

Influence of sodium salicylate on adventitious organogenesis of a commercial cucumber cultivar



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Abstract Cucumber is an important vegetable crop belonging to the Cucurbitaceae family. An optimized regeneration system is required to address different biotechnological approaches in this species, such as large-scale multiplication, as well as genome editing and genetic transformation techniques. The aim of this study was to investigate the effect of different concentrations of the phenolic compound sodium salicylate (NaSA), a salicylic acid derivative, on *in vitro* callus and shoot regeneration of a commercial cultivar of cucumber. Four-day-old cotyledon explants from the slicing cultivar 'Marketer' were employed. Murashige and Skoog (MS)-derived shoot induction medium containing 0.5 mg L⁻¹ indole-3-acetic acid (IAA) and 2.5 mg L⁻¹ 6-benzylaminopurine (BAP) was supplemented with NaSA. Frequency and shoot number were enhanced by 1.5-fold with NaSA at 0.1 μM. Higher salicylate levels led to increased callus formation and decreased shoot regeneration. The application of sodium salicylate at a specific concentration showed a positive trend in *in vitro* adventitious organogenesis of a commercial cucumber cultivar. Some probable mechanisms that may underlie the beneficial effects of salicylic acid/salicylates on *in vitro* regeneration were also discussed.

Keywords: salicylic acid sodium salt, morphogenesis, shoot regeneration, *Cucumis sativus* L., Cucurbitaceae

1. Introduction

Sodium salicylate (sodium 2-hydroxybenzoate; NaSA) is the sodium salt of salicylic acid (SA) (PubChem 2022a). SA (2-hydroxybenzoic acid) is an endogenous growth regulator and a signaling molecule involved in the regulation of various physiological processes related to plant growth and development, as well as in the modulation of plant responses to different abiotic and biotic stresses (Mohamed et al 2020; PubChem 2022b).

Exogenous application of SA may affect a variety of plant processes and attributes, such as photosynthesis and photosynthetic pigments (Khan et al 2003; Maurya et al 2019), respiratory pathways (Khan et al 2003), ethylene biosynthesis (Khan et al 2013), seed germination (Lee et al 2010), flower induction (Cleland and Tanaka 1979), thermogenesis (Rhoads and McIntosh 1992), ion uptake and transport (Harper and Balke 1981; Gondor et al 2016), nitrate reductase activity (Fariduddin et al 2003), protein content (Latif et al 2016), growth parameters (Damalas 2019), biomass production (Maurya et al 2019), plant water relations (Hayat et al 2010), stomatal closure (Khan et al 2003), accumulation of osmolytes (e.g., proline, glycine betaine, polyamines, and soluble sugars) (Khan et al 2014; Madany et al 2020; Shemi et al 2021), secondary metabolite content (e.g., alkaloids, flavonoids, and phenolics) (for review see Nandy et al 2021), allelopathic properties (Shettel and Balke 1983), antioxidant defense system (Maurya et al 2019), and senescence (Rivas-San Vicente and Plasencia 2011). It can also alleviate environmental stresses, such as heat (Khan et al 2013), cold (Saleem et al 2020), drought (Sohag et al 2020), UV-B/C radiation (Li et al 2014; Abrun et al 2016), salinity (Elazab and Youssef 2017), and heavy metals toxicity (Sharma et al 2020), and protect plants from a range of pathogens (Bakker et al 2014). The effect of exogenous SA is influenced by factors such as the plant species, its stage of development, tissue and organ type, mode of application, dose and duration of exposure, environmental and culture conditions, and its endogenous level in the plant (Horváth et al 2007; Janda et al 2014; Kračun-Kolarević et al 2015; Bhutia et al 2018). SA application has been reported to modulate plant functions dose-dependently (Maurya et al 2019). Inadequate levels of SA can also lead to oxidative stress (Gondor et al 2016). SA-like effects have been reported with structurally similar compounds, such as NaSA and acetylsalicylic acid (ASA). Some authors have previously described improved *in vitro* plant regeneration with exogenous SA or ASA. In the present work, it is investigated by applying NaSA.

The cucumber (*Cucumis sativus* L.) is an economically important species belonging to the Cucurbitaceae family, along with melon, watermelon, and squash. Its world production, including gherkins, ranked third among vegetable crops in 2020,



with 91,258,272 tons (FAOSTAT 2022). This species is an important source of valuable nutrients and bioactive compounds used not only as food but also in cosmetics, therapeutics, and perfumery (Uzodike and Onuoha 2009; Uthpala et al 2020).

In vitro regeneration in cucumber has been established and can be achieved through organogenesis and somatic embryogenesis. The most frequently used explants are cotyledons (Chee 1990; Selvaraj et al 2007; Miguel 2017), hypocotyls (Ziv and Gadasi 1986; Chee 1990; Grozeva and Velkov 2014), and leaves (Malepszy and Nadolska-Orczyk 1983; Lou and Kako 1994; Seo et al 2000). Regeneration from protoplasts (Jia et al 1986; Trulson and Shahin 1986; Burza and Malepszy 1995) and suspension cultures has also been reported (Malepszy and Solarek 1986; Bergervoet et al 1989; Kreuger et al 1996). However, regeneration in cucumber is still not optimal (Wang et al 2015) and is highly dependent on the genotype (Wehner 1981; Punja et al 1990; Miguel 2021a,b). An efficient and reproducible regeneration system is fundamental to address different biotechnological approaches, such as secondary metabolite production, pathogen elimination, germplasm conservation, and large-scale multiplication, as well as genome editing and genetic transformation technologies for functional genomics and genetic improvement.

Sodium salicylate (NaSA) is a derivative of salicylic acid (SA). Exogenous application of these phenolic compounds may affect a range of physiological processes in plants. Unlike SA, the influence of NaSA on *in vitro* regeneration has not been explored. The present investigation aimed to evaluate the effect of different levels of sodium salicylate on adventitious organogenesis of a commercial cucumber cultivar to improve its efficiency.

2. Materials and Methods

2.1. Plant material and *in vitro* regeneration

Cucumber seeds of the commercial cultivar 'Marketer' (Semillas Fitó S.A., Barcelona, Spain) were the starting material. It is a medium-cycle cultivar with vigorous growth, a monoecious flowering habit, and dark green cylindrical fruits 20-23 cm long. It is of good quality for the fresh market and tolerant to Cucumber Mosaic Virus (CMV) (Borrego 1989). Obtaining axenic explants and *in vitro* regeneration followed the methodology previously described by Miguel (2021a). Four-day-old cotyledons with proximal and distal ends excised by 1-2 mm deep were used as explants. They were cultivated for three weeks on MS (Murashige and Skoog 1962) derived shoot induction medium containing 0.5 mg L⁻¹ indole-3-acetic acid (IAA) and 2.5 mg L⁻¹ 6-benzylaminopurine (BAP) and supplemented with sodium salicylate (0.0, 0.1, 1.0, and 10.0 μ M; Sigma-Aldrich, St. Louis, MO, USA). Callus frequency (CF) and callus extension index (CEI) were then determined. The CF (mean $\pm$ SE) is the proportion of explants with the callus on the explant cut surface, and the CEI (mean $\pm$ SE) corresponds to the extent of callus on the cut surface and was graded as follows: 0 = absence of callus; 1 = trace of callus; 2 = callus on less than half; 3 = callus on half or more; 4 = callus covering the entire extent. Organogenic structures were then cultured for 2 weeks on shoot development and elongation medium containing 0.2 mg L⁻¹ kinetin. At the end, an evaluation of shoot regeneration frequency (SRF) and shoot number index (SNI) was made. SRF (mean $\pm$ SE) is the proportion of explants forming shoots, and SNI (mean $\pm$ SE) was scored according to the number of shoots per explant as follows: 0 = absence; 1 = one shoot; 2 = two shoots; 3 = three or more shoots. Individualized shoots were then rooted on a hormone-free MS medium, and within 3 to 4 weeks, the plantlets were ready for acclimatization (data not shown). *In vitro* culture media were solidified with 0.8% (w/v) agar and adjusted to pH 5.7 before autoclaving. Incubation was performed in a culture chamber at 26 $\pm$ 2 $^{\circ}$ C under a 16L:8D h photoperiod. The light was provided by cool-white fluorescent lamps (Grolux, Sylvania) at a photon fluence rate of 90 μ mol m⁻² s⁻¹.

2.2. Data analysis

The experiment was a single-factor design with four levels of sodium salicylate (NaSA) arranged in a completely randomized design. Twelve replicate flasks with six explants each were used in each treatment, except for 10.0 μ M NaSA with six replicate flasks. The R statistical computing environment (version 4.0.4; R Core Team 2021) was used to perform all statistical analyses. Non-linear regression analyses were applied to the data to compare treatment means. The R packages 'stats' (R Core Team 2021), 'COMpoissonReg' (Sellers et al 2019), and 'pscl' (Jackman 2020) were used to conduct logistic regression, COM-Poisson regression and Hurdle regression, respectively. The goodness of fit of the models was assessed using the Akaike Information Criterion (AIC; Akaike 1973) and the Bayesian Information Criterion (BIC; Schwarz 1978). The significance level was set at $P \leq 0.06$ for shoot variables and at $P < 0.05$ for all other analyses.

3. Results

3.1 Frequency and extension of callus

Results presented as mean $\pm$ SEM (Table 1), with significance determined as $P < 0.05$. Callus formation occurred within the first two weeks of culture, starting at the cut ends of the cotyledon explant and scoring 100% frequency. The application of 0.1 μ M sodium salicylate (NaSA) produced the lowest callus extension (1.22 ± 0.05), with significant differences from the other treatments that did not differ from each other. Callus extension scores lay between the arbitrary values of 1: traces of callus, and 2: callus in less than half, at explant cut, ends.

3.2 Frequency and number of shoots

Mean results $\pm$ SEM are showed in Table 1. Shoots formed from callus within 2-4 weeks of culture, mostly at the proximal end of the cotyledon explant. The highest frequency (45.83 ± 5.91) and shoot index (0.38 ± 0.06) corresponded to $0.1 \mu\text{M}$ NaSA, the lowest level, with differences compared to the NaSA-free control ($P = 0.06$), and the treatments with NaSA ($P < 0.05$), which did not differ from each other ($P < 0.05$). It represented a 1.5-fold increase compared to the control.

Table 1 Effect of adding sodium salicylate to MS-derived shoot induction medium containing 0.5 mg L^{-1} IAA and 2.5 mg L^{-1} BAP on *in vitro* callus and shoot regeneration from cotyledon explants of a commercial cultivar of *Cucumis sativus* L. Data presented as mean $\pm$ standard error of the mean (SEM).

Sodium salicylate		Callus regeneration frequency (%) ^p	Callus extension index ^q	Shoot regeneration frequency (%) ^r	Shoot number index ^s
μM	$\mu\text{g L}^{-1}$				
0.0	0	100	1.46 ± 0.06^a	30.56 ± 5.47^b	0.26 ± 0.05^b
0.1	16	100	1.22 ± 0.05^b	45.83 ± 5.91^a	0.38 ± 0.06^a
1.0	160	100	1.54 ± 0.06^a	23.61 ± 5.04^b	0.23 ± 0.06^b
10.0	1601	100	1.43 ± 0.08^a	20.00 ± 6.86^b	0.14 ± 0.05^b

^{p,q}Data obtained after three weeks of culture on shoot induction medium.

^{r,s}Data obtained after two weeks of culture on shoot development and elongation medium.

^qCOM-Poisson regression, ^rlogistic regression, and ^sHurdle regression used to analyze the data. Mean values followed by different letters in the same column are significantly different: ^a $P < 0.05$; ^{r,s} $P \leq 0.06$.

4. Discussion

The effect of sodium salicylate (NaSA) on *in vitro* regeneration of a commercial cucumber cultivar was studied. NaSA is the sodium salt of salicylic acid (SA) (PubChem 2022a) that dissociates to produce SA in a solution (Palmer et al 2019). SA is a growth regulator and a signaling molecule of phenolic nature ubiquitously distributed in plants (Raskin et al 1990; Mohamed et al 2020). Its basal levels vary greatly among species, even within the same family (Raskin et al 1990; Rivas-San Vicente and Plasencia 2011). Exogenous application of SA and its derivatives (salicylates) may generate various metabolic and physiological responses in plants and affect their growth and development. The effect of some of these compounds on *in vitro* regeneration has been reported in various plant species. Shoot regeneration of cucumber (cv. Poinsett 76) from cotyledon explants increased with $30 \mu\text{M}$ SA, whereas other levels at $10\text{--}50 \mu\text{M}$ SA were detrimental (Vasudevan et al 2006). In cucumber (cv. Zhongnong 18), root formation using hypocotyl explants improved at specific SA levels (50 and $100 \mu\text{M}$), not differing from the control (no SA) at $10 \mu\text{M}$ (Dong et al 2020). In melon (*Cucumis melo* L.), callus and shoot formation from cotyledon explants increased with SA and acetylsalicylic acid (ASA) at $50\text{--}200 \mu\text{M}$, while higher levels ($300\text{--}1000 \mu\text{M}$) had an inhibitory effect (Shetty et al 1992). Shoot regeneration of *Hibiscus acetosella* and *H. moscheutos* from shoot meristem explants improved with $500 \mu\text{M}$ SA. In comparison, $1000 \mu\text{M}$ SA did not differ from the control (no SA) (Sakhanokho and Kelley 2009). Somatic embryogenesis in callus culture of *Astragalus adsurgens* Pall. derived from hypocotyl segments increased with $75\text{--}200 \mu\text{M}$ SA, while 300 and $400 \mu\text{M}$ SA had no positive effect; SA levels did not affect callus growth, except for $400 \mu\text{M}$ SA, with a negative impact (Luo et al 2001). Somatic embryogenesis of ten chir pines (*Pinus roxburghii* Sarg.) genotypes using shoot apical dome explants from mature trees was enhanced by applying SA at $7.2 \mu\text{M}$ (Malabadi et al 2008). In suspension cultures of arabic coffee (*Coffea arabica* L.), SA at $10\text{--}6 \mu\text{M}$ had a positive effect on somatic embryogenesis (Quiroz-Figueroa et al 2001). Based on the literature review, applied SA/salicylates act in a dose-dependent manner. It can be stimulatory, causing no relevant changes, or inhibit *in vitro* regeneration. The results of the present investigation are consistent with these findings.

In the current study, the frequency and extension of callus were not influenced by NaSA application, except for $0.1 \mu\text{M}$ NaSA with lower callus extension. The same NaSA concentration showed a positive trend in both shoot regeneration frequency and shoot number index, with a 1.5-fold increase compared to the control. In data not shown, higher levels of NaSA were studied. At $100 \mu\text{M}$ NaSA, both shoot regeneration frequency and shoot number index were similar to those at $10.0 \mu\text{M}$ NaSA. Callus formation decreased at 160 and $800 \mu\text{M}$ NaSA, and no shoots were formed.

The mechanisms underlying the effects of SA/salicylates on *in vitro* regeneration are complex and remain to be elucidated. Multiple factors and signaling pathways are involved.

Phytohormones are crucial for regulating physiological processes throughout the plant life cycle (Kosakivska et al, 2020). They play a key role in *in vitro* regeneration. Crosstalk of SA with other phytohormones has been described under different growth, development, and stress conditions (for reviews, see Rivas-San Vicente and Plasencia 2011; Koo et al 2020; Hayat et al 2021).

In the study by Torun et al (2020), SA treatments changed endogenous levels of abscisic acid (ABA), cytokinins (CTKs), ethylene, IAA, and jasmonic acid, in leaves of barley (*Hordeum vulgare* L.) cultivars under control and saline conditions. Effects of SA depended on the treatment timing and the cultivar. The ability of SA to mitigate salt stress appears to result from increasing ROS scavenging and antioxidant enzyme activity, which is closely related to changes in endogenous phytohormones. In wheat, Shakirova et al (2003) reported that exogenous SA changed the hormone content in ABA, IAA, and CTKs in seedlings

during germination with rapidly reversible changes, increased cell division and root cell extension, plant growth, and yield. Under salinity, SA treatment lessened changes in phytohormones levels and alleviated salinity-damaging effects on seedling growth.

Auxins and cytokinins are two of the most critical factors for tissue culture (Szechyńska-Hebda et al 2007). The balance between endogenous auxin and cytokinin signaling is crucial for *de novo* organ regeneration (Su and Zhang 2014, and references therein). In a recent study, SA treatments promoted adventitious root formation in cucumber explants through competitive inhibition of the auxin conjugation enzyme CsGH3.5 and increased the level of free IAA (Dong et al 2020). GH3 family genes have been extensively identified and characterized in several plant species (reviewed by Liao et al 2015), including cucumber (Wu et al 2014). They may be responsible for cellular auxin homeostasis via the conjugation of auxin (mostly IAA) to amino acids (Liao et al 2015, and references therein). The crosstalk between SA and auxin is also known to balance plant defense and growth (Zhong et al 2021). Besides, SA and IAA share a common precursor (chorismate), the end product of the shikimate pathway (Pérez-Llorca et al 2019). Little is known about the interaction between cytokinin and SA signaling pathways. Its role in *in vitro* regeneration remains to be explored. However, its involvement in other processes has been reported, but the mechanisms underlying its effects are complex. In *Arabidopsis thaliana*, it was suggested that cytokinin up-regulates plant immunity by elevating SA-dependent defense responses and in which SA, in turn, feedback inhibits cytokinin signaling (Argueso et al 2012). Studies in japonica rice (*Oryza sativa* subsp. japonica) showed that cytokinins acted synergistically with SA to trigger defense gene expression (Jiang et al 2013). In barley, SA treatments reduced the total endogenous cytokinin content in the leaves of two of the three cultivars and increased it in the third. Under saline conditions (150 and 300 mM NaCl), SA treatments generally increased total CK levels, particularly at 300 mM salt (Torun et al 2020). Therefore, if SA can interact with cytokinins, it is likely that it may also influence the *in vitro* regeneration process.

It is known that SA operates through many targets to mediate its many effects on plant processes (Klessig et al 2016). A variety of SA-binding proteins (SABPs) have been identified in plants (Klessig et al 2016; Pokotylo et al 2019). Their wide range of affinities for SA, together with the varying SA levels in subcellular compartments, tissues, developmental stages, and following an environmental stimulus, provides great flexibility and involves multiple mechanisms by which SA can exert its effects (Klessig et al 2016).

Plant tissue culture conditions can cause stress that affects the protocol performance. It may also lead to genetic and epigenetic alterations (Pacheco et al 2008). Exogenous application of SA and salicylates may generate protective effects against a variety of biotic and abiotic stresses. Citrus exposed to NaSA in laboratory and field experiments alleviated heat, cold, and disease stresses (Mann et al 2011). Applied NaSA attenuated the adverse effects of salt stress on wheat (*Triticum aestivum* L.) and stimulated growth by increasing the photosynthetic rate and retarding dark respiration (Al-Hakimi 2001). The toxicity of the heavy metals Pb and Cu in duckweed (*Lemna gibba* L.) and cadmium (Cd) in maize (*Zea mays* L.) were reduced by exogenous NaSA (Duman et al 2010; Gondor et al 2016).

Stresses generated by *in vitro* culture, such as those resulting from excess ethylene, reactive oxygen species (ROS), and (poly) phenols (Miguel 2021a), may affect regeneration efficiency (Seong et al 2005; reviewed by Szechyńska-Hebda et al 2007; Klimek-Szczykutowicz et al 2022), could be mitigated by SA/salicylates. Ethylene biosynthesis decreased in mung bean (Lee et al 1999) and in two barley cultivars under 300 mM NaCl stress (Torun et al 2020) when exposed to SA. In cucumber seedlings, a SA treatment stimulated the antioxidant activity of the enzymes ascorbate peroxidase (APX), catalase (CAT), dehydroascorbate reductase (DHAR), guaiacol peroxidase (GPX), glutathione reductase (GR), and superoxide dismutase (SOD), decreased electrolyte leakage, H₂O₂ concentration, and thiobarbituric acid-reactive substances (TBARS), enhancing heat tolerance (Shi et al 2006). In another study, SA inhibited CAT and APX activities while increasing SOD, peroxidase (POD), DHAR, and GR activities, decreased ROS levels and lipid peroxidation, and alleviating manganese toxicity in cucumber plants (Shi and Zhu 2008). Total polyphenol content in shaken cultures of watercress (*Nasturtium officinale* R. Br.) decreased with applied NaSA (Klimek-Szczykutowicz et al 2022).

In some reports, the efficacy of applied SA/salicylates increased under stress conditions. For example, in *in vitro* propagation of three Cavendish banana (*Musa acuminata* Colla) cultivars, NaSA treatments under non-saline conditions were generally less effective than under salinity (120 mM NaCl) on the vegetative and physiological traits evaluated (Elazab and Youssef 2017).

In addition, other reported plant processes and attributes, particularly with NaSA application, may also influence regeneration efficiencies, such as changes in photosynthetic pigment content (Elazab and Youssef 2017; Klimek-Szczykutowicz et al 2022) and net photosynthetic and respiration rates (Al-Hakimi 2001), beneficial ion uptake and transport (Al-Hakimi and Hamada 2001; Elazab and Youssef 2017), enhanced growth (Al-Hakimi 2001; Elazab and Youssef 2017) and biomass parameters (Bhambhani et al 2012; Klimek-Szczykutowicz et al 2022), improved plant water relations (Al-Hakimi 2001), changes in secondary metabolite content (Silja and Satheeshkumar 2015; Klimek-Szczykutowicz et al 2022), and so forth.

Differences between the effects of exogenously applied SA and NaSA on plants have been reported, such as on bud formation, growth parameters, heavy metal tolerance, plant immune response, total phenolic content, and antioxidant activity (Flores-Tena 1993; Zhang et al 2001; Gondor et al 2016; Karn et al 2022). It is still unclear why SA and NaSA differ in their effects.

The findings and considerations of the present study can be further explored and extended to other cultivars and species. Genetic, molecular, and physiological studies will help to understand the role of salicylic acid/salicylates in *in vitro* plant regeneration.

5. Conclusions

From the present study, it is concluded that *in vitro* shoot regeneration of a commercial cucumber cultivar was enhanced by adding sodium salicylate to the induction medium. These findings are an added value to address different biotechnological approaches in this economically important species, such as large-scale multiplication and culture-based genetic transformation.

Conflict of Interest

The author declares no conflicts of interest.

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The influence of goat crossbreeding (Arbia and Saanen) on the cheese yield in Algeria, Djelfa: a preliminary study

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Abstract Goat's milk is an excellent source of nutrients because its composition is the closest to that of human milk. This work was concerned with the study of the influence of crosses between local (Arbia) and imported (Saanen) goat breeds raised in the Djelfa region on the yield of fresh cheese made from the milk of two goats. The cheese was made enzymatically using two enzymes of animal origin represented by the coagulating extract of the kaolin layer of chickens as well as bovine rennet, which were applied to goat milk. The obtained results showed that the cross goats cheeses presented better results compared to those of Arbia goats, where we noted cheese yields of 19.52 and 15.41, respectively, for the cheeses of cross goats and Arbia goats coagulated by the layer extract of Kaolin; likewise, the use of rennet confirmed a superiority of the cheese yield of around 17.62 for the product of crossbred goats against 14.45 characterizing that of Arbia goats.

Keywords: crossbreeding, goat milk, enzymatic coagulation, kaolin layer, bovine rennet

1. Introduction

In some poor regions of the world, the value of the goat is capital because it remains the animal that plays a crucial role in feeding human populations, especially during the great famines that hit the world, particularly on the African continent (Gourine 1989). According to Hafid (2006), the goat has always been part of the human daily life, where it is raised mainly for its milk, meat, and hair; it is called the cow of the poor.

In Algeria, according to Fantazi (2004), goat breeding is one of the most traditional agricultural activities associated with sheep breeding. The goat population remains marginal and represents only 13% of the national herd. The breeding of small ruminants constitutes an important economic activity for the rural human population of the Algerian steppe zones, where the number of goats occupies second place after sheep because of the higher financial income brought by sheep breeding. It ensures interesting meat production compared with goat farming, which provides milk production for self-consumption by the local human population.

Goat's milk is less known and less used than cow's milk, yet it has very important nutritional qualities. Goat's milk is a source of benefits for human health, and it deserves to be consumed more; this milk has the nutritional qualities closest to those of human milk. St-Gelais et al (1999) have shown that its composition, particularly in proteins, lipids, carbohydrates, and essential nutrients, distinguishes it from other species; goat's milk also offers a more incredible richness in minerals and trace elements, especially calcium, phosphorus, potassium, and magnesium. Not only is milk consumed fresh, but it can also undergo various biotransformations that contribute to considering broadening its sensory and nutritional qualities; one of the derivatives of these transformations is cheese (Vignola et al 2002).

In Algeria, as in several other countries of the world, a wide variety of fermented milk products are traditionally prepared whose purpose is the bio-preservation of milk; important traditional Algerian dairy products that have commercial significance are Rayeb, Lben, Klila, Zebda, and Jben (Hamla and Belgourine 2019). According to Daoudi (2006), cheese-making depends mainly on milk and the ferments necessary for its transformation.

The Algerian goat herd is made up of robust breeds that can ensure significant production in very harsh conditions. To improve their milk production, crosses have been made between our local breeds and imported goat breeds characterized by their high milk production and whose most interesting crossbreeding products are crossbreeding products Arbia X Saanen, which represent the most attractive combination because the Arbia goat is the most adapted local breed in Algeria, while the Saanen is considered the best dairy goat in Europe.



The objective of our work was to study the influence of crosses between goat breeds on the quantity of cheese by making cheeses using two types of milk; for this, the cheese yields of the Arbia X Saanen goat crossed with the Arbia goat were compared.

2. Materials and Methods

2.1. Selected breeds constituting the goat herd

Our choice fell on the goat breed characteristic of the Algerian steppe, which is the Arbia breed, and the products of crossing this breed with billy goats of the Saanen breed imported from Europe and introduced to improve the milk production of goats.

2.2. Milk sampling

The milk samples used were mixed milk from 40 healthy females of the same stage of lactation for each of the two goats: Arbia and the crossbred one led in semi-intensive breeding in a steppe zone located in the region of Djelfa in southern Algeria, characterized by a semi-arid climate and steppe vegetation. For each group of goats, we took the same quantity of individual milk (100 ml) to make a representative and homogeneous mixture (i.e., 4 liters). Then, a one-liter sample was used for cheese making. 10 milk samples were taken over a period of one and a half months from the beginning of April in order to work on milk from grazing animals. The milk was collected cleanly; then, the milk samples were stored at 4°C.

According to the survey carried out with the breeders, the animals which constituted our experimental material were vaccinated against brucellosis and were negative for tuberculin, and came from herds free from contagious diseases.

2.3. Samples of the Kaolin layer

The kaolin layer was the horny and wrinkled layer covering the internal face of the chicken gizzard, which was continuously regenerated to reach, according to Subhuti (2005), 3 to 3.5 cm long, 3 cm wide, and 3 mm thick. This diaper was not toxic as it has been used in traditional Chinese medicine, where it has been mentioned as a medicine for stomach diseases.

2.4. Bovine rennet

According to the results obtained by Hamidi et al (2018), the Arbia goat breed showed a very high cheese affinity with the immobilized Kaolin layer used as a coagulant; for this reason, we used purified and freeze-dried bovine rennet prepared in our laboratory diluted to 1% as a second coagulant to evaluate better the effect of crosses on the cheese-making abilities of the goats tested.

2.5. Extraction and immobilization of coagulating enzymes

The enzyme extraction was carried out according to Valles and Furet (1977) method. Powdered gizzard kaolin layer samples of weight P (in g) each were macerated at 42 °C in a volume ($V = 5 \times P$) of a 0.2 M hydrochloric acid solution for 60 minutes. After filtration of each mixture, we obtained crude enzymatic extracts. The latter then underwent clarification by adding 1% (V/V) of a 1 M solution of aluminum sulfate ($AlSO_4$) and 5% (V/V) of a solution of sodium sulfate (Na_2SO_4), 1 M heated to 42°C. After a second filtration, we obtained a filtrate to which we subjected a concentration by adding a saturated solution of NaCl to 1% (V/V) of a solution of HCl ($d=1.19$). After resting for one hour, followed by centrifugation (2100 G/20 min), we obtained a wet precipitate. The pH of these clarified gastric enzymatic extracts was adjusted to 5.5 with a 1 M disodium phosphate solution. They were then stored by refrigeration at 4 °C until use.

For immobilization, we used sodium alginate ($C_6H_7NaO_6$), which preserves the coagulating agent by avoiding protein denaturation after inclusion because this polymer gels at low temperatures in the presence of calcium chloride ($CaCl_2$) solution. According to Hamidi et al (2015), the immobilization of the enzymatic extract in alginate only slightly influenced the coagulant activity because the values of the cheese yields obtained by the extracts of the free and immobilized kaolin layer were comparable; but this treatment offered the advantage of preserving the enzyme after coagulation, which allowed it to be used again, which is of great economic interest.

In order to immobilize the coagulating enzyme, a quantity of 3 g of sodium alginate was dissolved in 100 ml of distilled water, then stirred for 24 hours in order to homogenize the gel. Then a volume of 6 ml of the enzyme was mixed with 100 ml of the sodium alginate solution prepared under agitation for 4 hours to ensure the inclusion of the enzyme in the gel. After preparing a 0.2 mol/l calcium chloride bath, the beads were formed by draining the polymer solution with a syringe into an excess of the prepared solution. Bringing the beads into contact with the $CaCl_2$ solution caused the alginate to gel, thus forming beads that contained the coagulating enzyme. Finally, the balls were soaked in the calcium solution for half an hour.

2.6. Milk coagulation

The milk from each sample from the two groups of goats was divided to make cheeses by the two coagulants used. The milk from each group (500 ml) was added with 0.1 ml of the coagulant and then placed on a heating stirrer at an optimal reaction temperature of 42°C until coagulation; in the case of the kaolin layer, the beads were recovered and rinsed twice with distilled water. According to Hamidi (2015), immobilization made it possible to maintain enzymatic activity after coagulation following the imprisonment of the coagulating agent inside the gel.

2.7. Cheese yields

For each coagulant used, we referred to the comparison between the two cheese yields, which corresponded to the cheese weight (in g) actually obtained after draining the milk of the two groups of goats.

2.8. Statistical analyzes

Was adopted a two-factor variance analysis represented by the goat breeds and the coagulants used for the preparation of the cheeses; this analysis was attested by an analysis of homogeneous groups using the Newman–Keuls test with $P < 0.05$ to highlight the breed whose cheese-making ability was the most interesting.

3. Results and discussion

3.1 Determination of cheese yields

The coagulation of goat's milk results in the formation of a mass called curd, which contains casein; this curd underwent draining to determine for each preparation the cheese yield representing the number of kilograms of cheese obtained from 100 liters of milk.

After each draining of the coagulums formed, we proceeded to the weighing of the cheeses obtained. The values of the yields are presented in Table 1.

Table 1 Results of the values of cheese yields obtained.

Cheese yields	Cheese prepared with bovine rennet	Cheese prepared by Kaolin extract
Arbia goat cheese	14.45 ± 0.34^a	15.41 ± 0.36^b
Cross goat cheese	17.62 ± 0.23^c	19.52 ± 0.19^d

The different letters (a, b, c and d) show heterogeneous groups.

The cheese yields of the coagulums of goat's milk coagulated by rennet are equal to 17.62 ± 0.23 and 14.45 ± 0.34 , respectively, for crossbred goats and Arbia goats. The same observation concerning the importance of yields was recorded for cheeses coagulated by the coagulating extract of the Kaolin layer, where we noted cheese yields of the order of 19.52 ± 0.19 and 15.41 ± 0.36 , respectively, for the cross goat and the Arbia goat.

The comparison between the cheese yields from different goats shows the superiority of this parameter in favor of crossbred milk (Arbia X Saanen). According to Grausclaude (1988), the difference is due to the genetic variant for caseins and their frequency, which is more or less important, depending on the animal. The author confirmed that the presence of this variant is not without impact on the cheese-making qualities of the milk.

Examination of the results shows that for each type of milk used, the yield is always higher with the coagulant extract of the Kaolin layer. According to the work of Hamidi (2015), the coagulant extract of the Kaolin layer is characterized by a coagulant activity superior to that of rennet. It can successfully ensure the coagulation of the most difficult milk to coagulate and ensure the production of good quality cheeses.

The analysis of variance showed that the four yields obtained present a significant difference; similarly, the analysis of the homogeneous groups revealed that the cheese yields of the milk of the two goats (Arbia and cross) are different (Table 1), which demonstrates the significant effect of the applied technique (cross) on the cheese-making abilities of goat milk.

The goats that provided the experimental kinds of milk are raised in a single herd under the same breeding conditions (food, habitat, etc.), and the only variable existing is genetic variability. To better assess this variable, we calculated a R coefficient, which represents the ratio between the cheese yield of the crossbred goat on the cheese yield of the Arbia goat characterizing the same coagulant.

The values of the coefficients in Table 2 (R_{rennet} and R_{CK}) are greater than 1, indicating the superiority of the cheese-making aptitudes of the crossbred goat compared with that of the Arbia goat.

Table 2 The calculated values of the R coefficients of the two coagulants used.

Cheese yields coefficient R	Arbia X Saanen / Arbia $R_{\text{rennet}} = 1.07$	Arbia X Saanen / Arbia $R_{\text{CK}} = 1.11$
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According to Bibe and Foulley (1976), a crossbred animal benefits from the heterosis effect (hybrid vigor); the subject's characteristics are superior to those of its parents.

In order to evaluate the effect of coagulants on the production of cheeses for the two experimental animals, we proceeded to the calculations of the C ratios between cheese yield obtained by the Kaolin extract on that obtained by bovine rennet characteristics of the two goat groups. The values of the coefficients in Table 3 (C_{Arbia} and $C_{Arbia \times Saanen}$) are greater than 1 indicator of the superior affinity of the coagulant extract of the Kaolin layer with the milk of the two breeds compared with bovine rennet.

Table 3 The calculated values of the C ratios of the two experimented goats.

Coagulants Ratio C	Kaolin extract / rennet $C_{Arbia} = 1.22$	Kaolin extract / rennet $C_{Arbia \times Saanen} = 1.27$
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Examination of the results shows that the $C_{Arbia \times Saanen}$ ratio and the R_{CK} coefficient are the highest, which confirms that the most captivating combination is that of the goat's milk crossed with the extract of the Kaolin layer as a coagulant, thus affirming the superior affinity of goat's milk crossed with this coagulant.

4. Conclusions

The cheese yields of goat's milk coagulated by rennet were 17.62 ± 0.23 and 14.45 ± 0.34 , respectively, for crossbred goats and Arbia goats. The higher yields of the order of 19.52 ± 0.19 and 15.41 ± 0.36 were obtained, respectively, for the milk of the crossbred goat and of Arbia coagulated by the Kaolin layer extract. The comparison between the milk yields from different goats announces the superiority of this parameter in favor of milk from crossed goats. Examination of the values of the calculated coefficients and reports shows that the $C_{Arbia \times Saanen}$ ratio and the R_{CK} coefficient are the highest, which confirms the superiority of the cheese-making abilities of crossbred goat's milk compared to that of Arbia goat's milk. The most interesting combination was of the goat's milk crossed with the extract of the Kaolin layer as a coagulant, which confirms the superior affinity of the goat's milk crossed with this coagulant.

Conflict of Interest

The authors declare no conflicts of interest.

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Development of brick by utilizing rice husk ash as the partial replacement for clay



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Abstract The study was conducted at Sylhet Agricultural University Campus to find out how adding rice husk ash (RHA) affected the characteristics of Sylhet clay bricks. The goal of the study was to establish the ideal RHA percentage to utilize in brick production as well as the impact of RHA on the water absorption, compressive strength, shrinkage, density, and thermal properties of bricks. Therefore, an attempt has been made by using RHA from 5-20% by weight as clay replacement for bricks. The study figured out that water absorption of bricks increases with the increasing percentage of RHA. Brick containing 5% RHA showed the lowest water absorption, which was 17.8%, and the highest was 21.33% for 20% RHA-containing brick. It was also found that the highest compressive strength among all types of bricks was 8.401 N/mm² for 5% RHA-containing brick. Similarly, the brick containing 5% RHA had the maximum density (1676.395 Kg/m³) and thermal conductivity (0.584 Wm⁻¹K⁻¹) of all the bricks combined with rice husk ash. The study also revealed no significant changes in shrinkage for all RHA Bricks and the percentages were the same, which was 14.28%. From the investigation, it is seen 5% rice husk ash can be the optimum percentage when mixing with clay and can be used in replace of first-class as well as second and third-class Manual Handling bricks, which are used in the construction of internal walls, foundations, and in temporary structures, respectively.

Keywords: water absorption, compressive strength, shrinkage, density, thermal conductivity, leachate

1. Introduction

Rice is a major agricultural crop in Bangladesh. The country produces 34.5 million metric tons of rice (the 4th largest in the world) annually and uses almost all of its production to feed its population (Baral 2016). About 78% of the weight of the paddy is received as rice, broken grains, and bran during milling, and the remaining 22% of the weight of the paddy is obtained as husk (Singh et al 2015). About 75% of the weight of this husk is made up of volatile organic stuff, while the remaining 25% is burned away to create rice husk ash (RHA) (Singh et al 2015). This RHA comprises 90%-95% amorphous silica (SiO₂) (Safiuddin 2010).

A small building component known as a brick is created from clay or mixtures and burnt in a kiln to achieve strength, hardness, and heat resistance. Due to its unique physical, chemical, and mechanical characteristics, brick is one of the most widely used building materials. Because of the significant demand for brick that has been created, particularly in the last few decades due to the growing population, brick materials are consistently in short supply. Currently, 1,500 billion units of bricks are produced each year worldwide, 1,300 billion (or 87%) of which are produced in Asia (Rahman 2022). Bricks are often exclusively produced of clay and water in Bangladesh. Engineers have been facing challenges in meeting the demand for brick material i.e., clay. To mitigate the demand for brick material and reduce environmental issues, alternative building material for bricks is required. This can be achieved by properly utilizing various agricultural or industrial by-products.

As Bangladesh produces enormous amounts of rice husk ash each year, which has an amorphous silica component, this will significantly lower the cost of building and can be used to create low-cost energy-saving brick (Kamruzzaman et al 2015). Khabir et al (2013) estimated that Bangladesh produces 9.9 million tonnes of rice husk and 2.5 million tonnes of rice husk ash per year. Tonnayopas et al (2008) successfully used burnt Rice Husk in clay brick to create high-quality bricks. The organic properties of RHA contribute more to the furnace's heat input. According to test results, the production of building-fired brick can employ a mixture containing up to 50% RHA additives by weight, especially for lightweight brick (Tonnayopas et al 2008). The addition of RHA material enhanced the physical and mechanical qualities of the clay mixture. The manufacturing of bricks from RHA waste contributes economically and offers building materials that are energy efficient. According to Hossain et al (2011), adding RHA to a brick does not modify the shape or size of the brick; hence the volume of the brick stays the same.



Therefore, the objective of this study was to determine how adding rice husk ash to clay bricks affects certain qualities while preserving other properties, such as compressive strength, water absorption, density, thermal conductivity, and shrinkage.

2. Materials and Methods

2.1. Materials for RHA Brick

The clay used for this experiment was collected from Khadim and Boteshwar (located in Sylhet Sadar Upazilla). It was retrieved from a 3foot deep trench close to the local river. An excavator was used to dig and excavate the pit. Clay-based building materials have plastic characteristics and are also exceedingly compressible, robust, durable, fire, and weather-resistant.

Rice Husk was collected from the local rice mill of Majortila and Shahparan area of Sylhet Sadar Upazilla. Kerosene (approximately 100 ml) was sprinkled over the rice husk material before being burned for 8 to 9 hours that was open to the air. The amorphous content is influenced by holding time and burning temperature. When burning was completed, grey to blackish ash was obtained (Figure 1).



Figure 1 Rice husk ash.

2.2. RHA Brick Sample Preparation

Water, clay soil, and rice husk ash were used as the investigation's primary basic ingredients. The clay particles were screened through 4.75 mm sieve (ASTM E11 mesh No. 4) to remove unwanted foreign objects, such as aggregates, stones, or other contaminants and to create uniformly fine clay. The clay was then transferred through a pug mill to be mixed together homogenously and it was naturally dried for a few days to remove the moisture content that was already present so that the moisture amount utilized to create the sample could not be varied.

Samples were prepared by mixing, molding, drying, and firing. According to weight %, clay, water, and uniformly sized RHA were combined in an optimum ratio. Of the total brick weight, 5%, 10%, 15%, and 20% of RHA were extracted and blended with 95%, 90%, 85%, and 80% clay, respectively (Table 1). Uniaxial pressing was used to prepare hand-molded bricks. After that, sample bricks were allowed to dry naturally for 4-5 days in the air (Figure 2). Bricks were fired in a brick kiln at temperatures between 900°C-1100°C for seven to ten days before being properly burned and collected.

Table 1 Mixing proportion of clay and RHA.

Rice Husk Ash Bricks			
Sample	Clay (gm)	Rice Husk Ash (gm)	Total Wt. (gm)
R-0%	3500	0	3500
R-5%	3325	175	3500
R-10%	3150	350	3500
R-15%	2975	525	3500
R-20%	2800	700	3500



Figure 2 Bricks with different % of rice husk ash.

2.3. Measurement of Properties

2.3.1. Water Absorption Test

Three sample bricks of each kind were taken to test the water absorption of the burnt bricks. In the beginning, bricks were exposed to sunshine for a day while the dry weight was recorded. The weight of the bricks after being submerged in water for a day was also measured. Then water absorption percentage was calculated using the following equation (IS 3495:1992, Part II):

$$\text{Water absorption \%} = \frac{W_2 - W_1}{W_1} \times 100 \quad (1)$$

where,

W_1 = Wt. of dry brick.

W_2 = Wt. of wet brick after 24 hours.

2.3.2. Compressive strength Test

Compressive strength tests on bricks were performed to measure the load-carrying capacity of bricks under compression. This test was carried out with the help of a Universal Testing Machine in the laboratory of the Department of Civil & Environmental Engineering at Shahjalal University of Science & Technology, Sylhet. Compressive strength was calculated from this formula (IS 3495:1992, Part I):

$$S = \frac{P}{A} \quad (2)$$

where,

S = Crushing strength, MPa.

P = Maximum applied load, N.

A = Cross-sectional area (Thickness $\times$ Width), mm^2 .

2.3.3. Shrinkage Test

The firing process causes shrinkage in clay brick. To measure the firing shrinkage of clay brick, the following formula was applied:

$$S = \frac{(L_a - L_d)}{L_a} \times 100 \quad (3)$$

where,

S = Percentage of firing shrinkage.

L_a = Actual length.

L_d = Dry length.

2.3.4. Leachate Test

- 4 bricks were taken for the leachate test i.e., R-5%, R-10%, R-15%, and R-20%.
- Sodium Sulfate (Na_2SO_4) was used as the reagent.
- Bricks were immersed in 6-liter water with 3000 gm of Sodium Sulfate (Na_2SO_4).
- Bricks were immersed for 24 hours.
- pH, temperature, and iron concentration tests were conducted.

2.3.5. Thermal Conductivity Test

Thermal conductivity was obtained using a model derived from a literature review using 256 test results for the thermal conductivity of various types of brick, concrete, and aggregates (Dondi et al 2004; Demirbas 2004; Blanco et al 2000; Glenn et al 1998), and measured as a part of this study by the following formula:

$$T = 0.0559e^{(0.0014D)} \quad (4)$$

Where T stands for Thermal conductivity in $\text{Wm}^{-1}\text{K}^{-1}$ and D is the Dry density of the bricks in Kg/m^3 .

3. Results and discussion

3.1 Water Absorption Analysis

Brick's strength depends on its water absorption capacity. Water absorption of bricks occurs due to the presence of pores or voids in the bricks. The more pores or voids in the brick, the more it will absorb water and reduces the load-carrying capacity. It was observed that for RHA bricks, water absorption increases with the increased percentage of RHA.

However, the rate of increase of water absorption was not the same, and it was relatively slow (Figure 3). According to Tonnayopas et al (2008), it can be seen that an increase in RHA replacement leads to an increase in water absorption. It was also observed that First Class bricks, in the case of Manual Handling bricks, absorbed a very lower percentage 15.93% (Figure 4) of water compared to RHA bricks (17.8%, 18.08%, 19.13%, 21.33%). But, Second and Third Class bricks absorbed (16.47% and 18.7%, respectively) nearly similar percentages to RHA bricks. The addition of 10% by weight of rice husk ash showed a minimum water absorption of 15.5% (Maheswari et al 2020).

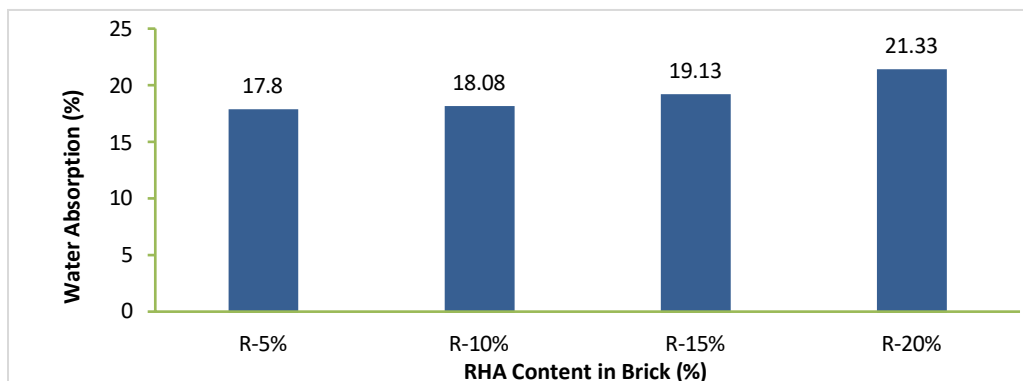


Figure 3 Water absorption % of RHA bricks.

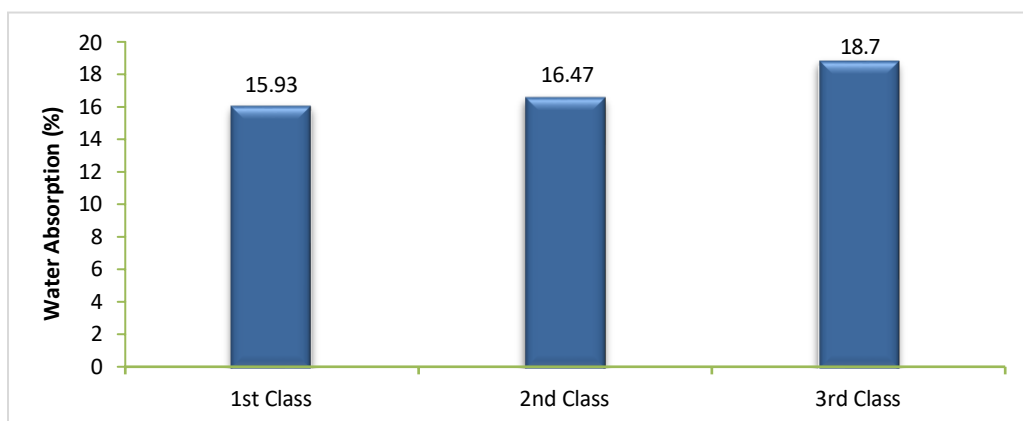


Figure 4 Water absorption % of manual handling bricks.

3.2 Compressive Strength

It was figured out that compressive strength for 5% RHA brick was higher (8.401 N/mm^2) than other percentages of RHA bricks. It seemed increasing the RHA amount decreases compressive strength. But, at 20% RHA bricks, the compressive strength was slightly higher than 10% and 15% RHA bricks (Figure 5). Adding 10 % rice husk ash showed the highest strength at 5.97 N/mm^2 (Janbuala and Wasanapiarnpong 2015).

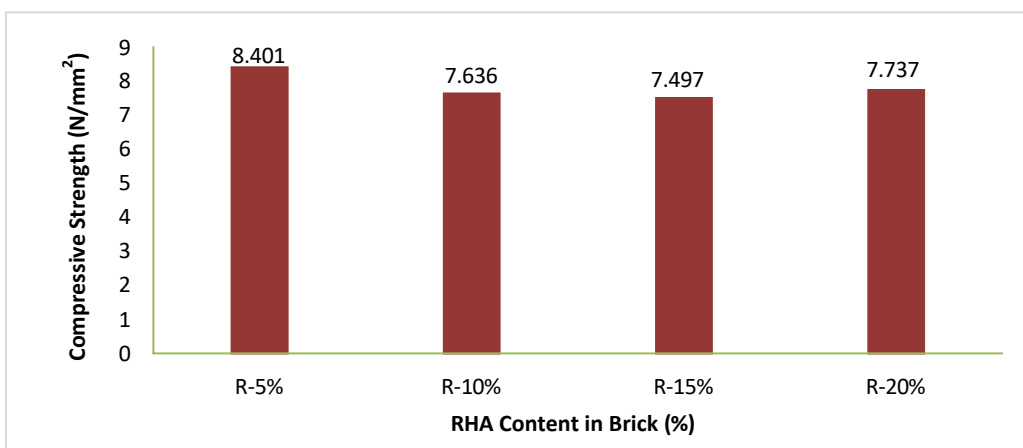


Figure 5 Compressive strength of RHA bricks.

It was observed that for Manual Handling First Class Brick, the compressive strength was 5.488 N/mm^2 (Figure 6). It was higher than the Second Class and Third Class bricks (5.191 N/mm^2 and 4.768 N/mm^2 , respectively). It also showed that the compressive strength for Manual Handling Bricks was relatively lower than RHA bricks. Up to 20% of rice husk added to clay causes a progressive loss in strength, after that point, the compressive strengths rapidly decline. The addition of 10% by weight of rice husk gave a maximum compressive strength of 4.44 N/mm^2 (Maheswari et al 2020).

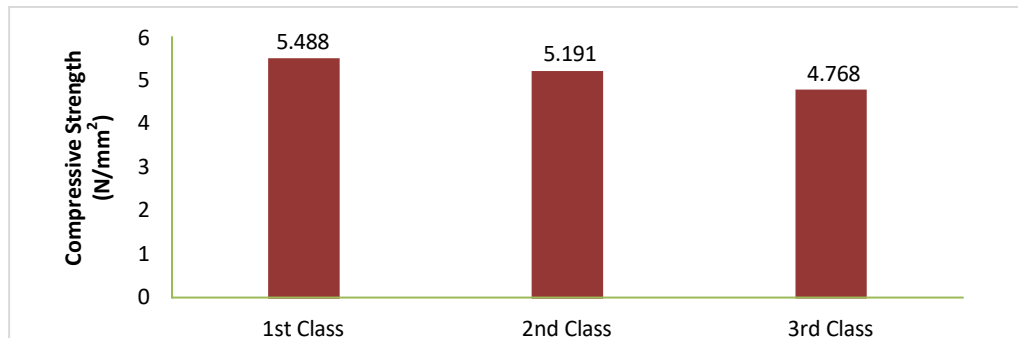


Figure 6 Compressive strength of manual handling bricks.

3.3 Shrinkage

Tensile stress increases due to shrinkage which can result in cracking, internal bending, and outward deflection. The quantity of shrinkage is affected by several variables, including the qualities of the constituent parts, their quantities, how they are mixed, how much moisture is present during molding, how dry the atmosphere is, and the size of the brick. The firing shrinkage effect will be greater if there is more water in the fresh brick.

It was observed that Firing Shrinkage for all RHA Bricks (5%, 10%, 15%, 20) was the same (14.285%) (Figure 7).

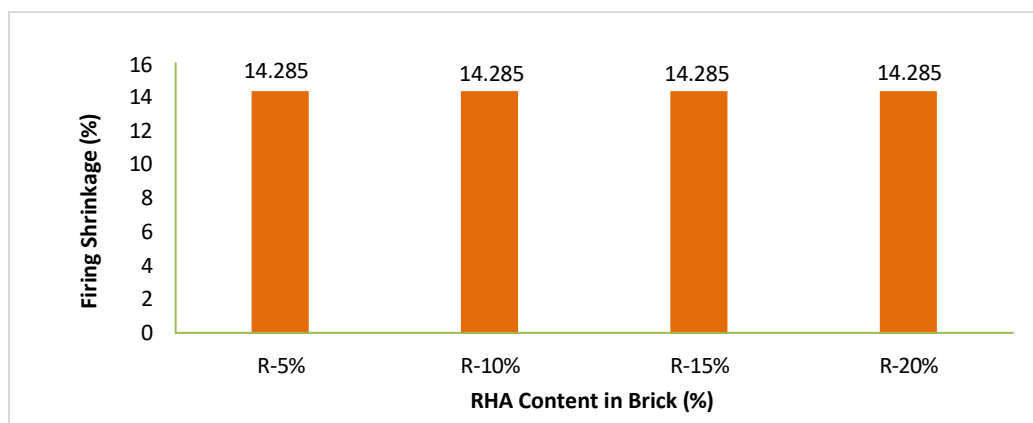


Figure 7 Firing shrinkage of RHA bricks.

It was figured out that, Firing shrinkage for 1st class manual handling bricks was 14.285% which was the same as RHA bricks. But, Firing Shrinkage for Second Class and Third Class bricks (both were 11.923%) lower than the First Class bricks (Figure 8). The linear firing shrinkage is decreased as the RHA addition content is increased (Tonnayopas et al 2008).

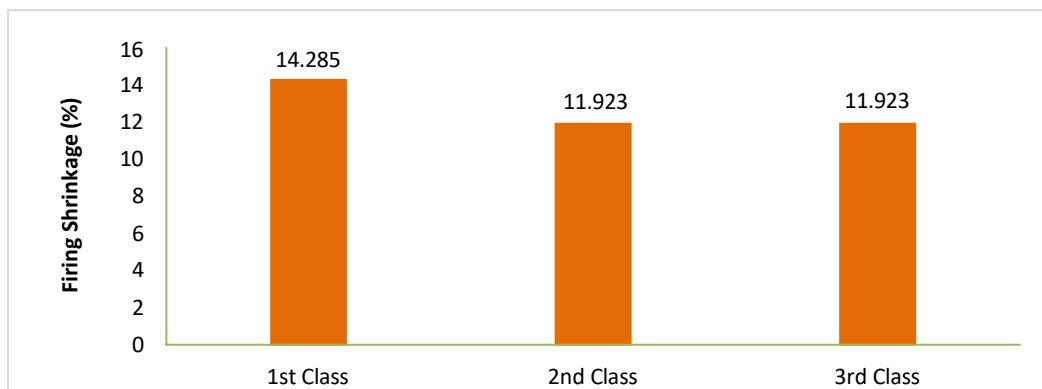


Figure 8 Firing shrinkage of manual handling bricks.

3.4 Density

Bricks became lighter as the Rice Husk Ash percentages increased (Figure 9). Bricks became lighter for 20% of the RHA percentage. The densities for burnt RHA brick samples R-5%, R-10%, R-15%, and R-20% had 1676.395, 1504.398, 1471.961, and 1403.98 Kg/m³, respectively.

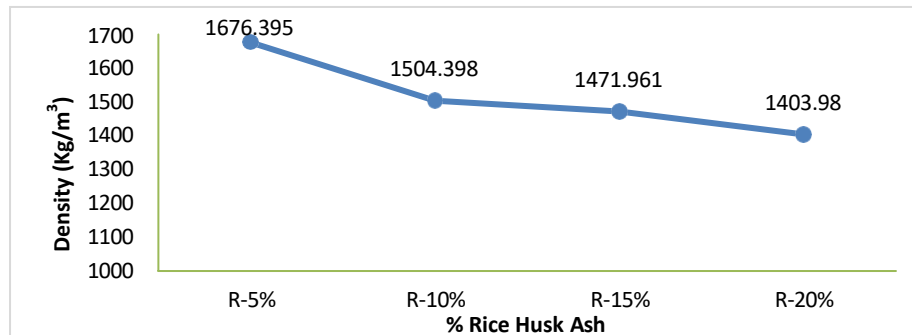


Figure 9 Density curve of RHA bricks.

Lastly, Figure 10 illustrates the density curve of Manual Handling bricks. For the Manual Handling bricks, 1st class had the most density among others, i.e., 1992.773 Kg/m³. Brick got the highest density 1676.395 Kg/m³, for 5% of Rice Husk Ash. Clay brick densities ranged from 1670 to 1850 Kg/m³ in Karaman's (2006) study.

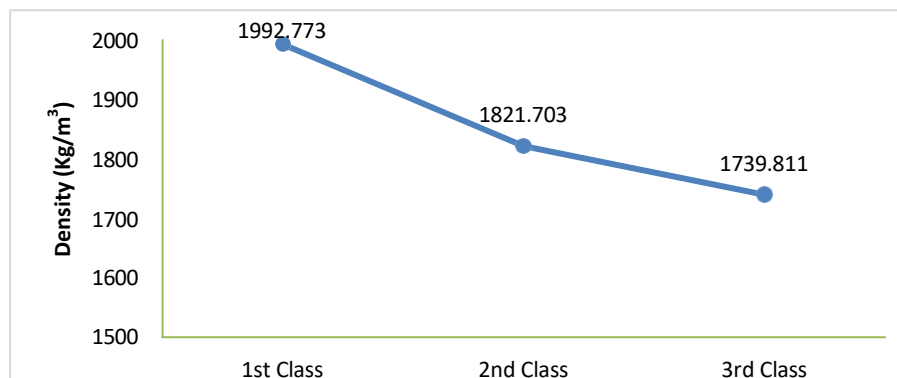


Figure 10 Density curve of manual handling bricks.

3.5 Thermal Conductivity

Bricks must reduce heat transfer from one side of the wall to the other. The good brick should have low thermal conductivity to keep the house cool in the summer and warm in the winter. According to earlier research, the thermal conductivity of handmade bricks varied from 0.59 to 0.61 Wm⁻¹K⁻¹ (Cabeza-Prieto 2022).

The Figures 11 and 12 depict the Thermal Conductivity of Rice Husk Ash and Manual Handling bricks. Our burnt RHA brick sample R-5%, R-10%, R-15%, and R-20% had 0.584, 0.459, 0.439, and 0.399 Wm⁻¹K⁻¹ and for Manual Handling, brick samples had 0.91, 0.716, 0.639 Wm⁻¹K⁻¹, respectively. Therefore, these render good-quality bricks. A lower density will result in a lower heat conductivity (Dondi et al 2004).

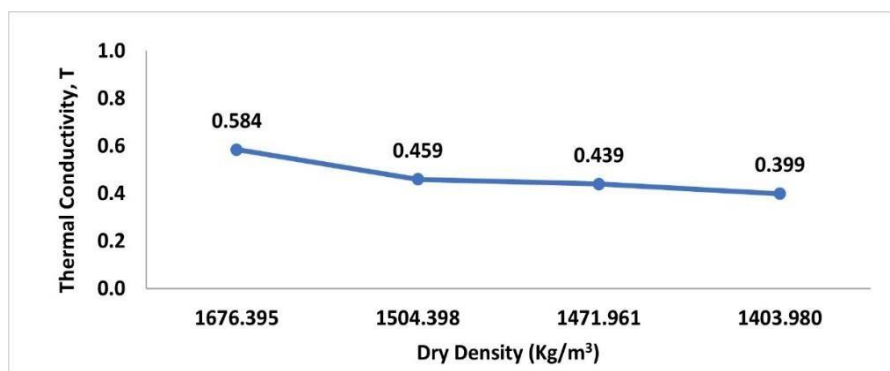


Figure 11 Thermal conductivity curve of RHA bricks.

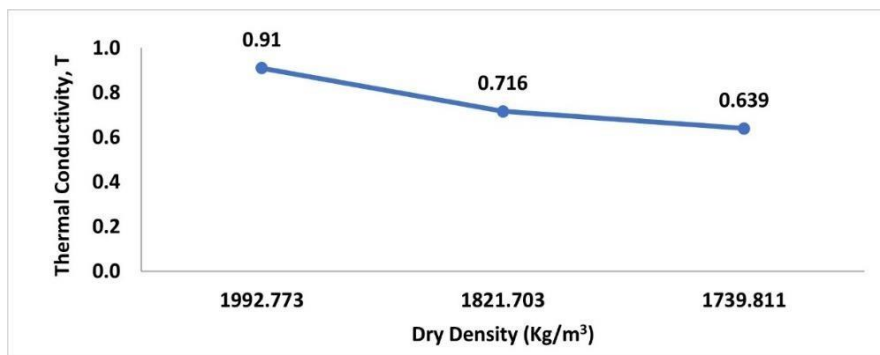


Figure 12 Thermal conductivity curve of manual handling bricks

3.6 Leachate Test

A half liter of sample water was taken from the leachate test, where RHA bricks were immersed in the sake of measuring pH, temperature, and iron concentration (Figure 13). The test results showed there was no remarkable leachate occurred (Table 2).

Table 2 Leachate test results.

Test (with Na ₂ SO ₄)	Initial Value	Final Value
Temperature	26.1°C	26.6°C
pH	9.11	7.11
Iron Concentration (mg/L)	0.05	0.3



Figure 13 pH, temperature, and iron concentration test.

4. Conclusions

Compared to manual handling bricks, the bricks having rice husk ash as an admixture showed higher compressive strength. According to the study, the 5% RHA brick has the highest compressive strength of all brick kinds (8.401 N/mm²).

Water absorption of Rice husk ash bricks is slightly higher than the manual handling bricks. It is observed that the lowest water absorption was 17.8% for 5% RHA brick and the lowest water absorption was 15.93% for 1st-class manual handling brick.

Bricks also become lighter, which can reduce the overall building's weight.

No noticeable leachate incident has occurred.

Thermal conductivity is also better than manually handled bricks. The highest thermal conductivity was found at 0.584 Wm⁻¹K⁻¹ for 5% RHA brick.

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Conflict of Interest

The authors declare no conflicts of interest.

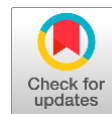
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Present status and prioritization of rural road accessibility: A case study of Sunamganj districts of Bangladesh



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Abstract This study was conducted to examine the Rural Transport Accessibility Index and improve the connectivity of the rural road network for agricultural development in the Sunamganj district, Bangladesh, and facilitate the distribution of agricultural products as well as its accessibility to people. The demographic, socioeconomic, and agricultural data of eleven Upazila's were obtained from the Bangladesh Bureau of Statistics (BBS) in order to fulfill the goals of this study. The administrative area boundary and transport network data were collected from the Local Government Engineering Department (LGED) and Roads and Highways Department (RHD), respectively. Rural Transport Accessibility was estimated using ArcGIS-Arc Map. Analyzes were performed using the Microsoft Excel Analysis Tool pack. To determine the priority ranking, Data Envelopment Analysis (DEA) and correlation analysis were used. The outcome of this method helped in ranking the Dharamapasha, Derai, Jagannathpur, Sullah, Tahirpur, Dakshin Sunamganj, Jamalganj, Chhatak, Dowarabazar, Bishwamvarpur, and Sunamganj Sadar Upazilas respectively inspect accessibility level. Improving rural road network considering agricultural productivity per kilometer and prioritizing the road ranking was prepared from the maximum habitations within the desired distance. These 121 links (Upazila Distance Matrix) were calculated. From Bishwamvarpur to Sunamganj Sadar, the maximum utility value was 12281.0. This link will be upgraded as the priority, and Jagannathpur to Sullah links will be upgraded as the least priority because of its minimum value of 149.9.

Keywords: rural transport accessibility, road network, Upazila distance matrix, Arc-GIS

1. Introduction

Road networks, as one of the oldest infrastructures of transport in the world is playing the main role in modernization, sustainable development, and daily human activities in both ancient and modern times (Al-dami and Haidar 2015). The integrated development of any region depends fundamentally on accessibility in general and the transport infrastructure in particular (Ribeiro and Silva 2011). A road network of high quality increases a nation's economic output by reducing journey times and costs, making a region more attractive economically (Rogers 2003). Bangladesh is a densely populated and laying country with around 165 million inhabitants living in 130,170 Km². A major portion of the population lives in rural areas. It is estimated that about 60.6% of its population lives in rural areas, most of whom fall below the poverty line.

Rural roads and transport are essential for sustainable agricultural development and are key components of rural development in Bangladesh. There is about 353,000 km of rural roads across the country. Rural road construction necessarily increases agricultural production and productivity by cultivating new land or using existing land to exploit the expanded market (URP BUET 2016). Rural roads play a task in the availability of physical access. In addition, physical accessibility is crucial for achieving the diversity of the Millennium Development Goals (Barret et al 2001).

The agricultural sector plays a vital role in the overall economic development of Bangladesh. The agricultural sector contributes 14.74% to the country's GDP and provides employment for about 41% of the labor force, according to the Labor force survey 2015-16 (Rahman et al 2020). Rural roads include secondary roads and other roads employed by communities in urban and rural areas and are operated by various municipalities. Local governments and communities generally manage these roads. However, improvements in the agricultural roads aren't managed and maintained. Management and financing arrangements for these roads are often scarce and sometimes aren't breathing (Buys et al 2010). Those roads serve dispersed households and populations, often with an agricultural or natural resources-based land use structure (Donnges et al 2007). Roads and bridges link to towns and villages, to motorable tracks, trails, and paths. Foot, animal, and bicycle paths also feed into rural roads; successively, rural roads link markets and peri-urban hubs (Fouracre et al 2006). A well-maintained road network will improve agricultural distribution and create new opportunities for agricultural trade (Inoni and Omotor 2009).



The longer-term economic development of place's infrastructural development joined the highest priorities. Infrastructure plays a strategic role in producing large multiplier economic effects with agricultural growth. As agricultural incomes grow, consumption expenditures increase in rural areas, creating an increased demand for urban goods-the multiplier effect (Mellor and Johnston 1984). Poverty is a simple reality and an advanced concept at the same time, often responsive to seeing it, but once you define it, the justification becomes more elusive (Dercon et al 2009).

One of the most important problems in a road network is evaluating accessibility (Weiping and Chi 2011). Accessibility determines how easy or difficult it is to encourage in an area. The area is accessible when people can reach there at a suitable time, and the risk of not getting there on time would be heavy. Proposed measuring accessibility in terms of disutility index for spatial location-allocation of multiple center villages using rural roads. The location-allocation method optimizes some functions of access to the facilities, but it doesn't provide accurate information needed for improving or ranking the road linkages between settlements (Kim and Chung 2001). Due to the poor rural road connectivity of the proposed study area, people face a significant problem to the distribution of farm products. This work has been done to identify the issues to inspect the present status of the rural road network to determine road accessibility in the study area.

2. Materials and Methods

2.1. Study area

Sunamganj district lies between 24° 34' and 25° 12' north latitudes and between 90° 56' and 91° 49' East longitudes, respectively. The LGED road network is depicted in Figure 1, where the black, orange, and red colors stand in for Upazila, Union, and Village roads, respectively.

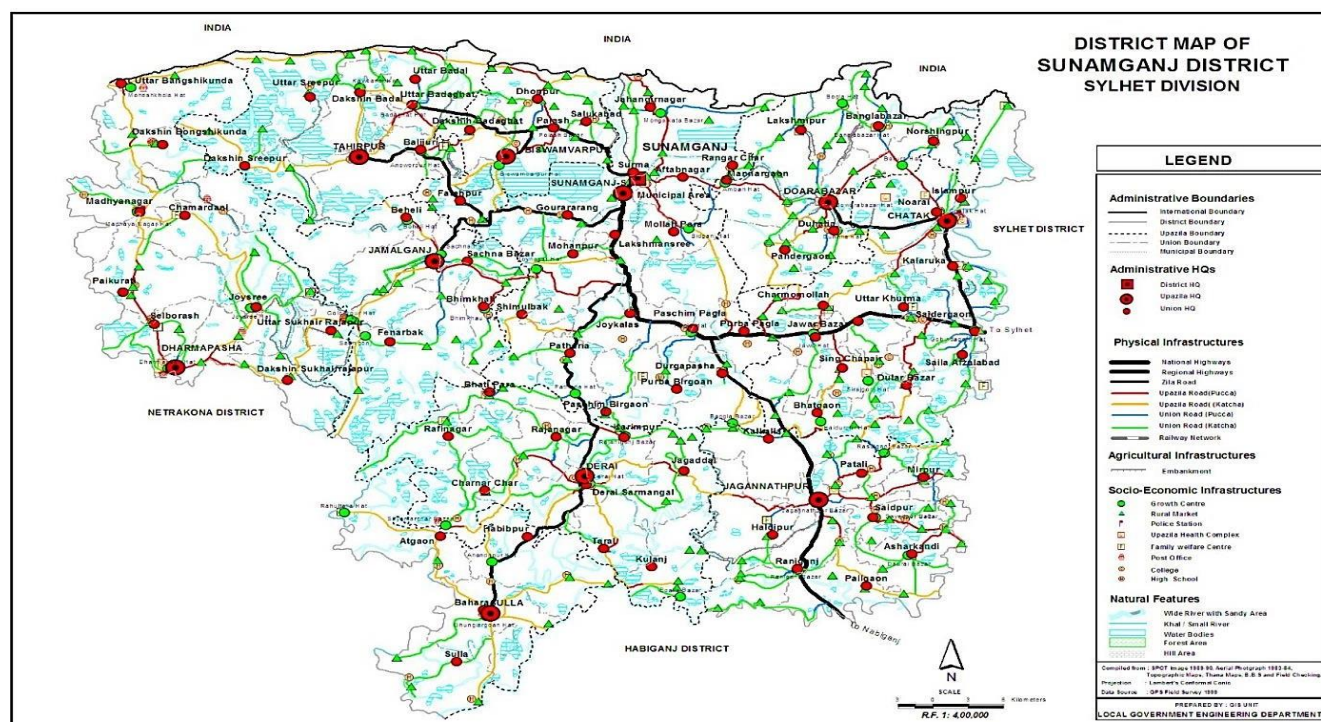


Figure 1 District map of Sunamganj.

2.2. Data Collection

Most of the secondary data were gathered from the Bangladesh Road Network under the supervision of the LGED and RHD. BBS provided the Head Count Index (HCI) data on poverty in the Sunamganj Districts of Bangladesh. The Department of Agriculture Extension (DAE) and BBS were used to compile agricultural statistics.

2.3. Data Processing

The ArcGIS-Arc Map 10.3 (64 bit desktop Esri Ireland) environment and the Microsoft Excel Analysis Toolset were used for data analysis. To establish the Pearson's correlation coefficient between accessibility index value and poverty statistics, population and poverty data were used.

2.4. Accessible Coverage Area

The number of rural residents who lived within two kilometers of an all-weather road was counted to calculate the rural transport accessibility index. Even short distances could be difficult for the populace to travel, especially in harsh weather. The indicator illustrates how crucial transportation is to enhancing rural access for rural residents. The fact needs to be expressly noted against the final RAI value. Every administrative Upazila in Sunamganj is measured for the RAI.

Step 1: The Upazila region polygon should be clipped by the RHD+LGED all-weather road.

Step 2: In GIS, locate the 2 km buffer zone surrounding an all-weather road on both sides.

Step 3: Using the buffer area to limit the demographic coverage for Upazila.

Step 4: Calculate the area under each Upazila using the clipping coverage.

Step 5: Determine how many populations are contained by the buffer zone.

Step 6: Apply the formula to calculate RAI, $RAI = \frac{\text{No of Rural People with Access}}{\text{Total Population}} \times 100$ (1)

The complete estimation process has been (added in the supplementary section) described in Supplementary materials

1.

2.5. Calculation of the Rural Transport Access Index

GIS was used to determine the accessible area underneath each Upazila (Figure 2). The spreadsheet that was supplied had a detailed estimation. The estimated RAI values are then used to determine the order of the RAI values. Lower ranking values denote a higher level of accessibility, whereas higher ranking values denote a lower level of accessibility. The rural transportation accessibility index was determined using the formula mentioned in equation (1).

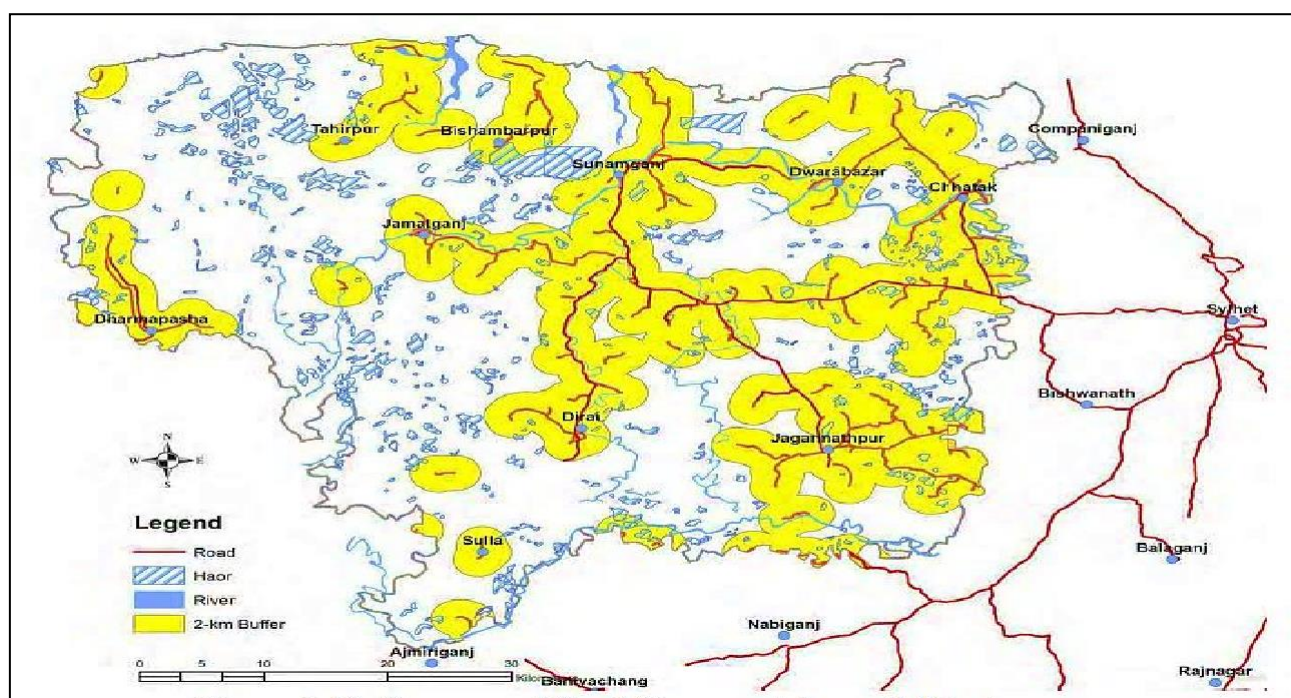


Figure 2 Land area and transport accessible area under each Upazila.

2.6. Data Envelopment Analysis (DEA)

DEA has been used to determine the most effective and equitable resource distribution for the rural transportation infrastructure. DEA uses the linear programming method to assess the comparative effectiveness of units with similar inputs and outputs. The only requirement is that the chosen inputs and outputs be measurable. Without scaling or translating them to a single standard measurement, the approach enables the examination of these various inputs and outputs in their original units. The DEA generates a single overall assessment of the relative efficiency of each comparable unit by accounting for these multiple inputs and outputs. In Supplementary materials 2, the full DEA history and procedure are presented.

The basic idea behind DEA analysis is that efficiency is measured as the proportion of weighted outputs to weighted inputs:

$$\text{Efficiency, } \eta = \frac{\text{Weighted sum of the outputs}}{\text{Weighted sum of the inputs}} \quad (2)$$

$$\text{The weighted output function is } \sum w_1 \times P_n \quad (3)$$

The weighted input function is $\sum w_2 \times RAI_n + w_3 \times L_n + w_4 \times E_n + w_5 \times H_n + w_6 \times EC_n$ (4)

Where,

w_1 = factoring in the objective function

P = Poverty

$n = 1$ to 11

w_2 = RAI's weighted input function

RAI = Rural Access Index

w_3 = weight of input in the Literacy Rate function

L = Literacy Rate

w_4 = Education Facilities' weighted input function

E = Education Facilities

w_5 = health facilities input function's weight.

H = Health Facilities

w_6 = weight of input in the economic facilities function

EC = Economic Facilities

2.7. Setting Target Value

Maximum Poverty value = 103 (within 11 Upazila)

Maximum Value Index Number = 17

Utilizing the Excel workbook function, determine which of the 11 Upazila zones has the lowest RAI value from the input function value range.

Minimum RAI value = 26

Least Value Index Number for the corresponding Upazila (having the minimum accessibility) in Dharmapasha is 11. The goal under the following constraints is to maximize input facility efficiency while minimizing the maximum Poverty Value by maximizing the minimum RAI value.

Setting Constraints:

1) Weightage factor, w_1 less than or equal to 1 ($w_1 \leq 1.0$);

2) The Sum of weightage factors, $w_2 + w_3 + w_4 + w_5 + w_6$, should be less than or equal to 1

($w_2 + w_3 + w_4 + w_5 + w_6 \leq 1.0$) and

Efficiency should be less than or equal to 1 ($\eta \leq 1.0$).

2.8. Rural Road network priority based on agricultural productivity

Priority lists were created using the average agricultural productivity across all linkages in all villages, calculated using the link-by-link provided formula.

$$\text{Agriculture productivity value per km} = \frac{\text{Total crop produced along that road}}{\text{Length of the road link}} \quad (5)$$

The population weight is multiplied by this agricultural productivity to obtain productivity value for that connection. The weighting of the population is determined per 1000 persons.

$$\text{Weightage of Total population} = \frac{\text{Calculated habitation benefited by the for per 1000 person}}{1500} \quad (6)$$

Finally, the utility value of each link was calculated for every link using the following formula Utility value per km = (Total weightage of road $\times$ agricultural productivity per km length of road) (7)

3. Results and discussion

3.1 Roads in Sunamganj

The district is crossed by regional roads R280 and R283; Sylhet-Sunamganj Road (66 km) and Sylhet-Sunamganj Bypass Road (7 km), respectively. They pass through this district and connect Sylhet with the North-Eastern part of Bangladesh.

3.2 Roads under Roads and Highways Department

Over 21,000 km of roads are currently maintained by RHD. This study is especially interested in paved roads that rural residents can access regardless of the weather to meet their daily requirements and activities. Table 1 shows the Distance Matrix (Upazila to Upazila) of Sunamganj road.

Table 1 Distance Matrix (Upazila to Upazila) of Sunamganj road.

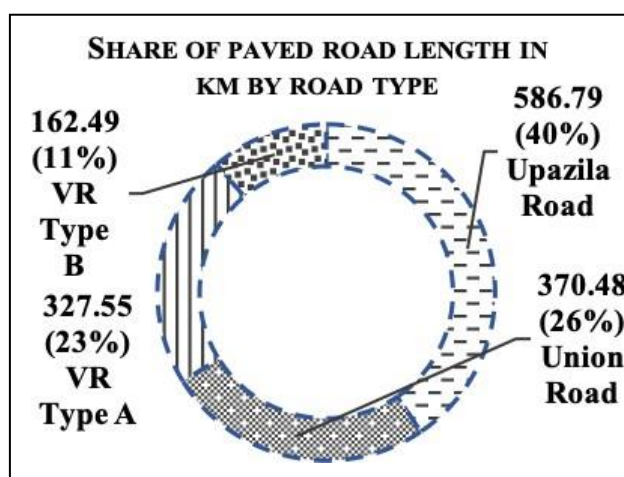
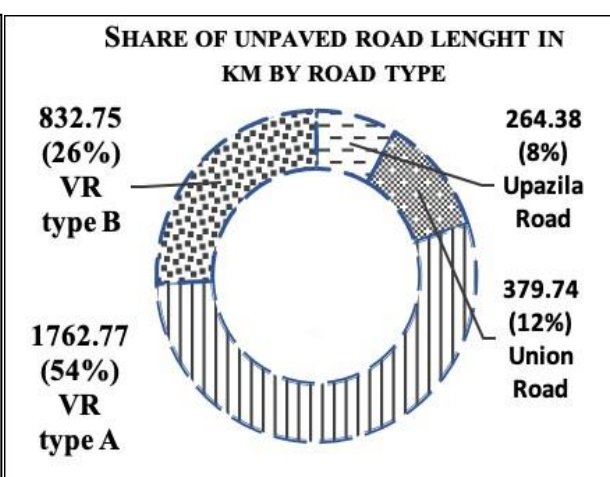
Distance Matrix (Upazila to Upazila) km	Bishwamvarpur	Chhatak	Dakshin Sunamganj	Derai	Dharamapasha	Dowarabazar	Jagannathpur	Jamalganj	Sullah	Sunamganj Sadar	Tahirpur
Bishwamvarpur	0	71	47	51	349	85	56	33	71	16	43
Chhatak	71	0	77	70	331	13	55	75	91	56	85
Dakshin Sunamganj	47	77	0	19	313	33	41	38	83	19	97
Derai	51	70	19	0	292	84	56	54	20	35	64
Dharamapasha	349	331	313	292	0	345	292	352	271	333	362
Dowarabazar	85	13	33	84	345	0	69	88	105	69	98
Jagannathpur	56	55	41	56	292	69	0	60	76	41	70
Jamalganj	33	75	38	54	352	88	60	0	75	20	23
Sullah	71	91	83	20	271	105	76	75	0	56	85
Sunamganj Sadar	16	56	19	35	333	69	41	20	56	0	30
Tahirpur	43	85	97	64	362	98	70	23	85	30	0

3.3 Roads under the Local Government Engineering Department

There are currently 4767.33 km of roads under LGED across Sunamganj. However, the length of the entire coverage has not yet been extended to all roads. The road density of the district is slightly below the national average (2.99 km / km²). However, there are wide variations in road density by Upazila. The highest road density is in Chhatak (2.6 km / km²) and the lowest in Sunamganj Sadar (1.33 km / sq. km). In Table 2, the current LGED network in Sunamganj is displayed. In Supplementary Materials 3, the full data processing procedure has been detailed, and Figures 3 and 4 depict the share of paved and unpaved road length in km.

Table 2 Status of the road in Sunamganj under LGED.

LGED – All Season Road Network	Surface Type		Total length (km)	Percentage	
	Paved (km)	Unpaved (km)		Paved(km)	Unpaved (km)
Upazila Road	586.79	264.38	931.32	63.01%	28.38%
Union Road	370.48	379.74	750.22	49.38%	50.61%
Village Road (Type-A&B)	490.04	2595.52	3085.79	15.88%	84.11%
Total LGED	1447.31	3239.64	4767.33	42.75% (avg.)	54.36% (avg.)

**Figure 3** Share of paved road length in Km.**Figure 4** Share of unpaved road length in Km.

3.4 Comparative Relation between RAI and Poverty

Here, the Lower Poverty Line (LPL) and the Upper Poverty Line are contrasted in terms of the level of transport accessibility (UPL). Table 3 shows the Poverty Head-Count Rates (%). The Upper and lower poverty level in Bangladesh is shown in figure 5 and figure 6, respectively.

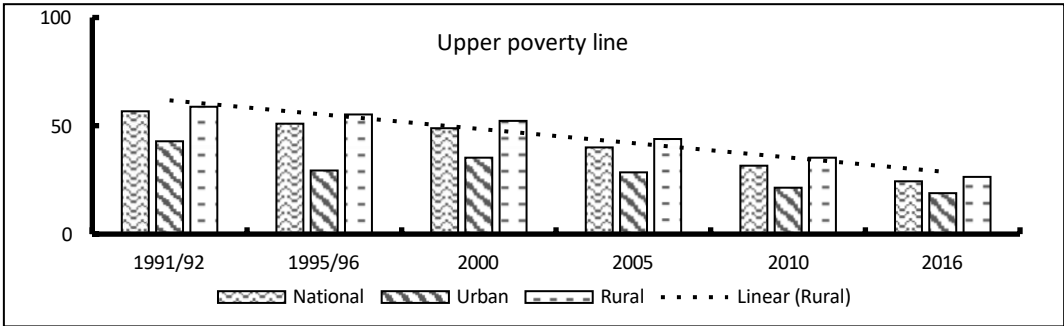


Figure 5 Upper Poverty Level in Bangladesh.

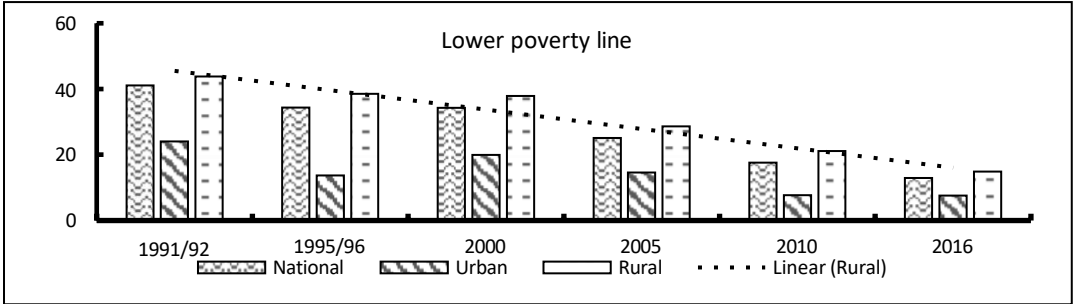


Figure 6 Lower Poverty Level in Bangladesh.

Table 3 Poverty Head-Count Rates (%).

	Upper poverty line						Lower poverty line					
	1991/92	1995/96	2000	2005	2010	2016	1991/92	1995/96	2000	2005	2010	2016
National	56.7	51	48.9	40	31.5	24.3	41.1	34.4	34.3	25.1	17.6	12.9
Urban	42.8	29.4	35.2	28.4	21.3	18.9	24	13.7	19.9	14.6	7.7	7.6
Rural	58.8	55.2	52.3	43.8	35.2	26.4	43.8	38.5	37.9	28.6	21.1	14.9

3.5 Comparative Relation of RAI with the Socio-Economic Parameters

3.5.1 RAI with Poverty and Literacy Rate

All types of population density, poverty rate, and literacy rate are included in Supplementary materials 4 from district statistics, and a line diagram has been built using these data to understand the relationship with the predicted RAI value.

Supplementary materials 4 include data from the district's statistics on population density, poverty rate, and literacy rate. Using this information, a line diagram has been created to visualize the relationship between these variables and the estimated RAI value. The relationship between each Upazilla's RAI and the poverty rate has shown in figure 7.

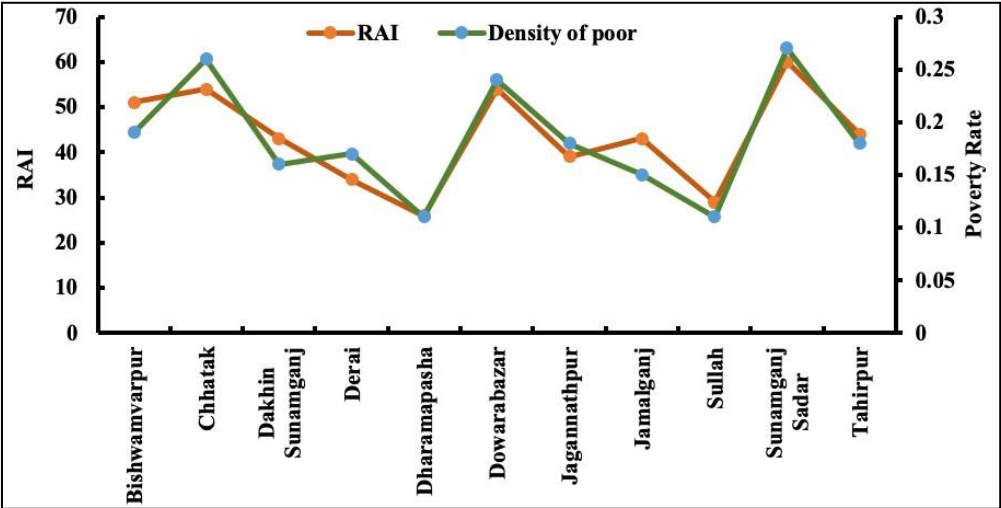


Figure 7 RAI with Poverty Rate.

The relationship between each Upazila's RAI and literacy rate is shown in Figure 8, where the overall trend is that, except Sulla, residents of areas with higher accessibility levels tend to have higher literacy rates than those with lower levels. As a result, this region has a higher literacy rate.

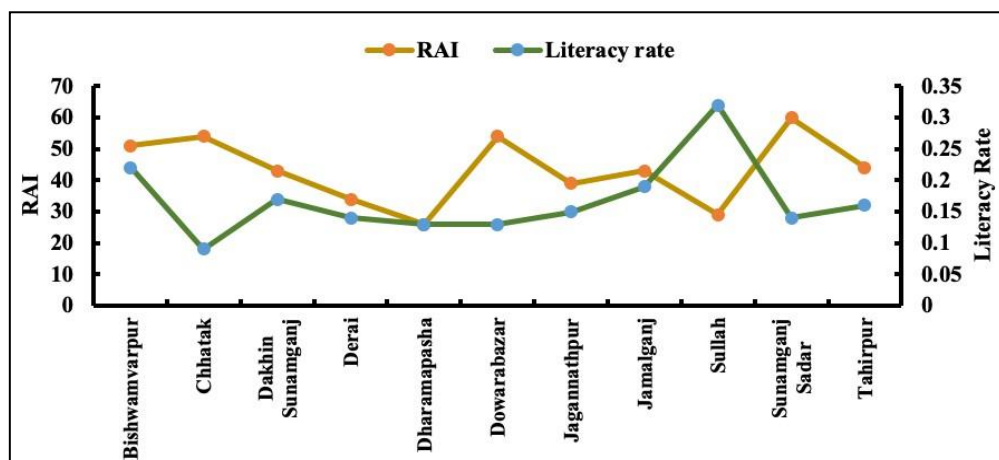


Figure 8 RAI with Literacy Rate.

3.5.2 RAI with Education and Health Facilities

In Supplementary Materials 5, district statistics are used to track all kinds of educational and medical facilities. Using these statistics, a line diagram has been created to illustrate the relationship between these facilities and the expected RAI value.

With certain exceptions, such as in Sulla, Tahirpur, and Dharamapasha, it can be shown in Figures 9 and 10 that the normal pattern is that education and healthcare facilities are more numerous where RAI values are higher and are less numerous where RAI values are lower. The accessibility of road transportation is limited due to its geospatial array. However, in actuality, due to the region's rugged terrain and some Union/Villages' isolation from the mainland, locals enjoy accessibility via waterways and unofficial roads (local walkways year-round).

On the other hand, a distinct situation exists in Bishwamvarpur, Chhatak, and Sunamganj Sadar, where there are fewer educational and medical services but a higher accessibility value. Because Sunamganj Sadar is an urban region and Bishwamvarpur and Chhatak are industrial hubs, a sizable population resides there. As a result, the formula takes the educational and medical facilities into account less (facilities per thousand of the population).

3.5.3 RAI with Facilities for Rural Economy and Industry

All types of economic and economic facilities are recorded from district statistics in Supplementary materials 6, and a line diagram has been created using these data to understand the relationship with the predicted RAI value.

With few exceptions, such as Dakshin Sunamganj, Derai, and Tahirpur, Figure 11 illustrates the overall trend that economic and economic facilities are higher when RAI value is higher, and are lower where RAI value is lower.

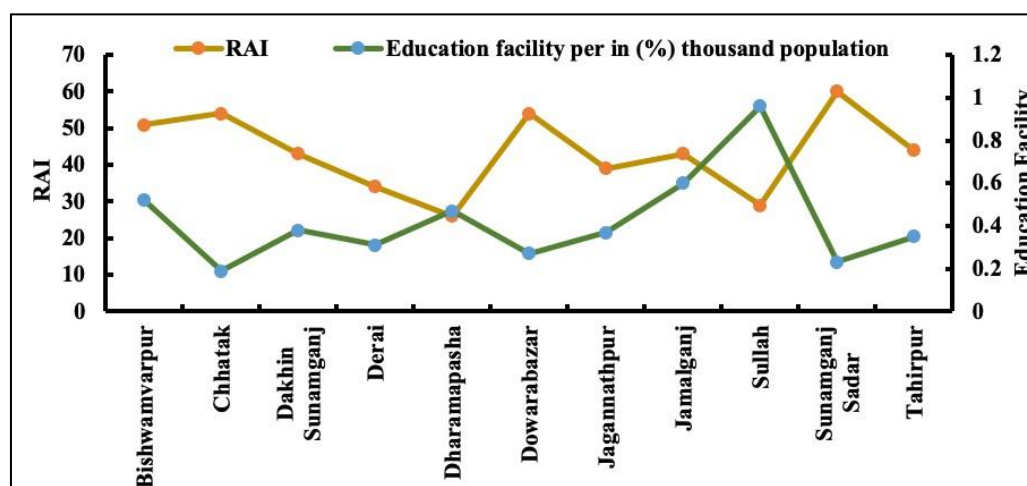


Figure 9 RAI with Education Facility.

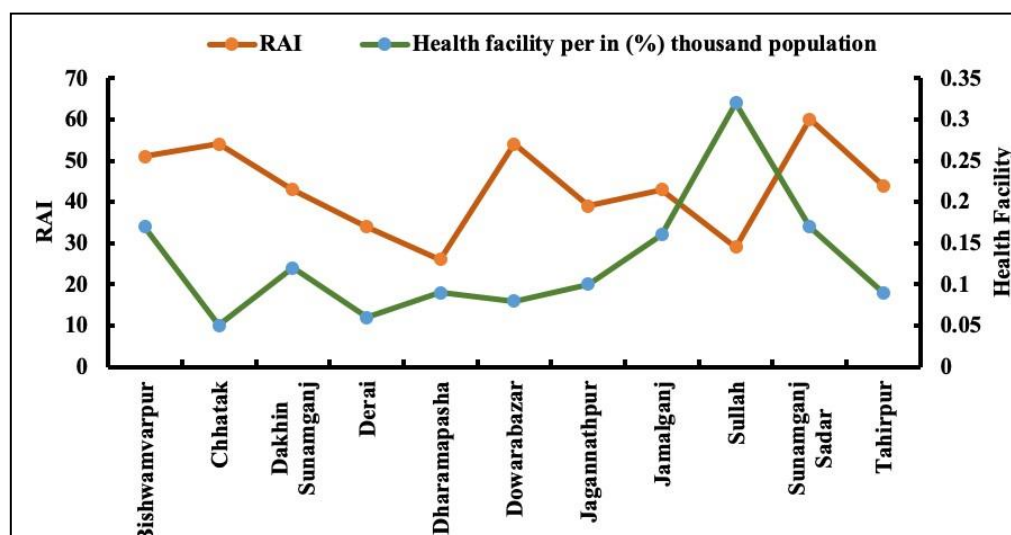


Figure 10 RAI with Health Facility.

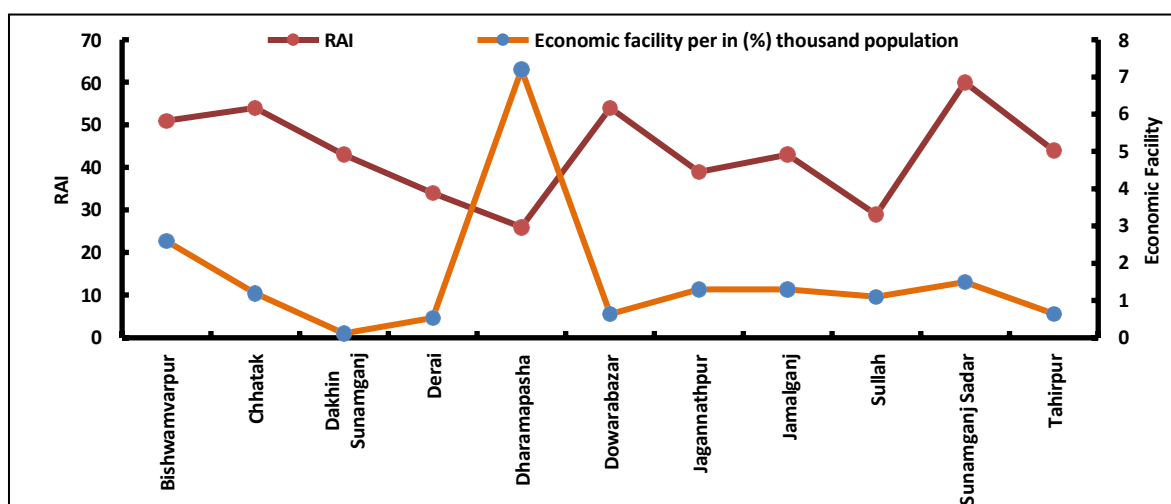


Figure 11 RAI with Economic Facility.

3.6 Interpretation of the Results of the Correlation Coefficient

3.6.1 Accessibility (RAI) Vs. Poverty

The correlation coefficient between the dependent variable (y = poverty) and the independent variable (x = accessibility) is -0.57982 . First, it is negative, demonstrating an inverse relationship between accessibility and poverty. This demonstrates that improving accessibility will probably reduce poverty and vice versa. Second, the result of 0.57982 indicates a moderate connection.

3.6.2 Accessibility (RAI) Vs. Literacy rate

The correlation coefficient between the dependable variable (y = literacy rate) and the independent variable (x = accessibility) is $+0.57235$, which is positive in the beginning, demonstrating a connection between accessibility and literacy rate. In light of this, it can be seen that increasing accessibility will likely increase literacy rates and vice versa. Also, a moderate association exists, as shown by the value of 0.57235 .

3.6.3 Accessibility (RAI) Vs. Educational facilities

The correlation coefficient between the dependent variable (y = educational amenities) and independent variable (x = accessibility) is $+0.41657$, which indicates that there is a positive relationship between accessibility and educational amenities. In light of this, it can be seen that increasing accessibility will likely increase literacy rates and vice versa. Also, the correlation is rather moderate, as indicated by the value of 0.41657 .

3.6.4 Accessibility (RAI) Vs. Health facilities

The dependent variable (y = health facilities) and independent variable (x = accessibility) have a correlation coefficient of +0.59022, which means, First of all, it is favorable, showing a direct correlation between accessibility and medical facilities. In light of this, it can be seen that increasing accessibility will likely increase literacy rates and vice versa. Besides, the correlation is rather moderate, as indicated by the value of 0.59022.

3.6.5 Accessibility (RAI) Vs. Economic Facilities

The correlation coefficient between the independent variable (x : accessibility) and the dependent variable (y : economic amenities) is +0.35742. This indicates that accessibility and economic amenities are directly correlated. In light of this, it can be seen that increasing accessibility will likely increase literacy rates and vice versa. Furthermore, as shown by the correlation's value of 0.35742, it is fairly moderate.

3.6.6 Accessibility (RAI) Vs. Total Socio-Economic Facilities

The correlation coefficient between the dependent variable (y = Total Socio-Economic Facilities) and the independent variable (x = accessibility) is +0.57159, which indicates that there is a positive relationship between the two variables. This demonstrates that improving accessibility will probably raise literacy rates and vice versa.

3.7 Testing the Significance of the Correlation Coefficient (t-Test)

The null hypothesis and the alternative hypothesis are suggested, and they are as follows: $H_a: > 0$ or $H_a: < 0$ or $H_0: = 0$ (the correlation is zero) (the correlation is different from zero), considering $n = 11$ with a degree of freedom for uneven variance and a 95% confidence level or 5% significance level. Thus, the significance level is $(100-95) = 5\%$ and the confidence level is $C = 95\%$. The following outcomes (Table 4) were obtained using the t-Test Excel data analysis tool:

Table 4 Significance Test Results.

t-Test: Two-Sample Assuming Unequal Variances		
(RAI and Poverty)	Variable 1	Variable 2
Mean	42.6	3.1
Variance	123.6	0.988888888888889
Observations	11	11
Hypothesized Mean Difference	0	
DF	11	
T stat	11.19070479	
P(T<=t) one-tail	6.96E-07	
t Critical one-tail	1.83311293265624	
P(T<=t) two-tail	1.39248E-06	
t Critical two-tail	2.262157163	

3.8 Interpretation of Results of Significance Test Results

(a) In this case, it is determined that t Stat = 11.190704 and t Critical two-tail = 2.262157. As a result, t Stat = 11.190704 $> t$ Critical = 2.262157.

In this case, the null hypothesis may be rejected.

(b) Here P value is = 1.3×10^{-06} ; $P < \alpha$ – indicates the relationship is statistically significant.

(c) The null hypothesis might be disproved because the P value in this instance is so low.

3.9 Results of DEA

A graph with Poverty and RAI on the vertical axis and Upazila on the horizontal axis was displayed (Figure 12) in the order of priority of resource allocation. The horizontal axis's left side denotes resource allocation with a higher priority, whereas the right side denotes resource allocation with a lower priority. Building physical infrastructure to promote accessibility and hence reduce poverty should receive higher financial priority, according to the Upazila on the left side of the graph's horizontal axis, which shows locations with higher poverty and lower accessibility levels. The left side of the graph represents high priority, and the right shows low priority, sending a message to policymakers about investment priorities.

3.10 Rural Road network priority based on agricultural productivity

The utility values were found for each link, and the maximum utility value was 33967.59, meaning these links will be upgraded as first priority. Likewise, utility values were found for each link, and on the basis of utility, value priority will be decided. For this research 11 Upazila has been shown, and these 121 links were calculated. The maximum utility value is

12281.01, which Bishwamvarpur to Sunamganj Sadar means this link will be upgraded as the first priority. Further, all the links can be compared and priority decided.

Secondary data was gathered from various sources, primarily from various government entities, to conduct the studies because no original data was gathered. It is encouraging to compare the methodology with (Anjaneyulu et al 2007), who developed a scheme for planning rural roads based on secondary data sources. Road network, demographic, socioeconomic, poverty data, and agricultural production of Sunamganj districts are the key topics covered by secondary data. In this study, the accessibility of road transportation was discovered and examined, as well as the relationship between accessibility and socioeconomic and poverty-related factors. This findings is consistent with that of (Singh 2010) found a link between infrastructure and agricultural development. Agricultural development was strongly correlated with the agricultural infrastructure index, followed by the transport and communication index. Prioritizing physical infrastructure and facility-based assessments of agricultural production improvement by the occupancy of rural areas was done using data envelopment analysis. Many roads in the district may be considered for improvement, further upgrading, and maintenance. The primary goal of rural road development, such as accessibility improvement, which is better reflected in utility value per km, lower utility values than the cut-off rate but has higher utility standards, can be prioritized for development. In conclusion, the decision may be based on the context of core network development and based on the overall context.

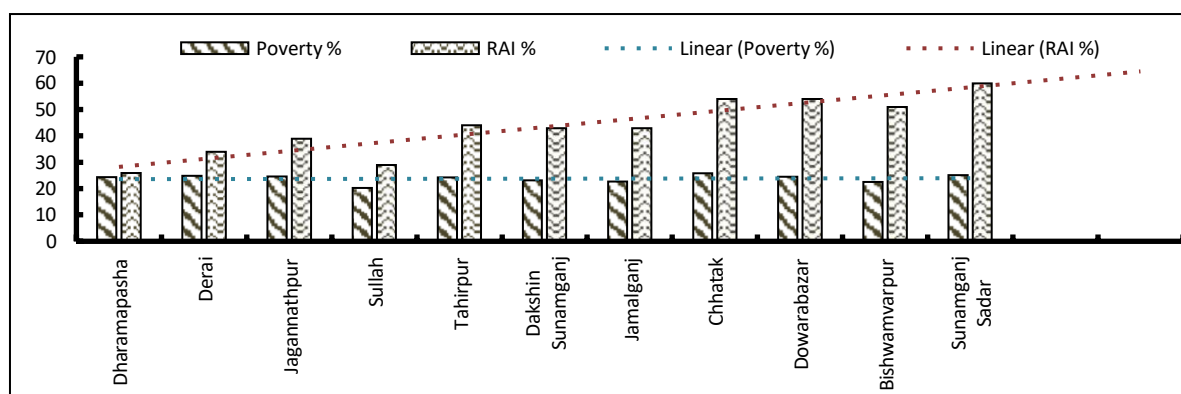


Figure 12 DEA-Based Priority Ranking of Upazila.

4. Conclusion and recommendations

This study developed methodologies to quantify accessibility at different levels. Also, an agricultural-based approach has been developed for rural road connectivity to improve access to basic facilities. Through this study, the distribution of funding for physical infrastructure fairly, and the Upazila priority listing for transportation accessibility and poverty incidence was created. Accessibility to transportation and socioeconomic factors are correlated. The social state of an area is better, whereas transportation accessibility is higher. The agricultural-based rural road network planning approach proposed in this study ensures accessibility to the needs of the rural population. The number of habitations with no accessibility increases significantly with the decrease in the population density of the region. Also, the percentage increase in accessibility per kilometer of road construction is higher in densely populated areas. Increasing household income will enable them to spend more on their family members' education, health, and social ties, all of which raise the standard of living for everyone. Despite this, the transport industry directly contributes 11.53% of GDP and serves as the foundation for all other sectors. In the long run, its indirect GDP contribution is tremendous.

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Conflict of Interest

The authors declare no conflict of interest.

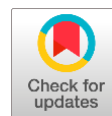
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Physicochemical characteristics of pork meatballs mixed with *Amaranthus caudatus*

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Abstract The main objective was to compare the physicochemical characteristics of meatballs produced from pork meat and wheat flour mixed with *Amaranthus caudatus*. Meatballs were produced with two different formulations: meatballs without *Amaranthus caudatus* and meatballs having *Amaranthus caudatus*. The different parameters, such as temperature, P^H , fat content, weight loss, and titratable acidity, were compared from one formulation to another. The results showed that the p^H value and fat content of those having *A. caudatus*, were lower than those found in meatballs without *A. caudatus*, but the temperature, weight loss, and titratable acidity were more than those found in meatballs without *A. caudatus*. By this, the P^H value for the initial time was 6.1 compared to 6.3, the meatball fat content without *A. caudatus* of about 3.7% than the meatball fat content with *A. caudatus* of about 2.9%, and the different weight loss between those two meatballs was 19.47% (59g), and finally, the titratable acidity was 1.8% in meatballs with *A. caudatus* than 0.26% in those without *A. caudatus*. The meatballs with *A. caudatus* had a greater acidity and lower lipids than the meatballs without *A. caudatus*. Also, the acid concentration of both meatballs has significant for consumers and the loss of weight means that the lowering of water content is an indication of a good storage process.

Keywords: pork, fat content, acidity, pH value

1. Introduction

Pork as meat from the domestic pig is eaten in many countries, accounting for about 38% of meat production worldwide and about 21% of total dressed meat in Rwanda, compared to 46% from cattle, and its myoglobin content is lower than beef but much higher than chicken (Angier 2009). In developing countries, the total demand for animal products is expected to be doubled in 2030; thereby, pigs are expected to show domination in the meat supply (Shyaka et al 2022). However, pig meat production is expected to increase to meet the growing Rwandan population's nutritional requirements and increase household incomes in rural areas (MINAGRI 2020).

In Rwanda, although the production of livestock products has increased, demand still outstrips supply, primarily due to the rapidly expanding population and the high price of meat (MINAGRI 2008). Livestock food products are a source of essential amino acids, minerals, and vitamins; their fat content is also a source of calories. Meat processing is needed by adding non-meat ingredients to produce nutritional, safe, and shelf-stable products at an affordable price (www.fao.org).

Rwanda's pig population is currently accounting for 1.7 million head, according to statistics from the Ministry of Agriculture and Animal Resources (MINAGRI). The growth has been driven by the growing appetite for pork, disease control in pigs, availability of animal feeds, and high returns that farmers get from pig farming (MINAGRI 2020). Similarly, pig production in Rwanda is increasing rapidly to meet rising demand in urban and rural areas and for export to neighboring countries. Most restaurants in Rwanda serve the pork with banana roasts and fried potatoes (Shyaka et al 2022).

Processed meat products contain relatively high amounts of saturated fats and sodium, and the production of healthier foods requires reducing these two elements (García-García 2008). Fat is important to the palatability of the products such as sausage (Gollehon et al 2001). Consequently, when fat is reduced in meat products, they tend to become tough, dry, and rubbery and do not effectively bind water (Pearson and Gillet 1999). Meatball is a product made of ground meat and mixed with spices, and the meats are the main ingredients (Ulu 2004; Gujral et al 2002). Amaranth may be a promising source of protein, and its protein does not contain gluten (Gallagher and Gormley 2011). The non-meat ingredients can be additive to meat processing for health benefits. Thus, amaranth leaves have been added to improve their nutritional value and to replace



some quantity of pork meat. The aim was to produce and compare improved quality meatballs made of pork meat and wheat flour mixed with *Amaranthus caudatus* and to assess the physicochemical characteristics of produced meatballs.

2. Materials and Methods

2.1. Meatball processing

Pork meat purchased in Musanze market, Northern Province of Rwanda, wheat flour and olive oil from Supermarket, *Amaranthus caudatus* leaves, and red onion harvested from the house-ground farm.

All ingredients were combined and minced in a machine, except olive oil, spices, and wheat flour, in a bowl and mixed with hands. The minced mixtures were mixed with wheat flour and spices using hands. Using hands, 36 small balls (15+ 21 balls without and with *A. caudatus*, respectively) were rolled (Figure 1). The balls were fried in butter in a frying pan (medium hot) for about 5 minutes and then turned around to get them fried on all sides. Meatballs were taken for consumption.



Figure 1 A: Mixture with *A. caudatus* B: Rolled balls without *A. caudatus* and C: Rolled balls with *A. caudatus*.

2.2. Temperature determination

Using a thermocouple, the internal temperature of the meatballs was measured. The temperature was taken at all steps, from meat reception to serving the last meal. The time of each preparation step was also registered. To evaluate the storage conditions of meat, thermometers for maximum and minimum temperatures were used.

2.3. P^H Determination

The P^H was measured using an electronic P^H meter; before each measurement P^H meter must be calibrated with a standard buffer solution and put in the solution composed of a mixture of sample and distilled water, noted the P^H value through the P^H meter for each sample.

2.4. Titratable acidity

The titratable acidity is expressed as a percentage of lactic acid and was determined by titration of a known amount of reconstituted meatball with 0.1 N NaOH using phenolphthalein as an indicator (www.gea.com).

The method used was as follows:

To prepare the NaOH solution was used a NaOH pellet and distilled water. Fill the burette with NaOH. Measure 10g of dry meat, Drop 5 drops of phenolphthalein with the help of a dropper into Erlenmeyer and mix. Open the cock on the burette and start dropping the NaOH solution into Erlenmeyer until a constant light pink color appears. Shake after each drop; when we get a light color, we stop the NaOH dropping and read how much NaOH is used on the buret's marking.

Titratable acidity results:

$$\text{Percentage titratable acidity} = \frac{mL.N.90.100}{V.1000} \text{ (www.gea.com)}$$

Where ml: ml 0.1 NaOH used, N: Normality of 0.1N NaOH, V: solution used in ml, MW of lactic acid: 90.

2.5. Fat Determination

Using Simplified Gravimetric after the chloroform-methanol extraction method (Katherine et al 1997); Samples of 1-5 g were massed into a polypropylene centrifuge bottle. Sodium acetate was added so that the total volume of the solution was

32 ml. Aliquots of methanol and chloroform were added, and the bottles were capped and shaken for 2 hours. Another aliquot of chloroform was added, and the bottles were shaken again for 30 minutes. Finally, an aliquot of water was added, and the bottles were shaken a final time for 30 min.

Centrifuge tubes that had been dried and massed were used to hold 20 ml aliquots of the chloroform layer. These are then centrifuged for 10 min and allowed to set in a 25°C water bath for 15 minutes. The samples were then evaporated to dryness under a nitrogen blanket, heated in a drying oven for 30 minutes, and cooled in a desiCooler (Desert, JBMR, and India) for at least 30 minutes. Finally, they were massed, and the total lipid content was determined by:

$$\text{Total lipid (g/100 g wet weight)} = \frac{(W_2 - W_1) V_c \cdot 100}{V_A \cdot SW} \quad (\text{Katherine et al 1997})$$

Where W_2 is the weight of the glass tube and dried extract (g), W_1 is the weight of the empty dried glass tube (g), V_c is the total volume of chloroform (ml), V_A is the volume of extract dried (ml), and SW is the weight of food sample assayed (g).

2.6. Weight loss determination

All ingredients used were measured before meatballs processing, and the weight of meatballs products was also weighed. The total weight loss was determined by taking the difference between the above measures.

2.7. Statistical Analysis

The data were analyzed in excel 2010 as well as the graphs were constructed there. The results of three replicates were expressed as mean $\pm$ standard errors.

3. Results

3.1 Temperature of meat and Meatballs

The results have shown that the temperature decreased with time till to the constant temperature and the constant temperature was 22 °C.

Table 1 Temperature of fresh and cooked meat with the variation of time.

Time (min)	0	30	60	90	120
Temperature (°C) - Fresh meat	30 $\pm$ 0.01	26 $\pm$ 0.00	24 $\pm$ 0.00	22 $\pm$ 0.00	22 $\pm$ 0.00
Temperature (°C) - Cooked meat	48 $\pm$ 0.00	31 $\pm$ 0.01	25 $\pm$ 0.00	22 $\pm$ 0.00	22 $\pm$ 0.00

For both meatballs before and after they cooked, the temperature was decreased with the increase in time till the constant temperature. The constant temperatures before cooking both meatballs were the same, and also the constant temperatures after cooked of both meatballs were similar. Still the constant temperatures before cooked and after cooked were different.

Table 2 Temperature of meatballs before and after cooking.

Time (min)	0	30	60	90	120
Temperature (°C) (A)	21.5 $\pm$ 0.01	19 $\pm$ 0.00	19 $\pm$ 0.00	19 $\pm$ 0.00	19 $\pm$ 0.00
Temperature (°C) (B)	22.5 $\pm$ 0.01	19 $\pm$ 0.00	19 $\pm$ 0.00	19 $\pm$ 0.00	19 $\pm$ 0.00
Temperature (°C) (C)	64 $\pm$ 0.01	26 $\pm$ 0.01	21 $\pm$ 0.00	20 $\pm$ 0.00	20 $\pm$ 0.00
Temperature (°C) (D)	69 $\pm$ 0.01	29 $\pm$ 0.00	22 $\pm$ 0.00	20 $\pm$ 0.00	20 $\pm$ 0.00

Notes: (A); (B); (C); and (D): of meatballs without *A. caudatus* before cooked; with *A. caudatus* before cooked; without *A. caudatus* after cooked; and with *A. caudatus* after cooked, respectively.

Normally the meatballs with *A. caudatus* showed a lower upper temperature than those without *A. caudatus*. Figure 2 explains the temperature of those meatballs.

Here the temperature of meatballs with *A. caudatus* in red varied from the highest to the lowest as the temperature of meatballs without *A. caudatus* in blue color; the same both represent the equally constant temperature but the average temperature of meatballs with *A. caudatus* represents the greater number.

The greater temperature of meatballs with *A. caudatus* is influenced by the high water activity of amaranths and its lactic acid, which is miscible with water as water activity increases as the temperature of the sample increases. The low-fat content of meatballs with *A. caudatus* can also influence the increase in temperature.

3.2 Hydrogen potential (pH)

With the P^H of wheat flour of 6.1, raw *A. caudatus* leaves of 7, and the cooked meat after two hours 5.9, the pH of meatballs with *A. caudatus* and without *A. caudatus* before and after cooked was measured as represented in Table 3.

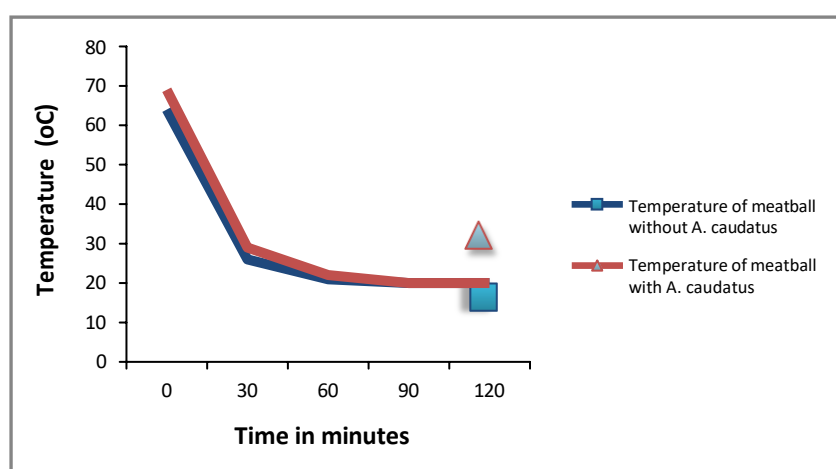
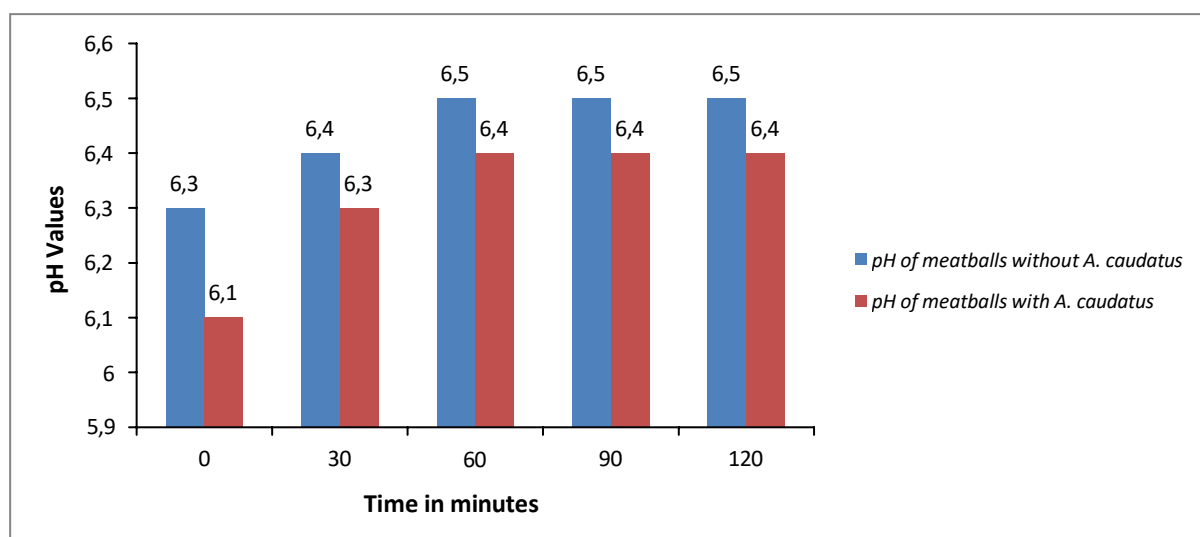
Table 3 Hydrogen Potential of meatballs.

Time (min)	0	30	60	90	120
P ^H value (A)	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00
P ^H value(B)	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00
P ^H value (C)	6.3 ± 0.001	6.4 ± 0.001	6.5 ± 0.00	6.5 ± 0.00	6.5 ± 0.00
P ^H value (D)	6.1 ± 0.001	6.3 ± 0.001	6.4 ± 0.00	6.4 ± 0.00	6.4 ± 0.00

Note: (A), (B), (C), and (D): Meatballs before being cooked without *A. caudatus*; with *A. caudatus*; after being cooked without *A. caudatus*; and with *A. caudatus*, respectively.

The P^H values were under the neutralization zone (P^H: 7); by this value, all meatballs were acidic, but the acidic degree is different in meatballs without *A. caudatus* to meatballs with *A. caudatus* where the last are more acidic. The change occurred only in meatballs after cooking, and for any time, the P^H was not changed. This information is explained in Figure 3, where the P^H value each time, the P^H value of meatball with *A. caudatus* each is always less than the P^H value of those without *A. caudatus*, but both reached the same constant P^H value.

Figure 3 shows the P^H variation of both meatballs in the function of time; the red color shows the P^H variation of meatballs with *A. caudatus*, and the blue color represents the P^H variation of meatballs without *A. caudatus*.

**Figure 2** Temperature of meatballs after cooked.**Figure 3** pH of meatballs after cooked.

The most commonly measured chemical attribute of water is its acidity or P^H. The P^H scale ranges from 1 to 14, with 1 being the most acidic and 14 being the most basic. The P^H value of meatballs without *A. caudatus* is greater than that of meatballs with *A. caudatus*; the cause is the lactic acid concentration of meatballs with *A. caudatus* that reduces the P^H value for increasing the acidity.

3.3 Titratable acidity

The titratable acidity of two meatballs was measured by following the procedures described in the methods. The measured titratable acidity in meatballs without *A. caudatus* by 7.2 ml of NaOH was 0.26%, whereas the titratable acidity measured from meatballs with *A. caudatus* by 50 ml of NaOH was 1.8%. This great acidity is more pronounced in meatballs with *A. caudatus* according to the P^H values.

3.4 Fat content

The lipids calculation using Simplified Gravimetric after chloroform-methanol extraction method (Katherineet al 1997), represents the meatball fat content without amaranthus of about 3.7% and the meatball fat content with *A. caudatus* of about 2.9%. This lower lipid level in meatballs with *A. caudatus* compared with the meatball without *A. caudatus* is explained by the reduction of meat, and the addition of *A. caudatus* leaves normally containing the high lactic acid than meat.

3.5 Weight loss

The weight variation was measured in all steps of meatball processing, where the wheat flour, the cooked meats, and the *A. caudatus* leaves were weighed before starting meatballs making. The measures were also taken during the processing of meatballs and finally, the measures of the weight of meatballs produced. The weight of the mixture for meatballs made without *A. caudatus* was 1,187g, and after their processing, the meatballs weighed 1,150g, whereas the weight of all meatballs was 1,065g being cooked. The weight loss in meatballs without *A. caudatus* was 122g.

The same measures of the weight of the meatballs with *A. caudatus* were done. The weight of the mixture was about 1,509g, while the balls weighed 1,495g, and finally, 1,328g of the meatballs weighed after being cooked. The weight loss of meatballs with *A. caudatus* was equal to 181g, and here is the difference in weight loss format balls with and without *A. caudatus* is that the *A. caudatus* found in meatball processing lost a high amount of water than the meatballs without *A. caudatus*.

The total weight loss of both meatballs was 303g (100 %); by this, the difference in weight loss between those meatballs of about 59g is 19.47%, and the weight loss in meatballs without *A. caudatus* was 40.26%, and the weight loss of meatballs with *A. caudatus* was equal to 59.74%.

4. Discussion

The production of meatballs from pork meat and wheat flour mixed with *A. caudatus* was possible, but the meatballs took a color like that of *A. caudatus*. The effect of *A. caudatus* on meatball production is explained by the decrease in P^H corresponding to the production of acidity. Water removal by drying has high chemical component values, such as vitamin C and beta carotenes than in fresh samples.

As discussed by Sureshkumar et al (2006), not only is the acidity increasing influenced by the *A. caudatus* on meatballs production, but also the temperature is first increased, then it starts to decrease up to the constant based on time.

The incorporation of *A. caudatus* into meatball production is different from the study of the quality of low-fat meatballs containing legume flours as extenders which all meatballs incorporated legume flours were tougher (Serdaroğlu 2005).

These parameters, such as the temperature, P^H , and weight, decreased in the time increase function. The comparison of temperature for both meatballs shows that the meatballs with *A. caudatus* had greater temperature than meatballs without *A. caudatus*, but both meatballs had a constant temperature (Figure 2).

In terms of fat content, the meatballs with *A. caudatus* had lower lipids (2.9%) than those found in meatballs without *A. caudatus* (3.7%). The fat level in *A. caudatus* (10%) affected the fat content of meatballs. The decrease in fat content from 3.7% to 2.9% significantly increased the cooking yield and fat retention. This point is very similar to the study of the effects of fat level (5%, 10%, and 20%) and cornflour (0%, 2%, and 4%) on some properties of Turkish-type meatballs (koefte) (Meltem and Ozlem 2004).

Based on the study of the effect of wheat flour, whey protein concentrate, and soy protein isolate on oxidative processes and textural properties of cooked meatballs showed that whey protein concentrate and soy protein isolate were inhibitory toward oxidation in cooked meatballs, the *A. caudatus* also explains this hypothesis (Ulu 2004).

The weight loss between the two meatballs was different, 59g. The difference can be defined by the water activity of *A. caudatus*. During meatball processing, the meatballs containing amounts of *A. caudatus* were those that showed greater weight reduction than the others, and their cooked characteristics took a long time. Ambient storage conditions can be due to the decrease in P^H and water activity (Sureshkumar et al 2006). The production of induced lactic acid decreases in P^H from 6.5 to 6.4/6.5 to 6.1 (Table 3).

Lactic acid production and subsequent drops in P^H influence the organoleptic properties of meatballs (Lucke 1986). Lactic acid has the potential to enhance saltiness, and the low P^H values may change the flavor by restricting proteolytic and lipolytic enzyme activity (Lucke 1986).

5. Conclusion

The meatballs with *A. caudatus* were more acidic (less P^H value) and had lower lipids than those without *A. caudatus*. However, the meatballs with *A. caudatus* represent the food quality compared to others by their greater acidity in which the sugar content is in low concentration. The acid concentration of both meatballs has significant for consumers and the loss of weight means that the lowering of water content is an indication of a good storage process. It is recommended to use *A. caudatus* meatballs containing good nutritional values, antioxidants, and vitamins for human life in preventing diseases.

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Conflict of Interest

The authors declare that they have no conflict of interest.

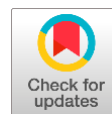
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Community diagnosis in Sei Selayur urban village, Palembang, Indonesia: Actual approach for the assessment of health and social factors



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Abstract Community diagnosis is a comprehensive assessment of the community state as a whole in relation to economic, social, physical, and biological environmental conditions. This study aimed to determine the priority of health-related problems and its potential problem-solving interventions. Community diagnosis process was carried out in the 41st neighborhood (*Rukun Tetangga*, RT 41), Sei Selayur, based on Lawrence Green's theory. Primary data were gathered through interviews, observations, and physical examinations. Meanwhile, secondary data was taken from Kalidoni primary healthcare profile. Home selection was based on maximum variance sampling. The priority of the problem was determined using the Reinke method, and the priority of the root cause of the problem was based on the Hanlon method. Final step in this activity is the determination of the problem-solving actions. Based on the results of the analysis, the main health problems found were Acute Respiratory Infection (ARI), hypertension, and hyperuricemia. These diseases were associated with knowledge, non-routine consumption of medications, and poor diet. Problem-solving alternative is implemented by referring to the PRECEDE-PROCEED theory in accordance with the needs of residents of RT 41. The biggest health problem in the community was an acute respiratory infection, which is associated mainly with knowledge factors. The Lawrence Green's community diagnosis theory, also known as the PRECEDE-PROCEED theory, can be used to enhance the precision of community diagnosis and make it possible to be applied in a broader context to achieve favorable health promotion.

Keywords: community health, PRECEDE-PROCEED, problem priority, problem intervention alternatives

1. Introduction

Community health is an inter-sectoral, inter-collaborative enterprise that employs public health sciences, evidence-based approaches, and other strategies in a culturally appropriate manner to improve the health and quality of life for everyone residing within a defined community or several communities (Goodman et al 2014). Indonesian community is composed of a rural and urban environment. Due to the differences in educational background, physical activity (including facilities), and habit (particularly smoking), these populations also have variable health behavior (Fogelholm et al 2006). Because of its capability to present the actual condition in the population, a method known as community diagnosis has been established to investigate the civilization's environmental, social, and cultural features (Vaidya et al 2008).

Community diagnosis is a comprehensive assessment of the community state as a whole concerning its economic, social, physical, and biological environmental conditions (Thapa et al 2012). It is composed of a quantitative and qualitative description of the resident's health status and the influencing factors. Implementation of community diagnosis is expected to correctly identify health problems and facilitate health promotion, disease prevention, and health service management in the community (Bhargava et al 2016).

Community diagnosis is based on Lawrence Green's theory, the PRECEDE-PROCEED theory, consisting of nine phases (Räihä 2014). These phases are: (1) social diagnosis, (2) epidemiological diagnosis, (3) behavioral and environmental diagnosis, (4) educational and organizational diagnosis, (5) administrative and policy diagnosis, (6) implementation, (7) process evaluation, (8) impact evaluation and (9) outcome evaluation (Weiss, 2016). The implementation includes epidemiological, social, environmental, and health personnel data components; in this theory, selecting suitable alternative innovations and evaluation plans is determined as the goal (Porter 2016).

We conducted a community diagnosis process in Sei Selayur urban village, Palembang, Indonesia. A community diagnosis needs to be carried out in the environment to establish the health status of the community and the problems inherent in the environment. Thus, the aim of this study was to determine the priority of health-related problems and potential problem-solving interventions for the community.



2. Materials and Methods

Primary data were gathered through interviews, observations, and physical examinations in ten houses in the 41st neighborhood (*Rukun Tetangga*, RT), Sei Selayur urban village, in order to collect the existing problems by December 2019. This area is included in the working area of Kalidoni Public Health Center, Palembang, Indonesia. The approximate mapping of this area is presented in Figure 1. The list of houses with the highest potential to provide health data is discussed with informants who helped to provide an overview of the local situation. House selection was based on maximum variance sampling to obtain data on health problems that were able to describe the majority of problems in the community environment.

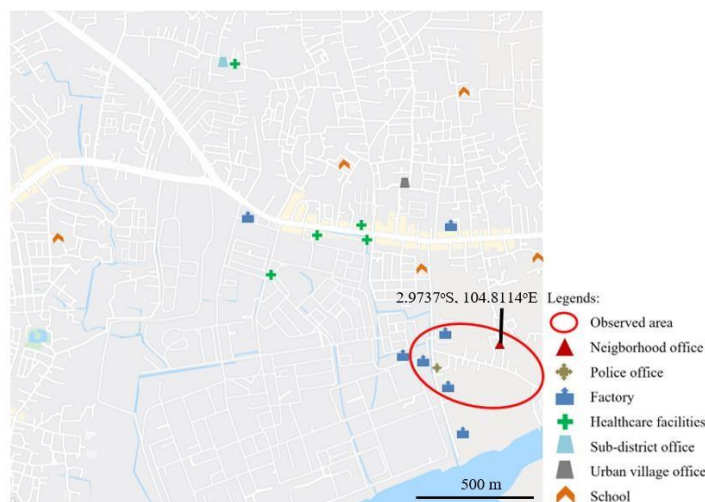


Figure 1 41st neighborhood mapping with adjacent Kalidoni Public Health Center Area. Source: maps.google.com, retrieved on January 7, 2020. Coordinates were determined at the 41st neighborhood office.

The results of the data collection were grouped based on the L. Green's theory (Weiss 2016) can be seen in Figure 2. Data in the first through fifth phases were obtained through direct observation in the field; secondary data was collected from the problem identification matrix and Public Health Monitoring Survey in Kalidoni Public Health Center. Problem priority was determined using the Reinke method (cost analysis), which contains the Magnitude (M) criteria, describes the magnitude of the problem; Importance (I), the type of population group affected by the problem; Vulnerability (V), whether or not there are methods or other ways to solve the problem effectively and Cost (C), whether it needed abundant resources or not to undertake the problem. Meanwhile, the root cause priority (Tables 2, 4, and 6) was evaluated by using the Hanlon method, with components of A (problem magnitude, 0-10 points); B (seriousness of the problem, 0-20 points from a total of four factors, which are urgency, severity, economic burden and involvement of others); C (intervention effectiveness, 0-10 points); D (probability of implementation, 0 or 1 point for every PEARL (propriety, economics, acceptability, resources, and legality) parts (Choi et al 2019). The final step is the determination of the problem-solving actions. This step is in accordance with L. Green's theory, especially phases 6 through 9.

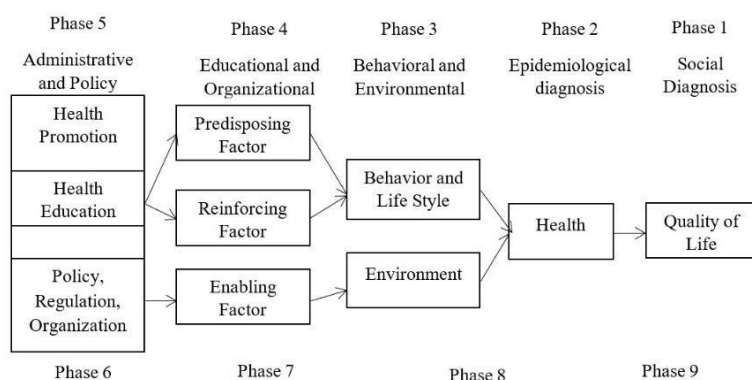


Figure 2 PRECEDE-PROCEED Model.

3. Results

3.1 Social Diagnosis

Interviews, with the help from informants, and field observations, were used to perform these activities. The term "social diagnosis" refers to determining a person's quality of life and social issues and needs. According to the results of home visits, the dependency ratio was relatively high, with only 39.4% of family members working and about 60% of the work being laborers, either manufacturing plants or construction workers. Furthermore, the level of education is quite low, with the majority of the population only having completed elementary school (32.07%). There were also 5.66% of residents who were not receiving formal education.

3.2 Epidemiological Diagnosis

Disease data was collected on residents by collecting illnesses that were currently or previously impacting the respondent in the previous three to six months. Figure 3 depicts the cases that were discovered.

As shown in the corresponding bar chart (Figure 3), five major diseases recognized during the observation were Acute Respiratory Infections (ARIs), hypertension, myalgia, hyperuricemia, and pulmonary tuberculosis. After the list of problems had been compiled, the problem priority was chosen. Disease data were scored based on the factors of interest and understanding of Focus Group Discussion (FGD) participants, consisting of RTs chief, Public Health Center, health cadres, and researchers. The results, along with the calculation using Reinke approach, are shown in Table 1. It is decided that ARIs, hypertension, and hyperuricemia were disorders that required particular considerations and were assessed to determine their potential solutions.

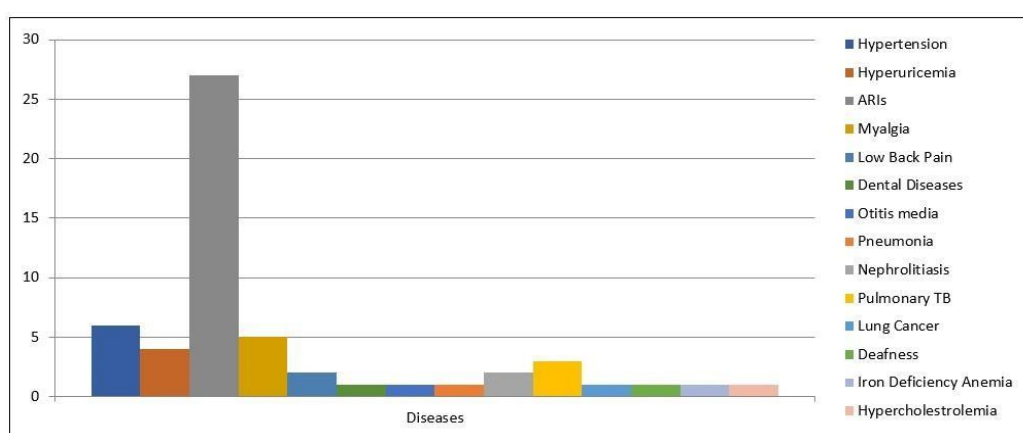


Figure 3 Observed diseases during home visits. Note: ARIs = Acute Respiratory Infections, TB = Tuberculosis.

Table 1 Determination of health-related problems priority.

Diseases	Magnitude (M)	Importance (I)	Vulnerability (V)	Cost (C)	Total	Priority
Acute Respiratory Infection (ARIs)	5	5	5	2	62,5	I
Deafness	1	4	2	5	1,6	XII
Dental Diseases	1	4	3	3	4	X
Hypercholesterolemia	2	5	4	5	8	VII
Hypertension	5	5	5	5	25	II
Hyperuricemia (<i>Gout arthritis</i>)	5	4	4	5	16	III
Iron Deficiency Anemia	1	4	4	2	8	VII
Low back pain	4	4	3	4	12	IV
Lung Cancer	1	5	1	5	1	XIV
Myalgia	5	2	3	3	10	V
Nephrolithiasis	1	3	2	5	1,2	XIII
Otitis media	1	5	5	4	6,25	IX
Pneumonia	1	5	2	3	3,33	XI
Pulmonary Tuberculosis	1	5	5	3	8,33	VI

Note: Each criterion gets a value of 1 to 5. The final value is obtained through the formula $\frac{MXVXI}{C}$.

3.3 Behavioral and Environmental Diagnosis

This stage evaluated the behavioral factors and environmental sources of each condition discovered. The absence of clean and healthy living behavior, particularly in smoking behavior, as 100% of the residences visited had at least one family member who smokes, is one of the predictors of behavior. The same facts remain when it comes to physical exercise. On this metric, 100% of households have family members who are less physically active and do not exercise regularly. 90% of chronic disease sufferers implement non-routine drug usage. Due to a lack of resources, healthy eating was also constrained. Meanwhile, environmental issues include the unhealthy housing conditions, with 60% of houses having inadequate ventilation

(the area does not reach 1/9 of the building), and stressful working conditions (shift system that disrupts breaks and meals) which places a heavy burden on family earners. Environmental concerns such as substandard housing, lack of sewerage, and proximity to numerous factories, such as fertilizer, tire, and food manufacturers, make this area particularly prone to infectious diseases and air pollution.

3.4 Educational and Organizational Diagnosis

This process aimed to identify behavioral and environmental conditions related to health status and quality of life by considering the causative factors and identifying factors that can be transformed. There are three main groups in this diagnosis, namely:

- a) Predisposing factors: The level of knowledge is generally low (only up to remembering), community attitudes were generally still positive because they accept input from researchers, there is no specific belief system (there is only 1 in 10 houses that trust alternative medicine), public perceptions are generally good for children's health including immunization, although there were two houses that do not carry out complete immunizations.
- b) Strengthening factor: Support and motivation from stakeholders, family, and neighbors are inadequate.
- c) Enabling factors: Integrated Post of Non-Communicable Diseases (*Pos Bina Terpadu Penyakit Tidak Menular, Posbindu PTM*) or Elderly.
- d) Integrated Health Post (*Pos Pelayanan Terpadu, Posyandu*) was not available, a limited number of residents joined the National Health Insurance, and access to transportation is limited even though health care facilities are relatively not too far away (the nearest clinic is one kilometer away from the location).

3.5 Administration and Policy Diagnosis

This process was oriented to the analysis of policies, resources, and events that support or hinder the development of health promotion. The process includes:

- a) Administrative diagnosis: Limited funds and personnel in the health sector, so the construction of health posts is still limited, the commitment of officers must still be improved, and the performance burden is quite heavy in the process of carrying out tasks.
- b) Policy diagnosis: Support from stakeholders is still lacking, and the implementation of health programs for chronic diseases has not been maximized.

3.6 Implementation

3.6.1 ARIs

Problem analysis aimed to determine the root cause of ARIs in the community. The analysis was carried out using the Hanlon method, as illustrated in Table 2. It is found that the main etiological factor of high ARIs prevalence is related to community knowledge.

The causes of the low level of public knowledge about the disease were analyzed based on the epidemiological concept of the cause of the problem using a web of causation based on the epidemiological concept of infectious diseases (Figure 4). The root causes of insufficient knowledge can be traced to three components: poor processing of information, inadequate information, and poor transfer of information. Based on this analysis, the researcher continues the assessment by analyzing alternative solutions to the problem using financing analysis (cost analysis). The results of the analysis can be seen in Table 3. The selected solution is increasing the frequency of free treatment and health education by involving factories around the site. This can involve holistic aspects of ARIs management, including promotive, preventive, and rehabilitative efforts.

Table 2 Root cause analysis for ARIs.

No.	Problems	A	B	Criteria						Total	Priority
				C	P	E	A	R	L		
1.	Less community common knowledge	10	18	10	1	1	1	1	1	280	I
2.	Smoking behavior and not wearing any protective equipment (mask)	10	20	6	1	1	1	1	1	180	II
3.	No variation in health promotion method	6	6	10	1	1	1	1	1	120	III
4.	No specific programs and budget allocation to prevent ARIs	5	10	4	1	1	1	1	1	60	IV
5.	Lack of cross-sectoral cooperation	6	16	8	1	0	0	0	0	0	-
6.	Burning house wastes and trashes	9	15	6	1	1	0	1	1	0	-
7.	Air pollution caused by smog and dust waste produced by factories operating around RT 41	8	20	4	1	1	1	0	1	0	-

Note: Numbers are calculated using $\frac{(A+B)C}{3} \times D(\text{Pearl Factor})$.

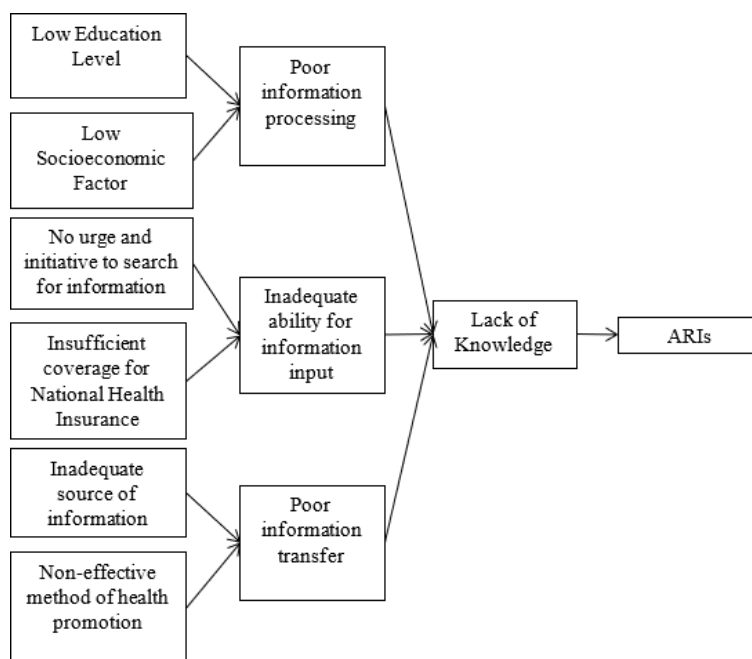


Figure 4 Web of causation for ARIs.

Table 3 Problem-solving alternative analyzed using cost analysis for ARIs.

No.	Problem-solving alternatives	Criteria				Total (MxIxV/C)	Priority
		M	I	V	C		
1	Increase the frequency of free medical checks and treatment, increase the frequency of health promotion (collaborating with factories around the area)	4	4	5	3	26.7	I
2	Cooperation with stakeholders to provide personal protective equipment	4	2	3	3	8	II
3	Home visit to observe home ventilation of houses in RT 41	3	3	3	4	6.75	III
4	New and updated educational video	2	2	2	2	4	IV
5	Selection for ARIs prevention ambassador	2	2	3	4	3	V

Note: M = Magnitude, I = Importance, V = Vulnerability, C = Cost.

3.6.2 Hypertension

The causes of hypertension are illustrated in Table 4. The main causative factor was related to non-routine drug consumption (medication in compliance). This is reportedly caused by patients' mindset of only getting medicated when they felt a complaint, such as a headache. This condition is analyzed using the concept of the web of causation (Figure 5).

The root of the problem could be traced from ten components, broken down into five elements, namely, poor ability to receive information, limited access to health services, lack of information delivery, difficulty in maintaining compliance, and lack of treatment awareness. Based on these conditions, researchers continue the assessment by analyzing alternative solutions to problems using the cost analysis method (Table 5). The chosen alternative solution is the formation of a team to collaborate on blood pressure assessment and medication supervision based on the main obstacle faced in this region (low rate of routine drug consumption).

Table 4 Root cause analysis for hypertension.

No.	Problem	A	B	Criteria						Total	Priority
				C	P	E	A	R	L		
1.	Incompliance with obligatory medications	10	14	6	1	1	1	1	1	144	I
2.	Smoking behavior and unhealthy lifestyle	10	19	4	1	1	1	1	1	116	II
3.	Poor community knowledge	10	10	5	1	1	1	1	1	100	III
4.	Low budget allocation specific to health	5	10	4	1	1	1	1	1	60	IV
5.	Low socio-economic level	10	10	2	1	1	1	1	1	40	V
6.	Inadequate facilities for hypertension screening.	5	12	2	1	0	1	1	1	0	-
7.	Less attention from family members	8	9	8	1	1	1	1	0	0	-
8.	Low motivation	4	8	4	1	1	1	1	0	0	-

Note: Numbers were calculated using $\frac{(A+B)C}{3} \times D(\text{Pearl Factor})$.

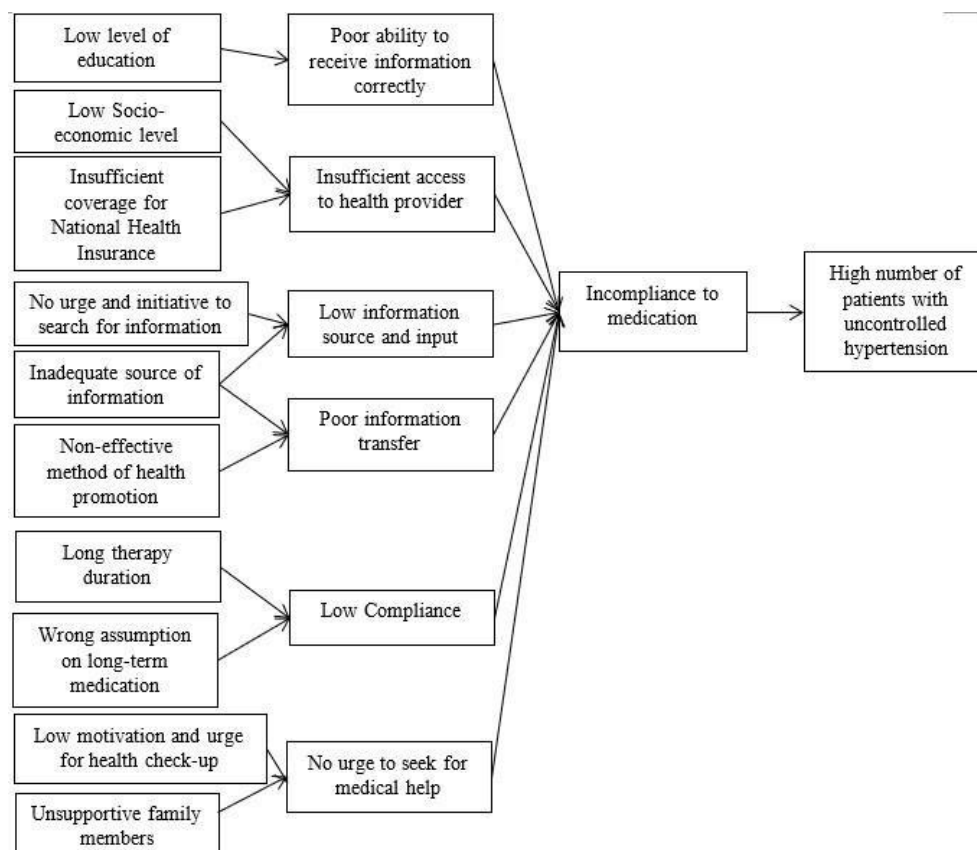


Figure 5 Web of causation for Hypertension.

Table 5 Problem-solving alternatives analysis using cost analysis for hypertension.

No.	Problem-solving alternatives	Criteria				Total (MxIxV/C)	Priority
		M	I	V	C		
1	Make a team of people (preferably health workers or cadres) to routinely check blood pressures	5	3	3	4	11.25	I
2	Hypertension booth	3	4	3	4	9	II
3	Conduct a cooking competition specifically for patients with hypertensive diets.	2	3	4	3	8	III
4	Weekly aerobic programs	3	3	3	4	6.75	IV
5	Design and produce an educational video	2	2	2	2	4	V

Note: M = Magnitude, I = Importance, V = Vulnerability, C = Cost.

3.6.3 Hyperuricemia

The cause analysis of hyperuricemia is depicted in Table 6. Dietary factors are the main issue associated with the high incidence of hyperuricemia. The causes of unhealthy (and purine-rich) eating patterns are further elaborated through the concept of the web of causation (Figure 6).

Figure 6 depicts factors that contribute to a lack of hyperuricemia control and incident of hyperuricemia that go undetected due to poor eating habits, particularly those high in purines. It is based on five main elements: a poor ability to obtain information, a limited food selection, inadequate information input, poor information delivery, and an inability to comprehend information. The researchers then evaluated potential problem-solving measures based on cost analysis, as shown in Table 7. Based on the assessment of alternative solutions to this problem using cost analysis, the chosen alternative is to conduct a competition to on preparing a healthy (low-purine) dish. This is in accordance with the causes of the problems associated with eating patterns and can potentially have a broad effect because of mass involvement.

3.7 Evaluation

Following the completion of prior stages, an evaluation of the selected alternatives is carried out. The evaluation process includes process, impact, and outcome evaluation in either short or long terms. The evaluation process is depicted in Table 8.

Table 6 Root-problem analysis for hyperuricemia.

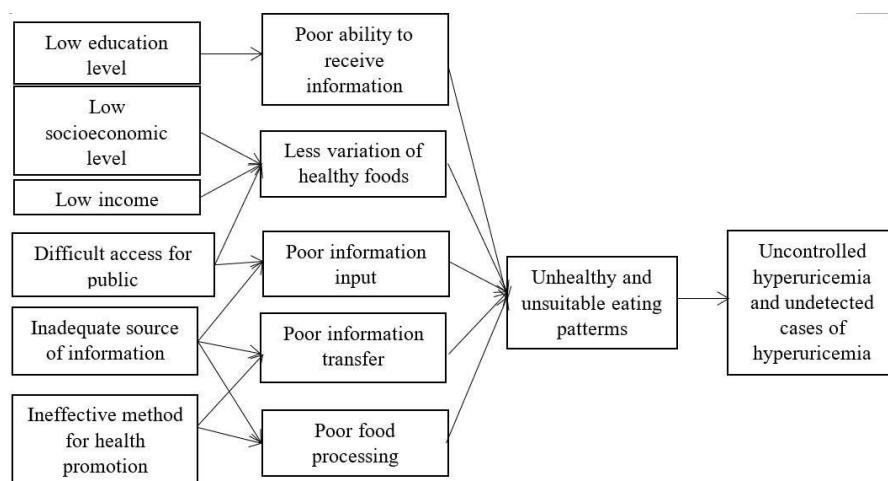
No.	Problems	Criteria								Total	Priority
		A	B	C	P	E	A	R	L		
1.	Unhealthy and unsuitable eating patterns	10	15	7	1	1	1	1	1	175	I
2.	Low compliance on consuming medications	10	16	5	1	1	1	1	1	130	II
3.	Low education level	9	12	6	1	1	1	1	1	126	III
4.	Unsupportive family members	9	11	6	1	1	1	1	1	120	IV
5.	Lack of self-awareness	10	10	6	1	1	1	1	1	120	IV
6.	Lack of screening facilities	2	15	3	1	0	1	1	1	0	-
7.	Low budget allocation for health promotion	4	10	1	1	0	1	1	1	0	-
8.	Low socio-economic level	9	18	1	1	0	1	1	0	0	-

Note: Numbers were calculated using $\frac{(A+B)C}{3} \times D(\text{Pearl Factor})$.

Table 7 Problem-solving alternatives analysis using cost analysis for hyperuricemia.

No.	Problem-solving alternatives	Criteria				Total (MxIxV/C)	Priority
		M	I	V	C		
1	Design and produce an educational video.	2	2	2	2	4	V
2	Increase the frequency of physical activities	2	3	3	3	6	IV
3	Conducting a competition on designing a low-purine menu	4	4	3	4	12	I
4	Home visit to evaluate in-house consumption pattern	3	4	4	5	9.6	II
5	Providing leaflets on lists of food items that have low purine level	4	2	3	3	8	III

Note: M = Magnitude, I = Importance, V = Vulnerability, C = Cost.

**Figure 6** Web of causation for hyperuricemia.

4. Discussion

The suburban areas, which were located outside the city center but within the same region as the metropolitan statistical area, were the focus of our research (Schnake-Mahl and Sommers 2017). Low socio-economic situation (which is linked to high-risk jobs) and low levels of education were the most prevalent social problems identified in this area. Furthermore, clean and healthy living behavior (particularly smoking, sedentary lifestyles, and unhealthy diets) is unsatisfactory, as well as low medication use adherence for chronic diseases such as hypertension, diabetes, and hyperuricemia. Poor housing, according to our findings, is also a source of problems, including insufficient ventilation, a lack of sewer systems, and proximity to numerous factories, all of which increase the risk of infectious diseases and air pollution (Fabre and Rodwin 2011; Mehraj et al 2013).

Behavioral and environmental constraints related to health status or quality of life were identified through educational and organizational diagnosis. Some issues can be identified in the three categories of predisposing, enabling, and reinforcing factors based on our findings (Ashoorkhani et al 2018). Low knowledge (only remembering) (Krouska et al 2018) is one of the major obstacles to the predisposing factors. However, the attitude (accepting the researchers' input) and belief (alternative medicine, pediatric immunization) were still permissible. The enabling factors lacked health post availability, the small number of national health insurance members, and limited transportation access. Problems in reinforcing factors entailed stakeholders, family, neighbors, and the individual's lack of support and motivation. The inability to solve issues related to these three factors could have an impact on residents' health behaviors and well-being (Mazloomymahmoodabad et al 2014).

Table 8 Problem-solving alternatives analysis using cost analysis for hyperuricemia.

Workplan	Process Evaluation	Impact evaluation	Outcome Evaluation
Acute Respiratory Infections (ARIs)			
(Short Term) Increasing the frequency of free medication and health education and collaborating with factories around the site.	Every three months	More reachable health access for the residents of RT 41 Sei Selayur. Residents of RT 41 Sei Selayur will get lots more information on adequate ventilation, treatments for ARI, and its complications. People get to understand and try applying activities to prevent ARI.	Decrease in ARI cases (per year). Increased public knowledge (per 3 months).
(Long Term) Collaborating with companies around RT 41 to make "health boxes" around RT 41 environment, the box contains personal protective equipment to prevent ARI, such as masks and hand sanitizers.	Every three months to restock masks and hand sanitizers	A community that has a high awareness of environmental health and is concerned with preventing ARI because of its location (near a lot of factories).	Reduction in cases of ARI (per 2 years). Increased awareness of to use of personal protective equipment (per year).
Hypertension			
(Short Term) Forming a team of Public Health Center workers and health cadres who routinely assess people's blood pressure every month (including supervisors to remind them to take medicines).	Every three months	The community knows and understands the complications of hypertension and develops a culture with controlled or steady normal blood pressure through routine drug consumption.	The dropout rate is reduced (per 3 months). Increased public awareness (per 3 months).
(Long Term) Hypertension booth	All-year	Early diagnosis for high blood pressure through screenings and independently seek for a routine blood pressure check. Increase in community's knowledge on hypertension, how to prevent hypertension, treatments and how to control high blood pressure.	Recorded data for blood pressure (per month). 75% of people's blood pressure is controlled and steady.
Hyperuricemia			
(Short Term) Conducting a competition about arranging a low-purine meal for residents who are diagnosed with hyperuricemia. (Winner will be awarded food stocks that have low purine content).	Every six months	Providing the community with an adequate and healthy diet. Residents are educated with diets that suit their hyperuricemia condition.	Increased number of patients that did follow-up to health facility about their hyperuricemia (per 6 months). Increased knowledge of the community about dietary restrictions for people with hyperuricemia (per 6 months).
(Long Term) Weekly aerobics that focuses on joint health.	Each month all-year	Increasing knowledge of the community about different joint problems and the right exercise for joint problems. Improving the health of the community by increasing their physical activities.	Recorded data for the number of cases of joint problems (per 3 months). Assessments on residents' physical health (per 3 months).

The previously observed phenomenon (predisposing, enabling, and reinforcing factors) was associated with administrative and policy issues (Porter et al 2018). Our findings revealed that the reluctance to maximize healthcare provision was linked to a lack of funds, personnel (number, workload, and commitment), health post-provision, and stakeholder support, particularly in the chronic disease domain (Mosadeghrad, 2014).

The main health-related problems identified in this study were acute respiratory infections (ARIs), hypertension, and hyperuricemia. The above-mentioned problems have also been identified as the main issues across several Asian nations (Ghimire et al 2013; Li et al 2021; Vaidya et al 2012; Zulaikhah and Sumarawati 2017).

ARIs become the top priority to be solved. The high incidence of ARIs is in line with the data on most diseases found in the working area of the public health center (Zulaikhah and Sumarawati, 2017). The main cause of this problem is related to a lack of knowledge. The level of knowledge based on Bloom's taxonomy is divided into six degrees, namely the ability to remember, understand, apply, analyze, evaluate and create a new knowledge base. All stages must be completed to achieve a behavioral change (Anderson and Krathwohl 2001). In our study, most people only have the lowest level of knowledge (remembering), classified as lower-level analysis (Farmer et al 2021). This is in line with the lack of public awareness to use

personal protective equipment (such as masks) to prevent ARIs due to conditions of the environment that are located very close to pollution sources such as factories and/or a high number of people with smoking habits (Zulaikhah and Sumarawati, 2017).

Based on the previous explanation, knowledge has been identified as the root of the high incidence of ARIs. The web of causation model was applied due to its ability to explain the dynamic changes change in one of the factors, which can change the balance between observed factors, resulting in the increase or decrease in disease development (Broadbent 2009). Three important factors as the mediator of inadequate knowledge were identified, related to the lack of information-capturing, information input, and delivery. This is in line with the concept of health information systems, an intersection between information processes from health service providers and information systems which is collecting data to provide better health services (English et al 2011). The success of this process is associated with cognitive functions, information processing, and communication of information on health practice, health education, and research (Conrick 2006). After the priority causes of the problem are outlined, the final stage includes the process of finding alternative solutions through the method of cost analysis. In analyzing alternative solutions to problems, selected priorities include increasing the frequency of free treatment and health education by cooperating with factories around the site. It is beneficial for promoting self-efficacy, self-management, and awareness in disease prevention (Tunny et al 2020) and in line with the World Health Organization approach from the identification of threats to practical advice (World Health Organization 2006).

The results of the analysis of priority problems found that hypertension becomes the second priority to be tackled. Hypertension has been considered a major problem and a significant contributor to morbidity and mortality in Indonesia (Astutik et al., 2020; Peltzer & Pengpid, 2018) and all over the world (van Kleef and Spiering, 2017). The main cause of hypertension-related concerns is associated with compliance with antihypertensive medication. Low drug use compliance is a severe problem faced by chronic disease sufferers (Nguyen et al 2017; Wiarsih et al 2020). A systematic review has shown that Indonesia has the highest level of non-compliance compared to the findings in 31 other countries, with only 11.8% compliance level (Carvalho and Santos 2019). Difficulty in maintaining adherence is based on various factors such as difficulty in remembering daily medication consumption, the misconception of drug side effects, the complexity of the therapeutic regimen, high treatment costs, difficult access to treatment, and long treatment period (Daniel and Veiga 2013). This is a contributing factor to the poor control of hypertension status in patients, especially in middle to lower-income countries, including Indonesia, which only has 27.1% of patients with controlled hypertension (Bawazir and Sianipar 2019). In addition, bad lipid control in the observed patients was significantly related to our findings (all patients with hypertension have uncontrolled blood pressure) (Umar and Mariana 2021).

In our study, non-routine hypertensive prescription consumption resulted in uncontrolled blood pressure. Information (poor receiving ability, input, and delivery method), limited access to healthcare facilities, difficulty sustaining compliance, and a lack of medical consciousness are all factors that contribute to the problem. This is consistent with widely recognized aspects related to drug use adherence, such as socio-economic, demographic, concomitant medical-behavioral conditions, modes of therapy application, doctor-patient relationships, health system impact, and individual patient factors (Burnier and Egan 2018). In our study populations, forming a collaborative team for blood pressure evaluation and medication supervision was considered as the most suitable alternative. It is a considerable tool for controlling blood pressure and ensuring patient medication adherence. The interaction of these factors has been shown to substantially impact hypertensive patients' blood pressure control (Akoko et al 2017).

Hyperuricemia is the third priority to be resolved in our study. This disorder received increasing attention as a major public health problem (Ni et al 2019) due to its association with numerous metabolic disorders (Chen et al 2007; Usman et al 2019; Wang et al 2018). Based on the root cause analysis, a poor diet was identified as the primary contributor to the high prevalence of hyperuricemia. Various factors influence diet, including knowledge of proper nutrition, processing capability, food awareness, social support, food availability, and grocery bills. Individual, ecological, and social factors are the three categories in which these factors are classified (Kabir et al 2017). Intake of fish and shellfish, according to a study, affects an increase in uric acid levels (Villegas et al 2012). The findings agree with the population's lower-middle socio-economic status, as saltwater fish is the most common source of animal protein, while other sources are unavailable due to cost constraints (Wake and Geleto 2019). Establishing a healthy menu preparation (low-purine dishes) for patients with hyperuricemia is the preferred priority in assessing problem-solving potentials. Because food (especially with purine-rich content) is the most common source of uric acid production, this initiative would be beneficial in reducing the risk of complications (Aihemaitijiang et al 2020). On the other hand, the application of a healthy diet was not limited to purine limitations but also included calorie, fat, animal protein, and salt restrictions (Zhang et al 2016).

Our study has several limitations. Due to the cross-sectional design of this study, respondents were asked to remember past events, which could lead to recall bias. Our study's low sample size has also become a limitation. Meanwhile, our study's strength came from the use of primary data collection, which allowed us to assess any information and ask for clarification directly.

5. Conclusions

Based on the community diagnosis using Lawrence Green's theory (PRECEDE-PROCEED), acute respiratory infections were the highest form of health problem in the studied region, followed by hypertension and hyperuricemia. Level of knowledge is the most significant determinant for the development of these disorders. Thus, the proposed intervention on the enhancement of health education within the community is very essential as a problem-solving alternative. Lawrence Green's theory implementation can significantly assess problems in society by employing a broader context of human life during the diagnosis process.

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Conflict of Interest

The authors declare no conflicts of interest.

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Managing reservoir fisheries: a critical look at reservoir physical environment



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Abstract This short note follows a discussion on a study that assessed reservoir fisheries and ecosystem-based management approaches in Ghana. The main objectives of the study were to develop an understanding of how differences in reservoir morphometry and physicochemical characteristics influence ecosystem structures and fisheries productivity. This involved reviewing and updating empirical models for reservoir harvest estimations, relating morphometric characteristics of the reservoirs to fish production, assessing the exploitation levels and stock status of the reservoirs' target species and providing a holistic description of the reservoirs' biological interactions through a food web modelling approach. To manage reservoirs and associated riverine environments for the benefit of fish and fisheries, reservoirs' status and contribution to capture fisheries production have to be evaluated and addressed. Furthermore, the technical criteria and measures germane to assessment frameworks must be improved. Protecting and enhancing the physical environment of reservoirs for fish production requires considerations of ecosystem perspectives, optimal morphometric characteristics, duration of reservoir filling and development and prevention of critical nutrient enrichment. For enhancing Ghana's fish production, development strategies should focus on fisheries and aquaculture production in rivers, floodplains, lakes, reservoirs, and brackish water systems. Research, policy, and capacity-building issues related to developing these production systems must be addressed adequately. Moreover, to fully exploit their potential, the management requirements of the individual reservoir systems need to be assessed and appropriate regimes implemented with stakeholders.

Keywords: morphometry, physicochemical characteristics, biological interactions, fish production, nutrient enrichment

1. Introduction

Globally, inland fisheries management (including those that operate in reservoirs) is hindered by a lack of scientific understanding of how human activities affect the production potential of rivers and lakes (Cowx et al 2010). Capture fisheries have been heavily exploited worldwide in the past three decades to the extent that fisheries production has stagnated and is likely to dip due to pressures from overfishing, habitat degradation, and pollution, all driven by population increases (Allan et al 2005; Delgado 2003). According to Allan et al (2005), owing to an incomplete understanding of how inland waters function, policymakers, and managers often fail to intervene when fisheries are in decline until the fishery resources have virtually collapsed. Incorporating fisheries into ecosystem approaches for the management of inland waters requires evaluating fisheries exploitation potential and to examine feedback between fisheries, ecosystem productivity and aquatic biodiversity (Beard et al 2011). Findings by (Abobi 2020) and (Abobi et al 2021) suggest reservoirs that are exposed to human activities should be adequately assessed and ecosystem-based management measures developed to sustain the contribution of reservoir fisheries to nutrition and food security and to livelihoods. Indeed, these findings require a critical assessment of approaches to protect and enhance the physical environment of reservoirs for fish production, which is the focus of this short communication.

2. Discussion: enhancing reservoir physical environment, key points for consideration

Reservoirs are rarely constructed solely for fishing. However, as a secondary purpose, fisheries augment the benefits derived from these artificial systems. The factors discussed in the ensuing four paragraphs should be considered in creating an "optimal" reservoir for fishing.

First, the desired fishery should be developed from an ecosystem perspective-including the introduction of commercial species that are adequate in terms of fish production characteristics and ecosystem demands. According to (Cowan Jr et al 2012), the ecosystem approach to fishery has been promoted as one way forward for sustainable management of fisheries resources since it more holistically addresses complex links across human and natural systems, finds conflicts between



competing ecosystem services, and also directly considers direct and indirect impacts of fishing operations on aquatic ecosystems. Similarly, Garcia and Cochrane (2005) highlight the importance of biotic interactions of target species, other species, living habitats, predators, and prey in a conventional fishery management approach. In Africa, the main goal of fish introductions in reservoirs is to sustain or increase yields from wild fisheries. Several studies indicate increases in yield following fish introductions in reservoirs (Aloo et al 2017; Fernando and Holčík 1982; Fernando and Holčík 1991; Ogutu-Ohwayo and Hecky 1991; Petr and Mitrofanov 1998). However, Fernando and Holčík (1991) stress the need to exercise caution in any fish introduction campaign. The impacts of predatory species have been noted. Piscivores have often reduced or even eliminated many resident species in areas where they have been introduced (Ogutu-Ohwayo and Hecky 1991). Also, it has been noted that fish introductions can lead to changes in aquatic ecosystem structure and function. Compared with the direct effects of predation or competition, the effects of ecosystem alterations may be more subtle but may have consequences for the entire fish community and total fish productivity rather than just for the immediate prey or competitor species. Therefore, it is crucial to introduce fish that are adequate in terms of fish production characteristics and ecosystem demands.

Secondly, reservoirs should be constructed with an appropriate size and depth that allows for adequate water spread and habitat diversity for the aquatic fauna and flora. They should be large enough to withstand intense periods of water loss due to droughts. Considering the projected severity of climate change impacts in the region and its associated high evaporation rate (1.5-2 m) and prolonged periods of droughts, a reservoir intended for both irrigation agriculture and fisheries should thus have a surface area of not less than 2 km² and a mean depth of 4m (Abobi 2020). It has been noted that there is a positive association between invertivorous fish and reservoir size (Dos Santos et al 2017). While work done by Abobi et al (2021) indicates that fisheries productivity is inversely related to reservoir size, it was reported that the use of small reservoirs in populated semi-arid environments for both irrigational farming and fisheries production is unsustainable due to problems associated with seasonal water loss, siltation and aquatic habitat degradation. In tropical regions, precipitation and filling of reservoirs are the most critical stages of reservoir fisheries production and thus making reservoir surface area and depth important factors to consider in creating an optimal reservoir for fisheries production. A study by Schneider et al (2015) compared the macrophyte species richness, composition, and vegetation height in water bodies and assessed the most important abiotic explanatory variables (morphometric, physical, and chemical) associated with these assemblage attributes. Species richness and macrophyte assemblage composition were associated with depth, among other factors. Again, these findings demonstrate the importance of reservoir morphometric characteristics to the functional composition and diversity of aquatic flora, which are responsible for primary production in aquatic ecosystems.

Third, the time for maximum filling and system development after construction needs to be taken into account, which very much relates to the size of the reservoir. During the reservoir filling stage, submerged vegetation needs to decompose and soils and sediments need to settle. This is crucial as it has been noted that it may take decades or even centuries for most of the organic matter to decompose (McCully 1996). A thorough clearing of vegetation in the submergence zone is needed before a reservoir is filled. This would allow the acceleration of the reservoir development.

Fourthly, critical nutrient enrichment should be prevented. Under eutrophication conditions, tropical reservoirs may be colonised by aquatic weeds such as water hyacinth (*Eichhornia crassipes*), which can cover water bodies entirely. While these aquatic macrophytes can function as shelter and substrate for young fish (Petrere 1996), excess growth and thick layers of aquatic plants may affect water quality. They can negatively impact the life of fish species and other aquatic organisms and fishing activity (Figure 1). Regulating agriculture and livestock activities within the reservoirs' catchment area will be needed to reduce the introduction of excessive organic matter input into the reservoirs (Abobi and Wolff 2020). In principle, adequate light penetration and nutrient cycling in the reservoir will create optimal conditions for enhanced production (Figure 1).

The Figure 1 provided in this short communication illustrates the benefits and negative environmental consequences of dam construction in tropical regions, which is useful in placing the adaptation and development of fish communities in a relationship with other environmental consequences of impounding the rivers of Africa. The figure was first developed following a project that assessed the environmental impact of a large tropical reservoir and provided guidelines for policy and planning, based on a case study of Lake Volta, Ghana, in 1973 and 1974 (Freeman 1974). The Figure demonstrates that the creation of a reservoir can lead to (i) inundation of agricultural lands, settlements, cultural and archaeological sites, and forests, which can negatively impact fishing as the forest when not adequately removed are left standing in the reservoir and obstructing fishing activities; (ii) the development of new aquatic ecosystem which subsequently creates new spawning environment, new temperature regime and new primary production which determine fish adaptation and fish production rates, phytoplankton and zooplankton production. Reduction in light and phytoplankton production results in reduced primary production and consequently a decline in total fish production and fish catch; and (iii) the creation of disease vector habitats such as open water with water weeds, reservoir edge, quiet water and spillway. These habitats lead to the breeding and prevalence of tropical diseases such as malaria, schistosomiasis, trypanosomiasis, filariasis, onchocerciasis, and other borne pathogens, which have an aquatic snail or fish as host. Management approaches to control water weeds and tropical diseases entail additional costs as well as benefits.

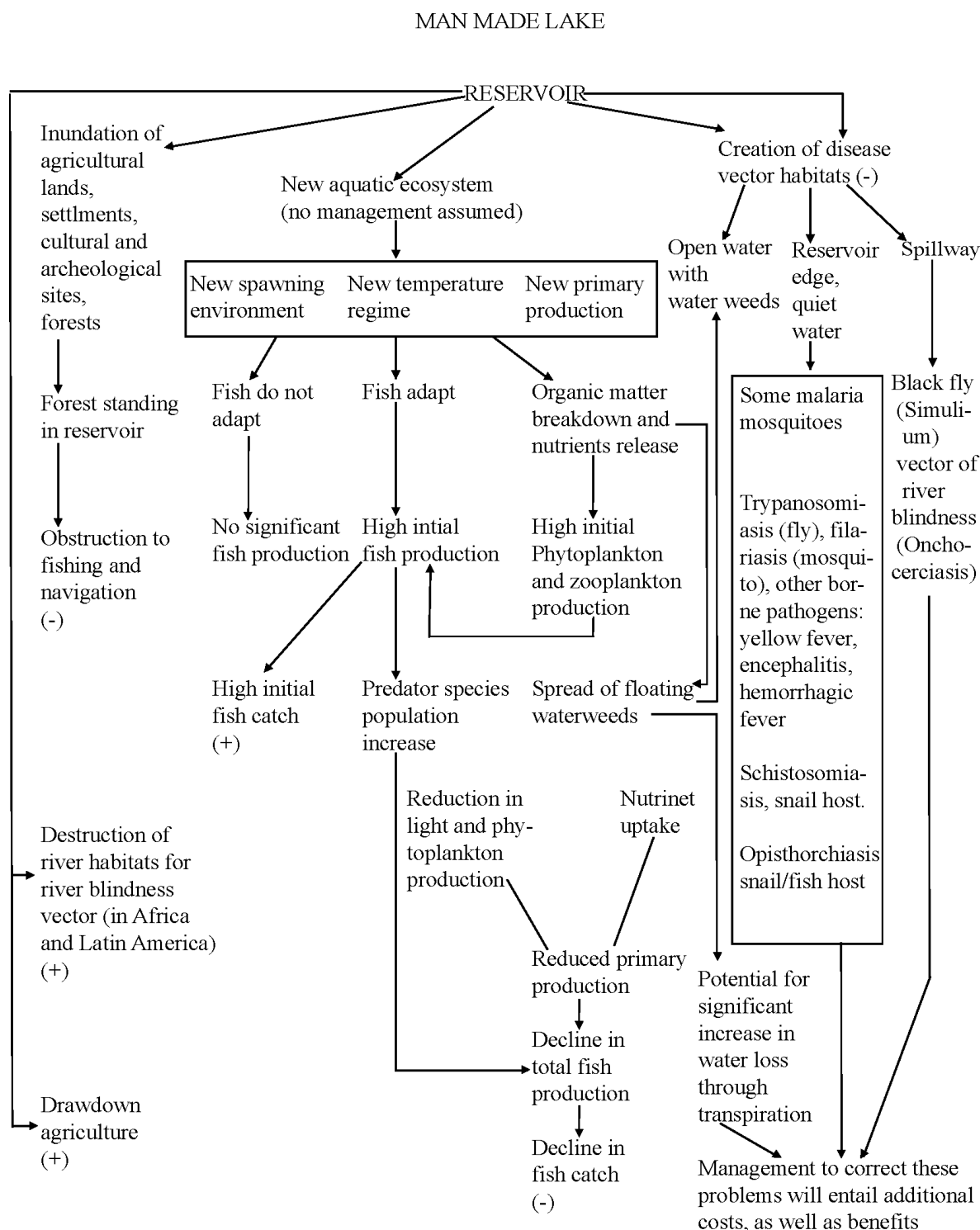


Figure 1 A simplified diagram showing the environmental consequences [Benefits (+) and Costs (-)] of a tropical river impoundment. Redrawn and modified from Freeman (1974) by Petr (1978).

3. Conclusions

Successful management of reservoir systems for fish production requires successful management of agriculture activities in reservoir catchment areas to create a win-win situation for fisheries and agriculture production. As shown in the Figure, the benefits and negative consequences of river impoundment are associated with the development of fish communities in reservoirs. The drawdown of a reservoir's water benefits agricultural production while reducing the size of the aquatic habitat available for fish production. Siltation is the most critical factor that affects reservoir shape, size, and turbidity.

It results from the excessive transport of sediments and silts from reservoirs' catchment areas, and this process has reduced the surface areas of the reservoirs in Northern Ghana (Abobi 2020). Controlling the submerged aquatic macrophytes of reservoirs will enhance the utilisation of primary production and improve the reservoirs' water quality and fishing activity.

Conflict of Interest

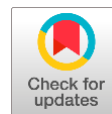
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Management of canine distemper, canine babesiosis, helminthiasis in a 6-month-old Nigerian indigenous breed of dogs bitch in Jos - Nigeria

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Abstract A 6-month-old Nigerian indigenous breed of dog bitch was presented to the Small animal clinic of the University of Jos veterinary teaching hospital, Jos, Plateau State, Nigeria, with the complaint of paresis and involuntary movement of the left hindlimb and no vaccination history. On clinical examination, the vital parameters were temperature of 39.4 °C, pulse rate of 80 beats per minute and respiratory rate of 60 cycles per minute. The clinical signs were congested ocular mucous membranes, bilateral mucoid oculo-nasal discharge, hardened nasal planum, inflamed submandibular lymph nodes (lymphadenopathy), paresis of the hind limbs, hardened footpads, myoclonus of the left hind limbs (distemper myoclonus), fleas on the ventral abdomen, and epilation. Diagnosis was made based on history, clinical signs, lymphopaenia, canine distemper inclusions bodies, and *Babesia canis* on the blood smear. The treatment was symptomatic and supportive. The patient partially recovered 7-days post-therapy as the hind limb myoclonus persisted.

Keywords: multisystemic, digestive, nervous, integumentary, myoclonus, hardpad

1. Introduction

Canine Distemper (CD) is a multisystemic viral disease of dogs and animals of the canine family as well as other carnivores, including large cats (Appel 1987; Headley and Graca 2000). It is highly contagious and caused by the canine distemper virus (CDV) currently known as *Canine morbillivirus*, a member of the genus *Morbillivirus* within the family *Paramyxoviridae* (Murray et al 1995; Anis et al 2018; Rendon-Marin et al 2019), closely related to the viruses which cause Rinderpest, Pestes des petit ruminants (PPR) in ruminants and Measles in humans (Beineke et al 2009).

The disease occurs in a wide range of domestic and wild animal species, and many of these wild animals are known to be reservoirs for maintaining the virus in the canine population through direct or indirect contact with domestic dogs (MacLachlan et al 2011; Martinez-Gutierrez and Ruiz-Saenz 2016). The canine distemper virus can cause disease even in vaccinated animals (SHELL, 1990; Amude et al 2006). Onset of the disease is characterized by diphasic fever, systemic signs affecting the integumentary, gastrointestinal, immune, skeletal, lymphatic, urinary, respiratory, and nervous systems (Lempp et al 2014). Canine distemper is characterized by lymphopaenia, diphasic fever, gastrointestinal and respiratory catarrh, and pneumonic and neurological complications (Mlaga et al 2018).

Clinical signs of canine distemper include a transient fever that usually occurs 3–6 days after infection, with or without leukopenia (especially lymphopenia), usually accompanied by anorexia (Amude et al 2007). The first fever subsides for several days before a second fever occurs (diphasic), which is usually accompanied by serous to mucopurulent oculonasal discharge, lethargy, and anorexia. Gastrointestinal and respiratory signs seen in this disease are typically complicated by secondary bacterial infections. Less frequently, pustular dermatitis may be seen. The occurrence of encephalomyelitis alongside these clinical signs is common, which may follow the systemic manifestations. Dogs that survive the acute phase may have hardened footpads and nasal planum, as well as erupting tooth enamel hypoplasia (Amude et al 2007; Schobesberger et al 2002; Koutinas et al 2004).

The classic neurological signs seen with this disease include localized involuntary muscle twitching (myoclonus, chorea, flexor spasm, hyperkinesia), convulsions including salivation, and chewing gum fits. Other neurological signs include circling, head tilt, nystagmus, paresis to paralysis, and focal to generalized seizures (Vandeveldt et al 2005; Ulrich 2014).

Canine babesiosis is a tick-borne haemoprotozoan disease caused by the large *Babesia canis* and the small *Babesia gibsoni* (Irwin, 2009). The dog population in Jos, Nigeria, is the largest in the country, and dog meat is culturally accepted as a delicacy (Vonkur et al 2022). They are typical intraerythrocytic piroplasms, pear-shaped, found in pairs, and transmitted by *Rhipicephalus sanguineus* in tropical and subtropical countries (S. Sivajothi et al 2014). The disease is characterized by lysis of the red blood cells leading to anaemia (pale mucous membranes), jaundice, depression, tachycardia, tachypnoea, anorexia, weakness, splenomegaly, and fever (Lobetti 2006, Taboada 1998).

Dogs are hosts to a wide spectrum of helminths caused by nematodes, cestodes, and trematodes, of which *Toxocara canis*, *Ancylostoma caninum*, *Dipylidium caninum*, and *Echinococcus* spp. are the most common, and are zoonotic resulting in increased public health risk (Pereira et al 2016). Helminthosis in dogs impedes the successful rearing of dogs resulting in losses manifested by lowered resistance to other infectious agents, poor growth, weight loss, reduced work and feed efficiency, general ill health, and sometimes death if untreated (Soulsby 1982). Clinical signs associated with helminthiasis in livestock and companion animals include epilation, weakness, emaciation, restlessness, unthriftiness, diarrhoea, anaemia, dull-rough hair coat, potbelly, decreased stamina or lethargy, coughing, colic, tail rubbing and sometimes intestinal obstruction or perforation (Stoltenow and Purdy 2003; Hiney and Giedt 2017; Ogbein et al 2022).

2. Case presentation

2.1. Case Signalment and History

A 6-month-old Nigerian Indigenous Breed of Dog bitch weighing 9.5kg was presented to the Small Animal Clinic of the University of Jos Veterinary Teaching Hospital, Jos, in February 2021 with the chief complaint of paresis and involuntary spasms (jerking movements) of the hindlimb. History revealed that limping was noticed four days prior to the presentation. The bitch is fed on a homemade meal supplemented with corn and soya bean meal and has neither vaccination record for Canine Distemper, Canine Hepatitis, Canine Leptospirosis, Canine parainfluenza, Canine Parvovirus, or rabies.

2.2. Clinical Findings

On presentation, the vital parameters were temperature of 39.4 °C, pulse rate of 80 beats per minute, and respiratory rate of 60 cycles per minute (Table 1). The clinical signs noticed were congested ocular mucous membranes, bilateral mucoid oculonasal discharge, hardening of the nasal planum, inflamed submandibular lymph nodes (lymphadenopathy), paresis of the hind limbs, hardening of the footpads (Figure 1 and 2), myoclonus of the left hind limb, fleas on the ventral abdomen and epilation.

Table 1 Patient's Vital Parameters on the day of presentation and subsequent days of treatment.

Parameters Days	Patient's Values					Reference Values
	1	2	3	4	5	
Temperature (°C)	39.4	39.2	39.6	39.4	38.8	37.5-39.4
Pulse Rate (beats/minute)	80	76	72	80	84	65-90
Respiratory Rate (cycles/minute)	60	40	32	28	28	15-30

Source: Hassan et al (2003).

2.3. Diagnosis

A tentative diagnosis was made centered on canine distemper and helminthiasis. Blood and Faecal samples were taken for laboratory assessments. A confirmatory diagnosis of canine babesiosis and canine distemper.

2.4. Laboratory results

The Haemogram showed severe neutrophilic leukocytosis with left shift, lymphopaenia, and eosinophilia. The blood smear shows intracytoplasmic inclusion with neutrophils consistent with canine distemper (Figure 3). *Babesia canis* was also seen on the thin blood smear (Figure 4). There was no gastrointestinal parasite found.

2.5. Management plan / Treatment

Administer the antibiotic indicated for use in the case of Gastrointestinal infection, which is common with Canine Distemper: 50mg Gentamicin injection 5mg/kg (0.95ml) intramuscular (IM) x 5/7 once daily (OD). Place the patient on a sedative to help relax Myoclonus and aid recovery: 25mg Chlorpromazine Injection 4mg/kg (1.52ml) IM x 3/7 OD. Administer an appetizer that also aids nerve regeneration: 9mg Vitamin B complex Injection 0.9mg/kg (0.95ml) IM x 5/7 OD, Use of a non-steroidal anti-inflammatory agent which is also beneficial in nerve regeneration: 25mg Diclofenac Sodium Injection 4mg/kg

(1.52ml) IM x3/7 OD, Place the bitch on ivermectin to handle ectoparasites and take care of intestinal helminths: 10mg Ivermectin Injection 400µg/kg (0.38ml) SC repeat after two weeks, Pour on should be applied to take care of fleas immediately: 2% cypermethrin 5ml.



Figure 1 Hardening the Right hindlimb footpad.



Figure 2 Hardening of the Left Hind limb Footpad.

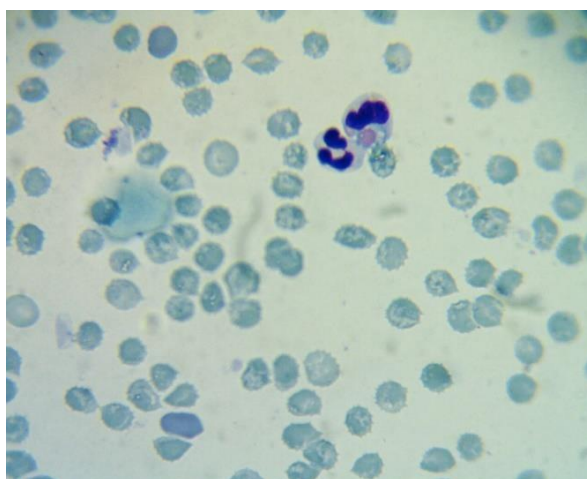


Figure 3 Canine distemper Intracytoplasmic Inclusions.

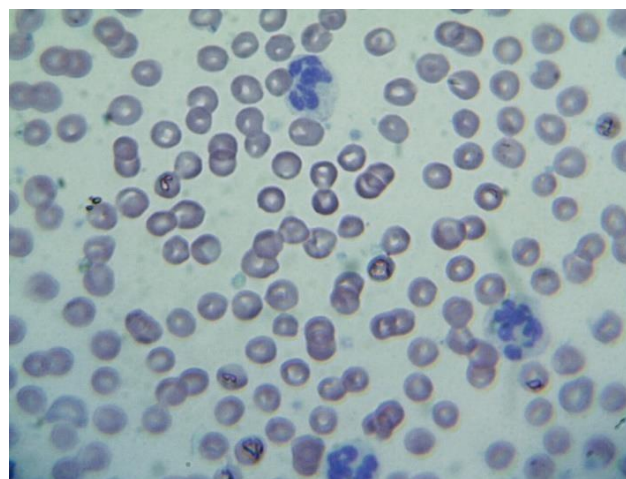


Figure 4 Merozoite of *Babesia canis* on the blood smear.

3. Discussion

On presentation, the history and clinical signs allude canine distemper and helminthiasis, although there were no ticks, pyrexia, or anaemia pointing towards canine babesiosis. Presence of distemper myoclonus, hardening of the footpads, nasal planum, and lymphopenia in blood reports strongly suggested canine distemper because myoclonus and hardening of footpad are considered as the pathognomonic signs of this disease (Tariq et al 2013). The virus can persist in the footpads and lymphatic cells to cause hyperkeratinization, which is why this disease is also called hard pad disease. The only confirmed preventive measure is routine up-to-date vaccination (Tariq et al 2013).

Canine Distemper and helminthiasis were tentatively diagnosed based on the history, and clinical signs, supported by lymphopenia seen on the haemogram and, to a lesser extent, inclusion bodies seen in neutrophils on blood smear, which was indicative of an ongoing viral infection suggested canine distemper. The management plan was to institute therapy immediately, which was targeted at symptomatic and prophylactic treatment as well as to aid nerve regeneration. Upon presentation of the laboratory results, *Babesia canis* was seen on the blood smear, which conferred our diagnosis and treatment towards canine babesiosis. Imidocarb Dipropionate at 5mg/kg B.W was instituted as a treatment for Canine babesiosis. This is due to the fact that disease presents in numerous forms in different animals, and in some animals, the disease may be asymptomatic. As in this case, the dog on presentation had no clinical sign pointing towards Canine Babesiosis, but the disease was present in the animal.

The animal, however, on physical examination, displayed a positive response to treatment within the first 5 days of treatment, but the left hindlimb myoclonus still persisted. Blood sample was also sent to the Pathology Laboratory 7 days post presentation this was done to assess the animal's response to treatment, and all the parameters fell within the normal range (Table 2). This implied that there was a positive response to therapy.

Table 2 Haemogram of the patient.

Parameters Treatment	Patient's Values		Reference values
	Before	After	
HB (g/dL)	14	15	12-18
PCV (%)	44	40	25-55
WBC ($\times 10^3$ /L)	28.20	16.90	6-17
Segmented Neutrophils ($\times 10^3$ /L)	21.99 (78%)	9.53 (56%)	3.6-13.1 (60-77%)
Band Neutrophils ($\times 10^3$ /L)	1.41 (5%)	1.74 (10%)	0-5 (0-29%)
Lymphocytes ($\times 10^3$ /L)	0.51 (1.82%)	4.60 (27%)	0.72-5.1 (12-30%)
Monocytes ($\times 10^3$ /L)	0	0	0.18-1.7 (3-10%)
Eosinophils ($\times 10^3$ /L)	4.29 (15%)	1.03 (6%)	0.12-1.70 (2-10%)
Basophils ($\times 10^3$ /L)	0	0	Rare
Plasma Proteins (g/dL)	10.4	6.2	5.4-7.9

Note: All values are absolute values with the exception of those parameters, which are relative values in percentages (%) (Robert, 2006).

4. Conclusion

Canine distemper, canine babesiosis, and helminthiasis management, in this case, were centered around the gradual improvement of the patient's whole body condition by boosting the patient's immune system and managing the clinical and laboratory conditions.

Acknowledgment

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Ethical considerations

Animal handling and procedures followed the guidelines of the ethics committee on the use of animals in experiments. It is pertinent to acknowledge that verbal consent was taken from the clients who presented their dogs at the University of Jos Veterinary Teaching Hospital for sampling.

Conflict of Interest

The authors declare that they have no conflict of interest.

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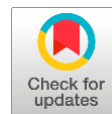
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Genital gangrene in a patient with type II diabetes mellitus, treated with dapagliflozin: a case report



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Abstract Fournier gangrene (FG) is a necrotizing soft tissue infection initiated from the genital area or perineum, irrespective of the sex of the patient. A patient presented in the hospital with the chief complaints of inflammation in the scrotum from the past three days, which finally led to a rise in the body temperature. He also observed the discharge from the scrotum for two days. Six days back, he got mildly injured on the left side of his scrotum after falling off from his two vehicle and did not take any treatment. Local examination revealed that the size of the scrotum is slightly enlarged, tender, and oedematous, along with palpable crepitations. There were very observable patches of gangrene all over the scrotum, with no past of Diabetes Mellitus (DM). After the investigation, broad-spectrum antibiotics cefoperazone with sulbactam along with metronidazole were prescribed. After that, the patient was prepared for surgery immediately. After the surgery, the patient was prescribed appropriate antibiotics, followed by a wet dressing. The antibiogram results interpretation confirms that the combined form sulbactam and cefoperazone cause sensitivity towards *Staphylococcus Aureus* and *Escherichia coli*. His response was positive towards the treatment. The morbidity and mortality of this medical condition have declined over time due to improvements in diagnostic methods, surgical procedures, powerful antibacterial, and intensive care. This is advised to use an advanced approach while handling FG cases to reduce morbidity and mortality, mainly when concomitant conditions like diabetes and multiple organ failure are present.

Keywords: fournier gangrene, soft tissue infection, diabetes mellitus, dapagliflozin

1. Introduction

Fournier gangrene (FG) is a urologic emergency with a potentially high fatality rate. It is polymicrobial necrotizing fasciitis with a rapid progression that affects the vaginal, perianal, and perineal areas (Czymek et al 2010). The use of SGLT2 inhibitors has been linked to an increased risk of genital infection resulting from increased glycosuria. This has caused the FDA to issue a warning regarding the possibility of FG in patients receiving SGLT2 inhibitor therapy. We present the first individual who got FG after dapagliflozin medication at our facility.

A dermatologist and venereologist named Jean Alfred Fournier (1832-1914) described a severe surgical condition known to be Fournier's Gangrene (FG) in 5 young male patients (Czymek et al 2009). They all were presented with an advancing infection of superficial tissue of the human penis and scrotum (Eke 2000). There is not any etiological factor responsible for the condition. It is a well-known fact that Bauriense represented a case similar to FG; the case presented was of scrotal gangrene arising from the wound caused by the impact of an ox horn (Levenson et al 2008). It was treated with multiple surgical interventions. With the passage of time, the definition of FG broadens to include necrotizing infections of the genitalia (Sharma et al 2021; Moon et al 2020).

Currently, FG can be put under the subclassification of necrotizing fasciitis. Therefore we can describe FG as necrotizing soft tissue infections initiated from the genital area or perineum, irrespective of the sex of the patients (Gupta et al 2018), (Muhammad et al 2020).

2. Case Presentation



A patient presented in the hospital with the chief complaints of inflammation in the scrotum from the past three days, which finally led to a rise in the body temperature. He also observed the discharge from the scrotum for two days. Six days back, he got mildly injured on the left side of his scrotum and did not take any treatment. He was a non-alcoholic, non-smoker. After his complete examination, his vitals were as listed: pulse- 110/min, blood pressure - 110/78 mm Hg, and no pallor, icterus, or lymphadenopathy. No abnormalities were observed in the systemic examination. At the same time, local examination revealed that the size of the scrotum is slightly enlarged, tender, and oedematous, along with the palpable crepitations.

There were very observable patches of gangrene all over the scrotum, with no past of Diabetes Mellitus (DM). After the investigation, broad-spectrum antibiotics cefoperazone with sulbactam along with metronidazole were prescribed. After that, the patient was prepared for surgery immediately. Before getting under surgery, his blood profile was seen, which revealed specific parameters like hemoglobin (Hb%) – 114 gm%, WBC – 19,500/cm, which shows polymorph nuclear leucocytosis (N-85%). Other blood investigations such as urea in blood; 39 mg%, blood serum creatinine: 1.0 mg%, LFT: within regular range random blood sugar: 110 mg%, all were within acceptable limits. The patient then underwent debridement, and the extracted tissues were removed. The extracted discharge containing pus cells was sent for laboratory investigation using a culture sensitivity test. After the surgery, the patient was prescribed appropriate antibiotics, followed by a wet dressing. The antibiogram results after interpretation confirm that the combined form sulbactam and cefoperazone cause sensitivity towards *Staphylococcus aureus* and *Escherichia coli*. His response was positive towards the treatment. The povidone-iodine solution was used regularly for antimicrobial action, followed by wet dressing. After ten days of the surgery, the missing tissue was restored through secondary suturing; the patient was discharged from the hospital on the 22nd post-surgical day. Follow-up and proper clinical examination conducted post six weeks of operation shows that the patient was now free of all the symptoms.

The study correctly followed the ethical policies on human subject studies, according to Helsinki guidelines.

3. Discussion

FG is a grave problem, resulting in a very high mortality and morbidity rate. Although FG revolves around men only now, we can also see it in the pediatric group (Auerbach et al 2020). Till today we have never encountered any such condition in females, but there is a high incidence rate of 31.6% in females, as suggested by a recent publication; it is all because of vulvar and Bartholin gland abscesses and also due to the post-surgical period followed by episiotomy and hysterectomy (Engels et al 2020).

Many etiological factors are responsible for the condition, such as obesity, renal insufficiency, alcoholism, age, and paraplegia (Ekingen et al 2008). Around 30 % to 40% of cases have no predisposing factors. A focus of infection usually arises from GIT in up to 50% of cases, gastro urinary tract in up to 40%, and cutaneous injuries and soft tissues (20%). According to the sources, we have observed that FG gets fulminant from minor injuries or soft tissue infections (Itami et al 2022).

FG is multi-microbial sepsis of (GU) genitourinary; it is nearly impossible to detect its entrance path. Two methods only observe the microbial growth: direct injury over the scrotum or directly speeded from urogenital organs or ruptured viscus, for example, colon, anal orifice, and rectum (Kostovski et al 2021). A study shows that the path of the entrance is found to be colorectal (21%), urogenital (19%), and dermatological (19%), whereas the remaining 36% do not have any exact way to enter was found. We usually see infection in three types of necrotizing soft tissues. TYPE1: in these, two or more bacteria act together, like gram +ve and gram -ve with anaerobes, which are observed in the culture. TYPE 2: usually, only one bacterium is responsible for the caused infection, Group A *streptococcus* or maybe *Staphylococcus aureus*. TYPE 3: we have never encountered this infection-causing variety called *Vibrio vulnificus*. Type 2 is more common than type 1 (Prasan et al 2012).

FG can be clinically diagnosed using different radiological methods; Plain radiography is used to detect gas in the soft tissues, and ultrasonography will help in the detection of gas in the wall of the scrotum. However, except all the methods, a CT scan will help in the diagnosis and will help reach the extent of the disease. Although all the above scans are beneficial, ultrasound is easily and commonly reachable by the patients and helps diagnose moderately. Therefore, ultrasound is used in almost every case to get a final opinion.

Biochemical studies such as WBC will be an indicator during diagnosis and clinical presentation. After observing several cases, we concluded that specific parameters such as low albumin, high (BUN) blood urea nitrogen, low hematocrit, hypercalcemia, and increased serum lactate indicate a high mortality rate (Serrano et al 2022).

FG management is very much dependent on the versatile approach. Firstly, rejuvenating the fluid therapy, controlling the cardiopulmonary functions, and getting it in the normal ranges, especially for patients with septic shock, is most important at that time. Broad-spectrum antibiotics were suggested to suppress all the aggressive surgical debridement. It is the primary treatment. We can modify the suggested antibiotics or their dose per the culture report. It is essential to remove all the devitalized tissues; it will help in the progression of the infection. It will simultaneously eliminate toxins and bacteria. It requires more than one surgical debridement to control the local infection. It is essential to handle the post. It has been recommended to use wet-to-dry dressings, VAC dressings (dressings with vacuum-assisted closure devices), and other topical treatments. We choose daily wet dressing and povidone-iodine topical treatment. Comparing VAC treatments to wet-to-dry dressings has revealed improved granulation tissue and decreased wound surface area. Healthy granulation tissue develops with appropriate

surgical debridement, regional wound care, and antibiotic therapy. Most of the time, as observed in both patients, primary wound closure is possible. However, any reconstructive treatment, including different flap covers, may be considered depending on the circumstances and the extent of the tissue loss. High morbidity from severe cell debris loss in the genitalia and perineum can be prevented by restoring surgery procedure that uses enough tissue to cover the defect (Thwaini et al 2006)

5. Conclusions

With a fatal outcome, FG is a significant surgical emergency. The morbidity and mortality of this medical condition have declined over time due to improvements in diagnostic methods, surgical procedures, powerful antibacterial, and intensive care. The mortality rate regarding FG in hospital settings has dropped to 10 and 20 percent due to the better multimodality therapy approach. Two FG cases are presented here. The young adult in our first example had FG but no other concurrent conditions. Without any substantial postoperative morbidity, he made a full recovery. Our second example was an elderly man with diabetes mellitus, other concurrent conditions, and numerous abnormal organ functions. The subject experienced a turbulent post-surgery period with considerable morbidity. He recovered more slowly than others. In our experience, lowering morbidity and mortality in FG with diabetes mellitus is almost always more complicated. This is advised to use an advanced approach while handling FG cases to reduce morbidity and mortality, mainly when concomitant conditions like diabetes and multiple organ failure are present.

Ethical considerations

The study correctly followed the ethical policies on human subject studies according to Helsinki guidelines.

Conflict of Interest

The authors declare that they have no conflict of interest.

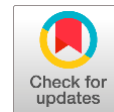
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Erratum to: HER2/p53 ratios among canine mammary tumours and respective derived cell culture



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The article was originally published with two missing author names and incorrect author name sequencing. This erratum aims to correct the original paper, which has been updated:

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