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Research Trends of Higher Education in Pakistan: A Case Study of Allama Iqbal Open University

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ABSTRACT

Allama Iqbal Open University (AIOU) is the only higher educational institution which serves the nation's needs in the open/distance education sector in Pakistan. This paper aimed to identify the trends and issues in doctoral dissertations between 2000 and 2014 using the content analytic approach in the Pakistani Higher Education context. A total of 37 dissertations were reviewed to explore the research areas, research design, research models, keywords, nature of participants, data collection instruments, and data analysis techniques. The results of this study contain a great potential in helping the researchers, supervisors, and practitioners in AIOU and higher education commission (HEC) in Pakistan to focus on the research gap and ignored areas of research in doctoral dissertations, and to prioritize the research agenda to develop and diversify the practical and theoretical research in Pakistani higher education context.
KEYWORDS: Higher education, content analysis, research trends, dissertations, Pakistani higher education.

1. INTRODUCTION

The technological developments brought about tremendous changes in the social and educational system all around the globe. Under the influence of these profound changes, higher education emerged as a multidisciplinary field, which responded to the technological advances and the resulting changes in such a way that it evolved into a distinct education system, oriented itself to satisfy the dynamic needs of the educators and students. With evolving and customized approach adopted by the educational institutions and learners, it is the need of time to develop good understanding of the trends and issues in the higher education for meeting the constantly emerging demands and social changes [2].

The research and scholarly work contribute to the reputation of the education and research institutions, and bear witness on the intellectual activities employed to enhance the sustainable social development. Research work organized by the universities distinguishes them from other educational institutions such as schools and colleges, which attracts the thinkers, scholars and people with research aptitude in order for providing the vibrant and socially constructive environment within the universities [10].

The deep insight into the contribution of the higher education to resolving the social and educational issues is only possible if the positive impact of the research activities conducted by the researchers is assessed through determination of research trends and issues. The research works in higher education would be able to provide a full understanding about the theories and practices embraced by the researchers to explain the social phenomena, changes in the social processes and behaviours [11].

In addition, the methodological approaches adopted by the researchers in higher education also justify the soundness and robustness of the research work in terms of promoting scientific activities and causing the constructive social developments. Therefore, dissertations generated as a consequence of the organized and systematic research activities may serve as a great source for examining the theories and practical considerations developed by researchers to produce the findings or explain the research issues under investigations [12].

Hence, they can provide a great means to examine the research trends in any educational field including the higher education. They are also authentic sources of distribution and dissemination of the scientific information for policy makers working in educational and governmental organizations [4].On this ground, this study was designed to examine the research trends and issues in higher education in Pakistani Higher Education context by assessing the dissertations produced as requirement of PhD degree [19].

A dissertation is a creative, formal, and lengthy piece of work with scholarly importance and significance and is written in partial fulfilment of the academic/professional degrees. Dissertations constitute useful, up-to-date and original contribution to the relevant field of study. In addition, they present the critical thinking, scientific

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procedures developed to address the research issues, and shows logical and coherent arguments in defensible manner. Similar to the review of the research articles, the dissertations are surprised by experts, scrutinized by the research Committees, and examined by the external experts. All these factors contribute to the originality and creativity in the writing and research exhibited in the dissertations [5]. Within this scope, this study intends to examine and discuss the research trends in higher education in Pakistani Higher Education by assessing the PhD level dissertations published from 2000-2014 [17].

2. REVIEW IN HIGHER EDUCATION

Several studies are previously conducted to examine the research trends and issues in higher education. Berge and Mrozowski (2001) analysed the research themes in the higher education from 1990 to 1999 using the content analysis approach. They conducted a large-scale study on four peer-reviewed journals in higher education publishing in English language with sample size 890 research articles. Lee et al (2004) assessed the research methods, research topics and number of citations of the journal articles on higher education in higher education literature from 1997 to 2002. Koble and Bunker (1997) employed the content analysis in combination with Porter's forum analysis (1992) to identify the research trends in terms of research methods, participants and statistical methods in the research articles [N = 129 articles] published in the American Journal of Higher Education from 1987 to 1995. For carrying out the content analysis, most of the researchers used the research template called The International Higher Learning's Classification System to collect data from the research sample between 1990 and 2000 [1], [15], [16], [20].

Shih and Tsai (2008) conducted a content analysis on the research article published between 1985 and 2001 (N = 235 articles) in the Journal of Higher Education, and classified data according the research method, first author's biographical information, type of research, and topic of research. Similarly, Lee et al (2004) examined four peer-reviewed journals: Open Learning, the Journal of Higher Education, the American Journal of Higher Education, and Higher Education, and reviewed 380 research articles to identify the research trends involving the research method and topic of research. In 2010, Davies and his colleagues performed the content analysis on dissertations published between 1998-2007. They analysed the sample for the following research trends: the topic of research, research design, research methods, data collection instruments and data analysis methods [23], [16], [6].

In contrast to previous attempts, Ritzhaupt et al (2010) examined the research articles published in two popular and per-reviewed journals: the Journal of Higher Education and the American Journal of Higher Education. They identified trends themes in higher education using the co-word approach applied on the abstracts of the research articles [N = 517 articles] published between 1986 and 2006; they reported the trends in three moan domains of e-learning: pre-Web, emerging Web and maturing Web. Another large-scale study aimed to identify the trends and issues in higher education was performed by Tuncay and Uzunboylu (2010), which covered the research articles from 160 sources form different parts of the world. They analysed grand total of 9866 research articles published during the years of 1972 to 2008 and examined them based on six main categories: Type of the research, sources of documents, year of publication, language of the research articles, authors, and the most frequently employed keywords. Similarly, Horzum et al (2013) conducted content analysis on 382 research articles published in four prominent peer-reviewed journals from 2005 to 2012 and examined the research trends according the three research methods used to address the research problem: qualitative method, quantitative method, mixed methods [21], [24], [13].

Furthermore, Zawacki-Richter carried out several studies to develop the system for classification of research trends in higher education. In his first study, a Delphi method was sued to classify the research trends based on macro-level (higher education, education systems and theories), meso-level (management, organization, technology and micro-level (teaching, learning and higher education) [Zawacki-Richter, 2009]. Zawacki-Richter et al (2009) examined the research articles published in five prominent journals in higher education from 2001 to 2007, and found the research trends based on the research gaps and the research topics. Zawacki-Richter and Von Prummer (2010) reviewed the research articles in the higher education, identified the gender role in higher education research, collaborative pattern among researchers, research productivity, diversity in the research topics and research methods [26], [28], [29].

Zawacki-Richter and Naidu (2016) examined the research trends in online higher education, showed it as an independent field of enquiry, participation of students in online higher education, and suggested the clear-cut orientations for the future research work in this field. Bazkurt et al (2016) conducted the comprehensive content analysis on the research articles [N = 861 articles) found in the seven journals during the years of 2009 and 2013, and classified the research trends based on the eight variables: data collection tools, data analysis tools, research methods, conceptual/theoretical frameworks, research models, type of variables, research areas, and number of participants [27].

In addition to global coverage of research trends in higher education, some studies attempted to identify the issues and trends locally. For instance, Nasr et al (2013) analysed the trends in higher education in dissertations

produced in India between 1972 to 1990. Following the analysis of 142 studies, they concluded that only few studies produced the findings with practical applications in the field, however, most of studies were generalized with less focus on the meso- and macro-level functions in higher education. Salar (2009) conducted content analysis on the research articles (N = 298 articles) published in 15 Turkish research journals and 12 conference proceedings. He reported that research articles in Turkish journals over-represented the following categories in the Turkish higher education: active learning issues, characteristics of learners in higher education, adoption of technologies for online learning, patterns of interactivity and roles of key participants. Another study conducted by Bozkurt et al (2015) reported the research trends in Turkish higher education by performing content analysis on dissertations published between 1986 and 2014. They examined the research trends according to most frequently used keywords, data analysis, tests, data collection, research design and leading contributor institutions in Turkey [18], [22], [3].

Koble and Bunker (1997) analysed the research trends in higher education in Brazil. They conducted content analysis on total of 983 research articles published in Brazilian journals from 1992 to 200 to identify the trends of research methods employed to address the research issues [18].

3. RESEARCH METHODS

3.1 Research design

In order to explore the research trends in the higher education in Pakistani academic institutions with focus on AIOU, the content analysis was performed on the doctoral theses during 2001-2014 at AIOU. Content analysis is a useful data analysis instrument for compressing a large textual data into functional codes and categories or themes (Duriau et al., 2007). Drysdale et al (2013) argued that content analysis is applied on the documents, texts, visual messages/communications in a written form to convnet them into codes which may be transformed into qualitative or quantitative form of data. This method has been used by authors because it has been deemed as the most suitable method for this study [9], [7].

3.2 Population

The doctoral theses submitted at AIOU between 2001 and 2014 in the higher education category called distance education formed the population of this study. These theses were accessed from the research repository of Higher Education Commission (HEC) and university library of AIOU. During online search, the following key words were used: distance education, online education, open and distance education.

3.3 Sample and sampling technique

The PhD theses in the domain of distance education, category of higher education was taken as sample of this study. For the selection of sample, the following inclusion and exclusion criteria were used

- The dissertations must be the PhD level research work.
- The selected dissertations must be submitted by students at AIOU between 2001-2014.
- The doctoral theses uploaded on HEC research repository and available at the university library of AIO would be included.
- The dissertations would be selected if they would address the issues in the domain of open and distance education in Pakistani higher education.

Following the aforementioned inclusion criteria, the 37 doctoral dissertations were retrieved from the HEC research repository and the university library of AIOU, which formed the sample of this study. The random sampling method was employed to select the sample.

The data were analysed using the content analysis, which generated the variables/categories. The summarization of data was done using the frequencies and percentages.

3.4 Classification system for research areas, methods and models

The classification system designed and validate by Zawacki-Richter (2009) was used regarding the classification of different categories obtained after application of content analysis on the doctoral theses (Table 1). The classification system developed by Zawacki-Richter (2009) was used because it has been previously employed by several studies investigating the research trends in higher education category called distance education (Tunacy and Uzunboylu, 2010; Salar, 2009; Ritzhaupt et al., 2010). This allowed the comparison of the research findings from the present study with other studies in the literature [26], [24; 22].

Table 1: Classification system for research areas at macro-level, meso-level and micro-level

Macro level: Distance education systems and theories.
1. Access, equity, and ethics: The democratization of access to distance education afforded by new media and by finding ways to deliver high-quality education to those who have limited resources and poor infrastructure; issues that refer to the (sustainable) provision of distance education in developing areas. What is the impact of distance education (e.g., via mobile learning) on narrowing the digital divide and what is the role of ICT (information and communication technologies) and/or OER (open educational resources) in terms of access to education? *2. Globalization of education and cross-cultural aspects*: It refers to the global external environment and drivers, the development of the global distance education market, teaching and learning in mediated global environments, and the implications for professional development. *3. Distance teaching systems and institutions:* Distance education delivery systems, the role of institutional partnerships in developing transnational programmes, and the impact of ICT on the convergence of conventional education and distance education institutions (hybrid or mixed-mode). *4. Theories and models*: Theoretical frameworks for and foundations of distance education, e.g., the theoretical basis of instructional models, knowledge construction, interaction between learners, or the impact of social constructivism learning theories on distance education practice. 5. Research methods in distance education and knowledge transfer Methodological considerations, the impact of distance education research and writing on practice, and the role of professional associations in improving practice. Literature reviews and works on the history of distance education are also subsumed within this area. *5. Research methods in distance education and knowledge transfer*: Methodological considerations, the impact of distance education research and writing on practice, and the role of professional associations in improving practice. Literature reviews and works on the history of distance education are also subsumed within this area.
Meso level: Management, organization, and technology.
1. Management and organization Strategies, administration, and organizational infrastructures and frameworks for the development, implementation, and sustainable delivery of distance education programmes. What is required for successful leadership in distance education? Distance education and policies relating to continuing education, lifelong learning, and the impact of online learning on institutional policies, as well as legal issues (copyright and intellectual property). *2. Costs and benefits:* Aspects that refer to financial management, costing, pricing, and business models in distance education. Efficiency: What is the return on investment or impact of distance education programmes? What is the impact of ICT on the costing models and the scalability of distance education delivery? How can cost effective but meaningful learner support be provided? *3. Educational technology*: New trends in educational technology for distance education (e.g., Web 2.0 applications or mobile learning) and the benefits and challenges of using OERs, media selection (e.g., synchronous vs. asynchronous media), technical infrastructure and equipment for online learning environments, and their opportunities for teaching and learning. *4. Innovation and change*: Issues that refer to educational innovation with new media and measures to support and facilitate change in institutions (e.g., incentive systems for faculty, aspects referring to staff workloads, promotion, and tenure). *5. Professional development and faculty support*: Professional development and faculty support services as a prerequisite for innovation and change. What are the competencies of online teachers and how can they be developed? *6. Learner support services*: The infrastructure for and organization of learner support systems (from information and counselling for prospective students about library services and technical support to career services and alumni networks). *7. Quality assurance Issues*: It refers to accreditation and quality standards in distance education. The impact of quality assurance and high-quality learner support on enrolments and drop-out/retention, as well as reputation and acceptance of distance education as a valid form of educational provision.
Micro level: Teaching and learning in distance education.
1. Instructional design Issues: It refers to the stages of the instructional design process for curriculum and course development. Special emphasis is placed on pedagogical approaches for tutoring online (scaffolding), the design of (culturally appropriate) study material, opportunities provided by new developments in educational technology for teaching and learning (e.g. Web 2.0 applications and mobile devices), as well as assessment practices in distance education. *2. Interaction and communication in learning communities*: Closely related to instructional design considerations is course design that fosters (online) articulation, interaction, reflection, and collaboration throughout the learning and teaching process. Special areas include the development of online communities, gender differences, and cross-cultural aspects in online communication. *3. Learner characteristics*: The aims and goals of adult learners, the socio-economic background of distance education students, their different learning styles, critical thinking dispositions, and special needs. How do students learn online (learner behaviour patterns, learning styles) and what competencies are needed for distance learning (e.g., digital literacy)?

4. FINDINGS AND DISCUSSION

4.1 Keywords

The keywords used in the PhD level dissertations submitted to AIOU were counted; total of 150 keywords were found, which were specific to define the higher education field. The keywords were ranked according to the frequencies which are shown in the Table 2. The most used key word was the online education (36%), followed by the distance higher education key word (23.1%). The third most commonly used keyword in the dissertations was the online education (16%). These results indicate that higher education is the keyword which is used as a generic term to define the higher education field in Pakistan higher education context.

Table 2. The key words used in doctoral dissertations between 2001-and 2014

Key words	Frequency	Percentage
Online education	110	36
Online learning	47	16
Open learning	33	11
Open learning	38	13
Virtual learning	2	0.6
Distance higher education	71	23.1
Blended learning	1	0.3
Total	302	100

The outcomes of this research exhibit the similar pattern as found by many other studies in the higher education (Bozkurt et al., 2015; Tuncay and Uzunboylu, 2010). The higher education was used a generic term for defining the higher education as an independent field of study. This study also showed that e-learning is the second most term used to describe the research in higher education, which is supported by Bozkurt et al (2015). Many studies supported our results that e-learning is the second most commonly employed keyword in the dissertations [3], [24].

4.2 Research areas

The research areas which were focussed on by the researchers in dissertations in higher education were identified by employing the classification suggested by Zawacki-Richter (2009), [26]. The PhD level dissertations submitted to AIOU were coded according to three categories of classification: macro-level, meso-level and micro-level. The categories in the macro-level (access, equity, ethics) were found to be ignored areas, as no work has been observed in these areas. In meso-level categories (management, organization and technology), the technology was revealed to be the less focussed areas. However, three key areas in the meso-level categories attracted the most attention from the researchers, which area 1) instructional design, 2) Students' support services and 3) Faculty support/development (Fig XXX).

All categories in the micro-level functions in the higher education were observed to be underrepresented in the dissertations in Pakistani higher education context. Learner's characteristics area was prominent at micro-level. At meso-level, most of the doctoral dissertations investigated the instructional design area, followed by students' support, and faculty support/development. The least researched areas included the educational technology, costs/benefits, and management at meso-level areas of research. Furthermore, the content analysis of doctoral dissertations between 2000-2014 at AIOU indicated that dominant research area at macro level was the research methods in higher education followed by the higher education teachings and institutions. The development of theories or models took the least rank, thereby showing that this area of research was under researched at AIOU in Pakistan (Figure 1). All of the categories in the micro-level, meso-level and macro-level functions of the higher education in dissertations between 2001 and 2015 were strongly interconnected with each other, and changes in one area triggered the developments on other areas of research, thereby casting a domino effect on each other.

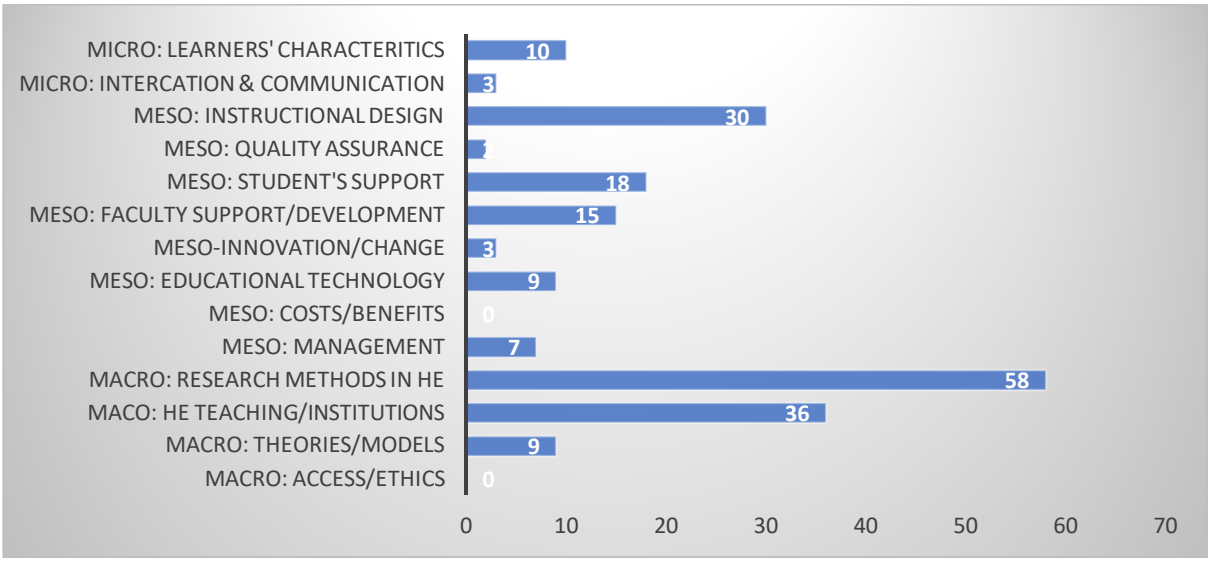

Figure 1: The research areas

Based on the results of the study, most of research categories in macro-level research in higher education dissertations submitted between 2001 and 2014 to AIOU were untapped in Pakistan. This indicates that the AIOU cannot fully develop flexible and open higher education as an interdisciplinary area unless the untapped areas are fully explored by the researchers in Pakistan.

The imbalance in three macro-level, meso-level research categories were observed in this study. This result was vindicated by some other studies which showed that there is an imbalance in these categories (Zawacki-Richter et al., 2009; Bozkurt et al., 2015, Bozkurt et al., 2016). This study demonstrated that some categories in meso-level research including innovation and change, macro-level research categories involving cross-cultural aspects, equity, access, ethics, research methods in higher education and globalization of education are not studied by researchers in the PhD level research endeavours, which is in accordance with the findings reported

by several other studies (Durak et al., 2017; Tunacy and Uzunboylu, 2010, Zawacki-Richter and Naidu, 2016). These data are significant in terms of portraying the highly researched areas and ignores areas of research, thereby highlighting the gap in the research areas. Interestingly, there was no single dissertation found focussing on the economic considerations and costs involved in the development of higher education in Pakistani higher educational institutions [29], [3] [2], [8], [24], [27].

Similarly, the instructional technologies were not explored in dissertations as well. This shows that policy makers and HEC experts would not be able to accommodate the resources and development of instructional technologies for the delivery of higher education to the students in Pakistani higher education. There are some areas, such as faculty development, teachers training, student dropout and issues of social justice, which were found be neglected in PhD level dissertations in higher education in Pakistani higher education. The lack of focus on these areas may hinder the capacity of the AIOU in providing the effective learning through higher education to the consumers in the market. This may also affect the reputation and impact of the research in higher education for AIOU as a sole education institutional in offering the qualifications in higher education.

4.3 Research design

The dissertations submitted between 2001 and 2014 to the AIOU were categorized based on the application three types of research design: quantitative, qualitative and mixed method. It was found that 14% of the dissertations employed qualitative research design, 80% of the dissertation used quantitative. Mixed method research design was used in only 6% of the dissertations in higher education field (Figure 2).

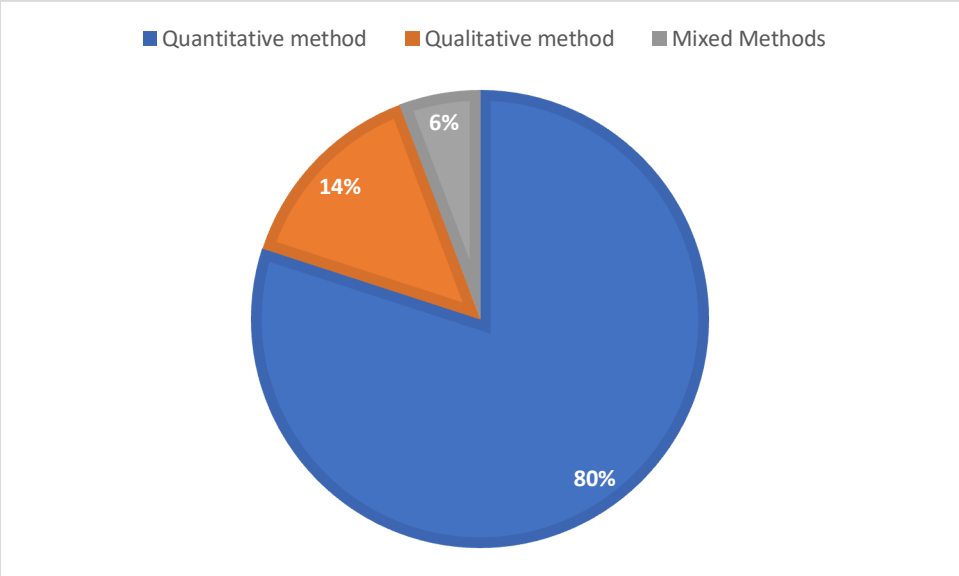

Figure 2: The proportions of quantitative method, qualitative method and mixed methods employed in doctoral dissertations between 2001-2014.

The data demonstrate that quantitative research design was the most employed research design, while the qualitative and mixed methods were the least used research designs. The preference of the researchers in higher education dissertations was found to the quantitative in AIOU, which is in accordance with the research works reviewed by various scholars globally and locally. However, several studies showed that researchers mostly used qualitative research design to address the micro-level and meso-level issues. In global perceptive, the researchers demonstrated preference for the quantitative research design, for example, Horzum (2013) analysed the pattern of research design usage in 189 research articles out of 382 articles (49%) applied the qualitative research design in four popular higher education journals. In contrast to the research studies in global perspective, the researchers in Pakistani higher education context, the preferred research design was quantitative, qualitative and rising trend of mixed method research design since 2009 [13].

4.4 Research models

The remarkable outcomes were revealed for the trends in terms of application of various research models in PhD level dissertations submitted to the AIOU during 2001 and 2014. The survey research model in the quantitative research design was the most predominantly employed method in dissertations, followed by correlational, causal and experimental model. The year-wise distribution indicated that first survey remained evenly distributed

between 2001 and 2006 (N =1), with some peaks in 2007 (N = 2) and 2009 (N = 5) and again in 2013 (N = 2) (Figure 3).

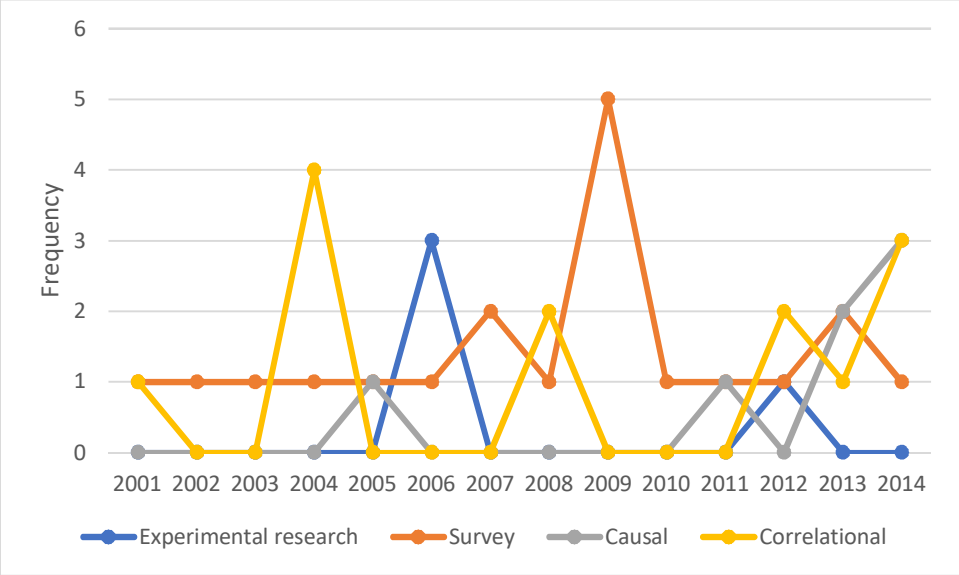

Figure 3: Distribution of quantitative research models used in doctoral dissertations between 2000-2014 at AIOU.

Within the qualitative studies, the grounded theory was the mostly used research model in dissertations (N =12) submitted at AIOU between 2000-2014, while the case study (N = 4) and historical research (N = 3) were the least applied research model. The content-analysis, meta-synthesis and ethnography were among the ignored research models in PhD dissertations submitted at AIOU in Pakistani higher education research. The year-wise distribution demonstrated that trend of using grounded theory model was increased between 2009 and 2014, while the applied research showed a single peak in 2011. However, this increase in applied research disappeared between 2012-2014 (Figure 4).

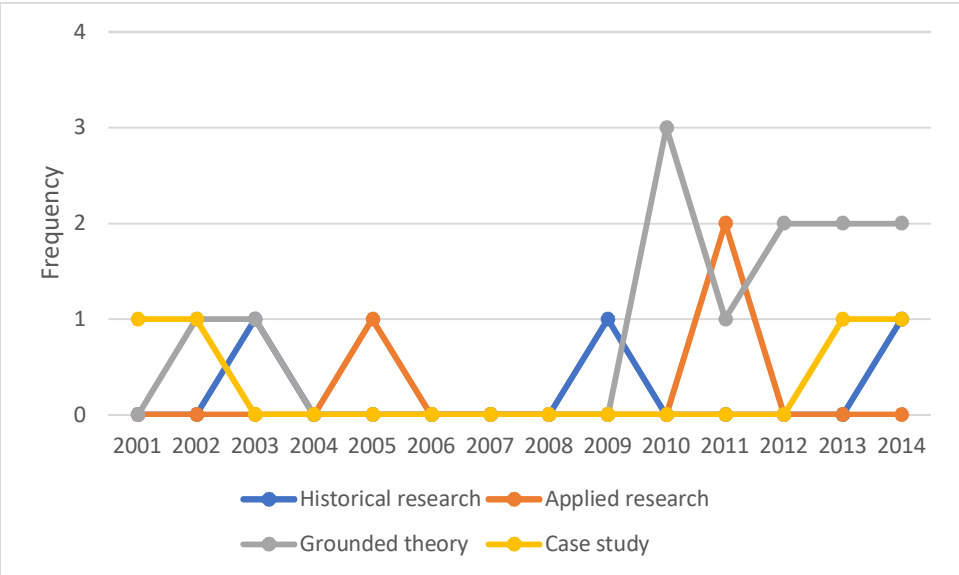

Figure 4. Distribution of qualitative research models used in doctoral dissertations between 2001-2014.

The results obtained in the domain of the research models demonstrated some interesting pattern of similarities and differences with the globally identified research trends. For instance, Bozkurt et al (2015) identified the survey research model as a predominantly used research model in dissertation in Turkish higher education context, which supports the findings of this study in Pakistani higher education context. Bozkurt et al (2016) showed the similar results to support high preference of researchers for the survey-based research model in the

quantitative research studies. Berg and Mrozowski (2001) conducted the content analysis of research articles, and found that descriptive model was the highly preferred model by the researchers in higher education, followed by the case study (6%) and correlational models (6%). These data correspond with our study showing the higher application of descriptive model in the qualitative research design compared to case studies and correlational which were least used research methods. Globally, the content analysed conducted by several scholar showed that 66% of the qualitative research use the case study model followed by design-based approach (9%) which does not correspond with the research in higher education supervised at AIOU. These differences may be related to the variations in the human and financial resources which are required to apply the different research models within specific research design. The preferences and expertise of the supervisor and students may also cause the deflection of the trends in Pakistani higher education context from those in global higher educational context. This indicates that AIOU need to build the capabilities in terms of streamlining the financial and human resources for fostering the diversity in the application of research models in mixed methods and qualitative research designs to promote the healthy impact on the research activities carried as part of PhD level qualifications in higher education at AIOU.

4.5 Tests and analysis

The findings relating to the tests and analysis used by the researchers in dissertations submitted to AIOU between 2001 and 2014 are shown in Table 3.

Table 2. The statistical tests used in doctoral dissertations between 2001-and 2014

QUANTITATIVE Statistical Tests					
Descriptive (65%)		Inferential (35%)			
		Parametric (80%)		Non-parametric (20%)	
Central Tendency (Mean/Median/Mode)	26	T-test	23	Chi-Square	27
Relative Standing (Percentage/z-score)	28	Variance analysis (ANOVA/ANCOVA/MANOVA)	8	Mann Whitney U	5
Variability (Variance/Standard Deviation/Range)	8	Reliability Analysis (Cronbach's Alpha)	22	Wilcoxon Test	4
Descriptive Statistics (Non-specific)	3	Pearson Correlation	12	Kruskal Wallis	6
		Regression Analysis	7		
QUALITATIVE					
Content Analysis				8 (40%)	
Thematic analysis				12 (60%)	

It was evident from data shown in the table XXX that the most preferred tests for analysing the quantitative data was the mean/percentage in doctoral theses between 2001 and 2014], followed by Test-test, Z-test, Chi-square test, ANOVA, correlation coefficient, standard deviations, Pearson R and Frequency distribution. In dissertations using the qualitative method, the thematic analysis was the most predominately used data analysis method followed by the content analysis. The previous studies have supported the findings of this study, for instance, Lee et al (2004) reported that chi-square and ANOVA were the most used statistical tools in analysing the data in higher education research. Findings of Davis et al (2010) also supported the outcomes of this study by showing that research articles in higher education filed showed preference for chi-square, ANOVA and T-test. Some other studies also reported in line with this study (Durak et al., 2017). Zawacki-Ritchter et al (2009) reported that thematic analysis was the second most commonly used data analysis tool in Turkish higher education while the thematic analysis was the second most employed data analysis tool, which differs from this study. This difference may the outcome of variation in resources available in Pakistani and Turkish contexts. The data also showed more emphasize of researcher from AIOU to use the inferential statistical tools to analyse the data, which is most likely related to the ability of inferential statistics to provided detailed picture data compared to the descriptive statistics which only offers the superficial explanation to the analysed data.

4.6 Data collection tools

Trends of data collection tools were identified, and outcomes are presented in this part. The finding showed that researchers mostly used the questionnaire as data collection tool in PhD level dissertations submitted to AIOU between 2001 and 2014. The second most data collection tool was interviews, followed by scale, observations, achievement test and personality test. (Table 3).

Table 3. The data collection tools used in doctoral dissertations between 2001-and 2014

Data collection tools	Frequency	Percentage
Multiple Choice Questions	28	32
Questionnaire (Scale)	21	24
Interviews	15	17
Electronic documents	8	09
Focus group	7	08
Documents	5	06
Achievement Test	3	03
Total	87	100

In line with the findings of this study, Davies et al (2010) reported that survey including multiple choice questions and scaled questionnaire constituted most resonantly employed data collection tool, followed by interviews, document analysis, observations, researcher developed assessment, and standardized tests. Bozkurt et al (2015) showed the similar results showing that questionnaire, interviews and scale are the most frequently employed data collection tools in dissertations in higher education field. Bozkurt et al (2015) also reported the questionnaire and interviews are main source of data collection.
Thus, the findings of this study demonstrated that questionnaire (qualitative and quantitative studies) and interviews (qualitative studies) were used as main source of data collection in PhD-level dissertations between 2001 and 2014 at AIOU in Pakistani higher education context, which corresponds to the global perspectives in higher education.

4.7 Participants

This study found that researchers have mostly collected data from the academicians, followed by master students, undergraduate students, adult learners, administrators, and documents (Table 4).

Table 4. The nature of participants in doctoral dissertations between 2001-and 2014

Nature of participants	Frequency	Percentage
Graduate students	17	25
Undergraduate students	9	13
Master students	14	20
HE teachers	10	15
HE specialists	5	07
HE courses/programs	8	12
HE institutions	5	07
Other (technicians, documents)	1	01
Total	69	100

The Table 4 shows that 25%, 20%, and 13% of the doctoral theses between 2001 and 2014 involved Graduate students, Master students and Undergraduate students as participants in doctoral level research at AIOU, respectively. It is evident from data that students and teachers were the main focus of the researchers in their doctoral level research in Pakistani higher education context, however, relatively less emphasis was placed to identify the perceptions and views of HE specialists (e.g. administrators and policy makers) in doctoral dissertations in Pakistani higher education. Several other studies supported these findings showing the researchers target the students and teachers to investigate the issues related to the development of higher education (Durak et al., 2017; Bozkurt et al., 2016, Bozkurt et al., 2015).

4.8 Strengths and limitations

This study has strengths and limitations. The main strength of this study is that it is the first of its kind in showing the research trends in Pakistani higher education sector from various perspectives. It has identified the research trends in doctoral level dissertations accepted from 2001-2014 at AIOU, which is the main regulator, provider and disseminator of higher education in Pakistani higher education sector. Against the background of its strength in context of showing the research trends and issues, this study can offer the base for future studies and developments in the doctoral level research in higher education in Pakistani higher education sector.

One of the limitations of this study is that it is assumed that doctoral dissertations submitted to AIOU represents the finished product which can be taken as the reservoir of intellectuality and knowledge for the future researchers, policy-makers and academicians. Furthermore, 2 dissertations submitted before 2000 to AIOU in 1999-2000 could not be accessed, therefore, they were excluded from this study.

5. CONCLUSION

This study was carried out to identify the trends in higher education research in Pakistani higher education sector by examining the doctoral dissertations submitted to AIOU between 2000 and 2014. Higher education is the most commonly used keywords in the dissertations reviewed in this study. The imbalances in terms of research areas studies at doctoral level were found in dissertations; some areas were more frequently studies than the others. The quantitative method was found to be the most used method, while qualitative and mixed methods were relatively less used methods. However, between 2009-2014, the tendency to use mixed method showed increasing trend in the doctoral dissertations. Surveys are preferred method compared to other research models. The questionnaire and interviews are preferentially used by researchers to collect data, while the mean/percentage and chi-square are the widely used tests for analysing data. The students and teachers are ranked at first and second position to be selected as sampling group.

The research trends identified in this study requires attention of doctoral researchers in Pakistani higher education sector. Based on the findings, this study has the implications for the future researchers. The neglected areas in the doctoral research should be explored and focussed by prioritizing the research agenda in higher education in AIOU. The sampling group should be diversified to include administrator's and policy-makers to improve the engagement of government bodies with higher education in Pakistan.

The harmony should be created in terms of using different categories of research models and research designs. The supervisors and researchers in AIOU should consider using all research designs and methods in equal proportions. Currently the use of mixed method is relatively low in doctoral research. The application of mixed method should be promoted to assess the research issues from different angles and perspectives. AIOU should also balance the theoretical and practical research in future doctoral dissertations. Currently there is only single university in Pakistan, which administers higher education to students locally and internationally. The higher education commission (HEC) Pakistan and provincial governmental bodies should consider opening more institutions to promote research in general and doctoral dissertations in particular in higher education.

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Evaluations of Arak Extract Effects and Comparison with Different Toothpastes on Oral Pathogens

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ABSTRACT

Purpose: To evaluate the *in vitro* antimicrobial activity of the arak crude extracts (*Salvadora persica*) compared to different toothpastes containing active ingredients against some selected different oral hygiene microorganisms.
Methods: Different strains implicated in oral diseases were tested for their susceptibility to the aqueous extract of arak as well as examining toothpastes using the agar diffusion method. Crude extracts of arak and selected toothpastes were challenged using *E. faecalis* at time intervals of 1, 10, 20, 40 and 60 min.
Results: Results showed that the aqueous extract of arak exhibited antimicrobial activity which was similar to that of the commercially available tested toothpastes.
Conclusion: According to these findings, it was concluded that arak stick can be used for oral hygiene as a good alternative to the toothpaste.
KEY WORDS: Arak, *Salvadora persica*, cariogenic bacteria, antimicrobial activities.

INTRODUCTION

Periodontal pathogens are one of the common problems and leading causes for development of dental plaque and periodontal diseases. The obtainable methods for the oral health protection are mostly chemical and mechanical. Toothpastes and toothbrushes are commonly used for plaque control and teeth cleaning [1]. There is a variety of plants commonly used as conventional chewing sticks or toothbrushes. The "arak or miswak" is the largely used tree brush wood since early times, which was obtained from a stick of a plant called *Salvadora persica*. The root pieces are generally aromatic and become spongy after water soaking [2]. Though the World Health Organization (WHO) has encouraged the usage of chewing sticks and promoted advance study of their effectiveness [3], limited studies had assumed the prospective antimicrobial activities of chewing sticks [4].

Many reports recommended that the presence of pathogens in medicinal plants was strongly related to the previous handing, drying methods and type of storage used. Different chemical methods of decontamination have therefore been used. Irradiation offers an effective option to chemical fumigation. Several countries have approved irradiation of medicinal plants for microbial decontamination; amongst these countries USA, Brazil, Argentina, France, and South Africa [5].

Toothpastes or gel are used to clean and develop the aesthetic appearance and health of teeth. Fluoride is considered as one of the best and effective caries inhibiting agents. Approximately, wholly toothpastes contain fluoride in their formulation [6]. Usually the total fluoride amount is ranged between 0.1 – 0.15%. Antiseptic composites can be included in some toothpaste like triclosan which have distinct antibacterial effects. Also, essential oils, like menthol, eucalyptol, basil and thymol, have many valuable properties as natural antimicrobial actions [7]. Few previous studies have investigated the comparative antimicrobial activity of arak and toothpastes. The current study aimed to:1) investigate the *in vitro* antimicrobial effectiveness of arak extract and different formulas of toothpastes against oral hygiene microorganisms. 2) evaluate the gamma radiation effects and storage time on the microbial contamination of arak.

MATERIALS AND METHODS

Samples of Chewing sticks, arak powder and toothpastes:

This study was carried out on arak (siwak), the most commonly used chewing stick in Saudi Arabia. Its sticks and powder were purchased from the local market in Riyadh, Saudi Arabia. The samples were packed (25g each) in sealed polyethylene bags to prevent recontamination. As well as, three commercially available toothpastes identified as formulas 1, 2 and 3 were purchased from the local market of Riyadh. Each formula

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contains different active ingredients that were described as sodium monofluoro-phosphate 0.76% and triclosan 0.10% (formula 1), fluoride 1450 ppm and calcium glycerophosphate (formula 2) and basil (Ocimum sanctum) and herbal extracts (formula 3) as described on the package.

Media:

The isolated organisms were grown in standard laboratory culture media prepared according to the specifications of the manufacturers. Media utilized included plate count agar, Czapeks-Dox yeast agar, Baird-Parker agar and Brain heart infusion agar (Difco Labs., Detroit, Michigan, USA), MacConkey agar and Tryptic soy broth (Basigstoke, Hants, UK).

Irradiation and storage:

The irradiated (1-10 kGY) and non-irradiated (control) arak sticks and powder were stored at ambient temperature for 6 months in sealed bags.

Microbiological quality of arak:

From both arak sticks and powder, twenty-five grams of each irradiated and non-irradiated samples were suspended in 225 ml of sterile saline and subjected to serial dilutions using normal saline solution (0.9% NaCl). Proper dilutions were used in enumeration of microbial counts. Total aerobic bacterial counts were enumerated on plate count agar [8] using pour plate technique then the plates were incubated at 30° C for 3 days. Total molds and yeasts were counted on Czapeks yeast extract agar medium according to the method described by [25] using pour plate technique then plates were incubated at 25° C for 5 days. The total numbers of thermophilic spore forming bacteria were determined according to the method described by [9] using plate count agar medium. The presence of coliforms was determined by cultivation of the tested samples on MacConkey agar plate according to [10]. *Staphylococcus aureus* were counted on laboratory prepared Baird-Parker medium according to [11] using surface plate technique. Suspected colonies were submitted to coagulase activity and biochemical reactions.

Antimicrobial spectrum of the arak extract and the toothpastes:

For determining the antimicrobial spectrum of the arak extract and the toothpastes, seven bacterial strains representing Gram negative and Gram positive bacteria and one yeast were used. They were grown on nutrient agar, Sabouraud agar and de Man, Rogosa, Sharpe (MRS) for *Lactobacillus acidophilus*. Out of them, six pathogenic strains were isolated from clinical samples; *E. coli, Pseudomonas aeruginosa, Klebsiella pneumoniae* (as Gram negative); *Staphylococcus aureus*, *Enterococcus faecalis* (as Gram positive) and *Candida albicans* (as Yeast). Two other strains were used; *Bacillus cereus*, ATCC 11778 and *Lactobacillus acidophilus*, DSM 20079.

Preparation of arak extract:

For 10 days, the arak sticks were kept dried at room temperature before extraction process. The sticks were reduced to small pieces then crushed to fine powder. In sterile dry screw-capped bottles, ten grams of fine powder was kept separately and the bottles were kept in a cool dry place for seven days before extraction. In each bottle, 100ml of sterile water was added to the fine powder and left to soak at 4°C. After 48 hours, the extract was centrifuged for 10 minutes at 2000 rpm. Finally, the supernatant was sifted through a membrane filter (0.45 mm) and freeze-dried as described by [12].

Antimicrobial activity of arak using agar diffusion method:

According to [13], the antimicrobial activity of arak extract was determined using the hole-plate diffusion technique. The plates were moistened with a suspension of the selected pathogenic microorganism, which contained approximately 10^7CFU/ml using sterile cotton swab. Into the wells, 100µl from the arak extract was added and allowed to diffuse for 30 min. at 37°C, the plates were incubated for 24 hours and at 30°C for 48 h for bacteria and yeast growth respectively. The diameter of inhibition zones was measured and the experiment was repeated, in its entirety, twice more to ensure repeatability. On the other hand, 10 ml of each toothpaste formula were moved to a small flask containing 5 ml of sterile water and homogenized by vortex mixer. After minutes, 100µl of each formula were added into the wells made at the center of pre-inoculated blood agar plates and allowed to diffuse. Plates were incubated as previously mentioned then the inhibition zones diameter was measured as described by [14]. The bacterial strain which showed sensitivity to the arak extract and all the tested formulas were chosen for further studies.

Antimicrobial activity of arak using microbial death profile (challenge test):

The profile of the microbial death (log CFU/ml vs. time) was evaluated according to [14]. Microbial suspension of the chosen microorganism (approximately 10^7CFU/ml) was transferred under aseptic condition to

a tube with 10 ml of the tested arak extract or the other tested formulas. Using the pour plate method, the viable microorganism was counted. The series of decimal dilution were made employing 9ml of sterile saline. After 10, 20, 40 and 60 min, the identical procedures were used again and the viable counts were determined.

Statistical analysis

All experiments were done in triplicate as a minimum. Data from those experiments were saved in an EXCEL 5.0 program (Microsoft) and the statistical analyses were carried out using version 19.0 SPSS software (SPSS, Chicago, USA). Differences were considered significant at $p < 0.05$.

RESULTS

Microbiological quality of arak:

Arak sticks and powder were evaluated for their natural microbiological quality i.e. total aerobic bacterial count, total molds and yeasts and spore forming bacteria. They were also examined for the presence of coliforms and *Staphylococcus aureus* (table 1 and 2). The level of microbial contamination in Arak powder was higher than that in arak sticks. The total bacterial counts, total mold and yeast counts and the counts of spore forming bacteria in non- irradiated control arak sticks were $4.0x10^5$, $8.0x10^3$ and $1.7x10^5$cfu/g, respectively. The corresponding counts in non-irradiated (control) arak powder were $6.0x10^5$, $8.5x10^3$ and $5.2x10^5$cfu/g. The examined sticks and powder had coliforms and *Staphylococcus aureus* at values $5.6x10^3$, $6.3x10^2$cfu/g, respectively.

Table (1): Effect of different doses of gamma irradiation and storage time on the total bacterial and fungal count containing arak (sticks and powder).

Microbial isolates	Doses (kGy)	Number of Survivors							
		Sticks				Powder			
		Storage period (month)							
		0	2	4	6	0	2	4	6
Total bacterial count	0	$4x10^5$	$2.8x10^4$	$3.2x10^6$	$4x10^6$	$6x10^5$	$6.9x10^3$	$4.9x10^4$	$1.3x10^5$
	1	$2.5x10^3$	$2.5x10^3$	$1.5x10^6$	$2.5x10^6$	$4.1x10^4$	$4x10^3$	$4.6x10^3$	$1x10^4$
	2	$2x10^3$	$1x10^3$	$4x10^4$	$4.2x10^4$	$8x10^3$	$7.2x10^2$	$7.5x10^2$	$1x10^3$
	3	$7x10^2$	$1x10^2$	$3.7x10^2$	$7.7x10^2$	2.9x10	6.3x10	8x10	$2.9x10^2$
	4	$5.6x10^2$	<10	$5x10^1$	5.5x10	<10	<10	<10	<10
	5	<10	<10	<10	<10	<10	<10	<10	<10
	6	<10	<10	<10	<10	<10	<10	<10	<10
Total molds and yeasts	0	$8x10^3$	$2.5x10^3$	$4.5x10^3$	$4.7x10^3$	$8.5x10^3$	$5.1x10^3$	$6.4x10^4$	$1.2x10^5$
	1	$3.5x10^3$	$1.9x10^3$	$2.9x10^3$	$3.2x10^3$	$3.7x10^3$	$3.4x10^3$	$7.9x10^3$	$1x10^4$
	2	$1x10^3$	$1.7x10^2$	$3.4x10^2$	$1.6x10^3$	$2.1x10^2$	$1.8x10^2$	$2.7x10^2$	7.1x10
	3	$1x10^2$	$1.1x10^2$	8x10	<10	1.9x10	3.2x10	7.1x10	7.1x10
	4	<10	<10	<10	<10	<10	<10	<10	<10
	5	<10	<10	<10	<10	<10	<10	<10	<10
	6	<10	<10	<10	<10	<10	<10	<10	<10

Table (2): Effect of different doses of gamma irradiation and storage time on the isolated microorganism containing arak (sticks and powder).

Microbial isolates	Doses (kGy)	Number of Survivors							
		Sticks				Powder			
		Storage period (month)							
		0	2	4	6	0	2	4	6
Thermophilic spore former bacteria	0	$1.7x10^5$	$1.4x10^4$	$2.1x10^4$	$4.5x10^5$	$5.2x10^5$	$3.7x10^3$	$7.5x10^3$	$3.7x10^4$
	1	$1x10^5$	$5x10^2$	$7.1x10^2$	$3.9x10^3$	$5x10^3$	$9.8x10^2$	$9.7x10^2$	$7.6x10^3$
	2	$1.2x10^4$	$2x10^2$	2.8x10	$2.7x10^2$	$3.3x10^3$	2.3x10	2.3x10	3.2x10
	3	$7x10^3$	2.9x10	1.9x10	3.8x10	$2.2x10^3$	<10	<10	<10
	4	$5x10^3$	<10	<10	<10	<10	<10	<10	<10
	5	<10	<10	<10	<10	<10	<10	<10	<10
	6	<10	<10	<10	<10	<10	<10	<10	<10
Coliforms	0	$5.6x10^3$	$6x10^2$	$3.2x10^3$	$7.1x10^3$	$7.6x10^2$	$1.5x10^2$	$6x10^3$	$6.2x10^3$
	1	$4.2x10^3$	6x10	$1.4x10^3$	$3.6x10^3$	2.5x10	1.4x10	$4x10^2$	$3.9x10^2$
	2	$3x10^3$	<10	$3.7x10^2$	$4.1x10^2$	1.5x10	<10	$3.1x10^2$	$2.9x10^2$
	3	$7.1x10^2$	<10	1.4x10	1.5x10	1.2x10	<10	$1.9x10^2$	2x10
	4	<10	<10	<10	<10	<10	<10	1.5x10	<10
	5	<10	<10	<10	<10	<10	<10	<10	<10
	6	<10	<10	<10	<10	<10	<10	<10	<10
Staph. aureus	0	$4.7x10^3$	$1.1x10^3$	$4.1x10^3$	$4.5x10^3$	$6.3x10^2$	$1.7x10^2$	$7.2x10^2$	$7.4x10^2$
	1	$4.1x10^3$	$4.7x10^3$	$2.9x10^3$	$3x10^3$	2.5x10	2.5x10	$6.5x10^2$	$6.3x10^2$
	2	$2.9x10^3$	$2x10^2$	3.7x10	$2.7x10^2$	2x10	2x10	3.7x10	2.7x10
	3	7.2x10	<10	<10	$1.9x10^2$	2x10	2x10	1.9x10	1x10
	4	<10	<10	<10	<10	<10	<10	<10	<10
	5	<10	<10	<10	<10	<10	<10	<10	<10
	6	<10	<10	<10	<10	<10	<10	<10	<10

Antimicrobial activity of arak using agar diffusion method:

Antimicrobial activities of arak extract as well as three different toothpastes; formulas 1, 2 and 3, was determined by using agar diffusion method against 8 pathogenic microorganisms. Even though most of the tested organisms were not strictly oral pathogens, selection depended on the role that those organisms play in oral hygienic and probability for causing dental diseases, periapecal lesions, periodontal abscesses and possible gingivitis [12]. It is clear from the data in table (3) that arak extract and the other tested formulas exhibited different levels of antimicrobial activities against the tested organisms.

Table (3) Diameter of inhibition zone (mm) of arak extract and three different formulas of toothpastes on some oral pathogens.

Tested samples	Diameter of inhibition zone (mm)							
	E. faecalis	*K. pneumonia*	*Ps. Aeruginosa*	*E. coli*	*Staph. aureus*	*L. acidophilus*	*B. cereus*	*C. albicans*
Arak extract	15	--	30	--	--	--	--	--
Formula 1	20	--	22	22	30	35	20	--
Formula 2	25	--	22	40	40	--	24	--
Formula 3	24	--	--	30	20	--	23	--

(-) no activity

Antimicrobial activity of Arak using microbial death profile (challenge test):

The results indicated that among the 8 tested microorganisms, *E. faecalis* was generally the most liable microorganism to all the tested formulas, therefore, this strain was chosen for the challenge test. The obtained data in table (4) and the figure (1) showed that all tested formulas were active against *E. faecalis* when reduced to 3 logarithmic cycles after 1 min of contact, a condition that's similar to brushing teeth while arak extract showed reduction of 2 logarithmic cycles. The data also showed that the activities of all the tested formulas were increased significantly by increasing time of contact.

Table (4): Effect of time on the Antimicrobial activity of arak extract and three toothpastes formulas on the number of survivors of *E. faecalis* selected strain (challenge test).

Time (minutes)	Log number of survivors (cfu/ml)				
	Arak extract	Formula 1	Formula 2	Formula 3	Control
0	8.60	8.60	8.60	8.60	8.60
1	6.60	5.93	5.78	5.30	8.60
10	6.30	5.78	5.32	3.80	8.59
20	5.20	5.78	5.70	3.38	8.57
40	3.56	4.90	4.93	3.20	8.61
60	3.0	4.48	3.80	3.0	8.60

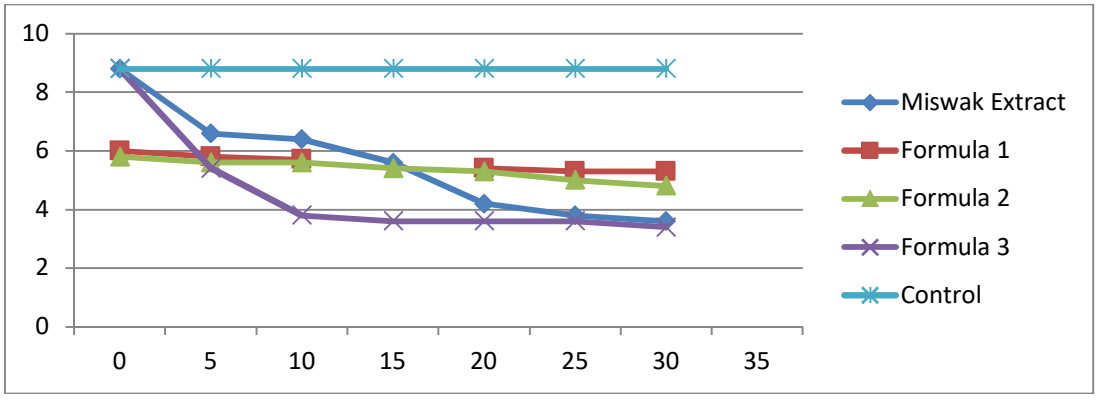

Figure (1): Lethality profile (log cfu/ml x minute) of *E. faecalis* for the arak extract and the other tested formulas.

DISCUSSION

The present study aimed to investigate the antimicrobial activity of arak extract in comparison with different formulas of toothpastes against oral hygiene microorganisms in addition to evaluation the effects gamma radiation on the microbial contamination of arak. Tables (1) and (2) indicated that both non-irradiated (control) arak sticks and powder had high microbial load. These results have been confirmed by [15] who found that the total bacterial and mold counts contaminating qarad were $8.2x10^6$ and $2.9x10^4$cfu/g, respectively. Generally, the results revealed that arak sticks and powder samples were of unsatisfactory from the view of

microbiological quality. It is clear from the same table that irradiation caused a marked decrease in all tested microbial counts and this decrease was proportional with irradiation dose. The irradiation dose of 5KGy was effective and sufficient to reduce all tested microflora contaminating both arak sticks and powder to non-detectable levels. [16] Studied the effects of ionizing energy and ozone treatments on the microbial decontamination of aloe powder. They found that gamma irradiation at 7.5-10 kGy reduced all bacterial count including coliforms and fungi to below detection levels. Treatment by ozone at up to 18 ppm for hours was not adequate to eliminate microorganis from the tested powder. The results showed that, the microbial weight of the control samples was enriched by storage time. It decreases in the number of survivors/g after 2 months of storage. On the other hand, increase in the total microbial load was noticed as storage progressed until 6 months but the rate of increase was much more pronounced in control samples (non-irradiated) in comparison with irradiated ones. All the microbial counts in arak sticks and powder samples exposed to 5kGy remained below detectable levels throughout the storage period (6 months). This indicated that irradiation treatment greatly reduced the initial counts and delayed the growth of microorganisms hence, extended the shelf-life of the tested samples. Long time storage boosted mold reduction in 5 kGy. However, [17] reported that by relying on the prevalent flora for complete fungal sterilization, the lethal dose required was reported to be not less than 5 kGy or not more than 7.5 kGy.

According to [18], the agar diffusion method has the ability to be used as a preliminary test for identifying antimicrobial activity in substances physical-chemical properties, as for instance, its diffusion coefficient as well as the medium where the diffusion occurs, is likely to obtain a qualitative sign of antimicrobial activity. The data from table (3) showed that *K. pneumoniae* was resistant to arak extract and all tested formulas are in agreement with [19] who reported that *K. pneumoniae* was resistant to the aqueous extracts of seven different kinds of chewing sticks including arak. The observed resistance may come from cell membrane permeability or due to further genetic factors as reported by [13]. The results tabulated in table (3) revealed that the arak extract was most effective on *Ps. aeruginosa* causing inhibition zone 30mm. This could attribute to the fact that arak extract inhibits the active transport oxidative phosphorylation and oxygen uptake by *Ps. aeruginosa* [20]. Among the tested microorganisms, *E. faecalis* was also susceptible to the arak extract and all the tested formulas. This may be due to the fact that the aqueous extract of arak contained some anionic components like nitrate (NO_3^-) which apply antimicrobial activities against various bacteria and has been reported to have an effect on the active transport of proline in *E. coli* [20]. The antimicrobial activity of formula 1 and 2 is a result of sodium monofluro-phosphate and triclosan which affects many essential enzymes of cell growth as reported by [21] and the cytoplasmic membrane causing lysis of the microorganisms [22]. The antimicrobial activity of formula 3 is attributed to the inhibitory properties of the herbal extracts where the essential oils kill microorganisms by distributing their cell walls, preventing their enzymatic activity, inhibit bacterial aggregation, release endotoxins and slow their multiplication as reported by [23]. On the other hand, arak extract had no antimicrobial effect on any other tested microorganism. These findings were consistent with the results obtained by [19] who found that *Staph. aureus* was not inhibited by the aqueous extract of the tested chewing sticks including arak. On the contrary, others found that *E. faecalis* was affected by aqueous extract of *Acacia arabica* (kikar). The tested toothpastes formula had antimicrobial effect on *E. coli, E. faecalis, Staph. aureus,* and *B. cereus* where they inhibited the growth of these strains and *L. acidophilus* was affected only by formula 1. In this study, the results showed that *K. pneumonia* and *C. albicans* were resistant to arak extract and to all of the tested formulas. These findings are similar to that obtained by other authors [19]. Although the tested formulas 1 and 2 showed remarkable bacteriostatic activity on *E. faecalis*, we must take into consideration that the FDA restricts the content of fluoride in toothpaste to 1150 ppm because of its harmfulness and therefore too much amount of fluoride can reproduce fluorosis, a common finding today. Also, ingested triclosan may affect the probiotic intestinal microflora of the human gastrointestinal tract which serves as defense system against pathogenic bacteria, hence, one become more susceptible to infectious diseases such as rotavirus, often resulting in diarrhea [20].

Based on our results, we concluded that, gamma radiation dose of 5 kGy was sufficient to decontaminate the tested arak sticks and powder from aerobic bacteria, mold, yeast, thermophilic arak sticks and main pathogens. Also, arak can be considered a good alternative to the toothpaste as it is cheap, easily available, doesn't require expertise or any more resources for manufacturing, has potential antimicrobial activity and safe for users, thus, it is advised as an important and operative tool for oral hygiene.

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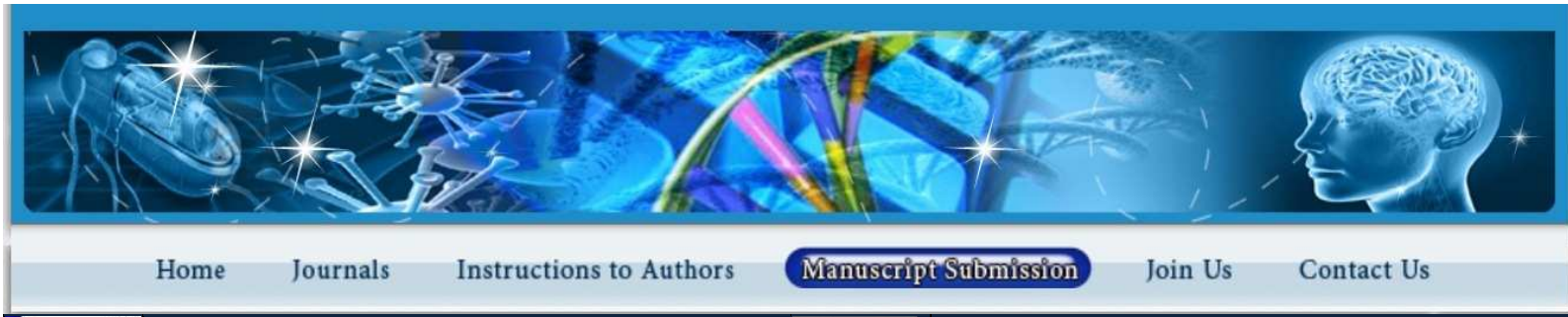

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