ASSESSING THE COMMERCIALIZATION OF HERBAL MEDICINE RESEARCH AND DEVELOPMENT OUTPUTS IN NIGERIA

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ABSTRACT
The commercialization of herbal medicine R&D outputs in Nigeria has not been widely studied. Hence this study examined the extent, evaluated the constraints and factors influencing herbal medicine commercialization.

Questionnaires were used to sort the opinion of herbal medicine scientists in universities, research institutes and manufacturing pharmaceutical firms to actualize the study objectives. Data were analyzed using descriptive and inferential statistics.

Herbal medicine scientists rated major constraints in commercializing herbal medicines as economic and institutional problems. There were significant correlations between commercialization of herbal medicine and market pull and technology push. Regression analysis revealed that market and strategy adopted by the organizations contributed significantly to the commercialization process. Strategies for improving commercialization of herbal medicines were discussed.
The study concluded that the commercialization of herbal medicine in Nigeria is low, sequel to some constraints.

KEY WORDS: Herbal medicine, Research and Development Outputs and Commercialization.

INTRODUCTION

The impact of research outputs, which may be in form of new products, services, machinery and equipment or the upgrading of local raw materials, may not be adequately felt if such research results are not commercialized. Therefore, commercialization of Research and Development (R&D) outputs could be defined as a process of transferring research results from research institutes, universities among others, to the commercial market for public benefit1. Research institutes unlike the universities, explore market needs and tailor R&D outputs to meet such needs in order to enhance the commercialization of R&D outputs[2]. This therefore entails making research outputs available to users of technology (industries) such that, both the researchers and investors in R&D activities should be able to make money out of their research activities and investments. Differently put, commercialization of research results is said to have taken place when the research institutes have successfully transferred them to investors who then establish these technologies as business outfits for profit making. This implies that the research must be linked to production and perhaps generate economic returns. The industries also play great roles in commercializing research outputs especially in developing and advanced countries such as China, India, United Kingdom and South Korea. For instance Ranbaxy (PVT) assisted in commercializing herbal products from local firms in India and China. They also helped in commercializing 35% of herbal tea produced by local industries3. In developed and industrializing countries research outputs are usually directed towards commercialization in order to gain competitive advantage and improve the economic well being of the populace[4].

Generally, industry research findings are deemed ready for commercialization after the technical feasibility and economic viabilities of the outputs have been properly ascertained, from the preliminary test stage to the pilot test stage and even to the commercial scale stage[5]. For research to be useful, it must be linked to production. The research outputs must be demanded by the society. Commercialization of R&D outputs also requires proper institutional and financial arrangements. It could be triggered off by either market demand or by the desire to develop and perfect certain technologies.

Improvement in science and technology and the problem of mass-producing herbal medicine were among the issues that promoted the growth of synthetic medicines. However, no information is available about the factors that have contributed to the commercialization or otherwise of herbal medicine R&D

outputs in Nigeria. At present, only 40% of herbal medicine consumed in the country are produced locally and the remaining 60% are imported from foreign countries mostly China and other East Asian countries[6]. The commercial interest to mass produce herbal medicine in Nigeria and make them available for local and international use is lacking and it would probably take a longer time for this to improve significantly[7]. Hence, this paper attempts to provide answers to the following research questions namely,

a. What is the extent of commercialization of herbal medicines R&D outputs in Nigeria?

b. What are the constraints in commercializing herbal medicines R&D outputs in Nigeria?

c. What factors influence the commercialization of herbal medicines R&D outputs in Nigeria?

d. What strategies could be crafted and employed to improve the commercialization of herbal medicine R&D outputs in the country?

Generally, the study is set to assess the commercialization of herbal medicines R&D outputs in Nigeria. This is with a view to formulating strategies that would enhance their commercialization process in Nigeria. The specific objectives of the study are to:

a. assess the extent of commercialization of the products in Nigeria;

b. examine the constraints in commercializing herbal medicines R&D outputs;

c. evaluate the factors influencing the commercialization of herbal medicines R&D outputs; and

d. formulate strategies to enhance the commercialization of herbal medicines in Nigeria.

In order to properly link research to production, the appropriate foundation must be laid through societal demand for such research outputs. The industries and pharmaceutical firms usually produce research outputs required by the market8. Therefore the market demand for such technology, products or services is a critical factor in determining the level of contribution of research to a productive economy. Most times ideas for new products can originate from specific market needs or market pull. Products developed this way are market oriented. Again the quest for new technology can facilitate the implementation of research findings to tangible products for commercial gains (Technology push). Therefore the level and pattern of demand of R&D outputs is essential for their successful commercialization. For instance, low demand constrains R&D investment[8].

However, promoting the linkage between research outputs and commercialization in general require proper institutional and financial arrangements as well as defining the role of the stakeholders in the R&D and commercialization process[9]. This involves a high level of linkage or interaction with entrepreneurs. Again the adequacy of research outputs is a function of the level of inputs made available for the R&D process. Inputs therefore must be sufficient in terms of the quality of manufacturing facilities, funding, and quality of personal (technical and managerial staff) that must be committed to the R&D process (Developers). In any case there must be a technological Gate Keeper or the presence of a product champion who is an ardent believer, developer, financier and marketing of the product[10].

Apart from the product being a high quality one, the organizational structure and culture of the R&D firm should be flexible in order to give room for individualistic imagination, thoughts, drive and zeal in view of the fact that the outcome of research remains highly unpredictable. While the R&D firm strives hard to provide an enabling environment for research activities, they should tailor the research results towards the particular needs of the expected end user, present the research results in usable forms, create awareness of the R&D results through adequate advertising campaign, strengthen academic-industry/research linkage, participation at exhibitions, trade fairs and use R&D linkage institutions to create awareness and market such research results1.

However, the integrated process of R&D requires an effective interaction between those involved in R&D (technical team) and others – (government, consumers/users/industry). Hence technical and non-technical factors are important in the commercialization process. The functions of the technical team in the commercialization of R&D results are to ensure that all technical activities necessary for the production of a consumer accepted product or service are met, prompt response of the technical team in solving technical related problems associated with R&D outputs and the laboratory and technical staff must be willing to continue the process of transformation of R&D outputs into commercial products11.Meanwhile, the research team's readiness to play its role depends on at least two factors. First, the laboratory has to be in good working condition. Secondly, the production of an acceptable product depends on the availability of an effective information system and interaction within and outside the laboratory/research institutions[11].

Anything that is at variance with the above assertions may lead to the non-commercialization of R&D results or outputs. Hence, the degree of success recorded by pharmaceutical R&D institutes may be hampered by numerous obstacles which[12], identified as: poor funding of R&D, non-coordination of R&D efforts nationwide, non-streamlining of R&D into areas of specialization, inability to systematically improve on our research products, inability to commercialize research results, non-fusion of indigenous technology with modern technology, lack of awareness creation of the activities of research institutes (lack of effective communication), and the absence of strategic approach to R&D, based on national priorities. Other notable variables that influence the commercialization of R&D outputs according to13, include market pull (Y1), technology push (Y2), availability of market (Y3), availability of inputs (Y4), presence of product champions or technology gatekeeper (Y5), organizational structure (Y6), organizational culture (Y7), commitment on the part of the developers (Y8), strategy adopted by the organization (Y9) and effectiveness of the regulatory system or judicial system to enforce patent law and intellectual property (Y10). However, the degree of influence of the above-listed variables on the commercialization of herbal medicines in Nigeria remains largely unknown.

To bridge the gap caused by incompatibilities in the ways the university and industry operate, specialized institutions have been set up to resolve the conflicts of interactions and pave ways for a better result – oriented R&D efforts and outputs. Also, it has been posited that these institutions are usually manned by certain professionals that possess dual or multicultural identities or attributes[14]. Three of such institutional links have been identified as:

(a) Interface agencies which manage the flow of science and technological knowledge, equipment, money and other resources across organizational boundaries without disturbing the laid down organizational rules and regulations. They act as buffer institutions that link industry with university researches[15]. They can also supply additional R&D resources to the universities. Examples of interface agencies are:

(i) Cooperative Research Centres which are usually involved in long-term research programmes in order to help reduce technical risks associated with R&D and innovation and develop other resources[16]. Pharmaceutical companies usually spend about 10-20 percent of their total R&D on co-operative researches with research institutions and universities[17]. The universities do not usually produce what research institutes and industries need and the linkage between research institutes and universities are very weak[16]. Interface agencies accounted for at least 35% of commercialized R&D results in Europe and Japan[17].

(ii) Science and Technology Parks: Science parks are groups of property-based facility that have operational links with the university research centres. Incubators with universities and nearby institutions can form science parks[18]. Technology parks are larger than science parks because they represent a zone of economic activity composed of the universities, industrial and other research centres.

(iii) Incubators are property-based facilities that simply share services to ensure the development of young firms for a short period.

(b) Bridging Institutions which represent applied research institutions that are permanently established to conduct strategic contract R&D, ranging from basic research to advanced engineering tasks. They mainly act as diffusers of information about new technologies to industry[19].

(c) Broker Organizations whose function is to facilitate communication between academic and industrial environments. They also coordinate linkage activities and supply seed capital to young organizations. Examples are:

(i) Industrial Liaison Offices which liaise between researchers and industries to monitor industrial needs, supply information, manage industry demands, as a contractor that negotiates contracts and offer necessary services to researchers and industries.

(ii) University-Run Development Companies help manage business spin-offs. However, they may not have the marketing and distribution facilities to effectively handle their research outputs. This may hamper commercialization efforts.

(iii) Technology Transfer Office assists in resolving early innovation and R&D problems[20]. They also help to commercialize technologies that emanated from research and educational institutions.

(iv) Regional Liaison Organization are established at regional levels to take advantage of research findings or outputs within and outside the region. Examples are Basic Research in Industrial Technologies for Europe

(BRITE) and European Strategic Programme for Research and Development in Information Technologies (ESPIRIT).

(v) National Research and Development Organizations help provide capital for research institutions. However, they are mainly involved in patenting and licensing of research outputs at national levels.

Nevertheless, the role of government (apart from the institutional linkage spin-offs earlier mentioned is crucial for a successful R&D activity in any nation.

METHOD

Major actors within the National Health Innovation System Environment (NHISE) where herbal medicine R&D activities occur in Nigeria were covered namely, the universities (Faculties of Pharmacy), research institutes and herbal medicine producers/pharmaceutical manufacturing firms.

The sample population consists of 13 universities involved in herbal medicine R&D, pharmaceutical teaching and research, 3 research institutes and 50 herbal medicine manufacturing pharmaceutical firms/herbal medicine producers of which 90% of the manufacturing pharmaceutical firms in Nigeria are located in southwestern Nigerian21. In all, a sample size of 325; made up of 100 respondents from the universities, 100 respondents from the research centres and 125 respondents from pharmaceutical manufacturing firms was used.

The (13) Universities which consists of 9 Federal-owned universities, 2 state-owned universities, 2 privately-owned universities were selected using a purposive and convenient sampling process from the list of universities (sample frame) that offer courses in pharmacy[22].The research institutes were drawn from two broad categories namely, medical and natural sciences in which they have their mandates. Random sampling technique was employed to select respondents in the research institutes as well as those from manufacturing pharmaceutical subsectors (chemical and pharmaceutical) to minimize bias.

Three different sets of questionnaire were designed and administered. The questionnaire for universities and research institutes were administered to the Deans and /or Chairmen of research committees, Senior managers or officers of the institutes who were responsible for the management of research activities or any appropriate person as identified by the Deans of relevant faculties/schools or Directors of research institutes and to core researchers in herbal medicine R&D. Questionnaires for manufacturing pharmaceutical firms/herbal medicine producers were administered to senior R&D and production managers who also answered follow up personal interview questions. Each questionnaire had two components: classification questions and questions on core issues .Classification questions assisted in classifying the targeted institution /organization by age, size or sector of operation for the purpose of analysis. The questions on core issues were derived from the statement of the problem and research questions hitherto formulated. The choice of any particular type of question was based on its appropriateness and power to elicit precise response to questions. All research instruments and interview schedules were pre-tested and subsequently used to make necessary modifications and corrections on the questionnaire before they were finally administered to various respondents. A reliability coefficient of 0.72 was calculated using test-retest method for reliability. In all, the number of harvested questionnaires from the universities was 74, research institutes 66 and pharmaceutical manufacturing firms/herbal medicine producers was 100.Therefore, the total number of questionnaire retrieved and used for analysis was 240.

Data analysis

Data were collated, coded and variables given sequential numbers and analyzed using the SSPS.
We modeled the performance of the explanatory variables which are market pull (Y1), technology push (Y2), availability of market (Y3), availability of inputs (Y4), presence of product champions or technology gatekeeper (Y5), organizational structure (Y6), organizational culture (Y7), commitment on the part of the developers (Y8), strategy adopted by the organization (Y9) and effectiveness of the regulatory system or judicial system to enforce patent law and intellectual property (Y10) by regressing them against the dependent variable, commercialization of herbal medicines R&D outputs(Co). Estimation was done by Ordinary Least Square using E-view software. Descriptive statistics such as percent and frequencies were used to determine the extent of commercialization of herbal medicine R&D outputs from various research bodies at 95% confidence level. Analysis of variance (ANOVA) and Duncan Multiple Range test were used to determine whether there were statistically significant differences between the levels of satisfaction and adequacy of the extent of commercialization of herbal medicine R&D outputs from the various research bodies. The factors that influenced the commercialization of herbal medicine R&D outputs were analyzed using inferential statistics such as correlation technique and multiple regression analysis. Level of significance was set at $p < 0.05$.

RESULTS

In Table 1, respondents assessed the extent of commercialization of herbal medicinal products at two levels namely, (a) on the degree of satisfaction of the commercialization exercise and (b) on the level of adequacy of the products based on the ratings provided therein. In all, 38(52.35%) of the respondents in the universities were satisfied with the

level of commercialization of herbal medicines R&D outputs; while 34 (45.95%) were not satisfied. Only 2(2.7%) of the respondents remained undecided. In the research institutes, 43 (65.15%) were satisfied with the commercialization of R&D outputs; while 19(28.69%) were not satisfied. Only 4(6.6%) were non- committal. Furthermore, 74(74%) of respondents in pharmaceutical manufacturing firms were satisfied with the level of commercialization of herbal medicines R&D outputs, while 16(16%) were not satisfied. However, 10(10%) of the respondents remained undecided. Majority 45(60.88%) of the respondents in the universities opined that the amount of herbal medicines in the market were inadequate .Only 29(39.12%) believed that the level of herbal medicine R&D output was adequate. Also, majority 43(65.15%) of respondents in research institutes averred that the level of herbal medicinal products in the market were inadequate. However, 23(34.85%) of these researchers believed that the amount of herbal medicines in the market remained grossly inadequate. The reverse was the case in the opinions of respondents in the pharmaceutical manufacturing firms. For instance 79(79%) of the respondents in the pharmaceutical firms rated the adequacy of herbal medicines high while only 21(21%) held contrary opinions.

Furthermore, the opinion of core researchers in herbal medicines R&D were sort, in order to determine the actual number of commercialized herbal medicinal products from their various research bodies since the establishment of the research bodies (Table 3). Results obtained showed that 85% of herbal medicinal products developed by herbal medicine producers were successfully commercialized. Also, 58% of developed products in research institutes were commercialized. Only 25% of developed herbal products by the 13 universities examined had been commercialized. This finding is 70% in agreement, with the results obtained in Table 1. In terms of developed products from the total research outputs in each of the research body, the universities developed only 31% of their total research output. The research institutes developed 50.6%, while herbal medicine producers developed 88.52% of their total research output. Instructively, this scenario appears to be in tandem with the extent of commercialization of research outputs in the research bodies. In all the universities generated a total of 839 outputs, the research institutes had 89 outputs to their credit while herbal medicine producers generated 1220 research outputs within the study period (Table 3).Non-commercialized inventions in the universities were 195, research institutes 19 and herbal medicine producers 162. On oral interview, reasons for not commercializing some of the inventions that had been developed were hinged on the constraints that hampered commercialization process (Table 4).

The statistical relationship between the levels of satisfaction in commercializing herbal medicine R&D outputs and adequacy of the outputs in the market is presented in Table 2, using ANOVA and Duncan Multiple range tests.

Table 1: Respondents Assessment of the extent of Commercialization of Herbal Medicine R&D Outputs

Parameters	Universities	Research Institutes	Pharmaceutical companies/Herbal Producers
Level of satisfaction			
Highly satisfied	12 (16.22%)	9 (13.64%)	45 (45%)
Satisfied	16 (21.62%)	8 (12.12%)	5 (5%)
Averagely satisfied	10 (14.51%)	26 (39.39%)	24 (24%)
Highly unsatisfied	34 (45.95%)	19 (28.79%)	16 (16%)
Undecided	2 (2.70%)	4 (6.06%)	10 (10%)
Total	**74 (100%)**	**66 (100%)**	**100 (100%)**
Level of Adequacy			
Most Adequate	11 (14.8%)	4 (6.06%)	16 (16%)
Adequate	10 (13.51%)	6 (9.09%)	18 (18%)
Averagely Adequate	8 (10.81%)	13 (19.70%)	45 (45%)
Not Adequate	45 (60.88%)	43 (65.15%)	21 (21%)
Total	**74 (100%)**	**66 (100%)**	**100 (100%)**

Source: Field Survey, 2010.

Table 2. Anova and Duncan Multiple Range results for levels of Adequacy and Satisfaction of Commercialization of Herbal Medicine R&D Outputs.

ANOVA result for Level of Adequacy in the Commercialization of Herbal Medicine R&D Output

	Sum of Squares	df	Mean Square	F	Sig
Between groups	9068.750	3	3022.917	3.640	0.045
Within groups	9967.000	12	830.583		
Total	19035.750	15			

ANOVA result for Level of Satisfaction in the Commercialization of Herbal Medicine R&D Outputs

	Sum of Squares	df	Mean Square	F	Sig
Between groups	7386.400	3	2462.133	3.468	0.041
Within groups	11359.600	16	709.925		
Total	18746.000	19			

Result of Duncan Multiple Range tests on the levels of satisfaction and adequacy in the commercialization of Herbal medicine R&D outputs

Variables	**Satisfaction**	**Adequacy**
Research Institutes	13.2[a]	16.5[a]
Universities	14.8[a]	18.5[a]
Pharmaceutical Firms/Herbal Producers	20.0[a]	25.0[a]
Herbal Medicine Consumers	60.0[b]	74.5[b]

Note: Means with same alphabet are not significantly different.

Table 3: The Distribution of Research Outputs, Number of Products Developed, No of Commercialized Inventions and Non-Commercialized Inventions in Herbal Medicine.

S/No	Institutions	Research Outputs	No of products developed	No of Commercialized Inventions	No of non-commercialized inventions
1. .	University Of Maiduguri	53(6.32%)	14(5.36%)	6(9.04%)	8(4.10%)
2.	University Of Ibadan	44 (5.24%)	10(3.83%)	2(3.03%)	8 (4.10%)
3.	University Of Port-Harcourt	36(4.29%)	12(4.59%)	3(4.55%)	9(4.62%)
4.	University Of Benin	68(8.11%)	22(8.43%)	9(13.64%)	13(6.67%)
5.	University Of Jos	51 (6.08%)	31(11.88%)	6(9.09%)	25 (12.82%)
6.	University Of Nigeria Nsukka	120 (14.30%)	40(15.33%)	13(19.70%)	27 (13.85%)
7.	Obafemi Awolowo University	162 (19.31%)	41(15.17%)	4(6.06%)	37 (18.97%)
8.	Madonna University	18 (2.15%)	6(2.29%)	1(1.52%)	5 (2.56%)
9.	Igbinedion University	12 (1.43%)	3(1.15%)	1(1.52%)	2 (1.03%)
10.	Olabisi Onabanjo University	14(1.67%)	9(3.45%)	2(3.03%)	7 (3.59%)
11.	Ahmadu Bello University	110(13.11%)	36(13.79%)	11(16.67%)	25 (12.82%)
12.	Niger/Delta University	19(2.26%)	4(1.53%)	2(3.03%)	2 (1.03%)
13.	University of Lagos	132(15.73%)	33(12.64%)	6(9.09%)	27 (13.85%)
	Total	**839**	**261**	**66**	**195(100%)**
14. .	Research Institutes National Institutes for pharmaceutical Research & Development (NIPRD)	28(31.46%)	11(24.44%)	6(23.08%)	5 (26%)
15. .	Nigerian Natural Medicine and Development Agency (NNMDA)	43 (48.31%)	18(40%)	8(30.77%)	10(52%)
16.	Pax herbal Clinic Ewu	18 (20.22%)	16(35.56%)	12(46.15%)	4 (21.05%)
	Total	**89**	**45**	**26**	**19(100%)**
17.	Pharmaceutical Firms/Herbal Producers	**1220**(100%)	**1080**(88.52%)	**918** (75.25%)	**162** (13.28%)

Source: Field Survey, 2010.

The mean ratings of the constraints affecting the commercialization of herbal medicine R&D outputs in the various research bodies are shown in Table 4.There were significant differences ($F=3$, $P<0.05$) among the mean ratings. The most severe constraints on a 5-point Likert Scale according to the respondents from the research bodies were, inadequate funding of R&D (4.73) and inconsistent government policies on funds allocation for research (4.68). The incessant change of government in Nigeria especially before 1999.This caused a lot of disruptions, not only in policy formulation and execution, but also in developmental programmes. This action gave room for sustainability because new governments usually discard previous regimes policies[23]. Constraints on commercialization of herbal medicinal products that were rated significantly the same ($F=$, $P<0.05$) and more severe include lack of interest for local R&D results by the industry (3.91), poor industry academic linkage (3.82) and lack of adequate infrastructural facilities such as electricity, building (3.70). Lack of adequate support for SME's (3.62) and apathy of financial institutions such as banks to invest in R&D activities (3.60) were other commercialization constraints rated severe. Lack of patronage of indigenous R&D results by industries has been the bane of commercialization of research results in Nigeria. Even entrepreneurs are not keen on investing money in projects that would not yield quick returns. Neither is government nor institutional support adequate to encourage SME's to take-up new R&D results8. Poor linkage between the industry and universities, which was rated a more severe constraint, continues to deteriorate because the universities more often than not, produced what the industries did not require16. Two main political factors that retarded commercialization of R&D results were colonialism and political instability which encouraged the influx of imported goods, killed indigenous enterprise, encouraged the export of local raw materials and scared away would-be investors[23].

Table 4: Rating of Constraints affecting Commercialization of Herbal Medicine R&D Outputs by Various Research Bodies.

Constraints	Overall rating by research bodies
Inadequate funding	4.73a
Inconsistent Government Policy	4.68a
Lack of interest for Local R&D results by industry	3.91b
Poor industry-academic linkage	3.82b
Lack of adequate infrastructural facilities	3.70b
Lack of adequate support for SME's	3.62b
Apathy of financial institutions e.g. banks to invest in R&D activities	3.60b

Key: Most Severe = 5, More Severe = 4, Sever = 3, Less Severe = 2, Least Severe = 1
Means with same letters along the columns are not significantly different at P>0.05.
Source: Field Survey, 2010

Suggested Solutions to Identified Constraints Affecting the Commercialization of Herbal Medicine R&D Outputs.

The various solutions suggested by respondents in the research bodies namely (the universities, research institutes and herbal producers) to arrest the problems confronting the commercialization of research results are presented in Table 5. About 69% of the respondents suggested the need for capacity building for R&D researchers. Adequate funding of R&D activities was suggested by majority (75%) of the respondents as panacea for the identified R&D constraints. About 63% of the respondents suggested that effort should be made to create more confidence in indigenous R&D results in order to enhance their acceptability. Improved linkages between the academia, industry and entrepreneurs as suggested by the (65%) of the respondents may help enhance the confidence in indigenous R&D results because duplications of research projects would be reduced as the universities would tailor their research along the needs of the entrepreneur. The industries in turn would map out R&D results that are market-oriented (45%) and communicate same to the universities; and to other research bodies. It was also revealed by the study, that about 71% of the respondents suggested that there is need to improve R&D infrastructure which include among other things, good roads, electricity, telecommunication, provision of potable water, and transportation. The importance of good infrastructural facilities for an effective R&D system had been reported[12].

Table 5: Suggested Solutions to Identified Constraints affecting the generation of Herbal Medicine R&D outputs and their Commercialization

Suggested Solutions	% of Respondents
Capacity building for researchers locally and internationally.	68.75
Adequate funding of R&D activities and to users or investors of R&D results.	75.00
Regulations to engender confidence in Indigenous R&D results by industry.	62.50
Improve the linkage between the academia and the industry.	65.00
Establishment of trust fund with universities and other stakeholders for research activities.	25.00
Enlightenment campaign to promote R&D results to entrepreneurs.	58.00
Encourage financial institutes such as the banks to provide loan able funds to investors in R&D results of low interest rate.	25.00
Improve infrastructural facilities for R&D.	70.60
Emphasis to be laid on market driven R&D projects.	45.00
Government to provide the much needed enabling environment for sustainable R&D activities.	66.50

Source: Field Survey, 2010.

In Table 4, 25% of the respondents claimed that the establishment of trust fund with universities and other stakeholders for research activities together with encouraging banks to provide soft loans for R&D investors would improve the commercialization of research results. About 67% of the respondents opined that government should provide an enabling environment for sustainable R&D activities

Table 6: Results of the regression analysis of factors influencing the commercialization of herbal medicines R&D outputs.(Dependent variable C, is the commercialization of herbal medicine (R&D) output.

Explanatory variables	Coefficients	t-statistics
Y_1	2.077*	1.080
Y_2	1.820	0.860
Y_3	3.618**	0.123
Y_4	4.061**	1.021
Y_5	-1.023	-1.100
Y_6	-0.526	-0.332
Y_7	2.634	0.104
Y_8	3.678**	0.098
Y_9	4.491**	0.061
Y_{10}	1.281	0.912

Other statistics

R^2=0.267; Adjusted R^2=0.183; DW=1.405; Standard Error=0.259; F=3.177*

Source: Field Survey, 2010. *Significant at 5%; **Significant at 10%.

The coefficient (1=2.077) of Y1 shows that as the market demand of herbal medicine increases by a unit, the commercialization of herbal medicine R&D output increases by 2.077 units. This relationship is significant at 95% confidence interval. The implication of this result is that herbal medicine R&D research outputs was actually geared or directed towards specific market needs especially in the institutions surveyed.

The coefficient of Y2 (technology push) was 1.820. This showed that embarking on herbal medicine R&D and taking advantage of technological possibilities would increase commercialization by 1.820 units. This value is however not significant at 5% and 10% levels indicating that generating research output in the laboratories especially in the universities and research institutes may have been stimulated by other reasons other than the market. Such other reasons may be the quest to acquire more publications in order to earn routine promotion for those researchers in the universities or the meet research mandates for those scientists in research institutes. The coefficient (1=3.618) of Y3 showed that when the independent variable, availability of market changes by 1 unit, commercialization increases by 3.618 units. This means that as the scope of the market widens, the commercialization will increase thrice as much. This value is significant at both 5% and 10% levels, which implies that the market had contributed significantly to the commercialization of herbal medicine R&D outputs. This finding also reinforces the earlier assertion that one of the motivations for embarking on herbal medicine R&D by the research scientist was the need of market or market pull. The coefficient of Y4 (4=4.061) showed that if independent variable availability of inputs changes by 1 unit, commercialization of herbal medicine R&D outputs increases by 4 times. The availability of inputs (Y4) is very important in the commercialization of R&D results. This value was significant at both 5% and 10% levels, which implied that the variable had contributed significantly to commercialization of research results. The presence of product champion as an important variable for commercializing herbal medicine R&D outputs had a coefficient of -1.023. This implies that as the number of product champion increases, commercialization of research results decreases by one unit too. The value of the coefficient is not significant at both 5% and 10% levels. The organizational structure of manufacturing firms and research institutes should positively influence the process of commercialization in these organizations. However the coefficient of -0.428 of Y6 means that when the variable changes by 1 unit, commercialization will decrease by 0.428 units. This value is not significant at 5% and 10% levels.

The coefficient of Y7 (7=2.634) shows that when the variable organizational culture improves marginally, commercialization will increase almost three times. However, the coefficient was not significant at both 5% and 10% levels. This means that if the research bodies examined do not give enough room to their workers to exercise their individual initiative when conducting researches, commercialization effort may be hampered. The organizational structure of most organizations is a reflection of their culture. Hence, organizational structure and culture militate against commercialization drive if such organizations operate rigid and hierarchical system.
The variable commitment of the developers (Y8), has a coefficient of (8=3.678) which is significant at 10% level. This means that for 1 unit increase in the level of commitment by the researchers, commercialization would increase almost by four times. The implication of this finding is that commitment of the developers influenced the process of commercialization of R&D results. Developers are generally regarded as technical and managerial staffs that are committed to the R&D process. They ensure that the manufacturing facilities are adequate and are in good condition. The strategy of the organization (Y9) has a coefficient of 4.491 (9=4.491) and it is significant at 10% level. This means that as the variable (Y9) changes by 1 unit, commercialization will increase almost by 5 times. Normally, since the universities and research institutions are not profit making organizations where competition in terms of research is usually given serious consideration, formulation of any competitive strategy may not be a priority. Therefore, commercialization is not expected to increase with organizational strategy. However, this is not the case with pharmaceutical manufacturing firms/herbal medicine producers where strategy to enhance commercialization is a major concern of management. This was different from what obtained in the universities and research institutes because commercialization of research outputs in this case was fairly high. This variable (Y9) strategy of the organization was positive and significant at 0.05 level of significance, the number of R&D outputs commercialized by each segment of the research bodies were, universities (66), research institutes (26) and pharmaceutical firms/herbal producers (918). The variable, effectiveness of the regulatory system to enforce patent laws and intellectual property (Y10) has a coefficient of 1.281, which is not significant at both 5% and 10% levels. This implies that as the variable changes by 1 unit, commercialization increases by 1.281. However, since this variable is not significant, it means that it had little or no influence in the commercialization of R&D outputs. Therefore the research bodies studied are yet to benefit maximally from the activities of the judicial systems in enforcing the issuance of patent laws and intellectual property rights to inventors, in order to encourage commercialization of herbal medicine R&D outputs.

Table 7: Step-Wise Correlation Matrix for the Commercialization of R&D Outputs(Co)

C_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}
1.000										
0.401**	1.000									
0.354**	0.310	1.000								
0.612**	0.360*	0.450**	1.000							
0.451*	0.401	0.382*	0.488**	1.000						
0.186	0.293	0.310	0.401**	0.240*	1.000					
0.081	-0.123	-0.141	0.014	0.136	-0.126	1.000				
0.146	0.304	0.128	0.259	0.281	0.112	0.165	1.000			
-0.485	0.213	0.319*	0.512**	0.610*	0.358	0.135	0.405*	1.000		
0.540*	0.218	0.333*	0.481**	0.512**	0.489	0.138	0.162*	0.492**	1.000	
0.231	0.150	0.163	0.102	0.082	0.190	0.269	0.81	0.145	0.216	1.000

** - Correlation is significant at the 10%
* - Correlation is significant at the 5%

The correlations between the dependent variable (C0) and each independent variable as well as the correlations among the independent variables are presented in Table 7. The commercialization of R&D outputs (C0) is significantly correlated to the variable; market (Y1), technology push (Y2), availability of markets (Y3), availability of inputs (Y4) and strategy adopted by the organization (Y9).Similarly, technology push (Y2) showed slight but significant correlation with availability of markets (Y3), availability of inputs (Y4), commitment on the part of the developers and (Y8) strategy adopted by the organization (Y9). Availability of the market (Y3) correlated slightly but significantly with availability of inputs (Y4), the presence of product champions or technological gate-keepers (Y5), strategy commitment on the part of the developers (Y8) and strategy adopted by the organization (Y9). Also the availability of inputs (Y4) showed fairly strong but significant correlation with the presence of product champions or technological gate keepers (Y5) commitment on the part of developers (Y8), and strategy adopted by the organization (Y9) .Furthermore, organizational culture (Y7) showed slight but positive correlation with commitment on the part of the developers (Y8) and the later showed significant but slight correlation with strategy adopted by the organization (Y9). The organizational structure (Y6) showed negative and insignificant relationship with market demand (Y1), technology push (Y2) and presence of product champion or technological gatekeeper (Y5). Commitment on the part of the developers (Y8) showed positive and significant correlation with technology push (Y2), availability of market (Y3), availability of inputs (Y4), and organizational culture (Y7). Strategy adopted by the organization (Y9) showed positive and significant correlation with technology push (Y2), availability of market (Y3), availability of inputs (Y4), organizational culture (Y7) and commitment on the part of the developers (Y8). Other independent variables had weak and insignificant relationships.

DISCUSSION

Results obtained showed that the research institutes were more actively involved in commercializing herbal medicine research outputs than the universities. The pharmaceutical companies/herbal medicine producers performed better than the universities and research institutes in commercializing herbal medicine research outputs. The feat achieved by pharmaceutical companies/herbal medicine producers may be due to the nature of such establishments which naturally, are profit-oriented organizations. As such, effort may have been made to produce what the market desired and the organizations would have done everything possible to ensure market success in view of the competitive environment in which they operate. Oral interview with some herbal medicine producers reinforced this widely held view on herbal medicine commercialization. Analysis of variance on the assessment of herbal medicine commercialization based on their levels of satisfaction and adequacy were statistically significant at P0.05 with values of F19 = 3.468 and F15 = 3.64 respectively. Duncan Multiple Range Test showed that there were statistically significant differences in the levels of satisfaction and adequacy of herbal medicine R&D outputs among the research bodies.

Older universities such as Obafemi Awolowo, Ahmadu Bello, Jos, Lagos, Benin and Nsukka with established Pharmacy Schools

developed more herbal medicines than new universities. This may be due to the presence of experienced personnel or researchers who had at their disposal adequate research equipment and perhaps funds inform of research grants. However, the rate of commercialization of herbal medicine outputs did not follow this expected pattern because some new universities had more commercialized inventions than older universities which were expected to have better research facilities. Likely reason could be linked to some of the constraints limiting commercialization process which were hitherto highlighted. Some of the notable constraints were inadequate funding of R&D, poor capacity building and inadequate infrastructural facilities. The creation of an enabling environment by the government as suggested by respondents could be a way of addressing the observed herbal medicine commercialization constraints.

Furthermore, the four factors that could be gleaned from the regression table, as having tremendous influence on herbal medicine commercialization process were the market (Y3), availability of inputs (Y4), commitment of developers (Y8) and strategy adopted by the organization (Y9). These factors were not only significant but positively influenced the commercialization of herbal medicines R&D outputs in Nigeria. One common feature inherent in these factors was the obvious roles that the organizations must play to achieve success in commercializing herbal medicine outputs. The impact of the four factors on the commercialization of herbal medicine R&D therefore depends on the amount of effort put in by various personnel or management in the research organizations.

The presence of product champion did not contribute positively to the commercialization of herbal medicine R&D outputs. An explanation for this could be that majority (83.33%) of the researchers were carrying out the research just for advancement in their careers (self commercialization) which could be a reason for not patenting inventions by research scientists. Also the organizational structure of the research bodies impacted negatively on the commercialization of herbal medicines R&D outputs. The implication of this is that the research scientists are operating in a rigid and hierarchal system where little or no room is given for personal imagination, free flow of ideas and thoughts. In such situations research mandates, which are designed by management, are vigorously pursued along laid down rules and regulations.

The suggested lead strategies for commercializing herbal medicines R&D outputs were increased R&D funding (75%) and improved infrastructural facilities (70.60%), while the proposed strategies to be least adopted were the establishment of trust funds for executing R&D projects (25%) and sourcing of cheap funds at low interest rate for R&D activities (25%). In order to optimally commercialize research outputs, an integrated approach should be adopted in the utilization of strategies in response to the prevailing circumstance or situation. This is so because commercialization is a dynamic process that may require consistent review of strategies with every emerging situation.

CONCLUSION

The commercialization of herbal medicine R&D outputs in Nigeria is still low in spite of the large number of herbal medicines already developed by various research bodies. Therefore, identified economic and institutional constraints hampering herbal medicine commercialization process must be tackled by the government. This could be done by creating a salubrious environment that would guarantee industrial peace and maintain consistent economic and industrial policy.

REFERENCES

1. Olaniyi, A.A. (1998). Basic Requirements and Strategies for Chemical Standardization and Evaluation of Herbal medicine, In Standardization and Utilization of Herbal medicine: Challenges of the 21st Century, Proceeding of An International Workshop, Department of Pharmacognosy, University of Ibadan. pp. 19-29.

2. Olatunji, O. (2000). Problems and Prospects of Commercializing Research Outputs: FIIRO's Experience. Paper Presented at the 1st Nigerian University Research and Development Fair Organized by National University Commission, 24th Nov. Abuja. pp. 2-3.

3. Organization for Economic Cooperation and Development (OECD) (1997). Diffusing Technology to Industry. Government Policies and Programmes, OECD, Paris p. 33

4. World Intellectual Property Organization (1997). Institutional Framework for the Commercialization of Invention and Research Result: The Industrial Property System.

National Seminar on Commercialization of Invention and R&D Results. (Abuja), Nigeria. 25-27, November.

5. Igwe, B.U.N.; Kumuyi, A.J. (1989). Commercialization of Technology Research and Development Results in Nigeria, In Research for Development 6, 5-8.

6. Federal Ministry of Health, (2006). National Health Summit on Roll Back Malaria, October, Abuja, Nigeria.

7. Ohuabunwa, S.I. (1998). Modern Herbal Medicinal Products. An Address Delivered at 1st International Workshop on Herbal Medicinal Products, University of Ibadan, Nov. 22-24,published in Standardization and utilization of Herbal medicine: Challenges of the 21st Century. pp. 1-2.

8. Oyelaran – Oyeyinka, B. (1996). Industrial Technology Management. Some Key Issues. A Paper Presented At a Seminar on Main Issues In Technology Management. Regional Centre for Technology Management, Lagos. July 24-26 p. 6.

9. Ilori, M.O.; Adeniyi, A.A.; Sanni, S.A.; Adekoya, (2005). Commercialization of Research and Development Results; Prospects and Challenges. Paper presented at the workshop on R&D, NACETEM O.A.U Ile-Ife pp. 5-7.

10.Lall, S. (1998). "Marketing Stimulating Technology Pòlicy in Developing Countries". A Framework with Examples from East Asia. World Development. 26, 8, pp.16-21.

11.Ogbimi, F.E. (1990). "Commercialization of R&D: Preparing for Commercialization of Scientific Research Results in Nigeria". Science and Public Policy, 17, pp.373-379

12.Momah, S. (2006). Technology is Power: Memoirs of a Soldier, Scholar, Strategist, Engineer in Government. Polar Press ltd, Lagos, Nigeria.

13.Irefin, I.A.; Ilori, M.O.; Oyewale, A.A.; Solomon, B.O. (2006). Developing a Biotechnology R&D and Innovation Agenda for Nigeria: Some Critical Technology Management Issues. NJEM, Vol. 7 No. 1 pp.1-13

14.Cabral, R. (1998). European Instruments for Technology Transfer and the Experience of the Innovation Relay Centres in UNCTAD. New Approaches to Science and Technology Co-operation and Capacity Building. Advanced Technology Assessment System: United Nations Publication UNCTA/ITE/EDS/6 Sales No E. 9911: 4D4 pp. 235-258.

15.Tiffin, S. (1997). Building Science and Technology Innovation Systems in Africa Paper Delivered at the First Regional Programme for Technology Management (REPTEM), Lagos May 12-16.

16.Papageorgion, J.C. (1977). Trends in R&D Human Resources and Findings in Major Industrial Countries. Int J. Technology Management. Special Issue on R&D Management 13, 7/8,pp. 874-894.

17.Taylor, J.B. (1994). Discovery of New Medicines: In Griffin, J.P.O.; Grady, J.; Wells, F.O. (Eds). The Textbook of Pharmaceutical Medicine, 2nd Edition, Greystone Books, Antrim, North Ireland.

18.Gross, B.T. (1997), Technology Centres and Business Incubators in Germany in OECD Technology Incubators: Nurturing Small Firms OECD/GD (97) 202. Paris.

19.Mickelvey, M. (1994). Evolutionary Innovation. Early Industrial uses of Genetic Engineering. Doctoral Dissertation. Institute of Tema Research, Linkopins University, Sweden.

20.Sheen, M.R.; Mac Bryde, J.C.; Houston, J. (1994). Managing IPR in an Academic Environment. Lessons Learned by Strathdyde University: Paper Presented at the Role of IPR in the Innovation Environment. A Multi-Disciplinary Workshop sponsored by the ESRC and Anglia Polytechnic, University, Danbury Park, 23rd – 24th March.

21.Osemene, K. P. (2006). A Study of Technology-based Strategic Alliances Among Pharmaceutical Companies in Southwestern Nigeria. Unpublished M.sc thesis submitted to the Technology Planning and Development Unit (TPDU) Obafemi Awolowo University, Ile-Ife, Nigeria p. 15.

22.Joint Admission and Matriculation Board (JAMB). Brochure 2007/2008. Pp.210-217.

23.Adjembemg-Asem, (1995). Translating Technical Innovation into Entrepreneur In Nigeria: Social and Policy Implication in Ogbu, Osita, M.; Oyeyinka, Banji O.; Miawa Hasa, M (eds). Technology Policy and Practice in Africa. Chapter 14. International Development and Research Centre, IDRC, Canada.