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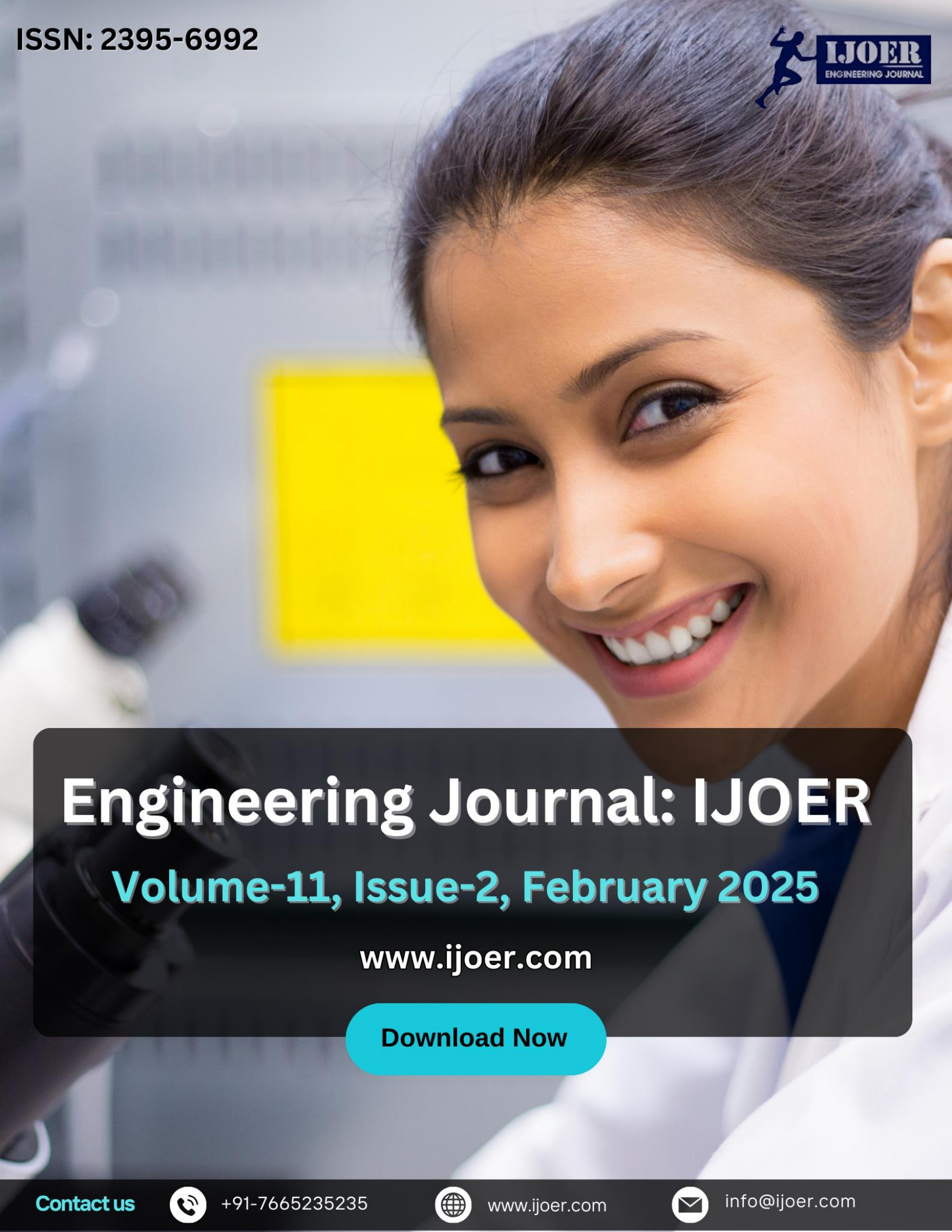

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Preface

We would like to present, with great pleasure, the inaugural volume-11, Issue-2, February 2025, of a scholarly journal, *International Journal of Engineering Research & Science*. This journal is part of the AD Publications series *in the field of Engineering, Mathematics, Physics, Chemistry and science Research Development*, and is devoted to the gamut of Engineering and Science issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

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Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with IJOER. We are certain that this issue will be followed by many others, reporting new developments in the Engineering and Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOER* readers and will stimulate further research into the vibrant area of Engineering and Science Research.

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Association of Socioeconomic Characteristics, Knowledge, Attitudes, and Practices towards Dietary Management with Anthropometric Indices of Type 2 Diabetics in Federal Medical Centre, Umuahia Nigeria

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Abstract—

Background: *Increasing prevalence of poorly controlled diabetes with huge health complications necessitated the evaluation of the association of socioeconomic characteristics, knowledge, attitude, and practices (KAP) towards dietary management with anthropometric indices of type 2 diabetics Federal Medical Center, Nigeria.*

Objective*: The study examined the associations between socio-economic characteristics, KAP towards dietary management, and anthropometric indices of diabetics.*

Methodology: *The cross-sectional study assessed 50 diabetics purposively selected from the hospital's outpatient clinic. Socioeconomic characteristics, KAP towards dietary management were obtained with a validated structured interviewer-administered questionnaire. Anthropometric indices (body mass index BMI and waist circumference WC) were assessed using standard methods. Data were analyzed with IBM Statistical Product for Service Solution (SPSS) version 21.0, and presented with descriptive statistics, Chi-square, and Pearson correlation.*

Results*: The patients were mainly rural (52%), female (62%), ≥ 40 years (88%), married (96%), and monogamous (84%). Sixty-two percent had below primary education status, 94% were employed, and 56% earned below ₦20,000/month. BMI and WC were high in 50% and 54% respectively; many (68%, 53%, and 67%) had good KAP towards dietary management respectively. Positive correlations exist between occupation and WC (r^2=0.537; p=0.000); education attained with BMI (r^2=0.293; p=0.039), and WC (r^2=0.676; p=0.000), income level and BMI (r^2=0.453; p=0.001), nutrition knowledge and WC (r^2 = 0.517; p=0.000); and KAP and BMI (r^2=0.355; p=0.012) of the diabetics. Negative relationships exist between knowledge of dietary management and BMI (r^2=-0.328; p= 0.020) and WC (r^2=-0.485; p=0.000).*

Conclusion*: Waist circumference had significant positive associations with education attained, occupation, and nutrition knowledge; nutrition knowledge correlated significantly with education attained.*

Keywords— Socioeconomic, knowledge, attitude, practice, anthropometry, diabetics.

I. INTRODUCTION

Diabetes mellitus is a metabolic disorder of chronic high blood sugar levels associated with disturbances in macronutrient metabolism resulting from absolute or relative insulin deficiency with dysfunction in organ systems [1]. It is globally associated with a high disease burden and has been described as one of the global leading causes of death [2, 3]. The world's prevalence of diabetes is on a steady increase, 10.5% of adults (20 – 79 years) about 537 million people are currently with diabetes, almost 50% are unaware of the condition and 90% have type 2 diabetes [3]. In Africa, the prevalence is 4.5% an estimate of 24 million adults (20 – 79 years) with diabetes, and it is predicted to increase to 129% (55 million people) by 2045 [2]. Mortality increases every second, and legs/arms are being amputated continually due to diabetes complications [4, 5]. Initially, Nigeria had about 3.2 million cases especially type 2 diabetes [6]. This prevalence is alarming, because the earlier rate in Nigeria was 1-7% of the population [7], but onward the prevalence of diabetes came up to 5.77% [8]. The increase in the incidence of diabetes

especially type 2 in developing countries has been attributed to urbanization, the aging population, lifestyle changes resulting in decreasing physical activity, and increasing overweight and obesity prevalence [3]. This upsurge in the prevalence of diabetes is known to be accompanied by tremendous losses in national income and livelihood [9]. In Nigeria, the blood glucose level of known diabetics continues to rise due to poor management resulting from poorly functioning National Health Insurance Scheme (NHIS) and health bills fully funded by individuals [10]. The situation is complicated and predisposes the patients to organ damage, dreadful chronic diseases like hyperlipidemia, hypercholesterolemia, cardiovascular diseases, kidney problems, and a host of other complications, leading to amputations and eventually death. The huge health cost attributed to this condition is regrettable considering that dietary modification apart from being the clinically recommended primary therapy for diabetes mellitus [11], is also the simplest and cheapest form of diabetes treatment. Diet has since been proven to be the best long-term therapy in the management of diabetes [12]. This global high prevalence of diabetes which is compounded with many undiagnosed diabetes and improper or unsatisfactory management and control of blood glucose of known diabetics, raises questions like what is the problem, why is there poor control of blood glucose in diabetics despite the existing dietary modifications?

As a chronic illness, diabetes requires sound knowledge of self-care and informed decisions by the patients for effective management. Patients with increased BMI are at higher risk of diabetes, and increased WC means that excessive fat have been deposited around the internal organs (liver and pancreas) which will result in insulin resistance. Both indices are associated with incidence of heart failure and other chronic diseases in diabetics [13]. The current increase in poorly controlled diabetes coupled with a dearth of research on the knowledge, attitude, and practices of dietary management of diabetic patients in Nigeria, calls for immediate investigation on the associations of socio-economic characteristics, knowledge, attitude, and practices towards the dietary management of diabetic patients with their anthropometric indices (BMI and WC) as these concepts could impact on the disease outcome.

II. MATERIALS AND METHODS

2.1 Study design:

A cross-sectional survey design was used for the study.

- **Survey area:** The survey was carried out in the outpatient clinic of Federal Medical Center (FMC), Umuahia, Abia State Nigeria. The Hospital is a tertiary health facility located in the state capital Umuahia [14]. The facility caters to patients in the state capital as well as referrals from within and outside the state and has an accredited Dietetic Center.
- **Population of the study:** The study population is composed of out-patients diabetics attending the Special clinic of the Federal Medical Centre Umuahia, Nigeria.

2.2 Sample size and Sampling technique:

The sample size was obtained using the prevalence of diabetes (4.3%) in Africa for adults (20-79) years [15] to calculate with the sample size formula - sample size (n) $=Z^2xP\ (100\text{-}P)/x^2$ where p= prevalence rate of diabetes (4.3%), z = confidence interval taken at 95% probability (1.69) and approximately 2%, x = width of confidence interval at 5% probability. Thus, sample size (n) $= 1.69^2$ x 4.3 (100-4.3)/5^2 = 12.28123 x 95.7/25 = 47.013 which was approximated to 50

2.3 Sampling techniques:

The Federal Medical Centre Umuahia has no clinic days for diabetic patients only, thus any diabetic patients that were available on each visit to the specialist clinic and willing to participate were purposively selected and used for the study.

2.4 Ethical approval and Informed consent:

A written proposal was submitted for approval to the Health Research Ethics Committee (HREC) of the Federal Medical Centre Umuahia. The proposal was thoroughly reviewed, scrutinized, and approved, and the ethical certificate was issued (FMC/OEH/G.596/Vol.10/039). The study respondents were duly informed of the study, and only those who gave their consent were used for the study.

2.5 Data collection:

- **Questionnaire**: A validated interviewer-administered structured questionnaire was used to obtain information on the socioeconomic characteristics, knowledge, attitude, and practice of diabetics toward dietary management.
- **Anthropometry**: Anthropometric indices weight, height, and waist circumference were obtained using standard procedure [16]. The weight of each respondent barefooted and with minimum clothing was measured with a

mechanical scale (M1206 Body weight Szt-120 with stadiometer) to the nearest 0.1kg. The height of each respondent standing erect on a platform without shoes looking straight ahead with hands on the sides, and the moveable headplate on the crown of the head was measured to the nearest 0.1cm with a stadiometer (M1206 Body weight Szt-120 with stadiometer). BMI was calculated with the equation Weight (kg) / Height (m^2), where Wt. (kg) = weight of the patient in kilogram, and Ht.(m^2) = height of the patients in meter square.

The waist circumference of the respondents was obtained with a flexible non-stretchable fiber tape. The respondents were made to stand at ease with their weight evenly distributed on both feet, with the feet placed about 25 to 30 cm apart. The waist circumference was taken midway between the upper hip bone and the uppermost border of the right iliac crest. The tape was placed around the abdomen at the level of the midway point, and readings were taken with the tape snug to the skin to the nearest 0.1 cm.

2.6 Statistical analysis:

Data generated from the study were analyzed with IBM Statistical Product for Service Solution (SPSS) version 21.0 software and results were presented with descriptive statistics (frequencies, and percentages). BMI and WC were obtained, graded, and compared with standards. BMI <18.5kg/m^2= underweight, 18.5 to 24.9 = normal weight, 25 to 29.9 overweight/pre-obesity, 30.0 to 34.9 = obesity class 1 (WHO). Healthy WC = ≤ 35 inches for women, ≤ 40 inches for men (National Heart, lung, and Blood Institute, American Heart Institute, International Diabetes Federation). Chi-square and Pearson's correlation were used to determine the associations between socio-economic characteristics, knowledge, attitudes, and practice of diet therapy of patients with BMI and WC.

III. RESULTS

More than half (52%) of the patients were Abia indigenes, residing in rural areas (table 1). Many (88%) were equal to or above 40years of age, more (62%) females than males (32%) and 100% Christians. Sixty-two percent were married and 84% were monogamous. Almost half (46%) attained primary education status, 28% in civil service and more than half (56%) earned less than ₦20,000/month.

TABLE 1
PERSONAL AND SOCIOECONOMIC STATUS OF TYPE 2 DIABETIC PATIENTS

Characteristics	Variables	Frequency (%)	Characteristics	Variables	Frequency (%)
State of origin	Abia	26(52)	Religion	Christianity	50(100)
	Anambra	4(8)		Others	0(0)
	Delta	1(2)		**Total**	**50(100)**
	Cross River	1(2)	Type of family	Polygamous	8(16)
	Ebonyi	1(2)		Monogamous	42(84)
	Imo	17(34)		**Total**	**50(100)**
	Total	**50(100)**	Education level	No formal education	8(16)
Area of residence	Urban	24(48)		Primary	23(46)
	Rural	26(52)		Secondary	11(22)
	Total	**50(100)**		Tertiary	8(16)
Age	20-29 years	1(2)		**Total**	**50(100)**
	30-39 years	5(10)	Occupation	Civil servants	14(28)
	≥40	44(88)		Business	15(30)
	Total	**50(100)**		Students	3(6)
Sex	Male	19(38)		Artisans	7(14)
	Female	31(62)		Farmers	7(14)
	Total	**50(100)**		Self-employed	4(8)
Marital status	Married	31(62)		**Total**	**50(100)**
	Single	2(4)	Monthly income	Less than ₦ 20,000	28(56)
	Divorced	1(2)		₦20,000-50,000	15(30)
	Widowed	16(32)		₦60,000-500,000	7(14)
	Total	**50(100)**		Above ₦ 500,000	0(0)

Most of the patients (96%) were diagnosed by doctors (table 2). Many (72%) have had diabetes for over two years, 52% had different complications with as much as 20% having diabetic retinopathy only. Many (62%, 44%) had chronic diseases and diabetes running in their families respectively, and up to 40% had family members (1 to 3) with (20% siblings) diabetes.

TABLE 2
DISEASE HISTORY OF TYPE 2 DIABETIC PATIENTS IN THE STUDY AREA

Parameters	Variables	Frequency (%)	Parameters	Variables	Frequency (%)
Type of diabetes	Type 1	2 (4)	**Diseases in family**	None	19(38)
	Type 2	48 (96)		Hypertension	6(12)
	Gestational	0 (0)		CVD	1(2)
	Total	**50(100)**		Diabetes	19(38)
Diagnosed by	Doctors	48(96)		Hypertension & diabetes	3(6)
	Nurses	0(0)		Hypertension & CVD	1(2)
	Dietitians	0(0)		Kidney problem	1(2)
	Family members	2(4)		**Total**	**50(100%)**
	Total	**50(100%)**	**Diabetic members**	None	9(18)
Diabetes duration	< 6month	4(8)		1 to 3	20(40)
	6months	2(4)		4 to 6	3(6)
	One year	4(8)		Above 6	2(4)
	Two years	4(8)		Uncertain	16(32)
	> 2 years	36(72)		**Total**	**50(100%)**
	Total	**50(100%)**	**Persons affected**	Father	5(10)
Complications	None	24(48)		Mother	1(2)
	Retinopathy	10(20)		Siblings	10(20)
	Nephropathy	1(2)		Father + others	4(8)
	Neuropathy	2(4)		Mother + siblings	3(6)
	Weight loss	2(4)		Father & mother	1(2)
	Foot ulcer	4(8)		Uncertain	26(52)
	Multiple complications	7(14)		**Total**	**50(100%)**
	Total	**50(100%)**			

Almost half (46%) of the patients had good nutrition knowledge, 68% had good dietary management knowledge, 52.8%, and 67% had good attitudes, and practice of dietary management respectively (table 3). Dietary care was mainly (38%) from doctors, 68% were on diet therapy with 36% over five years.

TABLE 3
KNOWLEDGE, ATTITUDE, AND PRACTICES OF THE TYPE 2 DIABETIC PATIENTS

Parameter	Variables	Frequency (%)	Parameter	Variables	Frequency (%)
Nutrition knowledge	Good	23(46)	Diet care	Doctors	19(38)
	Poor	16(32)		Nurses	2(4)
	Very poor	11(22)		Dietitians	13(26)
	Total	**50(100%)**		Self	16(32)
Dietary management. Knowledge	Good	34(68)		**Total**	**50(100%)**
	Poor	11(22)	Diet therapy	Yes	34(68)
	Very poor	5(10)		No	16(32)
	Total	**50(100%)**		**Total**	**50(100%)**
Attitude	Good	26.4(52.8)	Diet duration	0-6months	6(12)
	Poor	5(10)		6-1 year	1(2)
	Very poor	18.6(37.2)		1-3 years	6(12)
	Total	**50(100%)**		3-5 years	3(6)
Practice	Good	33.5(67.0)		> 5 years	18(36)
	Poor	10(20)		Uncertain	16(32)
	Very poor	6.5(13.0)		**Total**	**50(100%)**
	Total	**50(100%)**			

Most (80%) patients did not indicate quitting dietary regimen, 42% had inconsistent dietary regimen due to poverty, and 62% had no response for challenges encountered (table 4). Health was the main (32%) motivation for good attitude and practice of dietary management.

TABLE 4
FACTORS INFLUENCING TYPE 2 DIABETICS' ATTITUDES AND PRACTICES TO DIETARY MANAGEMENT

Parameters	Factors	Frequency (%)	Parameters	Factors	Frequency (%)
Quitting of diet regimen	Social	4(8)	**Challenges**	Expensive	15(30)
	Economic	4(8)		Lifestyle	2(4)
	Stress	2(4)		Religion	2(4)
	None	40(80)		No response	31(62)
	Total	**50 (100.0)**		**Total**	**50 (100.0)**
Inconsistent diet regimen	Friends& Family	2(4)	**Motivation**	Health	16(32)
	Limited time	1(2)		Advice	13(26)
	Poor food preparation skill	1(2)		Availability of resources	1(2)
	Lack kitchen facility	2(4)		Health and advice	1(2)
	Lack of money	21(42)		Nothing	19(38)
	Preference	2(4)		**Total**	**50 (100.0)**
	None	22(44)			
	Total	**50 (100.0)**			

Many (44%) had normal BMI while 38%, 12%, and 6% were overweight, obese, and underweight respectively, with no significant (x^2=5.453; p=0.141) difference in the BMI of the male and female patients (table 5). More than half of the population (54%) had abnormal waist circumference with significant (x^2=6.202; p=0.013) difference in the waist circumference of the male and female outpatients.

TABLE 5
BODY MASS INDEX AND WAIST CIRCUMFERENCE OF TYPE 2 DIABETICS

Parameters	Classification	Male Freq	%	Female Freq	%	Total Freq	%	X^2	p-value
Body Mass Index	Underweight (<18.5)	1	5.3	2	6.5	3	6	**5.45**	**0.141^{ns}**
	Normal weight (18.5-24.99)	5	26	17	55	22	44		
	Overweight (25-29.99)	11	58	8	26	19	38		
	Class I obesity (30-34.99)	2	11	4	13	6	12		
	Total	19	100	31	100	50	100		
Waist circumference									
Normal	Female (<88); Male (<102)	13	68	10	32	23	46	**6.2**	**0.013***
Abnormal	Female (>88); Male (>102)	6	32	21	68	27	54		
	Total	19	100	31	100	50	100		

Positive correlation coefficients $r^2 = 0.355$ at $p = 0.012$, and $r^2 = 0.517$ at $p = 0.000$ exist between KAP and BMI; and waist circumference and knowledge of nutrition respectively; and negative correlation coefficients ($r^2 = -0.328$ at $p = 0.020$; $r^2 = -0.485$ at $p=0.000$) between knowledge of dietary management of the respondents on their BMI and waist circumference respectively (table 6). There was also a positive correlation coefficient ($r^2=0.405$ at $p = 0.004$) between the attitudes of the respondents toward diabetes management and their waist circumference. The dietary practices of the respondents negatively correlated ($r^2= 0.328$ at $p=0.020$) with their BMI.

TABLE 6
RELATIONSHIP OF TYPE 2 DIABETICS' KNOWLEDGE, ATTITUDES, AND PRACTICES WITH BMI AND WC

Correlation Parameters		Nutrition knowledge	Dietary mgt	Attitude	Practice	BMI	WC
Nutrition knowledge	Pearson Correlation	1	-.485**	.405**	-.485**	.355*	.517**
	Sig. (2-tailed)		0	0.004	0	0.012	0
	N	50	50	50	50	50	50
Dietary mgt	Pearson Correlation	-.485**	1	-0.058	.357*	-.328*	-.485**
	Sig. (2-tailed)	0		0.687	0.011	0.02	0
	N	50	50	50	50	50	50
Attitude	Pearson Correlation	.405**	-0.058	1	-.659**	0.08	.405**
	Sig. (2-tailed)	0.004	0.687		0	0.58	0.004
	N	50	50	50	50	50	50
Practice	Pearson Correlation	-.485**	.357*	-.659**	1	-.328*	-0.227
	Sig. (2-tailed)	0	0.011	0		0.02	0.113
	N	50	50	50	50	50	50
BMI	Pearson Correlation	.355*	-.328*	0.08	-.328*	1	.458**
	Sig. (2-tailed)	0.012	0.02	0.58	0.02		0.001
	N	50	50	50	50	50	50
WC	Pearson Correlation	.517**	-.485**	.405**	-0.227	.458**	1
	Sig. (2-tailed)	0	0	0.004	0.113	0.001	
	N	50	50	50	50	50	50

*****. Correlation is significant at the 0.01 level (2-tailed)***
****. Correlation is significant at the 0.05 level (2-tailed)***

Nutrition knowledge was positively associated with education attainment ($r^2 = 0.535$; $p = 0.000$), Knowledge of dietary management of diabetes has negative association with the occupation of the respondents, income level significantly ($r^2 = 0.280$; $p = 0.049$) influenced the knowledge of dietary management (table 7). Attitude of the respondents towards diabetes significantly ($r^2 = 0.512$; $p = 0.000$) influenced their education attainment. There was negative association ($r^2 = 0364$; $p = 0.009$) between attitude of the respondents and age. No significant association was found between the practice of the patients toward diabetes and their socioeconomic variables such as age ($r^2 = 0.240$; $p = 0.093$), marriage ($r^2 = 0.135$; $p = 0.350$), occupation ($r^2= -0.020$; $p = 0.888$), education ($r^2 = -0.085$; $p = 0.555$) and income ($r^2 = 0.102$; $p = 0.481$).

TABLE 7
RELATIONSHIP OF TYPE 2 DIABETICS SOCIOECONOMIC DATA ON KNOWLEDGE, ATTITUDES, AND PRACTICES

Correlation Parameters		Nutrition knowledge	Dietary mgt	Attitude	Practice	Age	Marriage	Occupation	Education	Income
Nutrition knowledge	Pearson Correlation	1	-.485**	.405**	-.485**	0.078	-0.002	0.273	.535**	-0.037
	Sig. (2-tailed)		0	0.004	0	0.59	0.987	0.055	0	0.801
	N	50	50	50	50	50	50	50	50	50
Dietary mgt	Pearson Correlation	-.485**	1	-0.058	.357*	-0.188	0.135	-.354*	-0.055	.280*
	Sig. (2-tailed)	0		0.687	0.011	0.19	0.35	0.012	0.703	0.049
	N	50	50	50	50	50	50	50	50	50
Attitude	Pearson Correlation	.405**	-0.058	1	-.659**	-.364**	0.001	0.258	.512**	0.004
	Sig. (2-tailed)	0.004	0.687		0	0.009	0.994	0.07	0	0.976
	N	50	50	50	50	50	50	50	50	50
Practice	Pearson Correlation	-.485**	.357*	-.659**	1	0.24	0.135	-0.02	-0.085	0.102
	Sig. (2-tailed)	0	0.011	0		0.093	0.35	0.888	0.555	0.481
	N	50	50	50	50	50	50	50	50	50
Age	Pearson Correlation	0.078	-0.188	-.364**	0.24	1	-0.17	0.078	0.006	-0.134
	Sig. (2-tailed)	0.59	0.19	0.009	0.093		0.237	0.592	0.965	0.354
	N	50	50	50	50	50	50	50	50	50
Marriage	Pearson Correlation	-0.002	0.135	0.001	0.135	-0.17	1	-.333*	-0.157	-.482**
	Sig. (2-tailed)	0.987	0.35	0.994	0.35	0.237		0.018	0.277	0
	N	50	50	50	50	50	50	50	50	50
Occupation	Pearson Correlation	0.273	-.354*	0.258	-0.02	0.078	-.333*	1	.523**	0.112
	Sig. (2-tailed)	0.055	0.012	0.07	0.888	0.592	0.018		0	0.437
	N	50	50	50	50	50	50	50	50	50
Education	Pearson Correlation	.535**	-0.055	.512**	-0.085	0.006	-0.157	.523**	1	.437**
	Sig. (2-tailed)	0	0.703	0	0.555	0.965	0.277	0		0.002
	N	50	50	50	50	50	50	50	50	50
Income	Pearson Correlation	-0.037	.280*	0.004	0.102	-0.134	-.482**	0.112	.437**	1
	Sig. (2-tailed)	0.801	0.049	0.976	0.481	0.354	0	0.437	0.002	
	N	50	50	50	50	50	50	50	50	50

*****. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed)***

The patients age had no significant ((p>0.005) association with BMI and WC, marital status was negatively associated with their BMI (r^2= -0.484), and significant positive associations exist between occupation and the waist circumference (r^2=0.537), education attained and BMI (r^2=0.293) and WC (r^2=0.676) as well as their income level and BMI (r^2=0.453) (table 8).

TABLE 8
RELATIONSHIP OF TYPE 2 DIABETICS' SOCIOECONOMIC DATA WITH BMI AND WC

Correlations parameters		Age	Married	Occupation	Education	Income	BMI	WC
Age	Pearson Correlation	1	-0.17	0.078	0.006	-0.134	0.123	0.078
	Sig. (2-tailed)		0.237	0.592	0.965	0.354	0.394	0.59
	N	50	50	50	50	50	50	50
Marriage	Pearson Correlation	-0.17	1	-.333*	-0.157	-.482**	-.484**	-0.176
	Sig. (2-tailed)	0.237		0.018	0.277	0	0	0.221
	N	50	50	50	50	50	50	50
Occupation	Pearson Correlation	0.078	-.333*	1	.523**	0.112	0.04	.537**
	Sig. (2-tailed)	0.592	0.018		0	0.437	0.783	0
	N	50	50	50	50	50	50	50
Education	Pearson Correlation	0.006	-0.157	.523**	1	.437**	.293*	.676**
	Sig. (2-tailed)	0.965	0.277	0		0.002	0.039	0
	N	50	50	50	50	50	50	50
Income	Pearson Correlation	-0.134	-.482**	0.112	.437**	1	.453**	0.241
	Sig. (2-tailed)	0.354	0	0.437	0.002		0.001	0.092
	N	50	50	50	50	50	50	50
BMI	Pearson Correlation	0.123	-.484**	0.04	.293*	.453**	1	.458**
	Sig. (2-tailed)	0.394	0	0.783	0.039	0.001		0.001
	N	50	50	50	50	50	50	50
WC	Pearson Correlation	0.078	-0.176	.537**	.676**	0.24	.458**	1
	Sig. (2-tailed)	0.59	0.221	0	0	0.092	0.001	
	N	50	50	50	50	50	50	50

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

IV. DISCUSSION

Most of the patients were of Igbo ethnicity as the study was conducted in Abia state located in Eastern Nigeria, dominated by the Igbo ethnic group (table 1). It was surprising that more of the patients were rural dwellers as the hospital is in an urban area. This is contrary to the documentation that proximity/nearness to health facilities encourages attendance [17] and in consonance with the report on diet-related non-communicable diseases in Ghana which had fewer respondents (46.4%) from urban and more (53.6%) from rural [18]. The low turn-out of urban patients could be that they can manage their disease condition or may have other private health facilities available to them in the urban area. The age bracket of most patients (≥40 years) was related to type 2 diabetes which occurs mainly in adult populations over 40 years. Most diabetic patients in developing countries are within the productive age range of 40 years and above [19]. Diabetes is a chronic disease that advances with age because organs like the pancreas become incapacitated and unable to produce or utilize sufficient insulin. There were more female diabetic patients than males. Other studies have reported a female majority (64.9% female and 35.1% males) in diabetic patients attending Federal health facilities [20, 21]. It has already been explained that females are more vulnerable to diet-related non-communicable diseases than men [22]. The greater percentage of patients that were married and monogamous is a reflection that they were mainly adults and of Christian religion respectively. Marriage is usually convened between two adults, and Christianity encourages and compels its members to monogamy. The low education status of a good number of the patients explained why the majority were poorly occupied with poor monthly earnings too. Lower education status is synonymous with poor/low-paying jobs, and the inability to secure high-paying jobs. This status translated to very poor income. The percentage of patients with Type 2 and type 1 diabetes (table 2) was in line with the WHO global prevalence of type 2 diabetes which is about 90% and type 1 only about 10% [14, 23, 24]. Majority of the diabetic patients were diagnosed by doctors. This is expected as disease diagnosis in hospital patients is one of the primary assignments of medical officers. The duration of the disease condition in many of the patients was because of the chronic nature of diabetes. Type 2 Diabetes mellitus

is a disease that develops over time, once diagnosed, the treatment and management follow. When diabetes is poorly managed, it could predispose one to other complications like diabetic retinopathy as seen in a good number of the patients. The percentage of patients with diabetic retinopathy aligns with earlier studies on the high prevalence of diabetic retinopathy amongst diabetics. [15, 23, 25]. Kertes *et al.* [26] reported up to 80% diabetic retinopathy in people with diabetes. Diabetic retinopathy was a common complication among the study patients (20%), more so, patients who had other complications also had retinopathy (Table 2). This explained the challenges encountered during questionnaire administration as most of the patients, had trouble in reading the written questionnaire due to eye problems. It has been discussed that the prevalence of diabetes complications could be due to non-compliance to both dietary and medical advice and poor follow-ups [27]. Evidence has shown that patient education is the most effective way to lessen the complications of diabetes and its management [28]. IDF [3] listed genetic predisposition as one of the major causes of type 2 diabetes. This is consistent with the percentages of the patient's family members who have diabetes. The level of education affects patients' knowledge of nutrition and dietary management of diabetes [29]. Although most of the study patients had low education status, and are not economically empowered due to low income, a good number had good nutrition knowledge, attitude, and practice of dietary management respectively (Table 3). This could be that the patients were duly informed of the disease condition and were involved in their care process. It was revealed that dietary care for some patients (over five years on diet therapy) was mainly from doctors in the facility that is housing a nationally recognized Dietetic unit. This could mean that either the medical team in the hospital does not include Dietitians or the medical officers are not referring patients to dietitians who are experts in diet therapy. This situation could explain the 22% of the patients that had poor knowledge of diabetes dietary management. Diabetics' knowledge influenced attitudes and practices towards dietary intake [30]. It is encouraging that most of the patients do not indicate quitting their dietary regimen (Table 4), although some had inconsistent dietary regimens with poor economic status as the biggest challenge to dietary management. In this study, most patients revealed that health with lifestyle and religion was the main motivation for good attitude and practice of dietary management. A greater number of the patients had normal BMI (Table 5) this is because dietary modification encourages weight control. The total percentage (56%) of the respondents that were overweight, obese, and underweight could be that these patients were having difficulties in managing the disease situation; confirming the inconsistency in adherence or non-adherence to the dietary modification, and no contact with Dietitians in the hospital care reported above. This situation indicates the urgent need for Dietitians to be involved in assisting these patients to confidently manage the disease. The abnormal waist circumference (WC) recorded for more than half of the study population is an additional reflection of their inability to manage their situation. The significant (x^2=6.202; p=0.013) difference in the waist circumference of the male and female outpatients with the females having high WC implied that the females were more at risk of cardiovascular diseases. This could be attributed to the differences in body composition of women and men. Women have more body fat than men, although men have relatively more central fat distribution. Waist circumference has been known to predict abdominal fat better than waist-to-hip ratio, independently it can predict health risks when BMI is not markedly increased (BMI >35) and is important in diagnosing metabolic syndrome [31]. More explicitly, a high waist circumference is associated with an increased risk for type 2 diabetes, dyslipidemia, hypertension, and CVD in patients with a BMI in a range between 25 and 34.9kg/m^2 as documented [32]. Consequently, the number of patients that had abnormal waist circumference (54%) could be associated with the prevalence of complications among these patients. The positive correlation coefficient observed between KAP and BMI of the respondents (r^2=0.355; p=0.012) and waist circumference and their knowledge of nutrition (r^2=0.517; p=0.000) (Table 6) are indications that these components are positively related. Good nutrition knowledge, attitude, and practice (KAP) impart positively to BMI and WC. The positive relationship was more significant between respondents' WC and nutrition knowledge (52%) than respondents' KAP and BMI (36%). The negative relationships observed between the knowledge of dietary management of the respondents and their BMI (r^2=-0.328; p= 0.020) and waist circumference (r^2=-0.485; p=0.000) suggested that the respondents' knowledge of diabetes dietary management does not necessarily translate to better nutritional status, indicating the possibility of other causal factors. The positive correlation coefficient found between the attitude of the respondents toward diabetes management and their waist circumference (r^2=0.405; p=0.004), implied that a good attitude will initiate good health and poor attitude to diabetes management may prevent the respondents from making the right food choices which will in turn predispose them to abnormal waist circumference and poor health outcome. The negative association (no relationship) found between the respondents' dietary practice and their BMI (r^2=-0.328; p=0.020) suggested the existence of other factors in maintaining a good BMI. Nutrition knowledge was significantly (r^2=0.535; p=0.000) associated with the respondents' education attainment (Table 7). Knowledge of dietary management of diabetes has no relationship with their occupation, this implied that the respondents' occupation was not a major determinant of their knowledge of dietary management. Conversely, their income level was directly (r^2=0.280; p=0.049) related to the knowledge of dietary management of diabetics. This implies that more income (coupled with better knowledge) will translate to better dietary management. The

respondents' attitude towards diabetes management was significantly (r^2=0.512; p=0.000) related to their educational attainment. Education is known to inform and broaden one's knowledge of a concept, and consequently, better knowledge will encourage better attitude, practice, and adherence to dietary regimens. The negative association (r^2=0364; p=0.009) found between the attitude of the respondents and their age was expected as one's attitude toward diabetes may not necessarily relate to one's age. The relationship between the practice of the patients toward diabetes and their socioeconomic variables such as age (r^2=0.240; p=0.093), marriage (r^2=0.135; p=0.350), occupation (r^2= -0.020; p=0.888), education (r^2= -0.085; p=0.555) and income (r^2=0.102; p=0.481) was not significant. There was no significant (p>0.005) relationship between BMI and WC of the respondents. Their marital status was negatively associated with their BMI (r^2= -0.484; p=0.000), meaning that marriage is not a direct factor that may either increase or decrease their body composition, showing the existence of other stronger factors. Factors like Food consumption pattern, diet quality, activity level and genetics have stronger associations with BMI [33, 34]. The significant positive association found between occupation and the waist circumference (r^2=0.537; p=0.000) of the respondents is an indication that the type of job one does can affect the person's waist circumference. It could further indicate that an active person may not have excessive fat accumulation in the waist compared with one who is sedentary. There was a significant positive association between the education attained by the respondents and their BMI (r^2=0.293; p=0.039) and WC (r^2=0.676; p=0.000). This indicates that the level of education acquired by a person could go a long way in determining his dietary and lifestyle pattern which will end up affecting the BMI and WC of the person. The positive significant association between the income level of the respondents and their BMI (r^2=0.453; p=0.001), may suggest that those with high income will be able to make informed food choices that will prevent overweight or obesity, and further diabetic complications. It may also enable them to adhere to prescribed dietary regimens, unlike low-income patients.

Conclusion Weight is an important factor in Diabetes management. The appreciable percentage of the patients who had complications and were unable to manage their weight suggests an urgent inclusion of the hospital's Dietitians in the patients' care process. Correlations exist between socioeconomic characteristics, KAP of diabetic patients to dietary management, and their anthropometric indices. These associations were positive and significant between education attained, occupation, and nutrition knowledge, with WC respectively. Nutrition knowledge was significantly associated with the respondents' education attainment. Diabetes management needs a holistic approach for sustainable success.

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Probiotic Potential of Fermented Yam Wash Water and Unprocessed Milk: Lactobacillus Isolation and Characterization

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Abstract— *This study investigated the fermented yam wash water and raw milk for their probiotic potentials through detailed isolation and characterization of lactobacillus. There were a total of eleven different types of lactobacilli isolated by traditional methods of fermentation. Their morphological and biochemical characteristics were well studied. A number of microbiological methods such as Gram staining, application of various biochemical tests and microscopic examinations were performed to accurately identify and characterize bacteria. Results showed concordant results in species of lactobacillus with variant biochemical profiles, indicating the rich microbial potential of indigenous fermentation processes. Similarly, enzymatic capabilities demonstrated variability, hence giving variable probiotic functionality. All the eleven samples were identified to belong to Lactobacillus spp. based on striking differences from the oxidase and catalase reactions. This study serves as formidable evidence in the application of locally fermented substrates in probiotic interventions, particularly in animal nutrition. These findings have bearing on the understanding of indigenous fermentation techniques and further development of probiotics in a sustainable manner within agricultural systems.*

Keywords— Fermentation techniques, microbiological methods, lactobacillus spp, unprocessed milk, yam wash water.

I. INTRODUCTION

Probiotics have emerged as one of the leading areas of research into animal nutrition and health, presenting promising alternatives to traditional antibiotic interventions in livestock productions (Cameron and McAllister, 2019). Lactobacillus species have, therefore, taken centre stage for their immense potentials in enhancing the health of animals and improving gut microbiota for enhancing overall performance in poultry production (Shivajyothi and Krishna, 2020). With an increased world demand for animal protein that is safe and produced in a sustainable manner, impetus has arisen for researchers to find new sources of probiotics which can be developed locally and inexpensively.

Fermentation is one classic biotechnological process yielding useful micro-organisms (Maicas, 2023). Products of fermentation had proven their great potential to be used in agriculture for the development of probiotic cultures containing huge nutritional as well as health-enhancing traits (Dahiya and Nigam, 2022). Traditional techniques of fermenting substrates available at local levels, including yam and milk, have lately started offering an exciting opportunity for developing probiotics for the tropics (Ilango and Antony, 2021).

Considering nutritional value and the prospect of being a good fermentation substrate, yam-one of the staple crops in most African countries-has been underutilized over the years for microbial studies. In this regard, Price *et al.* (2017) showed that yam has good intrinsic microbiological qualities that may support microbial life and related metabolic activity. On the other

side, raw milk is a complex substrate with high levels of a variety of nutrients that could make growth and proliferation of efficient bacterial strains easy (Medvedova *et al.,* 2020).

Poultry production in developing countries seriously suffers in respect of animal health and production due to high antibiotic resistance and general poor veterinary interventions (Mottet and Tempio, 2017). One promising strategy is the use of probiotic administration that could improve feed conversion ratios and enhance the status of immune responses and reduce pathogenic loads within livestock systems (Mia *et al.,* 2024). As Ringø *et al.* (2020) has suggested, locally derived probiotics could be one option. However, local probiotic development is at its infancy; therefore, serious research on indigenous microbial resources needs to be done.

Literatures vary with a number reporting efficacy on Lactobacillus strains that perform better in broiler chickens; specific Lactobacillus isolates selected have been shown to exert positive modulation of gut microbiota, enhance nutrient absorption, and elicit immune responses (Zhao *et al.,* 2022). Locally isolated lactobacillus strains should perhaps be characterized and utilized for regional probiotic interventions.

These are gaps that this present research has attempted to fill by undertaking an intensive study on the probiotic potentials of fermented yam wash water and raw milk. Consequently, this research attempts to isolate, identify and describe the species from Lactobacillus in these local substrates and assess their probiotic potentials for broiler chicken nutrition. The study contributes to a better understanding of traditional fermentation techniques and their microbiological end products as one avenue toward sustainable probiotic development in agriculture. Hence, this research is designed to isolate and identify Lactobacillus species from fermented yam wash water and raw milk, describe the biochemical and morphological characteristics, and further explore the potentials of probiotic functions through the assay of its efficacy in improving performance and health parameters in broilers.

This study marries traditional fermentation knowledge with modern microbiological techniques for new frontiers in the development of probiotics. Besides the scientific merit, it would provide a potent, affordable, and locally made probiotic means of enhancing the productivity and health of livestock to local farmers and other crop producers.

II. MATERIALS AND METHODS

2.1 Experimental Site:

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science and Technology, Faculty of Agriculture, Nnamdi Azikiwe University, Awka campus, Anambra State, Nigeria. The location is situated at Latitude 6°12'25"N and Longitude 7°04'04"E, with an average altitude of 9 meters above sea level.

2.2 Collection and Preparation of Experimental Materials:

2.2.1 Raw Materials:

Unprocessed cow milk was sourced from the Amansea Abattoir, while water yam tubers were purchased from Oye Agu Market in Abagana, Njikoka Local Government Area of Anambra State.

2.2.2 Fermentation Process:

Fermentation of yam wash water and milk was carried out at No. 2 Ezingwu Street, Umuokpu Awka, using the method described by Jones (2024). The yams were washed, peeled, diced and washed in the ratio of 1:1.5kg yam to 1.5 litres of water. The first two cloudy rinse waters were collected in a clean white jar and covered with muslin cloth fixed with a rubber band. The jar was then kept on a shelf, undisturbed, to ferment. After five days, a sour odour deduced lactobacillus multiplication.

The floating scum was skimmed off while the pale-yellow layer was decanted into the fresh unprocessed cow milk in the ratio of 10: 1 parts milk to one part yam wash water. It was left to ferment for five more days to separate the liquid and solid forms.

2.3 Isolation and Identification of Lactobacillus:

2.3.1 Sample Collection:

Eleven samples of fermented yam wash water and unprocessed milk were collected for laboratory analysis.

2.3.2 Identification Methodology:

Lactobacillus species was identified according to the methods described in Bergey's Manual of Systematic Bacteriology (Sneath *et al.*, 1986). Identification involved the:

1) Physical and microscopic observation of colony morphologies on selective media.
2) Gram staining to observe cell morphology.
3) Confirmation of Gram-positive, catalase-negative, non-spore-forming, rod-shaped isolates.

2.3.3 Biochemical Characterization:

Final identification employed the following classical microbiological tests: Gram staining, catalase and oxidase tests, motility test, indole production test, growth at 15°C and carbohydrate fermentation tests for: Arabinose, Fructose, Galactose, Lactose, Mannitol, Salicin, Sucrose and Trehalose

2.4 Probiotic Mixture Preparation:

2.4.1 Preparation of Bacterial Culture:

1) Inoculation of the isolates in MRS broth was done and incubated for 48 h at 37°C.
2) Tubes were centrifuged at 5000 rpm for 5 min.
3) Cells were harvested and washed three times with Phosphate Buffered Solution (PBS).
4) Pellets were dissolved in PBS and again centrifuged at 10,000 rpm for 5 min.
5) Added 300 µL of 30% glycerol in each tube.
6) Samples were stored at -80°C.

Strains were evaluated for growth and stability by viable cell count after one week storage under refrigeration in a liquid fermentation medium.

2.4.2 Microbiology Laboratory:

A sample of the fermented mixture was then taken to the Microbiology Laboratory, School of Pharmaceutical Studies, Nnamdi Azikiwe University, Agulu campus for the species identification of lactobacillus.

2.5 Statistical Analysis:

Data collected during the experiment were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) with a 2 × 4 factorial arrangement in CRD. Data analysis was carried out using the SPSS statistical package, version 20. Means showing significant difference were separated using the LSD test at 5%. However, systematic comparison of the treatment effects through time allows any statistically significant differences among the experimental groups to be determined and provides rigorous statistical validation of the research findings.

III. RESULTS AND DISCUSSION

TABLE 1

RESULT OF FINDINGS ON LACTOBACILLUS CONTENT OF THE YAM WASH WATER AND MILK MIXTURE

Sample code	Colonial morphology / characteristic	Gram character	Microscopic feature	Biochemical / confirmatory test		Probable organism
				Oxidase	Catalase	
1	Milky, mucoid colonies	+ve	Oval purple rods	+ve	+ve	*Lactobacillus spp*
2	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
3	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
4	Milky-brown, mucoid colonies	+ve	Oval purple rods	+Ve	+Ve	*Lactobacillus spp*
5	Milky-brown, mucoid colonies	+ve	Slender Oval purple rods	+Ve	+Ve	*Lactobacillus spp*
6	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
7	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
8	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
9	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
10	Milky, mucoid colonies	+ve	Oval purple rods	-Ve	-Ve	*Lactobacillus spp*
11	Milky-brown, mucoid colonies	+ve	Slender Oval purple rods	+Ve	+Ve	*Lactobacillus spp*

3.1 Lactobacillus Characterization and Identification:

The fermentation of the yam wash water-milk mixture presented a complete spectrum of lactobacillus isolates, mapping the tremendous microbial diversity traditionally encapsulated in any fermentation process. A total of eleven bacterial isolates of dissimilar types were obtained showing different morphology and biochemical characteristic features typical of lactobacillus species presented on Table 1.

It was observed that colony morphology for the samples was fairly similar, characterized mainly by milky and mucoid colonies typical for lactobacillus organisms. The relatively consistent microbial morphology could indicate a steady state in the microbial fermentation conditions and, therefore, good substrate conditions by which lactobacillus organisms could flourish. The presence of milky and mucoid colonies agrees with earlier observations on the morphological features of lactobacillus cultures in fermented broths as opined by Gutiérrez *et al.* (2016) and in much older studies as seen in Norris *et al.* (1954).

Microscopical observation gave a really interesting insight into the morphological diversities among the isolates. All the samples (except sample 5 and 11), had been in the form of oval purple rods. Sample 5 and 11 had slender oval purple rod morphology. Such minor variations in morphology underscore the complex heterogeneity within lactobacillus populations, pointing out the possibility for subspecies or even strain level differences that could influence functionalities as a probiotic.

Gram staining showed positive results for all the eleven isolates, thus re-affirming that the isolate was a Gram-positive bacterium. This is a primary means of characterization of lactobacillus and is important in microbiological taxonomy by Zheng *et al* (2020). The consistency in Gram-positive Gram reaction further verifies the efficiency of the method of isolation and identification adopted in this work.

Confirmatory biochemical tests indicated the interesting trend in oxidase and catalase reactions, where six isolates (samples 2, 3, 6, 7, 8, 9, and 10) were negative in respect to both oxidase and catalase, while five isolates (samples 1, 4, 5, and 11) gave

positive results. These so-called biochemical differences also indicate their metabolic diversity, which may substantially be responsible for different probiotic effects and functional properties.

However, the most striking observation has been the consistent identification of all these isolates as *Lactobacillus spp*; thus, showing the enormous microbial potential of the fermented yam wash water and milk mixture. This substantiates the hypothesis that traditional fermentation techniques are most conducive to developing a diverse population of potentially probiotic bacterial strains (Ilango & Antony, 2021).

3.2 Probiotics Application and Implication:

The observed microbial diversity presents compelling evidence for the probiotic potential of locally fermented substrates. The consistent prevalence of lactobacillus strains bearing various biochemical profiles may present a rich repository of putative beneficial microbes. Previous studies have shown that such diverse lactobacillus populations are capable of showing multiple health benefits in animal nutrition by modulating gut microbiota, enhancing immune responses, and possibly inhibiting pathogens in several cases (Rastogi and Singh, 2022).

This biochemical heterogeneity, as represented by the oxidase and catalase reactions, might indicate a difference in metabolic capability among the isolates. Accordingly, strains with different enzymatic profiles may offer different modes of probiotic action, which could involve the improvement of nutrient metabolism, competitive exclusion of pathogens, or some other immunomodulatory function(s) (Plaza-Diaz *et al.*, 2019).

3.3 Comparative Setting and Significance of Research:

These findings contribute significantly to the few studies into indigenous fermentation techniques as sources of probiotic microorganisms. The present study has further demonstrated the ability of traditional fermentation techniques using locally available substrates, such as yam and milk, to generate a rich, probably highly valuable microbial ecology. Consistency in morphological and biochemical characters in isolates outlines a very consistent and stable microbial microenvironment throughout fermentation-a very important aspect necessary for the development of dependable probiotic interventions, especially in agricultural settings that have high demands on consistent microbial performances.

While the current study provides comprehensive insights into the characterization of lactobacillus, further studies should focus on; determination and complete genetic characterization of identified strains, deep assessment of the individual probiotic strain potential, evaluation of strain-specific performance in animal nutrition models. Results obtained highlight the prospects of indigenous fermentation techniques being a very valuable approach toward the development of probiotics-a promising avenue to ensure sustainable and locally derived microbial solutions in agricultural systems.

IV. CONCLUSION AND RECOMMENDATIONS

This in-depth study of the probiotic potential of fermented yam wash water and unprocessed milk has provided very important insights into the microbial diversity and potential of indigenous fermentation techniques. The present study was able to isolate and characterize eleven distinct strains of Lactobacillus, showing high microbial richness inherent in traditional fermentation processes. These findings are of huge importance to locally sourced substrates for generating valuable probiotic microorganisms with diverse biochemical and morphological characteristics.

The constant presence of species of the genus Lactobacillus was proven for all isolates, with strong variability expressed in biochemical profiles and microscopic characteristics. These variations might mean differential functionality of probiotics and open exciting possibilities for developing specific probiotic interventions in animal nutrition. This further underlines the intricate microbial ecosystem formed by traditional fermentation processes through the constantly Gram-positive nature and diversity in enzymatic abilities of the isolated strains. These will form the basis for more tailored genetic characterization of strains found to be Lactobacillus, complete investigation into the probiotic potential of each strain, and deep assessment of their specific performance in animal nutrition models. Further research into mechanisms of probiotic action and possible immunomodulating function of these strains with standardized protocols on how to select and apply these probiotics in agriculture is therefore warranted.

These findings justify the expectation of developing locally sourced, inexpensive probiotic products. Crossing traditional fermentation knowledge with new techniques from microbiology can truly let the researchers open entirely new venues for

sustainable innovation in agriculture. The presented research puts an emphasis on the critical value of indigenous fermentation techniques, which are of great importance in generating high-value microbial resources that probably enable improvement in productivity and health of livestock.

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Examining the Influence of Cutting Parameters on Tool Life for Tungsten and Molybdenum During CNC Lathe Turning of Mild Carbon Steel When Flank Wear is Present

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Abstract— *This study investigates the effects of cutting parameters on the tool life of two grades of high-speed steel tools, Tungsten (T1) and Molybdenum (T2), during the turning of mild carbon steel on a CNC lathe. Experiments were conducted on mild steel rods (200 mm length, 30 mm diameter) at three feed rates (0.1, 0.2, and 0.3 mm/rev), with a constant depth of cut (0.4 mm) using an 18-spindle rotational speed CNC lathe. Power and linear regression models were employed in MATLAB to determine and validate R^2 values. Analysis of variance (ANOVA) was performed to identify the best-fit model for experimental tool lives. Furthermore, chip-tool interface temperatures were modeled and compared with established literature to ensure accuracy and reliability.*

Keywords— ANOVA, Cutting parameters, CNC lathe, High Speed Steel, Tool life.

I. INTRODUCTION

Lathe turning operation is probably the most used of all the machining processes. About one third of the machines in production are employed in turning. In a turning operation, the work piece, held in the chuck is rotated and a cutting tool removes the work material strip by strip and then layer by layer as the latter is being turned [11].

Computer-controlled (numerically controlled, NC, CNC) lathes incorporate a computer system to control the movements of machine components by inserting coded instructions in the form of numerical data. A CNC lathe is especially useful in turning operations and precise machining

Some of the cutting conditions that influence tool life and tool wear include the cutting speed, the feed rate and the depth of cut. Much effort has been done to establish the relationship between cutting speed, tool wear and tool life [2]. The cutting speed influences the tool life such that at low cutting speeds, the tool lasts long and the tooling cost is low [3]. But the metal removal rate will be low and hence the cutting cost and the total costs are high. However, at high cutting speeds, the metal removal rate will be high resulting in low cutting cost, shortened tool life and giving high tooling cost [12]. The life of a cutting tool can be terminated by a number of means, although they fall broadly into two main categories;

a) Gradual wearing of certain regions of the face and flank of the cutting tool and

b) Abrupt tool failure.

Considering the more desirable case, the life of a cutting tool is therefore determined by the amount of wear that has occurred on the tool profile, and which reduces the efficiency of cutting to an unacceptable level or causes tool failure. When the tool wears reaches initially an unacceptable level, there is the need to replace the tool with the right geometry in accordance to ISO 5610 standard [7,9].

Excessive increase in the cutting speed will result in the tool wear and increasing the cutting speed increases the rate of production but decreases the tool life the most. [2,6]

Similarly, excessive feed will cause tool wear. Increasing the feed rate will increase the production rate but decrease the tool life the least. [2,6]

Increasing the depth of cut influences the tool life more than increasing the feed does. Therefore, at an intermediate cutting speed, the total cost is at a minimum. The tool life corresponding to the cutting speed is the economic tool life. Values for the machining variables traditionally used by industry may gradually be replaced with values based on economic considerations. Only continuous research in this area and the application of the results, whether it is directly or by handbook revisions, will enable Manufacturing organizations to operate economically under the ever- increasing production requirements of today [12].

II. TOOL LIFE MODELS USED FOR DATA EVALUATION

The relationship between the tool life and the machining independent variables, cutting speed, and feed rate can be represented by the following equations:

$$T = KV^{a}\epsilon \quad (1)$$

$$T = KV^{a}f^{b} \in \quad (2)$$

Where T is the response variable, tool life in minutes, V and f are the cutting speed in meters per minute (m/min) and feed rate in millimeters per revolution (mm/rev). K, a, b are constants and $\in$ is the random error having normal distribution with zero mean. To facilitate the determination of constants and parameters, the mathematical models will be linearized by performing logarithmic transformation [13]

This research considers the flank wear of the High-Speed Steel tool as Linear, Quadratic, Polynomial, power, logarithmic, and exponential regression models using MATLAB to validate and find their R^2 values. Analysis of variance was developed for each tool to predict the model that will give the closest fit compared with the experimental tool lives.

The Chip-tool interface temperatures were also modeled and compared with the measurements from established literature.

2.1 Linear Model:

In fitting a linear regression model, there are just two variables; (the independent and the dependent variables).

Starting from

$$y = mx + k \quad (3)$$

Where,

x = cutting time (min)

y = Flank wear (mm)

k and m are regression coefficients to be determined.

Applying regression techniques to evaluate “m” and “k”, the error sum of squares (SSE) can be expressed as:

$$SSE = \sum_{i=1}^{n}(y_0 - mx - k)^2 \quad (4)$$

Differentiating equation (4) with respect to m and k respectively and equating it to zero yields the following normal equations

$$\sum_{i=1}^{n} y_i + m\sum_{i=1}^{n} x_i + nk \quad (5)$$

$$\sum_{i=1}^{n} x_i y_i = m\sum_{i=1}^{n} x_i^2 + k\sum_{i=1}^{n} x \quad (6)$$

Solving these normal equations simultaneously gives the values of m and k respectively.

2.2 Power Model:

Power model of the general form

$$y = ax^{k} \quad (7)$$

is assumed.

Where,

y = Flank wear, x = cutting time.

a and k are the regression coefficients to be determined [14].

Transforming equation (7) by taking logarithms of both sides of the equation gives;

$$Logy = Log\text{a} + kLog\text{x} \tag{8}$$

Equation (8) can then be compared with the straight-line general equation, applying the same procedure to determine the coefficients.

2.3 Exponential Model:

An exponential equation of the general form

$$y = ae^{bx} \tag{9}$$

is assumed.

Where,

y = Flank wear

a and b are regression coefficients to be determined. Smith [14].

Transforming equation (9) by taking the natural logarithms of both side of the equation gives

$$Iny = Ina + bx \tag{10}$$

Equation (10) can be compared with straight line general equation and the same procedure is applied to determine the coefficients.

2.4 Quadratic Model:

A general form of the Quadratic equation

$$y = k + bx + ax^2 \tag{11}$$

is assumed.

Applying the regression techniques to evaluate a, b and k in equation (11), yields

$$SSE = \sum_{i=1}^{n}(y_0 - k - bx - ax^2)^2 \tag{12}$$

$$SSE = \sum_{i=1}^{n}(y_0 - k - kb - ax^2)^2 \tag{13}$$

Differentiating equation (12) with respect to a, b and c in turn and equating it to zero yields the following normal equations.

$$\sum_{i=1}^{n} y_i = nk + b\ \sum_{i=1}^{n} x_i + a\sum_{i=1}^{n} x_i^2 \tag{14}$$

$$\sum_{i=1}^{n} x_i y_i = k\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2 + a\sum_{i=1}^{n} x_i^3 \tag{15}$$

$$\sum_{i=1}^{n} x_i^2 y_i = k\sum_{i=1}^{n} x_i^2 + b\sum_{i=1}^{n} x_i^3 + a\sum_{i=1}^{n} x_i^4 \tag{16}$$

The coefficients of the regression model can then be determined by solving these normal equations simultaneously [14].

III. EXPERIMENTAL SETUP

The experiment was set up with a tailstock and a running center to hold the workpiece at one end, and a 4-jaw chuck to secure the workpiece at the other end. The tool was positioned on the tool post for the orthogonal cutting. This study aimed to determine the influence of cutting conditions on the tool life of High-Speed Steel (HSS) cutting tools during the turning of mild carbon steel at various cutting speeds and feed rates.

A standard chromel-alumel thermocouple, inserted near the rake face of the tool, was used to measure the interface temperatures. An experimental design based on the 2^2 factorial method was applied to evaluate the cutting speed and feed rate. The tests were conducted under a constant depth of cut of 0.4 mm and dry cutting conditions. According to Erik et al. [6], the depth of cut has the least effect on tool life, so the heaviest possible depth of cut should always be used. Therefore, a pre-cut of about 0.1 mm depth of cut was performed on each workpiece using a different HSS tool to remove the rust layer from the outer surface of the mild steel and minimize any effect of inhomogeneity on the experimental results.

The mild steel rods were fixed to a four-jaw chuck one after the other, center drilled, and set up with a running center to avoid wobbling of the workpiece and achieve accurate results. The speeds and feed rates were selected before starting the turning operation. A stopwatch was used to record the initial time in minutes when the machine began cutting, and it was stopped when the tool could no longer cut and made a squeaking noise. The flank wear was evaluated according to the flank wear model given by Peres et al [5].

A design comprising seven experiments was chosen. Four of these experiments form a 22 factorial design with an additional center point repeated three times, allowing for an assessment of process stability, inherent variability, and curvature checking. The general guideline suggests adding 3 to 5 center point runs to your design [10]. This design incorporates three levels for each independent variable.

IV. RESULTS AND DISCUSSION

The Tool life models have been developed using Matlab. The models have been validated by finding their R^2 values. The Matlab code used to determine the analysis of variance is presented in Appendix C. These models and their R^2 values are presented in Appendix E1 and E2 which also show the analysis of variance for the tool life for both the power and the linear models.

Figures 1, 2 and 3 show the graphs of tool life against the Cutting Speed at feed rates of 0.1, 0.2, and 0.3mm/rev for the High Speed Steel grade T1.

The tool life models developed and the R^2 values for high speed steel grade T2 are tabulated in Appendix E2, which also show the analysis of variance for tool life models.

The graph of tool life against cutting speed was plotted at feed rates of 0.1, 0.2 and 0.3 mm/rev. Figures 4, 5 and 6 show the graphs of tool life against cutting speed at various feed rates.

TABLE 1
CHEMICAL COMPOSITION OF MILD CARBON STEEL ROD USED (RST 34-2)

C	Mn	Si	P	S	Cu	Fe
0.08-0.15	0.20-0.50	0.03-0.30	0.05 Maximum	0.05 Maximum	Traces	Balance

(Source: Scientific Equipment Development Institute (SEDI), Minna).

4.1 Results of Tool Life Models for High Speed Steel Tool, T1:

The Tool life models have been developed using MATLAB. The models have been validated by finding their R^2 values. The MATLAB codes were used to determine the analysis of variance. These models and their R^2 values are presented in Table 2 for the high-speed steel grade, T1. Table 3 and Table 4 show the analysis of variance for the tool life for both the power and the linear models.

TABLE 2
TOOL LIFE MODELS AND R^2

S/N	Model	Equation	R^2
1	Power	$T = 723.935\ V^{-0.8544}\ f^{-0.02}$	0.96
2	Linear	T = 95.9102-1.2501 V-18.625f	0.6

TABLE 3
ANALYSIS OF VARIANCE OF POWER MODEL FOR TOOL LIFE

Source	SS	DF	MS	F
A(Speed)	0.358	1	0.358	0.7192
B(feed rate)	7.21E-04	1	7.21E-04	1.45E-03
AB(Interaction)	1.58E-04	1	1.58E-04	3.17E-04
Curvature	0.055	1	0.055	0.1105
Error	1.9911	4	0.4978	
Total	2.405			

TABLE 4
ANALYSIS OF VARIANCE OF LINEAR MODEL FOR TOOL LIFE

Source	SS	DF	MS	F
A(Speed)	4571.78	1	4571.78	18.826
B(feed rate)	20.026	1	20.026	0.0824
AB(Interaction)	13.876	1	13.876	0.0571
Curvature	43.588	1	43.588	0.1795
Error	971.37	4	242.84	
Total	5620.6			

Figures 1, 2 and 3 show the graphs of tool life against the Cutting Speed at feed rates of 0.1, 0.2, and 0.3mm/rev for the High Speed Steel grade T1.

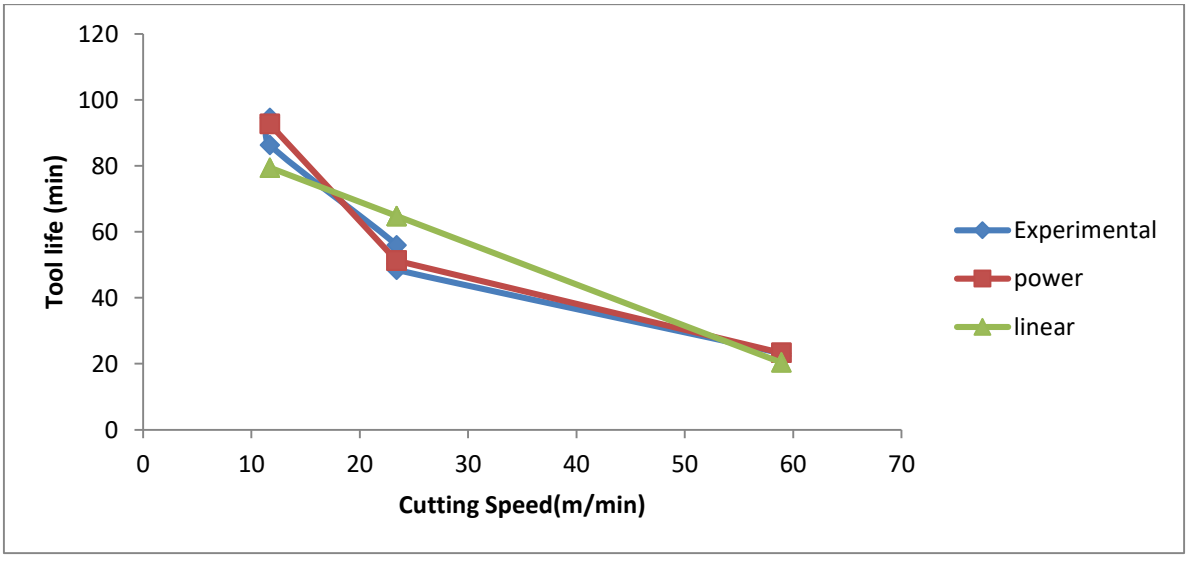

FIGURE 1: Graph of Tool life against Cutting Speed at feed rate of 0.1 mm/rev

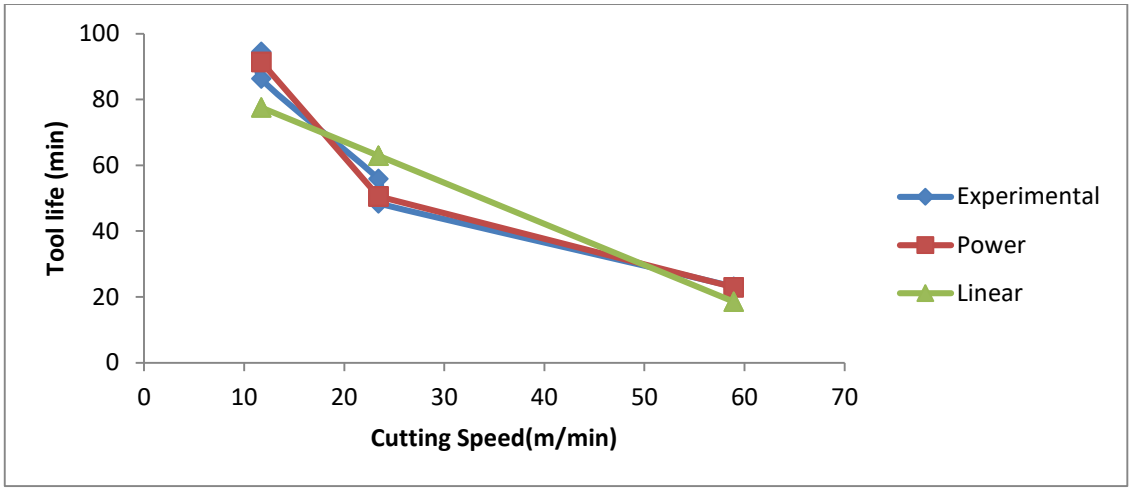

FIGURE 2: Graph of Tool life against Cutting Speed at feed rate of 0.2 mm /rev

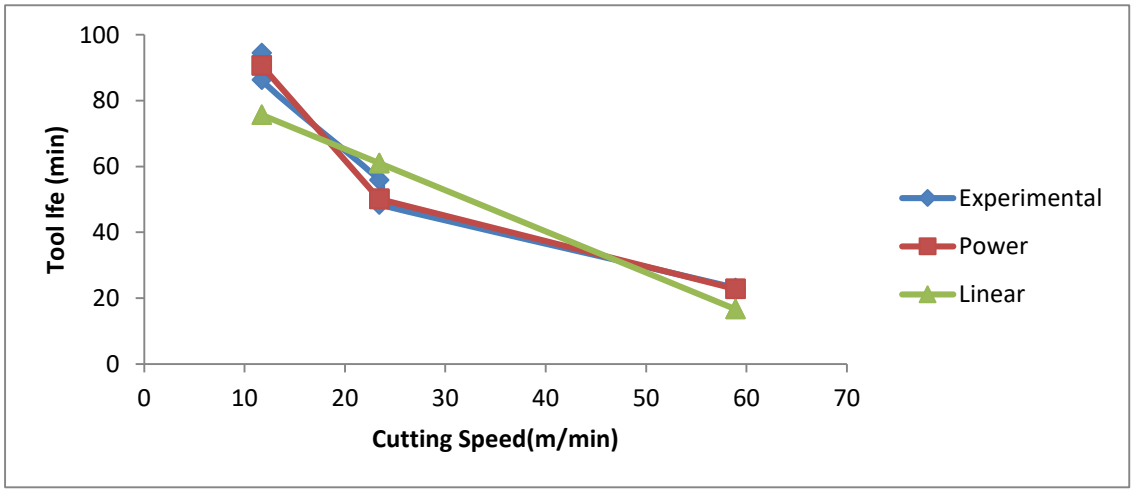

FIGURE 3: Graph of Tool life against Cutting Speed at feed rate of 0.3 mm/rev

4.2 Results of Tool Life Models for High Speed Steel Tool, T2

The tool life models developed and the R^2 values for high speed steel grade T2 are tabulated in table 6. Tables 6 and 7 show the analyses of variance for tool life models.

TABLE 6
TOOL LIFE MODELS AND R^2

S/N	Model	Equation	R^2
1	Power	$T = 1408.96\ V^{-1.0496}\ f^{-0.0049}$	0.95
2	Linear	T = 108.2406-1.5429V-16.75f	0.7

TABLE 7
ANALYSIS OF VARIANCE OF POWER MODEL FOR TOOL LIFE

Source	SS	DF	MS	F
A(Speed)	0.53377	1	0.53377	1.1526
B(feed rate)	2.33E-04	1	2.33E-04	5.04E-04
AB(Interaction)	1.83E-04	1	1.83E-04	3.94E-04
Curvature	0.01806	1	0.01806	0.03899
Error	1.8527	4	0.4631	
Total	2.405	8		

TABLE 8
ANALYSIS OF VARIANCE OF LINEAR MODEL FOR TOOL LIFE

Source	SS	DF	MS	F
A(Speed)	6844.25	1	6844.25	-21.354
B(feed rate)	11.6964	1	11.6964	-0.0365
AB(Interaction)	11.225	1	11.225	-0.035
Curvature	35.4617	1	35.4617	-0.1106
Error	-1282.036	4	-320.509	
Total	5620.6			

The graph of tool life against cutting speed was plotted at feed rates of 0.1, 0.2 and 0.3 mm/rev. Figures 4, 5 and 6 show the graphs of tool life against cutting speed at various feed rates.

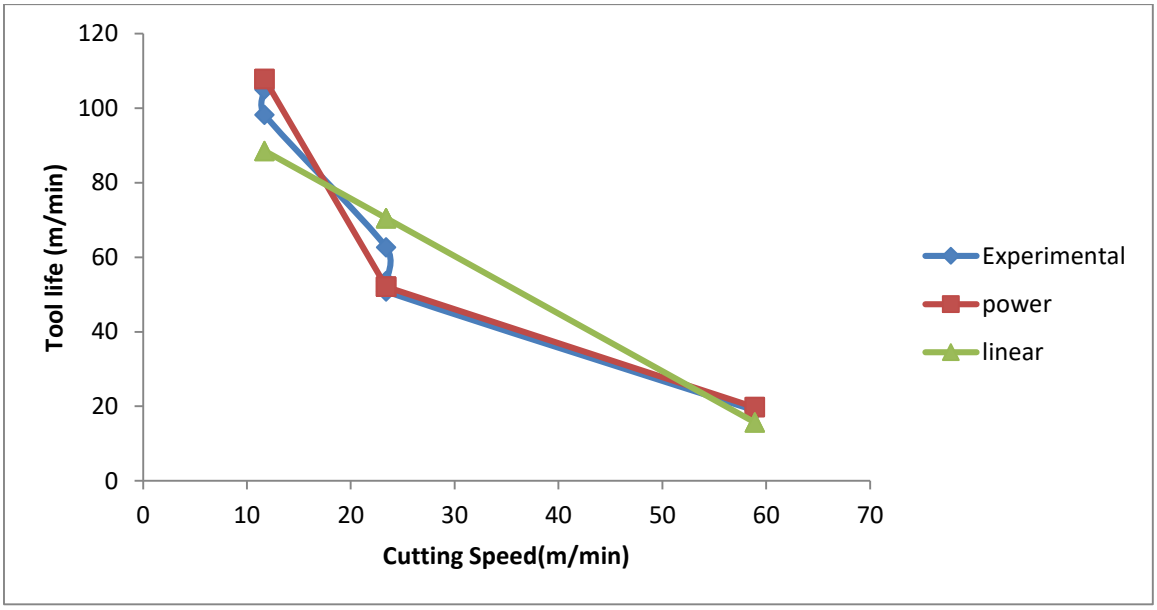

FIGURE 4: Graph of Tool life against Cutting Speed at feed rate of 0.1 mm/rev

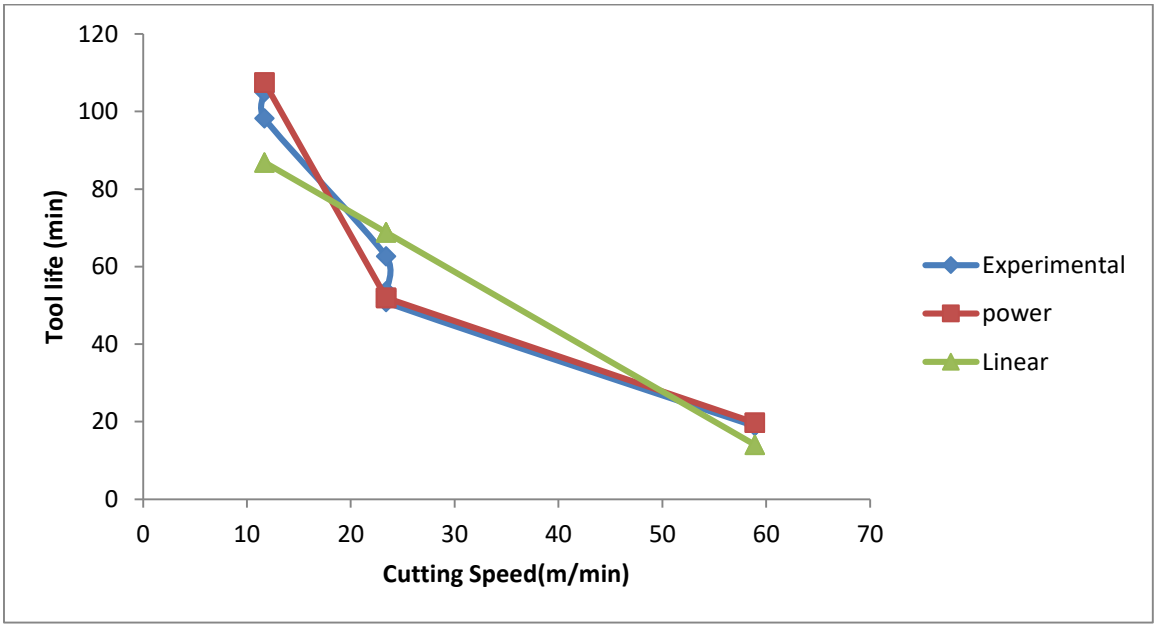

FIGURE 5: Graph of Tool life against Cutting Speed at feed rate of 0.2 mm/rev

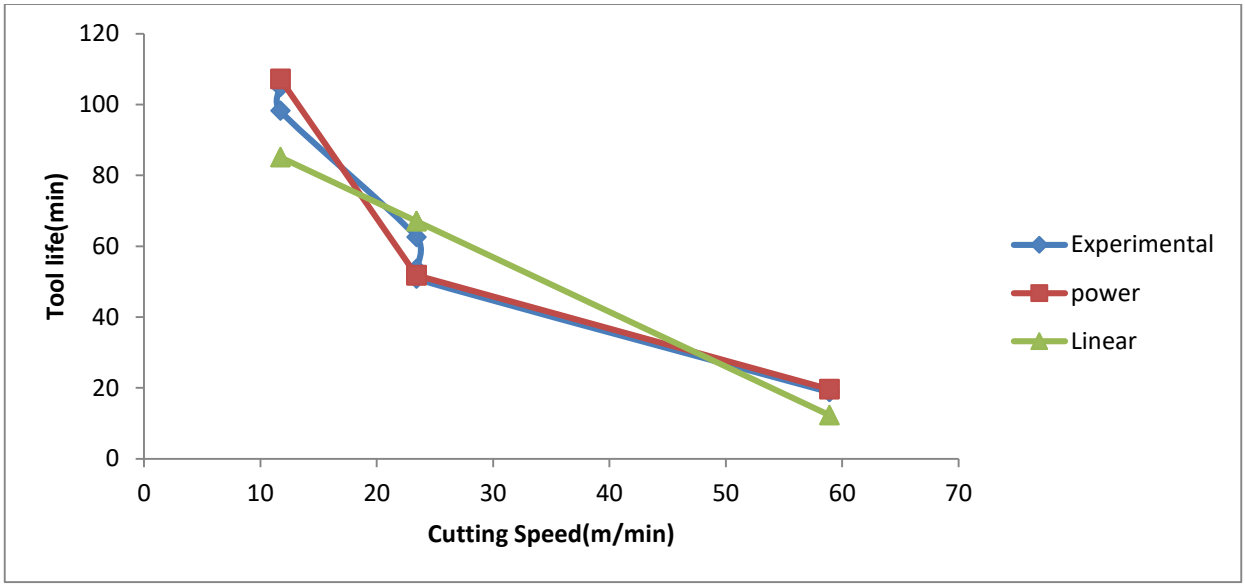

FIGURE 6: Graph of Tool life against Cutting Speed at feed rate of 0.3 mm/rev

The tool life model developed based on the experiments is given in equation (17)

$$T = 723.935\ V^{-0.8854}\ f^{-0.02} \quad (17)$$

V. CONCLUSION

Two Tungsten grades of High-speed steel tools were used to machine mild steel rods at various combinations of cutting speeds and feed rates to determine their influence on tool life. The conclusions drawn are as follows

1) The effect of feed rate and cutting speed on tool life was studied successfully. The power and linear regression models were developed for each tool. The power regression model gave the closest fit compared with the experimental tool lives. The R^2 values for the T1 grade are 0.96 for power model and 0.60 for the linear model. For T2, the R^2 values of 0.95 and 0.70 were found for power and linear model respectively. It is therefore adequate to predict the tool life with power regression model.

2) The power model gave the highest R^2 values throughout the prediction of flank wear. It is, therefore, the best to use for prediction of tool life. All the other regression models are also adequate for prediction of flank wear.

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