for young children. The concentrations were as follows Protein: 18.32mg/100g of flour; ash: 3.62mg/100g in composite flour comparing to Protein: 6.25mg/100g and ash 1.85mg/100g sorghum flour.

Background

The term to wean means to accustom and it describes the process by which the infant gradually becomes accustomed to the full adult diet. During the weaning period the young child's diet changes from milk alone to one based on the regular family meals. Milk should be given as a supplement to the child for as long as possible [1]. Weaning is a dangerous time for infants and young children. It is well known that there is higher rate of infection particularly of diarrhoeal diseases during the weaning than any other period in life [1]. This is because the diet changes from clean breast milk with certain anti-infective factors to foods which are often prepared stored and fed in very unhygienic ways. Malnutrition is more common during this transitional period than in the first six months of

life because families may not be aware of the special needs of the infant, may not know
how to prepare weaning foods from the foods that are available locally, or may be too poor
to provide sufficient nutritious foods. Often, the weaning foods for infants are of poor
nutritional value and unhygienically prepared and this often leads infection and
malnutrition. Today traditional child feeding habits that were reasonably satisfactory can
no longer be followed because of urbanization, new patterns of family structure higher
prices of foods and changes in the pattern of women's work [1]. The need for weaning
food for some babies from six months to two years old is being met through commercially

produced weaning foods. These foods are normally excellent products and meet the
nutritional requirements of the infant. However the products marketed are expensive for
the target groups who need such product especially in poor communities in Rwanda. It is
therefore necessary to develop less costly but equally nutritious weaning foods that may be
within the reach of the target group. It is advised that the development of weaning foods
should utilize raw material based on locally available staple grains such as maize and other
cereals and legumes [2]. It is also advised that the technology for developing such foods
should not be sophisticated and should be highly adaptable. From the point of view of
children's nutritional requirements, the weaning food mix should be nutritionally well
balanced in carbohydrates, proteins, vitamins and essential minerals. It should be
precooked if possible so that it can be fed to babies as soft products by simple stirring in
hot or boiling water. The fiber content in the material should be low within permitted
limits. Traditional cereal foods play an important role in the African diet [3]. Attempts
have been made to improve the protein quality of many cereal based foods including ogi in

Nigeria, corn dough in Ghana, Kisra in Sudan and many others [3,4]. Supplementation of legumes is one way of improving the protein quality of cereals diets. Most of the protein enrichment of traditional foods has used soybean as source of protein. Another approach is to develop high protein foods with physical and organoleptic characteristics similar to those existing foods but based on readily available commodities and technology. The current study aims at developing a Quality Protein Maize based composite flour for nutritionally vulnerable groups.

Hypothesis

The QPM based weaning gruel is higher in nutrients density than the normal sorghum based gruel from the market and is organoleptiqually acceptable.

Objectives

1. To develop a QPM based composite flour for weaning porridge enriched with either soybean or high Fe and Zn bean
2. To determine the nutrients content of the composites flours
3. To assess the acceptability of the QPM based weaning gruels

Methodology

Materials

The materials used included QPM, high Zn and Fe bean, sorghum, soybean, and orange fleshed sweet potatoes. They were newly produced raw materials from Institut des Sciences Agronomiques du Rwanda (ISAR). We used pool 26 for QPM, Caccarpedo for OFSP, CAB2 for bean and Peka 6 for soybean.

Preparation of QPM grain

In the first methods, grain maize was soaked in water at ambient temperature for (°C) 24 hours after which water was drained. The grain was steamed for about 10 minutes and then sun dried.

In the second method, the grain was soaked for about 24 hours, dried followed by roasting sparingly in order to improve the taste and odor. The reason to use non roasted maize was to see how the lysine lost during the roasting step may be minimized.

Preparation of high Zn and Fe bean

Beans were sorted, washed and then steamed for about 10 minutes. The steamed beans were cooked for about 30 minutes in order to reduce antinutritional factors. Beans

were cooled and the skin removed using hands. The deskinned beans were then sun dried
and milled into flour using a normal commercial hammer mill at ISAR.

Preparation of germinated sorghum flour

Sorghum was soaked into water for about 2 days. It was then drained, washed and put into a dark place for two days to germinate. The germinated grains were sun dried, and
then millet into flour.

Preparation of soybean flour

Soybean was sorted, washed, sun dried and roasted. All these steps were covered for one day. The roasted soybean was then milled into flour.

Preparation of OFSP flour

Orange fleshed sweet potatoes (OFSP) were prepared by washing, peeling, cutting, soaking in sodium metabisulfite solution for three hours. The chips were then removed
from the solution, washed and sun dried. They were milled into flour.
All these steps were covered for one day.

The preparation of composite flour for weaning porridge

The simplest recipes for weaning foods are composed of only two ingredients. An example is of cereals and roots mixed with legume and this is called basic mix. However
other foods must be added to make a complete meal [5]. Based on this principle, the
following square in Figure 1 was proposed by [1] and was used for the preparation of
different proportions of simple flours to be used in the mixtures.

Preparation of composite flours

Four composites flours types were prepared. The first formulations were
(composite flours I) was prepared by mixing roasted Quality Protein Maize , High Fe and
Zn bean flour, OFSP flour and germinated red sorghum flour.

Fig 1: Food square followed during the preparation of composite flours

I
Breast milk

Table 1 shows different proportions of the ingredients used in preparing composite flour I.

A
The staple :
cereals, tubers,
roots

B
Protein food supplements:
all legumes and animal
foods

C
Vitamin C and mineral
supplement: fruits and
vegetables
D
Energy supplements:
fats, oil, sugars

Table1: Proportions of ingredients used during the preparation of the gruels for Composite flour I

Samples * codes	**Maize roasted (g)**	**Bean (g)**	**OFSP (g)**	**Germinated sorghum (g)**
923	85	10	0	5
886	75	15	5	5
779	65	20	10	5
766	55	25	15	5
745	45	30	20	5
445	35	35	25	5
567	25	40	30	5
351	15	45	35	5
614	5	50	40	5

Composite flour II was composed with a mixture of non roasted QPM, high Fe and Zn bean, OFSP, and germinated red sorghum.

Table 2: Proportions of ingredients used during the sensory evaluation of the gruels

Samples codes	**Maize non roasted(g)**	**Bean (g)**	**OFSP(g)**	**Germinated sorghum (g)**
852	85	10	0	5
735	75	15	5	5
652	65	20	10	5
544	55	25	15	5
432	45	30	20	5
378	35	35	25	5
298	25	40	30	5
427	15	45	35	5
356	5	50	40	5

Composite flour III was made with a mixture of roasted soybean, OFSP and germinated
red sorghum (Table3). Composite flour IV was composed with a mixture of non roasted

QPM, roasted soybean, OFSP and germinated red sorghum. Table 4 shows different proportions used during the sensory evaluation test of the gruels.

Table3: Proportions of ingredients used for the preparation of the gruels for composite flour III

Samples codes	Maize non roasted(g)	Soybean(g)	OFSP(g)	Germinated sorghum (g)
891	85	10	0	5
224	75	15	5	5
390	65	20	10	5
135	55	25	15	5
265	45	30	20	5
589	35	35	25	5
754	25	40	30	5
537	15	45	35	5
491	5	50	40	5
10	25	20	50	5
347				

Table 4: Proportions of ingredients used during the sensory evaluation of the gruels

Samples codes	Maize roasted(g)	Soybean(g)	OFSP(g)	Germinated sorghum (g)
662	85	10	0	5
859	75	15	5	5
922	65	20	10	5
864	55	25	15	5
591	45	30	20	5
246	35	35	25	5
100	25	40	30	5
340	15	45	35	5
230	5	50	40	5

Preparation of gruels

All the ingredients used in a gruel sample were hand mixed together in the mentioned proportions. The gruels were prepared using the traditional methods of mixing
cold water with the flour, putting on the electrical oven and cooking while stirring until the
gruel is ready to be tested.

Sensory evaluation

Sensory evaluation was done when the gruel attained the normal temperature at which it is normally consumed at household level. Gruel in identical glass bowls were
coded in three digit numbers for the presentation to 13 trained panelists (a mixture of boys
and girls) of ISAR. They were given distilled water in colorless glasses to clear the palate.
Panelists were asked to taste the foods and indicate how acceptable the foods were using 5

point hedonic scale. The hedonic scale used for samples scoring according to the panelists
preferences was as follows: 0= very poor, 1= poor, 2= passable, 3= good; 4= very good;
5= excellent. The sensory attributes evaluated were color, aroma, taste, texture and overall
acceptability.

Statistical analysis

Data were subject to one way analysis of variance using MSTAT C, and a difference was considered to be significant at $P<0.05$ according to[6].

RESULTS AND DISCUSSION

The following tables 5, 6, 7, and 8 show the panelists results of different formulations.

Table 5: Mean scores of the sensory attributes for the nine different gruels made with non roasted, QPM, high Fe and Zn Bean, OFSP and germinated red sorghum

Samples codes	color	Texture	Aroma	Taste	Viscosity	Overall acceptability
852	2.615	2.615	2.538	2.615	2.769	2.885
735	2.846	2.385	2.615	2.654	2.538	2.769
652	2.615	2.577	2.615	2.808	2.538	2.692
544	2.615	2.308	3.000	2.462	2.538	2.615
432	2.846	3.007	3.077	3.077	2.538	3.308
378	2.538	2.923	2.92	3.000	2.927	3.077
298	2.769	2.846	2.69	2.615	3.077	2.769
427	2.591	2.427	2.77	2.538	2.923	2.769
356	2.538	2.538	2.538	2.462	2.846	2.462
CV %	24.15	30.57	30.32	28.50	30.69	27.13
LSD (5%)	0.506	0.632	0.650	0.599	0.656	0.595

348

The above nine formulations were not significantly different for all parameters. Since the overall acceptability parameter is scored after the panelist has considered all the
other parameters, and since the formulations are QPM based, the relatively high scored
formulation (3.308) under overall acceptability was kept as the one for further analysis.
That formulation is a mixture of 55 g of roasted QPM, 25 g of high Fe and Zn bean flour,
15 g of yellow cassava flour and 5 g of germinated sorghum. The time for cooking for this
formula was estimated at 5 minutes using a kitchen oven with minimum of 800 ml of hot
water.

Table 6: Mean scores of the sensory attributes for the nine different gruels made with roasted, QPM, bean, OFSP and red sorghum flours

Samples Codes
Color Texture Aroma Taste Viscosity Overall acceptability
923 2.846 2.923a 3.000 2.846a 2.646 3.000
886 2.692 2.538a 2.615 2.462ab 2.923 2.841
779 2.846 2.846a 2.615 2.846a 2.615 2.923
766 2.923 2.923a 3.000 2.615a 2.462 2.574
745 3.154 1.846b 2.615 2.923a 3.077 2.910
445 3.077 1.923b 2.462 2.615a 3.000 3.080
567 2.923 1.715b 2.308 2.692a 3.231 2.225
351 2.538 1.684b 2.077 1.923ab 2.846 2.000
614 2.231 1.542b 1.826 1.615b 2.077 2.462
CV % 26.60 24.70 31.21 33.91 34.18 27.00
LSD (5%) 0.581 0.508 0.629 0.661 0.730 0.560
The formulations were statistically significant different in texture and taste ($P<0.05$). Thus the most acceptable formulation was a mixture of flours with 55 g of
roasted QPM, 25 g of bean, 15 g of OFSP and 5 g of germinated sorghum. The cooking
time for this formulation was estimated at 5 minutes using a kitchen oven with minimum
of 600 ml of hot water.

Table 7: Mean scores of the sensory attributes for the nine different gruels made with non roasted QPM, soybean, OFSP and Sorghum flours

Samples codes Color Texture Aroma Taste Viscosity Overall acceptability
891 2.846 2.731 3.192 3.000a 2.308 3.000
224 2.692 2.654 2.923 2.808ab 2.462 2.771
390 2.846 2.846 2.923 3.115a 2.769 2.923
135 2.923 2.846 2.885 2.654ab 2.615 2.910
265 2.846 2.077 2.538 2.231ab 2.462 2.412
589 2.808 2.769 2.615 2.369ab 2.538 2.790
754 2.538 3.000 2.846 3.038a 4.000 3.052
537 2.462 2.692 2.308 2.154ab 2.462 3.000
491 2.462 2.500 2.385 2.385ab 2.154 2.531
CV % 22.04 28.57 31.05 32.77 66.57 26.23
LSD (5%) 0.466 0.596 0.668 0.683 1.369 0.520
Overall acceptability of gruels in the above table was statistically similar for all
nine formulations. However, for the taste, the formulation made from a mixture with 35 g
349
of non roasted QPM, 25 g of roasted soybean, 15 g of OFSP and 5 g of germinated

sorghum scored high comparing to other formulations with minimum cooking time of 7
minutes and 700 ml of cooking water. This formulation was kept for further analysis.

Table 8: Mean scores of the sensory attributes for the nine different gruels made from roasted, QPM, soybean, OFSP and sorghum flours

Samples	color	Texture	Aroma	Taste	Viscosity	Overall acceptability
662	3.462a	2.769ab	2.962a	3.000	3.154	3.000a
859	3.231a	3.385a	3.154a	3.462	3.192	3.308a
922	2.731ab	2.769ab	2.923a	3.000	2.769	2.923a
864	2.808ab	3.038a	2.269b	3.423	3.000	3.192a
591	3.077a	2.923a	3.000a	3.262	3.308	3.195a
246	3.077a	2.538ab	2.538b	3.615	3.077	2.615ab
100	2.462ab	2.385ab	2.231b	2.692	2.538	2.577ab
340	2.577ab	2.615ab	2.769a	2.462	2.669	2.692ab
230	2.423ab	2.385ab	2.385b	2.462	2.231	2.385ab
CV %	24.77	28.25	26.64	29.33	39.03	23.68
LSD (5%)	0.554	0.606	0.581	0.673	0.862	0.530

Results in Table 8, show that the parameters taste, aroma, color and texture for the formulation made with 55 g of roasted maize, 25 g of roasted soybean, 15 g of yellow cassava and 5 g of germinated sorghum was the most appreciated with minimum time of cooking of 10 minutes and 500 ml of cooking water. Thus, this formulation was kept for further analysis. The most accepted formulation and the sorghum flour were analyzed by ISAR laboratory. Results showed that QPM based composite flour was higher in nutrient density than sorghum flour. The concentrations were as follows Protein: 18.32mg/100g of flour; ash: 3.62mg/100g in composite flour comparing to Protein: 6.25mg/100g and ash 1.85mg/100g sorghum flour. The high density in nutrient content of the QPM based flour was expected. This is because it is well known that the addition of soybean flour and maize with high content of lysine and tryptophan were expected to improve on the nutrition composition of the flour/

Conclusion

The gruels were acceptable for all tested parameters. There was no single rejected

formulation of tested ingredients. . Panelists scored the gruels made with 55 g of QPM,
35g of soybean and 10g of OFSP as the more testing than other nine tested gruels. Therefore, knowing that Protein Energy Malnutrition (PEM) is the most common malnutrition disorder among the most nutritionally vulnerable groups (infants, pregnant
and lactating mothers in Rwanda, there is a need of developing more recipes using the
newly introduced biofortified crops in Rwanda in order to diversify the preparations based
on the most simple, less costly methods with maximum nutrient retention. This study also
demonstrated successful use of locally available and affordable foods to enhance nutritional quality of nutritionally vulnerable groups.

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350

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351

Benchmark study on husbandry factors affecting reproductive performance of smallholder dairy cows subjected to artificial insemination (AI) in Nyagatare, Gatsibo, and Kayonza districts of Rwanda

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Key words: Artificial insemination, Husbandry, Reproduction, Smallholder, Dairy, Rwanda.

Abstract

The objective of this study was to identify existing farmer practices that may influence reproductive performance of cows bred through artificial insemination. A random sample of 1080 households supplying milk to the milk-processing centre was drawn in Nyagatare, Gatsibo, and Kayonza districts of Rwanda between October and November 2007. Extensive grazing (71 %) was the predominant production system identified with only 10 % of the farmers supplementing veld pastures with barna grass during the dry season. Farmers use a variety of signs to detect estrus in cows. Among these, 'standing to be mounted' (6.83 %), was rated the least while mucus discharge (35.58%) was regarded as the most important sign of heat in cows. Further, only 11.54 % of the farmers invited inseminators after observing standing heat, while the majority (88.46 %), observe for signs such as decreased feed intake (26.51 %), 'mounting of other cows' (21.54 %), clear mucus discharge from vulva (15.38 %), swelling of vulva (13.85 %), and 'being followed by a bull' (11.54 %). Non-return to heat after service was the predominant method of pregnancy diagnosis used by about 86 % of the farmers. The major reproductive problems encountered included abortion (13 %), retained placenta (33 %), and dystocia (37 %), while tick borne diseases (27.6 %) and gastrointestinal parasites (18.4 %) were among the most prevalent general diseases reported. Very few farmers (1.1%) vaccinated their cattle

against reproductive diseases such as brucellosis and more than 95 % do not keep records. None of the respondents completed the sections requiring disclosure of critical reproductive events such as dates of service and calving. Seventy-eight percent of the respondents were below primary school education. Poor heat detection, diseases, nutrition, and lack of record keeping were the major husbandry factors identified whose performance was below expected. The implications of these findings are discussed in the text.

Background and justification

Artificial insemination (AI) has become one of the most important biotechnologies ever devised for improvement of reproductive performance of farm animals. Todate, it is the main tool for dissemination of outstanding germplasm, control of venereal diseases and cost-effective dairy farming. The dairy industry plays an important role in the agrarian economy of Rwanda. Development of this sector is viewed as a means of reviving the

rural economy, achieving national self-reliance and ensuring food security in milk and milk products. However, of the many constraints facing dairy development in Rwanda, low genetic merit of indigenous cattle is understood to be the most important. As a result, since 1996, the government of Rwanda vigorously pursued genetic upgrading of indigenous stock through crossbreeding with exotic germplasm in order to enhance milk production. In order to rapidly achieve this objective, artificial insemination (AI) was accepted as the primary breeding method (19). The number of inseminations over the last two years has increased drastically from 10 000 in 2006 to 47 000 in 2007, and milk production improved from 55 500 tonnes in 1999 to 158 700 tonnes in 2007. Over the same period, milk powder imports dropped from 1280 tonnes to 500 tonnes (19). Although both number of inseminations and milk production has improved to some extent,

the overall pregnancy rate following AI has been very low, around 50%. The precise cause of this failure of AI, however, is unknown. The resulting decrease in rates of reproduction has direct economic implications on the Rwandese dairy industry and warrants identification of the aetiological factors involved and formulation of appropriate interventions. Clearly, there is a need to undertake a comprehensive assessment of fertility and to identify various factors affecting the success of AI. With this in mind, a series of studies were designed to assess the performance of the AI service and identify its constraints, in order to develop and implement remedial measures.

Initially, a field survey was carried out to identify prevailing animal husbandry practices among smallholder farmers. Part of the objectives of the initial survey was to identify problems that required further investigations so as to enable generation of tailor -made solutions. These field observations will be complemented with data on measurement of milk progesterone using radioimmunoassay (RIA) to monitor the success of AI. Monitoring the success of AI through conventional methods, such as rectal palpation of genitalia and non-return rate, has very limited value. On the contrary, measurements of progesterone profiles of cows by RIA has been used to assess the suitability of animals for AI, monitor stages of estrous cycle, perform early diagnosis of non-pregnancy (1), and diagnose factors limiting reproductive efficiency (7). This paper presents the results on the initial benchmark survey on prevailing husbandry practices that may negatively influence success of AI in Nyagatare, Gatsibo, and Kayonza districts. The overall aim of the project is to improve the productivity of smallholder dairy farms through improvement in the performance of AI services.

Materials and Methods

A random sample of 1080 smallholder households in the former Umutara Province (Nyagatare, Gatsibo, and Kayonza Districts) was carried out between October and

November 2007. Twenty per cent of farmers delivering milk to each milk collection centre
in the target area were randomly selected. Data collection was through household interviews conducted by trained enumerators using a pre-tested semi-structured questionnaire. The information gathered included level of education, record keeping,
production system, heat detection, diseases and disease control measures. The number of
questionnaires administered to farmers in each district were 761 (Nyagatare), 169 (Gatsibo), and 150 (Kayonza). The data collected was entered into SPSS Version 8 databases for descriptive statistical analyses.
353

Results

Three production systems were identified with the extensive grazing system (71 %) being
the most common followed by semi-zero or mixed grazing (15 %), and zero grazing (9 %).
Only 10 % of the non-zero grazing farmers gave extra feed (supplementary feed) to their
cows during the dry season. Communal dams or rivers were the major source of drinking
water for their cows. Farmers use a variety of signs to detect estrus in cows. Among these,
'standing to be mounted' (6.83 %), was regarded as the least important sign while mucus
discharge (35.58%), was ranked the most important sign of heat in cows. Not surprisingly, the least (11.54 %) of the farmers invited inseminators after observing
standing heat, while the majority (88.46 %), observe for a number of varied secondary
signs of heat such as decreased feed intake (26.51 %), 'mounting of other cows' (21.54
%), clear mucus discharge from vulva (15.38 %), swelling of vulva (13.85 %), and 'being
followed by a bull' (11.54 %) (Figure 1). None of the farmers had a heat detection
programme, and estrus detection was carried out on an ad hoc basis. After mating, nonreturn
to heat (85.6 %) was the predominant method of pregnancy diagnosis used, followed by rectal palpation (4.8 %), while 4.4 % did not utilize this management tool.
General animal health problems identified by the farmers included dystocia (37 %),

retained placenta (33 %), tick borne diseases (27.6 %), gastrointestinal parasites (18.4 %),
abortion (13 %), Blackleg and Anthrax (9.0 %), Foot and Mouth Disease (8.3 %), Trypanosomiasis (8.2%), Lumpy Skin Disease (7.9%), and many others reported by less
than 5% of the farmers. While vaccination was used to control general diseases such as
Foot and Mouth Disease, Anthrax and Lumpy Skin Disease, very few (1.1 %) vaccinated
their cows against specific reproductive diseases such as brucellosis. Seventy-eight percent
(78 %) of the farmers had not attended school beyond the primary level, and 95 % did not
keep records. None of the respondents completed sections requiring disclosure of critical
reproductive events such as dates of service and calving.

Table 1. The distribution of signs of heat observed before inseminators are invited.

0
5
10
15
20
25
30
Decreased Feed intake
Mounting other herd mates
Mucus discharge
Swelling of vulva
Being followed by bull
Standing when mounted
Sign of heat observed
Prevalence (%)

354

Discussion

Extensive grazing management systems where cows are given very little supplementary
feeding may affect reproductive performance of cows subjected to artificial insemination.
These systems do not generally guarantee enough feed for the cows unless a comprehensive supplementary programme supports it, and, the mixing of cows from different herds and different disease status promotes spreading of diseases. As reported by
Obese (17), and Domecq et al (8), lack of supplementary feeding in extensively grazed dairy
cows affect their reproductive performance. Frequently, extensively grazed cows are
exposed to heat stress, which suppresses estrus activity in cows (13, 20, 25), making its

detection difficult. In addition, exposure to heat stress 1-3 days after insemination induces embryonic death (9), leading to poor conception rate and repeat breeding.

Almost eighty-nine percent (88.46 %) of farmers under study are inseminating cows while they are not in true estrus. Such a level of heat detection error is alarming, and well outside the 5 - 30 % range frequently observed on most farms (21). Estrous detection errors are brought about by identifying cows to be inseminated based on secondary signs of estrus.

The problem with use of secondary signs is that they vary in duration and intensity, and may occur before, during, or after standing heat. As such, these signs cannot be used to correctly predict the time of ovulation. Therefore, inseminating cows based on secondary signs of heat will result in asynchrony of sperm-oocyte interactions leading to poor conception (12, 11, 16), and wastage of semen and labor (18, 24). Perhaps, instead of using these signs for deciding when to inseminate, farmers should use these signs as clues or watch the specific cow more closely for standing behavior.

There are many possibilities as to why farmers in the study inseminate cows based on secondary signs of heat. Common practices resulting in high heat detection errors include inadequate animal identification, poor record keeping, lack of a specific heat detection programme, and lack of knowledge on significance of the various heat signs displayed by cows. All these negative practices are highly prevalent in the study area. Standing to be mounted' (6.8%), was ranked the least important sign of heat yet the converse is true. This shows that those responsible for checking for heat do not fully understand signs of heat. In the absence of a heat detection programme, people involved in heat detection will only be present with the cows at regular working hours. This can give rise to increased missed

heats because the pattern of heat onset in cows is variable, with the greatest activity occurring early morning and late evening (2). According to Senger (23), the ideal goal for estrous detection error rate should be less than 2% in any herd. With 89 % of farmers failing to observe standing heat, it is clear poor heat detection is the major reproductive management problem in the study herds. The error margin as reported herein is a serious cause for concern. It should be noted, however, that estrous detection efficiency is under the total control of the management team and significant improvements in overall herd reproductive performance can be achieved if estrous detection is improved (15). Implementation of programs designed to focus exclusively on detection of estrus is highly recommended.

Farmers in the study use non-return to heat 18-24 days after service as a sign of pregnancy. However, while this is considered the easiest and cheapest method of pregnancy diagnosis, it requires keen and timely observation superimposed on heat detection skills for it to be accurate. As observed, farmers in the present study have a serious problem with heat detection, hence pregnancy diagnosis using non-return rate

could be inaccurate and misleading. As reported by Senger (22), the efficiency of nonreturn rate is further confounded by embryonic mortality, which results in lower calving rates. This method further suffers the disadvantage that farmers are generally not keen to follow up on heat detection on the same cow after insemination. In addition, cattle kept under zero grazing (though a small percentage in our study), exhibit a high degree of silent heats, which are difficult to detect. Because of these shortfalls, rectal palpation remains the most reliable, efficient method of pregnancy diagnosis. However, its requirement for skilled labour may explain why it is not a favorite with the farmers.

Farmers identified a number of systemic and reproductive diseases, which are a major

cause for concern. Among the reproductive problems reported, dystocia was the major cause for concern. Dystocia means "difficult birth." The prevalence of dystocia (37 %) reported in this study is much higher than the 2-12% as reported from many field studies (23). Although it can occur due to other causes, the crossing of exotic, large framed breeds such as the Friesian Holstein with the short, framed local Ankole cows precipitate fetopelvic disproportions (calf too large for the birth canal) leading to dystocia(3). The problem with dystocia is that with few exceptions, cows that have 'difficult births' almost always have "downstream" reproductive problems inclusive of retained placenta, metritis, delayed uterine involution and poor cyclicity (23). Similar findings were reported by (15, 25). Further studies are needed to identify the true factors behind this unprecedented increase in prevalence of dystocia.

The causes of retained placenta are fully known (23). Nevertheless, the prevalence of retained placenta (33 %) reported in this study is much higher than the literature values of between 4% and 10% (22, 23). Like dystocia, cows with retained placenta almost always experience infertility syndromes characterized by delayed return to estrus, increased services per conception, lengthened calving interval, higher culling rate, reduced milk production and increased days open (6, 10). These infertility syndromes are believed to be because of the subsequent endometritis and pyometra that develop following retained placenta (4, 5). The combined high prevalence's of abortion and retained placenta is highly suggestive of the presence of brucellosis infection among the cows (14). Because of zoonotic and reproductive effects, urgent longitudinal studies are needed to rule out the suspicion on brucellosis.

Regardless of when and how pregnancy diagnosis is carried out, the identified

reproductive problems affects performance of Ai through poor conception, embryo mortality, and abortion, hence farmers might be justified in their complaints on poor pregnancy rate in dairy cows subjected to artificial insemination. However, it must be noted that problems such as dystocia, retained placenta, and abortion, are under the direct influence of the reproductive system of the cow. For that reason, these factors are somewhat difficult to manage and control because the cow's reproductive system is the primary component influencing the outcome. Nevertheless, reduction in incidence of dystocia can almost always occur when sires used in AI are selected for a high degree of calving ease especially in heifers. Further, calvings should be accompanied by attendants with the appropriate obstetrical skills. Thus, management can exert a strong preventive influence by keeping records and selecting calving-ease bulls for use in heifers and employing proper heifer management and maternity pen care. Further, a good reproductive health program, which provides for checking normal uterine involution and return of ovarian cyclicity, is required.

356

Apart form specific reproductive disorders, a high prevalence of general systemic diseases such as East Coast fever (ECF), black leg, anthrax, and lumpy skin (to mention but a few), were observed. These diseases result in sickness and or death of cows. In particular, East Coast Fever can have severe impacts on exotic cattle. Diseases, whether associated with the reproductive system or other systems of the body, have deleterious effects on fertility of dairy cows (15). The high prevalence of diseases for which disease control technology such as effective vaccines, and acaricides is available maybe taken to reflect failure of veterinary extension. Further studies are needed to determine the effectiveness of

veterinary extension in the country.

More than 95 % of the farmers in the study did not keep records, while the few records being kept were incomplete, inaccurate or not updated. Poor record keeping affect performance of artificial insemination in several ways. Any attempt to improve the efficiency of AI has to be based on an understanding of the most important causes for failure under each specific production system. Traditionally, methods used to gain this understanding rely on accurate recording and analysis of reproductive events such as estrus, services, pregnancies and calvings. However, farmers in the study area rarely kept records, and even when available, they do not allow an assessment of the importance of factors such as efficiency and precision of estrus detection by the farmers or incorrect timing of insemination. Without proper records, elements used when reproductive performance is evaluated such as conception rate, numbers of services per conception, pregnancy rate, day’s open, calving interval and many others cannot be measured. Simple, complete and accurate records about the entire reproductive life of the dairy cow are required to monitor components contributing to reproductive management. This aspect of management needs to be improved. Poor record keeping has been reported to be one of the major management attribute affecting AI in dairy cows (1, 11).

The majority of farmers interviewed (77 %) were illiterate. This might possibly be a directly aftermath of the 1994 genocide which wiped out most of the skilled labour force of the country. While it is debatable, in our view, such a high illiteracy level among farmers is a potential in breeding of animals through AI because it creates imbalance balance between technical demands of the AI technology and the skills of the existing farm laborers. Further analyses are needed to determine the impacts of education level on reproductive performance.

Conclusion

Artificial insemination is a comparatively sophisticated method of animal breeding whose impact on cattle development is closely linked to the simultaneous introduction of reasonable standards of animal husbandry. In our study, the major basic animal husbandry practices are well below expected standards. Poor heat detection, diseases, nutrition, and lack of record keeping were the major husbandry factors identified that needed further investigation. Training is needed to uplift management capacity of most of the farmers because most if not all of the factors identified fall directly or indirectly under the control of the individuals performing the task or making a decision about the task. It is our conviction that fertility factors controlled by man, can be improved significantly with the appropriate management decisions and implementation of well-focused herd health, 357 production and reproduction management programmes. For example, greatest improvement in reproductive performance can be made by improving estrous detection efficiency, estrous detection accuracy, nutritional management, and record keeping, among others. The probability of successfully implementing and controlling most of the factors identified in this study is much higher than attempting to control other factors, which cannot be totally controlled by the management team.

Recommendation

The nature of our study, do not allow us to determine any causal relationships. It is therefore imperative to carry out further studies to determine the effects of each of these factors on reproductive performance of artificially inseminate cows before any corrective measures can be taken.

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The Role of Government in the Establishment of Appropriate Industries for the Manufacture of Construction Products with Non-Conventional

Materials

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Key words: Non-conventional construction products, appropriate technology industries, government role, development economics)

ABSTRACT

The cost of construction materials represents a disproportionately larger percentage of total construction costs for a building compared to costs for the same building in a developed economy. This is partly attributable to the developing economy's dependence on construction products manufactured by the developed economies. These imported construction products are often inappropriate to the local socio-economic environment where they are used. They bear a high energy cost in their manufacture and transport and generate excessive carbon emissions into the atmosphere. Significant research has been conducted in non-conventional construction materials (NOCMAT) and technologies which are non-polluting, consume little energy in their production and utilization, are low in cost, and are environmentally sustainable. This paper takes a look at the critical role government must play in the establishment of appropriate manufacturing industries which utilize this body of research to make affordable, environmentally friendly, construction products. Government can be the change agent for the creation of appropriate industries which feature NOCMAT-based construction products by shaping, enabling, and regulating public policy.

Introduction

For certain developing and underdeveloped economies, the prolonged reliance on conventional construction materials is inappropriate to their economic development. The use of these same construction materials by developing and industrialized economies is environmentally inappropriate with global impacts. Buildings consume 71% of the

electricity and generate 65% of the waste in the United States. Their environmental
contribution to carbon dioxide emissions is around 39% [1]. The world-wide movement
towards sustainable construction is a direct effort to reduce this dependence on energy
intensive, environmentally insensitive construction materials. This paper considers the
body of research in non-conventional construction materials (NOCMAT) and looks
towards their rapid integration into the construction industry. To this end, government is
expected to play a significant role.

The development of new industries and the reshaping of existing ones based on NOCMAT products must first make economic sense. In a competitive marketplace, industries have little incentive to embrace NOCMAT unless the rules of the game dictate
it. The marketplace has no environmental conscience. Instead, the pursuit of profitability
perpetuates a culture of waste of global proportions. Government has the ability to
positively shape the rules of the marketplace and take leadership in the creation of
appropriate industries which are responsive to their economic and environmental priorities.

"A critical examination of current design and build (or manufacture) practices shows its close tie to trends in conventional industry, which "take, make and waste" ideal can only produce what environmentalists refer to as "cradle-to-grave materials and products, designed for a oneway trip to the landfill". Under exploitation, these products generate waste which are toxic, dangerous to health, impacts negatively on the environment and are not renewable - hence the search for a burial place for them after use. Within their life span as buildings, they unsustainably consume energy and other non-renewable resources with the emission of abundant waste. And at the end of their useful life, the body parts remain a nuisance to the natural system." [2]

Appropriate Construction Industries

The use of the term 'appropriate', in this paper, is an adaptation of green engineering
principles established at a 2003 conference in Sandestin, Florida.[3] The criteria of
appropriateness for the manufacture of construction products is presented below.

Criteria of Appropriateness for Manufacture of Construction Products

1. Holistically use systems analysis and integrate environmental impact assessment
tools in their development
2. Conserve and improve natural ecosystems while protecting human health and wellbeing
3. Use life-cycle thinking in their implementation within the built-environment
4. Ensure that all material and energy inputs and outputs are as inherently safe and
benign as possible
5. Rely on renewable natural resources common to the geographic region
6. Strive to minimize waste and maximize resource conservation
7. Are grounded in engineering solutions which are responsive to the physical environment, socio-economic conditions, and potential for workforce development in the local marketplace.
8. Reflect sustainable engineering solutions beyond current or dominant technologies
9. Are easily implemented and maintained without high levels of education and training
10. Includes input from local communities in their development process
11. Are affordable
12. Specifically address society's basic need for shelter; particularly for those who
have been the least satisfied.

Rooted in the principles of appropriate technology, the criteria seeks to make technology relevant to the real needs of the society that uses it, is affordable, is harmonious with the
environment, does not compromise the quality of life for subsequent generations, and results in economic
empowerment at the broadest level.

Most construction products begin by converting commonly available raw materials into refined materials which can then be used to create products such as: roof shingles,
wall and floor sheathing, framing elements, and exterior cladding. For example, the steel
industry melts iron, burns off its impurities, and then blows oxygen through the molten
material to reduce the carbon content. A wide array of structural shapes, with varying
physical and geometric properties, is then produced for construction use. Other staples of
361
the construction industry include: concrete, masonry, lumber products, aluminum, gypsum, glass, stone, plastics, and a range of composites.

The environmental cost of conventional construction materials borne by society is only
now being quantified. The manufacture of cement, for example, a key component of concrete, emits significant quantities of CO_2, NO_X, SO_2, particulates and dioxins into the
atmosphere. Quarrying activities associated with the cement industry also impacts land use
and biodiversity [4]. In the case of steel, the environmental cost is linked both directly and
indirectly to its energy cost.
The energy consumption of steel production in the United States, one of the largest
steel producers in the world, represents about 2.5% of domestic energy use and about 8%
of all U.S. manufacturing energy use. About half of this energy is derived from coal. [5]
Under pressure from government agencies and environmental groups, voluntary goals have now been set for these industries to reduce their greenhouse emissions and use
renewable energy.

IC-NOCMAT and ABMTENC

Since 1984, IC-NOCMAT (the International Committee on Non-Conventional
Materials and Technologies) and ABMTENC (Brazilian Association of Materials and Non-Conventional Technologies, founded in 1996) have organized a series of events and
collaborations to promote the development and dissemination of knowledge on nonconventional
construction materials which are non-polluting, consume little energy in their production and utilization, are low-cost, and are environmentally sustainable. Their
principal areas of research are:
1) Bamboo as a construction material, 2) Vegetable fibers and soil construction, 3)
Environmentally friendly, energy-efficient construction, 4) Technology applied for lowcost
housing, 5) Durability aspects of non-conventional materials, 6) Composite materials,
7) Non-conventional materials and technologies management, and 8) Waste materials in
building construction.
Given this body of research, NOCMAT-based construction products are still far from integration into the construction marketplace. What are the pathways to product

development, manufacturing, and conventionalization of these technologies? What is the character of a marketplace where these industries are both healthy and satisfy the essential criteria of appropriateness? What forms of partnerships between government, industry, and academia are required to facilitate a healthy marketplace and a healthy economy? This paper examines the role the government must play to advance such industries.

Governments Role to Protect and Enhance the Commons

The commons refers to the common heritage resources which are the collective birthright of our species, to be shared equitably by all. The commons includes all aspects of our natural environment, our freedoms, and the vast mosaic of our heritage on this planet.[6] Given the general inclination of individuals to pursue their self-interest, issues of community and our collective welfare (past, present, and future) are typically placed under the domain of government. It is the accepted role of government to protect and enhance the commons. The establishment of a thriving business environment which is in alignment with the principles of appropriateness and stewardship of the commons must, therefore, begin with government.

Good governance, at any level, will rally to this responsibility of protection and enhancement of the commons. Good governance balances self-interest with the common

good. Three generic areas of responsibility will be examined with respect to the development of appropriate NOCMAT industries. They are: 1) Declaration of sound economic development policy based on research, 2) Enabling policy implementation, and 3) Regulating, enforcing, and modifying policy.

A seminal document proclaiming government's responsibility to protect the commons came out of a United Nations Conference on Environment and Development in Rio de Janeiro in 1992.[7] The document promoted cooperation among nation-states and key sectors of society to protect the integrity of the global environment and the developmental system.

Subsequent conferences in Santo Domingo and Peru have continued to build upon these declarations and are the root of the Millennium Development Goals and Agenda 21, a comprehensive blueprint of action to be taken globally, nationally and locally by organizations of the UN, governments, and major groups in every area in which humans impact on the environment.

By establishing policy, governments are able to establish national priorities in the interest of the commons and shape the behavior of the marketplace. Using Brazil as an example, the Agenda 21 declarations and goals were adopted as national policy in the Green Protocol of 1996. One of the guidelines of the document was the creation of special lines of credit and financing for undertakings which promote environmental protection and preservation. Public banks committed themselves against financing environmentally aggressive undertakings and to provide support to sustainable production systems. To this end, the banks adapted their procedures for analysis and concession of credit. Policy was translated into economic growth and it shaped the behavior of the marketplace.

Declaration of Sound Economic Policy

Government must place a high priority on the protection and enhancement of the commons through its public policy. Sound economic policy must be fact based, relying on a breadth of research. There is already an abundance of research and experiential data relative to global warming and environmental degradation to warrant alarm and immediate corrective policy from all levels of society. Within the United States, local governments are now rapidly establishing policy on low-carbon emissions and embracing the construction standards of the U.S. Green Building Council [8]; this trend, in spite of resistance at the federal level to do the same with greater impact [9] .

The critical gap between research and initiation of public policy for the construction industry requires the active involvement of technocrats (technically trained managers employed in government) who are able to comprehend the essentials of NOCMAT research, validate, analyze and then debate their long-term economic and

ecological fit for their targeted communities. Technocrats are able to simplify and craft
this information into a rational, sustainable public policy. Consider the dramatic and rapid
rise of India in the global marketplace. The role of the Indian Institutes of Technology
(IIT) in expediting this development is obvious but is not always publicized.
Commensurate with India's economic and technological growth has been the prevalence
of IIT graduates in government and industry. "Many of these graduates (IIT) occupy the
highest echelons of the private (and even Government) sector bureaucracy. They also form
a significant proportion of the scientific manpower pursuing cutting edge research across
the globe." [10] The absence of technocrats in key decision-making positions will
inevitably frustrate all efforts to implement meaningful public policy and can hinder an
agenda of appropriate economic development.
363
Unfortunately, the looming threats to the commons are often heard but rarely translate to
policy until there is a crisis. "After it suffered severe damage from natural disasters in the
late 1990s, the Baha de Carquez (Ecuador) government and nongovernmental
organizations working in the area forged a plan to rebuild the city to be more sustainable.
Declared an "Ecological City" in 1999, it has since developed programs to protect
biodiversity, re-vegetate denuded areas, and control erosion. The city, which is marketing
itself as a destination for eco-tourists, has also begun composting organic waste from
public markets and households and supporting organic agriculture and
aquaculture." [11]
Systematic structures are needed in government which filter out special and self-interests,
objectively evaluates reliable, fact-based environmental policy demands, and generates
proactive, appropriate responses. Once policy is established, feedback mechanisms must
be in place to validate its adequacy and need for improvement. Proof of reduced
environmental degradation and the stimulation of economic self-sufficiency on a region

level are desired outcomes.

Enabling Policy Implementation

Government must initiate actions which enable its policies to be successful. They can facilitate the nurture of thriving and appropriate construction manufacturing industries through a variety of development incentives, bonds, low-interest financing solutions, regulatory process, tariffs, and taxes. A healthy business environment can be facilitated if both scale and partnerships are comprehensively addressed within a regional economic master plan, guided by effective leadership. The master plan must consider the character of the local labor force and their guiding self-interests, required investments in training, existing and projected demand for construction products, local availability of raw materials, and transport costs.

The creation of the Brazilian Business Council for Sustainable Development，a part of the Latin American Council of the Business Council for Sustainable Development, was significant to the development of “green industries” in Brazil. The organization has an ambitious plan for sustainable development of the Amazon which balances both economic and environmental priorities.

"We all understand that the Amazon needs to develop, but we also understand that there had to be a development model that is well thoughtout, and not predatory, just like we have in other regions of the country,"

President Luiz Inacio Lula da Silva [12]

One sector of NOCMAT implementation where government has a clear role involves the recycling of wastes from agriculture and industry to produce building materials. For example, vegetable fibers such as bagasse, a by-product from the extraction of sugar from sugar cane, may be used to form cementitious composites for use as roof tiles.[13] Bagasse is already used in Brazil’s ethanol industry where the material is burned as an energy source to operate the plants. Brazil now boasts the world’s first sustainable bio-fuel economy. With three quarters of the world’s sugar made from sugar cane in

tropical zones of the southern hemisphere and with increasing concern for the disposal of agricultural residues, this industry has the potential for tremendous gains in efficiency by selling bagasse to manufacturers of cement products. Other vegetable fibers with favorable research results include bamboo, coconut, sisal, coir, banana, and eucalyptus pulp. Even disintegrated newsprint offers similar value. An array of actions may be introduced by government to facilitate win-win partnerships where the wastes from the agricultural industry may be directed into the manufacture of affordable, locally-manufactured construction products.

364

Other forms of waste materials which may be introduced into NOCMAT industries include: soil reinforced with waste tire shreds, egg shell waste substituted for sand in mortars, rice husk ash, peanut husk ash, and corn leaf ash as a pozzolanic material in cement, building demolition waste ground into fine recycled aggregates and substituted for sand, and the residue of marble and granite in mortar and concrete.

Bamboo is the most important non-wood forest product and, in India, is known as the ‘poor man’s timber’. In China, it is the valuable raw material for the booming bamboo industry. Its high strength, light weight, low cost, and fast growth cycle are some of its notable physical properties. Although, additional research is needed relative to its durability and susceptibility to decay, it remains a superior substitute for wood, bamboobased panels and boards are hard and durable. Bamboo can be used as posts, roofs, walls, beams, trusses, and fences. Bamboo offers tremendous potential as a NOCMAT industry leading to increased economic and environmental development and international trade.

The cultivation and harvest of bamboo is an early stage market sector which must be established. Unless there is a clear financial benefit for small and medium-sized farmers to cultivate bamboo, their economic situation will demand that the land be used

for food crops or shared with more reliable cash crops. There must be a matrix of economic incentives that must be initiated by government to foster the widespread cultivation of bamboo, in all its feasible species and varieties.
Government must also play a key role in promoting regional reliance on bamboo as an affordable construction material or as the raw material of a manufactured product.
India presents one successful example of government investment in the bamboo industry.
The National Mission on Bamboo Applications [14] has been tasked with helping to enlarge the bamboo sector, and with supporting the efforts of the Government of India to
augment economic opportunity, income and employment. Areas of investment have included: 1) improved bamboo propagation and cultivation techniques, 2) development of
a range of efficient, sturdy and low-cost tooling and processing machinery, suited to
Indian conditions and species, to reduce drudgery, improve productivity and minimize
waste, 3) developing mechanisms, methodologies and markets to encourage entrepreneurs
to take up the processing of bamboo shoots for the marketplace, 4) supporting applicationoriented
research and developmental activity, utilizing bamboo for constructional applications, and 5) enabling activities to develop and validate technology, encourage
entrepreneurial and community enterprise, test products and promote their usage and
application. The mission promotes the use of bamboo and bamboo-based composite material and innovation with different construction techniques. It sets benchmarks of
quality for construction, functionality, strength, safety and aesthetics
Technical training is a necessary investment to the large scale cultivation of bamboo. Beyond the background of agricultural science required for successful bamboo
cultivation, principles of industrial engineering are also needed. The harvested bamboo
must be sorted and systematically rated and graded, presumably at a mill, with processes
similar to those found in the lumber industry. Agricultural and technical institutes
established near the source of bamboo production must have programs to train the local
labor force to carry out this work.

India’s National Mission on Bamboo Applications can serve as a practical model for how government initiatives can spearhead the creation of appropriate industries.

Starting with policy statements, an action-oriented structure was established to stimulate local and regional economic activity in alignment with a national agenda for sustainability.

A premium was placed on building a knowledge base and transferring it to all levels of production. In support of the needs of the marketplace, research and standardization of

products is an on-going activity. Projects which best demonstrate the economic value created by this agency are: 1) Design, development and prototyping of hydraulic hot presses for the manufacture of bamboo composite materials in Hyderabad, 2) Preparation and dissemination of a data base written in the form of an annotated bibliography of bamboo literature (published in CD form), 3) Arched engineering models for wide-span structures in low-cost housing, 4) Development of simple processing and packaging technologies for bamboo shoots intended to provide value addition and income generation options at the community and tiny enterprise level, and 5) Testing of the physical, chemical and mechanical properties of bamboo culms, slivers and composites of identified species.

Regulating, Enforcing, and Modifying Policy

In the time-sensitive, cost-conscious world of construction, building codes help to ensure minimum standards of public safety by establishing material specifications and engineering performance expectations. Collaborations between government, engineers, builders, and the manufacturers of construction products are essential to effective code development. Engineers specify construction products based on building code requirements. These products must be accessible to the point of use, should come in

modular dimensions, compatible with other construction products, must be routinely tested and certified to be reliable, and must not require a highly skilled labor force to install.

Building inspectors and building permit agencies serve as the agents of government to enforce building codes in their respective regions. While this fabric of relationships and infrastructure is inherent for conventional construction materials and products, it is still at an embryonic stage for NOCMAT. Developing economies which lack the technological resources and trained workforce needed for regulatory enforcement commonly adopt the codes and standards of the more industrialized nations. Code enforcement, however, remains problematic and ineffective.

Conclusions

Research in the area of NOCMAT has been a high priority for developing economies, particularly those in the southern hemisphere. The infrastructure required to develop appropriate industries which manufacture construction products based on NOCMAT is still in its infancy. However, substantial progress has been made in some countries where national policy has declared this a priority. In contrast, for many other economies, the United Nations' Millennium Development Goals are far from within reach and they remain victims of their own history. In 1999, the Declaration of Santo Domingo recognized that the countries of Latin America and the Caribbean need to collaborate with one another to confront the declining quality of life of their inhabitants and health of their respective economies. Similar collaborations and partnerships between Africa, Asia, and Latin America are needed to address the Agenda 21 goals, in general, and the integration of NOCMAT into the construction industry, in particular. A change of culture from waste to sustainability is mandated on a global scale.

There are two different aspects to be considered in the fight against waste. The first involves the change in consumption patterns which ultimately is a cultural change. However, it is necessary to start this combat against waste

while still during the productive process, by adopting technologies less intensive in energy and which are less demanding on raw materials. Civil construction is a segment which has a lot to contribute as, for example, searching for alternatives to waste practices in the work sites. [15]
366
As a steward of the commons, government carries the burden of addressing global, national, and regional issues on behalf of individual communities. Through the establishment of sound public policy and initiatives which enable those policy goals to
take shape, and through the adoption of regulatory standards which are then reasonably
enforced, a reversal of the chronic under-development and the un-sustainable management
of natural resources of the can be experienced. The ranks of government must include
technically trained professionals who possess the communication skills needed to translate
NOCMAT research into profitable and appropriate industries. A marketplace based on
collaboration rather than on competition may best lead to eliminating the disparities which
plague our global community and slow the rapid erosion of our common heritage.

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The prevalence of bovine brucellosis in milking dairy herds in Nyagatare and its implications on dairy productivity and public health

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Key words: bovine brucellosis, zoonotic disease, infertility, dairy herds, Rwanda

Abstract

*Between April and June 2008, 998 serum samples from 205 herds located in 10 different
sectors within the district were screened for brucellosis using Rose Bengal Plate test. Out
of a total of 998 serum samples tested, 99 (9.9 %) reacted positive for brucellosis using
the Rose Bengal Plate Test (RBPT). Bovine brucellosis was detected in nine out of the ten
sectors in Nyagatare, and out of the 205 herds studied, 62 were seropositive. The overall
brucellosis herd prevalence rate (HP), i.e. at least one positive RBT reactor identified in a
herd, was associated with sector (X^2 = 8851.228, P = 0.000), Breed (X^2 = 413.567, P=
0.002), and parity of the cow (X^2 = 580.292, P = 0.000). Significantly higher brucellosis
herd prevalence values were reported for Byera (100 %), Katabagemu (45.45 %), and
Rwimbogo (42.86 %) sectors. The herd prevalence was 29.62 % in Ankole cattle (95 %
CI: 28.36 to 30.87) and 23.71 (95 % CI: 17.23 to 30.19) in purebred Friesian-Holstein
cattle, with a statistically significant difference (x^2 = 413.567, P = 0.000). Individual
animal prevalence (IAP), i.e. number of individual positive reactors, differed (P < 0.05)
between and within the sectors, and was also associated with the breed of the cow.
Significant higher overall IAP´s were found in Byera (20 %), Rwimiyaga (12.17%), and
Rwimbogo (12 .00 %). Individual animal prevalence was 9.75 % (95 % CI: 9.34 to 10.16)
in Ankole cattle and 7.15 % (95% CI: 5.46 to 8.84) in Purebred Friesian-Holstein cattle
with a statistically significant difference (x2 =335.339, P= 0.000). There was no
statistically significant difference in individual prevalence between Ankole cows and*

crossbred cows. On the other hand, the prevalence of brucellosis in cattle was also found to be higher in the older parities than younger ones. Overall seropositive reactors recorded were 12/204 (5.9 %) for parity 1, 20/181 (11.05 %) for parity 2, and 11/77 (14.29 %) for the fourth parity cows. However, no statistically significant difference was observed in the prevalence of brucellosis between male and female animals. Overall, the study reveals that bovine brucellosis is endemic in Nyagatare. The public health and livestock productivity implications of the present findings are discussed.

Background and justification

Bovine brucellosis is a highly contagious systemic bacterial disease caused by Brucella abortus (12, 7). It is primarily a disease of ruminants (5), and is regarded as one of the most widespread zoonoses in the world (13). The disease is of economic importance in dairy production because it adversely affects the reproductive and productive potential of dairy cows and is a major impediment for trade and export of livestock products (28).

Infection in pregnant cows is characterized by abortion, birth of dead or weak calves, retained placenta, endometritis, repeat breeding, infertility, as well as reduction or complete loss of milk yield after the abortion. In bulls the disease result in testicular

lesions such as orchitis, epididymitis, and seminal vesiculitis which affect their breeding capacity.

Besides the impacts of the disease on livestock, brucellosis is also an important zoonoses, more commonly known as undulant fever. Infection in human beings result in chronic debilitating illness which requires prolonged treatment. The established mode of transmission of *Brucella* spp. to humans is usually by direct contact with infected animals or their carcasses (32), or through ingestion of infected unpasteurized milk or dairy

products (12). Affected humans develop a chronic debilitating, on- and off (undulating)
febrile flu-like illness (8, 33), that is frequently confused with malaria or typhoid with the
result that inappropriate treatment is often given. The course of the disease is prolonged
leading to considerable medical expenses in edition to loss of income due to loss of
working hours.
Brucellosis is of particular public health importance in societies that live closely
together with their livestock. In Rwanda, about 92% of the population live in rural areas and
depends on agriculture for survival. The rural areas or 'villages' in Nyagatare are generally
regarded as resource-poor areas with a weak infrastructure, a high unemployment rate and
subsistence livestock farming dominate over other agricultural activities. As observed
elsewhere (21), consumption of unpasteuralised milk, undercooked or fresh meat are not
uncommon in the rural households. However, very little is known about the prevalence of
important zoonotic and production diseases of cattle in these areas, which is essential
information for the prioritization and implementation of disease control schemes.
In our previous study (6), we observed unusually higher incidences of abortion,
retained placenta, and infertility of unknown origin in dairy cattle in Nyagatare, Gatsibo,
and Kayonza Districts. Although these symptoms are commonly seen in brucellosis
infected herds (29, 22, 21), there is no documentation about the occurrence of this disease
in this district. To gain an understanding of the prevalence of brucellosis in Nyagatare, and
to seek possible explanations on the causes of abortion in dairy herds and devise
appropriate control strategies in the area a large scale serological brucellosis screening
survey was undertaken.

Materials and methods

Study site

Nyagatare is located in Eastern Rwanda, bordering Uganda, and Tanzania. The
district is about 150 km away from Kigali, the capital city. Nyagatare, Gatsibo, and

Kayonza (the former Umutara Province) hold about 40% of the cattle population of the country currently estimated at just over 1.2 million. While some of the milk produced in the district is sold at big urban markets in Kigali, most of it is sold through the informal market within the district. Presently the province is in a transition phase from the extensive traditional husbandry to the market orientated systems. The cattle population consists of predominantly local Ankole types and various crosses between these and exotic breeds, raised in extensive traditional husbandry system. However, there is an increasing proportion of introduced purebred cattle such as Friesian- Holsteins, Jerseys and Guernsey. Both cattle and small ruminants are often grazed or tethered together. All study herds were selected by stratified random sampling, milk collection centers being the strata.

The criteria for selection of herds was the supply of milk to local milk collection centre, and high reported prevalence' s of abortion, and retained placenta of unknown origin in previous studies (6).

370

Blood Sample Collection

About 10 mL of blood was collected form the jugular or coccigeal vein of each selected animal using plain vacutainer tubes and allowed to clot overnight at room temperature. The serum samples were separated and transported in iceboxes to Rwanda Animal Resources Development (RARDA) Veterinary Research and Diagnostic Laboratory, in Kigali and stored at -20° C until testing.

Serological detection of Brucella antibodies

At RARDA, the Rose Bengal Plate test (RBPT) was used to screen the serum samples to detect the presence of *Brucella* agglutinins. Serum samples from cattle were tested using RBPT according to standard methods as described by (1, 2). Briefly, the sera and antigen were brought to room temperature for 45 min before use. One *Brucella* positive and one negative reference samples were used on each plate. Equal volumes (30 μl) of serum and antigen (concentrated suspension of *B. abortus*, Weybridge strain 99;

Institut Pourquier, France) were mixed and rotated on a glass plate for 4 minutes. Presence of agglutination was regarded as positive.

Data analysis

The data collected in the field were entered into a computer on a Microsoft Excel spreadsheet. Statistical analysis (multivariate logistic regression) was performed using 'Statistical package for the social sciences' (SPSS), version 11.5 (for Windows). The prevalence proportion was calculated as the number of animals testing positive by the RBPT, divided by the total number of animals tested. Three epidemiological parameters were generated, the herd prevalence, within-herd prevalence, and individual prevalence.

Herd prevalence was calculated by dividing the number of herds with at least one reactor in RBPT by the number of all herds tested (Equation 1). The within-herd prevalence was calculated by dividing the number of RBPT reactors within a herd by the number of serum samples tested in the herd (Equation 2). The individual or total prevalence was calculated by dividing the number of RBPT positive animals by the total number of animals tested (Equation 3). Equations below show how the three epidemiological parameters were derived.

1. Herd prevalence = number of herds with at least one positive reactor
Number of herds sampled

2. Within-herd prevalence = number of positive reactors
Number of serum samples tested from this herd

3. Individual animal prevalence = number of individual positive reactors
Number of serum samples tested.

Analyses were carried out to compute proportions of seropositive animals (stratified by sector, breed, sex, and parity where relevant) and their 95% confidence intervals (CI). The association between each risk factor and the outcome variable was assessed using the Chi-square (2) test. For all analyses, statistical significance between variables was examined using P-value at critical probability of $P < 0.05$ (a *p*-value of less than 0.05 was taken as significant).

Results

Out of a total of 998 serum samples tested, 99 (9.9 %) reacted positive for brucellosis using the Rose Bengal Plate Test (RBPT). Bovine brucellosis was detected in
371
nine out of the ten sectors in Nyagatare, and 62 herds out of the 205 herds studied were
seropositive. The overall brucellosis *herd prevalence* rate (HP), i.e. at least one positive
RBT reactor identified in a herd, was associated with sector (X_2 = 8851.228, P = 0.000),
Breed (X_2 = 413.567, P= 0.002), and parity of the cow (X_2 = 580.292, P = 0.000). Significantly higher HP values were reported for Byera (100%), Katabagemu (45.45 %),
and Rwimbogo (42.86 %) sectors (Table 1). In Gatunda sector, while all the two herds
from Byera Sector were seropositive giving an HP of 100 %. HP in other sectors ranged
from 0 % to 33.33 % (mean 15.46 % ±11.35) in Karama sector, 7 % to 60 % (mean 32.18
± 13.21) in Karangazi sector, 0 % to 41 % (mean 35.49 % +/- 8.920) in Rwimiyaga sector, and, 0 % to 100 % (mean 18.41 % ± 26.60) in Tabagwe sector. The herd prevalence was 29.62% in Ankole cattle (95% CI: 28.36 to 30.87) and 23.71 (95% CI:
17.23 to 30.19) in purebred Friesian-Holstein cattle, with a statistically significant
difference (x_2 = 413.567, P = 0.000).

Individual animal prevalence (IAP), i.e. number of individual positive reactors, differed (P < 0.05) between and within the sectors. Significant higher overall IAP´s were
found in Byera (20 %), Rwimiyaga (12.17%), and Rwimbogo (12 .00 %) (Table 1).This study showed a higher seroprevalence (by RBT) of brucellosis in local cows than purebred
Friesian Holstein cows (Table 2). Individual animal prevalence was 9.75 % (95 % CI: 9.34
to 10.16) in Ankole cattle and 7.15 % (95% CI: 5.46 to 8.84) in Purebred Friesian-Holstein
cattle with a statistically significant difference (x2 =335.339, 28 df, P= 0.000).

There was no statistically significant difference in individual prevalence between
Ankole cows and crossbred cows, Ankole and purebred Jersey, and Ankole and purebred

Guernsey cattle (Table 2). Similarly, the prevalence of brucellosis in cattle was found to
be higher in the older parities than younger ones. Overall seropositivity to bovine
brucellosis was 5.9 % (12/204) for parity 1, 11.05 % (20/181) parity 2, 11.04 % (18/163)
parity 3, 14.29 % (11/77) parity 4, and 8.82 % (3/34) for parity 5. However, no statistically
significant difference was observed in the prevalence of brucellosis between male and
female animals.

Table 1. Herd, within herd, and individual animal prevalence based on RBT stratified by sector in Nyagatare

N_1 +ve herds	Herd prevalence in % (CI)	Within Herd prevalence in % (CI)	N_2 Cases	Individual prevalence in % (CI)
Byera	2	2	100.00$_{a}$ (100.0, 100.0)	20.00$_{a}$ (20.00, 20.00)
10	2	20.00$_{a}$ (20.00, 20.00)		
Gatunda	3	0	0.00$_{b}$ (0.00, 0.00)	0.00$_{b}$ (0.00, 0.00)
9	0	0.00$_{b}$ (0.00, 0.00)		
Karama	15	2	15.46$_{c}$ (11.15, 19.78)	8.05$_{ai}$ (-1.92, 18.02)
29	3	10.34$_{c}$ (9.47, 11.22)		
Karangazi	81	26	32.18$_{d}$ (30.92, 33.44)	9.92$_{ag}$ (8.36, 11.49)
427	42	9.84$_{dc}$ (9.38, 10.30)		
Katabagemu	11	5	45.45$_{e}$ (45.45, 45.45)	11.53$_{ah}$ (7.01, 16.04)
59	7	11.86$_{ec}$ (11.86, 11.86)		
Matimba	8	1	12.50$_{fc}$ (12.50, 12.50)	1.89$_{c}$ (0.54, 3.23)
53	1	1.89$_{fb}$ (1.89, 1.89)		
Musheri	5	1	20.00$_{gc}$ (20.00, 20.00)	5.56$_{d}$ (1.68, 9.44)
36	2	5.56$_{g}$ (5.56, 5.56)		

Rwimbogo 7 3 34.38hd
(34.38, 34.38) 21.71af
(11.93, 31.50) 35 7 12.00hc
(12.00, 12.00)
Rwimiyaga 54 19 35.49ih
(34.45, 36.53) 11.19aj
(9.14, 13.23) 286 32 12.17ieh
(11.82, 12.52)
Tabagwe 19 4 18.41jcg
(11.15, 25.67) 5.56e
(0.91, 10.20) 54 3 5.56jg
(4.21, 6.90)
Total 205 63 31.66 (30.68, 32.65) 9.93(8.85, 11.01) **998 99** 9.92(9.62, 10.22)
N_1 = Number of herds, N_2 = number of animals sampled, CI = Confidence interval
Figures with similar superscripts within a column are not statistically different at P < 0.05
Figures in parentheses represent the lower and upper limits of the confidence interval
372

Table 2. Herd, within herd, and individual animal prevalence based on RBT stratified by breed in Nyagatare.

Breed N Cases Herd prevalence in % (CI) Within-Herd prevalence in % (CI) Individual Prevalence in % (CI)

Ankole 520 52 29.62a (28.36, 30.87) 11.19 (8.57, 13.81) 9.75a (9.34, 10.16)
Friesian 53 3 23.71b (17.23, 30.19) 4.03 (1.76, 6.29) 7.15b (5.46, 8.84)
Crosses 248 22 33.16c (31.07, 35.24) 8.42 (6.67, 10.16) 9.50a (8.91, 10.09)
Jersey 12 1 28.89ac (-10.40, 68.19) 6.11 (-3.89, 16.11) 8.88ab
(1.29, 16.46)
Guernsey 13 1 31.69ac (-16.25, 79.63) 4.00 (-7.11, 15.11) 7.17ab (-2.18, 16.53)
Total 832 30.30 (29.18, 31.42) 9.83 (8.10, 11.55) 9.49 (9.15, 9.82)
Figures with similar superscripts within a column are not statistically different at P < 0.05

Discussion

The serological prevalence of brucellosis for 6 out of the 9 infected sectors of Nyagatare district included in this survey was around 10 % with a 99 % confidence.

Considering that no formal control programme is in place, that about 1.1 % vaccinate their
cattle against brucellosis each year (6), and that other surveys in East African and sub-
Saharan Africa frequently encountered prevalence in excess of 10 % (31), the high prevalence of the disease here, is not surprising. Overall, our results indicated that bovine

brucellosis was endemic in Nyagatare district.
Since very few vaccinations against brucellosis are carried out in the district, the seroprevalence figures obtained are a reliable estimate of exposure to wild type *Brucella* spp. The mean prevalence of the disease ranged from 1.89 % in Matimba sector to 20 % in Byera sector (Table 1). The finding of such a higher prevalence of the disease among the sectors is supported by observations of high incidences of abortion and retained placenta previously reported in Nyagatare (6).
The observed significant difference in herd, within herd, and individual animal prevalence of brucellosis signifies differences in breeds of dairy cows kept and animal husbandry practices prevailing among the different sectors. For example, 18 out of the 54 animals tested in Tabagwe sector (individual prevalence 5.56 %) were improved breeds while 55 out of the 59 tested in Katabagemu sector (individual prevalence 11.96%) were crosses between exotic and local cows. The low prevalence in herds with a higher proportion of improved breeds is likely to be explained by zero grazing feeding practices that minimizes contacts between herds and animals. Most purebred cows are concentrated along the peri-urban centers, townships, and are mostly fed barna grass through the cut and carry system (6). However, the “cut and carry” system of feeding may serve as a potential risk for bovine brucellosis when the fodder is collected from areas used by indigenous traditional cattle.
The higher prevalence of bovine brucellosis in herds with a higher proportion of local or cross bred breeds of cattle is likely to be explained by the extensive system of grazing management practiced for such cows. In extensive grazing, animals from different locations, and likely of different brucellosis status, come into close contact in pastures or at watering points which facilitates spreading of the disease between and within herds (16,

17). Discharges from aborting animals or following normal birth contaminate pastures and
possibly lead to higher herd prevalence rates in extensively managed animals. In addition,
the mixing of local and exotic herds favors increased spreading of brucellosis between and
within herds (26, 27). The prevalence of brucellosis in cattle in the extensive management
system in this study agrees with reports from other countries with similar cattle husbandry
systems (15, 4, 19, 26, 27).
373
It was observed that the local Ankole cattle or their crosses with exotic breeds made up the
majority of the total sampled and also the sero- positive animals, hence, breed alone may not have
played a key role in the results reported. As explained above, the breed factor relates more to how
the breeds are perceived and managed rather differences in breed susceptibility to brucellosis per
ser. It can be argued that the observed differences in prevalence of brucellosis between
indigenous and exotic animals are mostly attributed to differences in exposure to
infectious animals or materials as a result of differences in management. The finding of
high proportions of seropositive animals in indigenous as apposed to exotic breeds
conform to results of a recent study in Tanzania which also reported similar observations
(18).
There was no further investigation to identify the *Brucella* species infecting cattle
in this area, where breeding of cattle alongside goats and sheep is a common practice. It is
therefore not possible from the results of this study to rule out that besides *B. abortus*
infections, *B. melitensis*, originating from the small ruminant reservoir, may also infect
cattle as described by OIE (24). However, despite this limitation, this study has revealed
that, in spite of the fact that official data from Rwanda about brucellosis is lacking, the
disease is still enzootic in some parts of the country and the risk posed to the human

population and the economy of cattle production should not be underestimated (11).
In this discussion, parity was taken as a rough estimate of age and it appears a statistically significant effect of parity on prevalence of brucellosis existed. The prevalence of brucellosis increased with increasing parity or age of the cow. Susceptibility of older cows has been attributed to the effects of sex hormones and erythritol, which stimulate the growth and multiplication of *Brucella* organisms. These substances tend to increase in concentration with age and sexual maturity of cattle (30). The observations that the prevalence of brucellosis increases with parity or age of the cow are consistent with the findings of several other researchers who reported significantly higher proportion of positive reactors in older animals (29, 3, 34, 21).

In the present study, no male reactors were identified. None of the bulls tested in the present study reacted positively to RBPT. However, the absence of male reactor animals in this study could probably be due to the smaller number of male (n = 24) animals studied as compared to females (n = 974). Even though it is difficult to draw a firm conclusion, due to the smaller sample of males, the lack of difference between the two sexes observed in this study corroborates established facts about the disease. Hirsh and Zee (14) have reported that male animals are less susceptible to *Brucella* infection, due to the absence of erythritol. Further, testes of infected male animals do not always react to the infection or show low antibody titers (23, 10), thereby contributing to low seroprevalence in this particular sex. Present observations are comparable with many others (3, 4, 21).

In estimating exposure to brucellosis, the Rose Bengal Test (RBPT) should ideally be used as a screening test, followed by more specific tests such as Serum agglutination (SAT) or compliment fixation test (CFT) because the specificity of this test is low (20). In

addition, RBPT has limitations in the diagnosis of chronic brucellosis because the test
mainly detects IgM, yet the amount of IgM in serum of infected animals declines with
time to levels below the sensitivity of this test (34). However, these more specific tests are
currently not available in Rwanda. Nevertheless, regardless of low specificity, RBPT is an
excellent test to use in order to detect early infections (11). Therefore, it's possible the
prevalence reported herein maybe an underestimation of the true situation on the ground.
Despite the dairy productivity implications, the high prevalence of brucellosis as
observed in this study pauses undisputable risk to the human population given the fast
growing dairy farming sector and intensification of livestock production in Nyagatare. The

high prevalence of bovine brucellosis, a livestock and zoonotic disease, which is easily
amenable to control through effective use of existing disease control technology such as
use reliable vaccines reflects failure of veterinary extension within the country.

Conclusion

From this study, it can be concluded that brucellosis is enzootic in Nyagatare and
could be the major cause of reproductive wastage previously reported from the same
district (6). This disease presents a significant impediment to the economic potential of
dairy production and is a zoonotic hence preventive and control measures should
immediately and strictly be implemented to protect animals and humans from brucellosis.
Further significance of the present findings relate to the fact that brucellosis is a
significant health hazard in human beings, causing a variety of chronic debilitating
illnesses for people who either come into contact with infected animals or consume
infected dairy products. Both, the control of infertility and prevention of brucellosis

infection in humans provide enough justification for the advocacy of brucellosis control
measures.

Recommendations

The authors recommend further epidemiological studies and isolation and identification of the biotypes of *Brucella* responsible for infection in Nyagatare. Such investigations have important implications for the type of vaccine that should be used and when monitoring the efficacy of control programmes. The further investigations above could should pave the way for mass vaccination to reduce the incidence of the disease to significantly low and manageable levels prior to implementing a test and slaughter policy where cattle, sheep and goat testing positive for brucellosis are slaughtered to remove source of infection from the herd.

Large-scale studies are also required to determine the epidemiology of brucellosis in humans. The impacts of the disease on the health of the local population can be decreased through awareness campaigns which can be initiated through training of animal health technicians on the routes of infection and preventive measures such as boiling of milk before consumption and avoidance of contact with aborted material and placentas.

Owing to the relatively nonspecific symptoms in humans and a frequent lack of information on zoonotic diseases (9), it is further important to inform and collaborate with the human health services to increase the likelihood of correct diagnosis and treatment as well as to advocate the prevention of the disease through precautionary measures.

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SURVIVAL ETHICS: CONSEQUENCES FOR APPROPRIATE TECHNOLOGY

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Key words: ethics, science, appropriate technology, survival
Abstract
This essay examines critically the demarcation of ethics and science. While its method is
theoretical rather than experimental, it proposes a research program as a logical next
step to test its conclusions. It offers a conceptual foundation for a new ethics whose chief
aim is the survival of life. Only a global consensus can challenge contemporary threats to
life. The foundation of this new ethics is compatible with classical ethical systems. The
essay's concluding sections will sketch the consequences of survival ethics for new
definitions of "appropriate" technology. The conclusion proposes both a new discipline

called teleonomics *that combines philosophy, science, and technology, as well as a demonstration project to test the feasibility of this new discipline.*

INTRODUCTION

The discipline of ethics has never achieved consensus. Historically, this aspect of ethics has been an asset rather than a failure. The varieties of philosophical disagreement have amplified our choices about how we should live our lives. However, humanity now confronts a crisis never before experienced: the human destruction of life as we know it.

A nuclear war of significant proportion will destroy the food chain through nuclear winter.

Growing consensus acknowledges that global warming carries the threat of imminent species extinction. The unprecedented magnitude of these threats to life demands a global response. That response must be grounded in a common sense of ethics, a *whole earth* ethics.

Saturated in the wrangling that characterizes philosophy, current ethical systems cannot achieve that consensus. Philosophers and neuroscientists have recently suggested new methods for doing ethics as we begin to understand more clearly the relations between brain and behavior. Kwame Anthony Appiah's *Experiments in Ethics* insists that ethics is at its core an experimental discipline [1]. Richard Joyce's more radical *The Evolution of Morality* displaces ethics into the neurobiological and psychological sciences [2].

This essay examines critically the demarcation of ethics and science. While its method is theoretical rather than experimental, it proposes a research program as a logical next step to test its conclusions. It offers a conceptual foundation for a new ethics, a *survival ethics,* whose chief aim is the survival of life. Only a global understanding can challenge contemporary threats to life. The foundation of this new ethics is compatible with classical ethical systems developed over the past five thousand years. The essay's

concluding sections will sketch the consequences of survival ethics for new definitions of
"appropriate" technology. The conclusion proposes a new discipline called *teleonomics*
that combines the strengths of philosophy, science, and technology. The conclusion also
proposes a demonstration project to test the feasibility of this new discipline.
378
The foundation for a survival ethics springs from a comparison of rationality and ethicality. Richard Joyce collapses ethics into the neurobiological and psychological
sciences. These sciences attempt to explain the origins and development of ethics by
means of evolutionary theory. The mainspring of this kind of explanation is genetic
change and natural selection. More traditional philosophers like Kwame Anthony Appiah
resist the conflation of science and ethics. For them, science is an instrument of
generalized description. Scientific generalizations do not have the force of ethical
prescriptions. The first two sections of the paper will compare rationality as the
embodiment of contemporary science with ethicality to examine their separability.

RATIONALITY

Rationality's deepest meaning is to be discovered in its Proto-Indo-European root.
The *ar* sound in *rationality* is linked with other words like *harmony, architecture,*
arithmetic, arm, art, ratio. The sound *ar* means to join or to connect. Like all rationality,
human rationality is connecting by means of abstractions. Abstractions are patterns
common to environmental and brain states and accessible through transform mechanisms
not now understood. The virtue of an abstraction is its generality, which enables us to
predict and thereby control our environmental and brain states.
This essay engages an instrumental or pragmatic definition of *rationality*.
Rationality evolves in the service of survival. To be rational, a belief or theory must
correspond with experience, be consistent with other beliefs, be practical, be of wide

scope, be generalized to an appropriate degree, call itself into question when appropriate,
and be meaningful in both semantic and emotional senses.
The conditions of rationality are set by its survival function. Three common theories of truth express this relationship. The correspondence theory of truth derives its
plausibility from the consideration that brain states must mirror environmental states so
that the organism may make appropriate decisions about actions. The coherence theory of
truth is based on the foundational principle of rationality as connectivity. A connection
either exists or it does not exist; it cannot both exist and not exist at the same time in the
same way. The pragmatic theory of truth reflects the evolutionary origins of rationality.
A theory or belief as an expression of rationality must serve its intended use. The remaining constraints of rationality follow from evolutionary mechanics. To be rational is to know all possible facts and theories pertaining to a decision. A rational
belief or theory covers all pertinent belief and experience. The most perfect expression of
the rationality of a belief or theory is its degree of generality. The test of generality is the
ratio between the number of symbols required to express a belief or theory, and the area of
experience covered by the theory or belief. Since the rationality of our beliefs and theories
itself evolves constantly, a penultimate test is the propensity of a belief to call itself into
question.
The final test is a function of the instrumentality of expressing our beliefs. We at
present can only do that through symbols, literally in Greek “throwings-together.”
Symbols are aspects of experience that we choose to re-present other aspects of experience. The potentially arbitrary nature of the relation between symbol and symbolized means that we must constantly test that relationship-both for ourselves and
our interlocutors.
With this definition, we can now ask whether there can be a science of rationality.

At this stage of human evolution, there is no algorithm for making guaranteed decisions about what to believe in making the foundational choices that direct our lives in general, or our choices of theories and beliefs more particularly. The seven tests of rationality

constitute a basket that must be sorted through in making rational choices. *In extremis*, one might create a hierarchy of values in the basket.

When faced with urgent choices upon which our survival might depend, practicality can become an overriding concern. Consistency is infamously the "hobgoblin of narrow minds." The simplicity or beauty of a theory might encourage its proponents to dismiss experiments that contravene the theory. Well-established theories become nearly impossible to question. Widely-shared symbols assumed to have meaning over long periods may acquire a false semantic stature.

Nonetheless, deeply seated theories that persist over time meet all seven tests of rationality to the degree possible given the historical limits of understanding. Perfect rationality implies total knowledge, the myth that animates Plato's definition of *philosophy* as love of wisdom or perfect knowledge. Philosophers through the ages have made their reputations through acts of hypertrophy-emphasizing one of the tests of rationality to the exclusion or diminution of others.

Thus Leibniz's "universal calculus" sets the stage for computation based on noncontradiction or consistency as the primary test of rationality. Locke, Berkeley and Hume exaggerate the role of empirical (rather than imaginary or calculative) experience. The eponymous pragmatists embellish the role of practicality in rationality. Idealists like Hegel, Spinoza, and Plato focus on the importance of generalization or simplification.

Socrates makes his mark by emphasizing the hyper-reflexive character of rationality: "We know only that we don't know." Twentieth-century analytic philosophers like Wittgenstein make the most important if not the sole burden of philosophy the need to

clarify meanings.
These European philosophers demonstrate the variegated nature of rationality. Given our historical perspective, it would be a grave mistake to imagine with them that one aspect of rationality is of overriding importance—or even to imagine that there is no more to life than rationality. Rationality is in fact itself a value. As the primary instrument of human survival, rationality's importance may appear to be paramount.
Humans are weak, slow, dimly sensing, poorly naturally armed, tasty creatures that would yield to our competitors at the top of the food chain if not for our ability to think.
Thinking is generalizing through abstraction in order to predict and control the future.
Philosophers like Plato, Aristotle, and Kant have exaggerated rationality's importance, declaring it to be the primary human value. However, rationality itself depends on our survival for its exercise. Pleasure also drives us toward survival, as do love, caring, and community bonding in our lives. Freedom, happiness, and contemplation as well are close allies of survival. Nevertheless, survival cannot be given a role as the preeminent value because many humans whom we respect and cherish over the ages have sacrificed their own survival for the sake of values they deemed more important than survival--love in the case of Christ, duty for Socrates, *satyagraha* for Gandhi.
Rationality and ethicality are analogous in that no single element or trait can encompass the whole of either characteristic, as I will show in the next section of the paper. The bridge to ethicality is to ask what the value of rationality is for life itself. Shall we use "rational" means to judge our fundamental values? Does rationality receive its own value through an instrumental analysis along evolutionary lines? Is rationality valuable as an end in itself, or only as it serves other ends, such as survival or freedom or happiness?

ETHICALITY

Ethicality first requires its own definition. *Ethics* has acquired the sense of a field distinct from morals. *Morals* refers to behavior that is customary or acceptable in a given society. *Ethics* means the study of morals and more deeply the study of value itself. What is valuable is what is desired or, more strictly, what is desirable given some set of fundamental assumptions.

At its most basic level, ethics considers appropriate mechanisms for choosing principles or values to guide our lives. Rationality and ethicality are analogous in the sense that both are complex phenomena that cannot be given a single-factor analysis. Both are indispensable for choosing the directions of our lives. What I want to do in this section is to draw an analogy between tests for rationality and ethicality. Just as rationality cannot have a single defining criterion, so ethicality is expressed through a basket of values. The separate values have their champions in the history of philosophy. Each philosopher makes a case for a single value's having overriding status.

The history of African, Asian, and European ethics presents a medley of sometimes conflicting goods. Early African and Asian primary values appear to be commonsensical and grounded in the conditions necessary for human survival and flourishing. The oldest written philosophy, that of ancient Egypt starting around 2800 BCE, presents *Maat* as the highest good. *Maat* is variously translated as harmony, order, peace, justice, tranquility.

Other African cultures like the Oromo in Ethiopia emphasize a similar overriding ethical principle. The principal ethical good of the Borana, the Oromo group in the southernmost part of Ethiopia bordering on Kenya, is *Nagaa*, translated as peace or harmony. The Oromo ensure a community-wide harmony among themselves, their neighbors, and the environment through a democratic system called *gaada*.

The ancient Chinese philosophy of Taoism, canonized by Lao-Tzu and Chuang-Tzu around 600 BCE, enjoins the ethical principles of *wu-wei*, translated as passive nondoing.

The Taoists, as their name suggests, believe that the universe is comprised of a single principle, the *Tao*, which is a balance of complementary principles striving for harmony. As the *Tao* or nature seeks its balance, humans live well if they follow nature's guiding principle of harmony rather than forcefully imposing an artificial system of control on nature.

The common-sense principles of *Maat, Naaga*, and *Wu-Wei* contrast sharply with the ethical maxims of other ancient traditions. Hindu philosophy enjoins a value of *moksha* or liberation from our common-sense conviction that this life we live daily is real rather than a dream. The primary ethical practice of this tradition is meditation, known through the practices of yoga, or the union of Self with God. Buddhism dispenses with the metaphysical presuppositions of Hinduism to focus on a single practical problem-how to eliminate suffering or achieve *nirvana*. Like Hinduism, however, Buddhism focuses on meditation as the instrument of liberation from suffering.

Plato's concept of the good is the very idea of good itself. For Plato, the whole point of life is to contemplate the perfect model of all that is good. Plato stands out among Greek ethicists for making the contemplation of the good by an immortal soul the overarching end of humanity. Other Greek ethicists are much more down to earth. The hedonists notoriously make pleasure the end of all ends. Aristotle rejects pleasure and substitutes happiness. He defines happiness as activity in accord with excellence.

Excellence is a function of the nature of an organism. As thinking beings, our highest activity is thinking, and the greatest kind of thinking is thinking about thinking itself, defined by Aristotle as contemplation or philosophy.

Subsequent European philosophies lose this passion for pure abstraction, but make abstraction the ground for more practical pursuits-the enslavement and colonization of large portions of the world's populations. Augustine carries on the theoretical Christian

tradition of universal, unconditional love as the primary ethical principle. However, this principle, first enunciated by the now little known Chinese philosopher Mo Di (or Mozi) in the fifth century BCE, is honored more in the breach than in the observance. Subsequent ethicists in the European tradition subscribe to more common-sense ethical principles: pleasure for Bentham and Mill; duty expressed through universalization for Kant; freedom for Hegel, Marx, and the existentialists; and the return to the basics of survival and flourishing by "American" pragmatists like James, Dewey, and Rorty. These apparently quite diverse and seemingly random ethical "goods" or values can be reduced to a basket of seven fundamental values. My reduction here is provisional.

The basic values are survival, rationality, pleasure, love, happiness, freedom, and contemplation. They cut across African, Asian, and European traditions, and they are associated with the most illustrious philosophers in the traditions of these continents. The common key values are the following: survival for Darwinists, pragmatists, Taoists, and Africans; pleasure for hedonists, Bentham, and Mill; rationality for Kant, Hegel, and Spinoza; love or caring for Christians, Mohists, and feminists; happiness for Aristotle; freedom for Hegel, Marx; and contemplation or meditation for Hindus, Buddhists, and many Judaic, Christian, and Muslim sects.

Can these disparate values be ranked or does each hold an independent status, as is the case with the basket of values comprising rationality? As the pragmatic criterion for believing a theory may sometimes take precedence over other rational values, so survival may under certain circumstances trump all other values—particularly for communities or for the whole earth population when survival is at risk. To be good, after all, is first to be.

If survival is not an issue, however, it may deserve little consideration in choosing the fundamental values that are to serve as guidelines for one's life.

Nonetheless, the six values other than survival may be given an explanation through evolutionary considerations. Rationality is the primary instrument of human survival. Pleasure is the stimulus for the behaviors most necessary for the survival of the species--breathing, temperature control, hydration, eating, reproduction, and the like. Love is indispensable for human survival, given the long maturation period of humans and the need for community bonding for group survival. Variation is key to survival, and the value of freedom promotes variation. Contemplation may seem to be quite disconnected from the immediate concerns of survival. However, the primary focus of contemplation or meditation is the control of the attention. Ordinarily, random environmental circumstances dictate the attention's direction. Survival under this condition is a matter of luck. Meditation gives the individual rational control of her attention.

The fact that basic human values may be grounded in considerations of survival does not confer a privileged status on survival. In fact, we may deliberately choose to dismiss survival as a ground value. We may very well be the kind of species that sets up the "ethical" conditions for its own extinction. Powerful historical slogans point in this direction: "Live free or die!" "Give me liberty or give me death!" "*Patria o muerte*!" Religions like Hinduism, Buddhism, Judaism, Christianity, and Islam proclaim that this life is merely a test. "Real" life starts only after death or transcendence of life.

However, the fact that the survival of the species is now at risk makes survival an issue of overriding contemporary concern. The key question is whether enough humans believe that a primary mission of our lives is pass life on to our successors in better condition than we have received this gift. If this proves to be the case, we need a new

"technology" to furnish the grounds for continuing life. This technology must synthesize

three disciplines: ethics or philosophy, science, and technology itself. The technology
must find a common ground for a "whole earth" ethics that the majority of humans, regardless of their individual cultures and religious beliefs, can subscribe to. This new
ethics must have as its primary focus the survival of the species.

TELEONOMICS: A NEW STRATEGY FOR A SURVIVAL ETHICS

My proposal for a new discipline assumes that basic human values or ends are naturally defined. Just as we are born to be grammatical, so we are conceived to be ethical
[3]. Nevertheless we can assign hierarchies to naturally ordained values as well as subvert
them. The enterprise of selecting our deepest ethical ends, interpreting what they mean,
and assigning weights to them is a basic task of philosophy or more specifically ethics.
This task includes highly theoretical proposals for achieving ends or values in ways that
are consonant with other ends.
A quite separate enterprise is the task of actually achieving these ends. This part of
the enterprise must be both scientific and technological. I define *science* as the system of
generalizations and explanations that we use to understand, anticipate, and control
experience. *Technology* is defined as the art of translating our understanding of experience into action. I call the fusion of philosophy, science, and technology *teleonomics* after the Greek terms for ends and laws.
The point of teleonomics is threefold: to choose ethical ends consonant with survival; to propose general means for achieving those ends through scientific reflection;
and finally to propose practical means for realizing those ends through a synthesis of
appropriate technologies.
The epistemological status of teleonomics must be comparable to that of economics, the "rules of the house" in Greek. Scientific generalizations about "what
happens when" with respect to human behavior are notoriously statistical and often
unreliable. However, the less general aspects of teleonomics are based on experience, and
are quite reliable. Appropriate technologies exist to translate scientific or common sense

generalizations into practical arts. The statements of teleonomics are hypothetical rather
than categorical. Ethics tells us "Thou shalt do thy duty!" or "Thou shalt survive!" or
"Thou shalt maximize pleasure!"
Teleonomics phrases its commands in hypothetical form: "If you wish to survive, then you must breathe, regulate your temperature, drink, eat, sleep in descending orders of
urgency." Techniques for survival have been worked out over perhaps hundreds of thousands of years. Teleonomics is a synoptic discipline in that it relies on all other
sciences to project its conclusions. It is an evolving science because it must change its
hypothetical imperatives to fit altered circumstances. Weapons of mass destruction and
global warming provoke unprecedented calls for ethical action.
Teleonomics is a bridge between ethics and science in unique ways. All sciences have a philosophical component—the extreme assumptions that drive research in the sciences in different directions, assumptions that cannot be tested given the current state of
knowledge and their degrees of generalization. The Duhem-Quine hypothesis holds that
theories can neither be refuted nor verified, because we cannot test the deepest assumptions. Parallax serves as an example. Geocentrists held that the failure to detect
parallax meant the earth could not be moving. But geocentrists assumed that the distance
between the earth and the stars was not sufficient to make parallax detection difficult. The
falsity of that assumption required better instruments for measuring stellar distances.

All sciences face this difficulty. However teleonomics must not only cope with our inability to test deep ethical assumptions, but also translate scientific generalizations
into appropriate technologies. *Appropriate* here means *ethically* appropriate—productive
of global peace and sustainable with respect to the rights of future generations. Teleonomics must bridge the spectral divides between science and philosophy as well as
between science and technology.
The relations among the three disciplines are not hierarchical. Working with

appropriate technologies may in fact show that our philosophical choices of ends or our basic scientific understanding of their realization have been wrong. The current hypertrophy of technology ("things are in the saddle and ride mankind," as Emerson declares) illustrates this claim. Choosing to focus on rationality and using complex technologies to realize basic human values have threatened our survival.

In translating philosophical assumptions into scientific generalizations, and those generalizations in turn into ethical and sustainable technologies, teleonomics is neither philosophy nor science nor technology, but a fusion of all three disciplines. The sciences should furnish the chemistry, physics, and biology of alternative renewable safe energies and other resources. The technologists or engineers using these fields should propose appropriate techniques for survival. By reason of its synoptic character, teleonomics is not a discipline that can be exercised by a single researcher.

CONCLUSIONS

This paper sketches a theoretical instrument for assessing technologies that are *ethically* and *practically* appropriate in the largest possible sense of ensuring human survival and sustaining our environment. Implementation would entail recruiting interdisciplinary teams to collaborate on the planning of appropriate micro- and macrotechnologies.

The first phase of a practical execution of this research proposal will select a small-scale demonstration project on water treatment and management to be developed by an interdisciplinary team of philosophers (Charles Verharen), scientists (George Middendorf, biology, Howard University) and engineers (John Tharakan, chemical engineering, Howard University). Because the appropriateness of a technology is inseparable from reflection on local culture, the team will include anthropologists (Bruce Dahlin, Shepherdstown University) and critical members of the community (to be selected from the Global South) where the project is to be implemented and tested.

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