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1440هـ

مجلة الشمال
للعلوم
الأساسية والتطبيقية

دورية علمية محكمة

جامعة الحدود الشمالية
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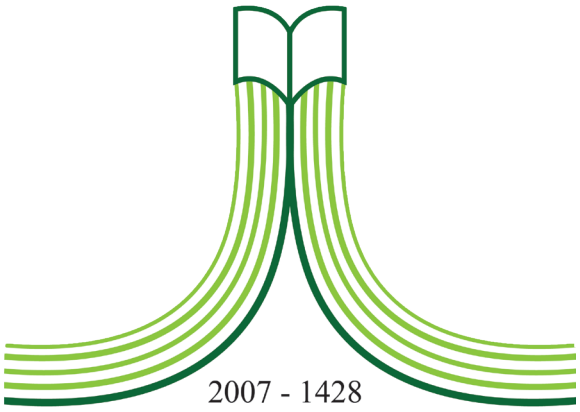
مجلة الشمال للعلوم الأساسية والتطبيقية (JNBAS)

هيئـة التحـــرير


بسم الله الرحمن الرحيم



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المملكة العربية السعودية

مجلة الشمال
للعلوم الأساسية والتطبيقية
(JNBAS)

دورية علمية محكمة

تصدر عن

مركز النشر العلمي والتأليف والترجمة

جامعة الحدود الشمالية

المجلد الثالث ـ العدد الثاني

نوفمبر 2018م ـ ربيع الأول 1440هـ

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مجلة الشمال للعلوم الأساسية والتطبيقية (JNBAS)

التعريف بالمجلة

تعنى المجلة بنشر البحوث والدراسات العلمية الأصيلة في مجال العلوم الأساسية والتطبيقية، باللغتين العربية والإنجليزية، كما تهتم بنشر جميع ما له علاقة بعرض الكتب ومراجعتها أو ترجمتها، وملخصات الرسائل العلمية، وتقارير المؤتمرات والندوات العلمية، وتصدر مرتين في السنة (مايو ـ نوفمبر).

الرؤية

الريادة في نشر البحوث العلمية المحكمة، وتصنيف المجلة ضمن أشهر الدوريات العلمية العالمية.

الرسالة

نشر البحوث العلمية المحكمة في مجال العلوم الأساسية والتطبيقية وفق معايير عالمية متميزة.

أهداف المجلة

1) أن تكون المجلة مرجعًا علميًا للباحثين في العلوم الأساسية والتطبيقية.
2) تلبية حاجة الباحثين إلى نشر بحوثهم العلمية، وإبراز مجهوداتهم البحثية على المستويات المحلية والإقليمية والعالمية.
3) المشاركة في بناء مجتمع المعرفة بنشر البحوث الرصينة التي تؤدي إلى تنمية المجتمع.
4) تغطية أعمال المؤتمرات العلمية المحكمة.

شروط قبول البحث

1) الأصالة والابتكار وسلامة المنهج والاتجاه.
2) الالتزام بالمناهج والأدوات والوسائل العلمية المتبعة في مجاله.
3) الدقة في التوثيق والمصادر والمراجع والتخريج.
4) سلامة اللغة.
5) أن يكون البحث غير منشور أو مقدم للنشر في أي مكان آخر.
6) أن يكون البحث المستل من الرسائل العلمية غير منشور أو مقدم للنشر، وأن يشير الباحث إلى أنه مستلٌ.

للمراسلة

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الاشتراك والتبادل

مركز النشر العلمي والتأليف والترجمة
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شروط النشر

أولاً: ضوابط النص المقدم للنشر

1) ألا تزيد صفحاته عن (35) صفحة من القطع العادي (A4).
2) أن يحتوي على عنوان البحث وملخص باللغتين العربية والإنجليزية في صفحة واحدة، بحيث لا يزيد عن (250) كلمة للملخص، وأن يتضمن البحث كلمات مفتاحيةٍ دالةٍ على التخصص الدقيق للبحث باللغتين، بحيث لا يتجاوز عددها (6) كلمات، توضع بعد نهاية كل ملخص.
3) أن يذكر اسم المؤلف وجهة عمله بعد عنوان البحث مباشرة باللغتين العربية والإنجليزية.
4) أن تقدم البحوث العربية مطبوعة بخط (Simplified Arabic)، بحجم (14) للنصوص في المتن، وبالخط نفسه بحجم (12) للهوامش.
5) أن تقدم البحوث الإنجليزية مطبوعة بخط (Times New Roman) بحجم (12) للنصوص في المتن، وبالخط نفسه بحجم (9) للهوامش.
6) كتابة البحث على وجه واحد من الصفحة، مع ترك مسافة سطر واحد بين السطور، وتكون الحواشي 2.5 سم على الجوانب الأربعة للصفحة، بما يعادل 1.00 إنش (بوصة).
7) التزام الترتيب الموضوعي الآتي:

المقدمــة: تكون دالة على موضوع البحث، والهدف منه، ومنسجمة مع ما يَرِدُ في البحث من معلومات وأفكار وحقائق علمية، كما تشير باختصار إلى مشكلة البحث، وأهمية الدراسات السابقة.

العرض: يتضمن التفاصيل الأساسية لمنهجية البحث، والأدوات والطرق التي تخدم الهدف، وترتب المعلومات حسب أولويتها.

النتائج والمناقشة: يجب أن تكون واضحة موجزة، مع بيان دلالاتها دون تكرار.

الخاتمة: تتضمن تلخيصًا موجزًا للموضوع، وما توصل الباحث إليه من نتائج، مع ذكر التوصيات والمقترحات.

8) أن تدرج الرسوم البيانية والأشكال التوضيحية في النص، وترقم ترقيماً متسلسلاً، وتكتب أسماؤها والملاحظات التوضيحية أسفلها.
9) أن تدرج الجداول في النص، وترقم ترقيماً متسلسلاً، وتكتب أسماؤها أعلاها، وأما الملاحظات التوضيحية فتكتب أسفل الجدول.
10) ألا توضع الهوامش أسفل الصفحة إلا عند الضرورة فقط، ويشار إليها برقم أو نجمة، ويكون الخط فيها بحجم (12) للعربي و (9) للإنجليزي.
11) لا تنشر المجلة أدوات البحث والقياس، وتقوم بحذفها عند طباعة المجلة.
12) أن يُراعى في منهج توثيق المصادر والمراجع داخل النص نظام (APA)، وهو نظام يعتمد ذكر الاسم والتاريخ (name/year) داخل المتن، ولا يقبل نظام ترقيم المراجع داخل النص مع وضع الحاشية أسفل الصفحة، وتوضع المصادر والمراجع داخل المتن بين قوسين حسب الأمثلة الآتية: يذكر اسم عائلة المؤلف متبوعا بفاصلة، فسنة النشر، مثلا: (مجاهد، 1988م). وفي حالة الاقتباس المباشر يضاف رقم الصفحة مباشرة بعد تاريخ النشر مثلا: (خيري، 1985م، ص:33). أما إذا كان للمصدر مؤلفان فيذكران مع اتباع الخطوات السابقة مثلا: (الفالح وعياش، 1424هـ). وفي حالة وجود أكثر من مؤلفين فتذكر أسماء عوائلهم أول مرة، مثلا: (مجاهد والعودات والشيخ، 1408هـ)، وإذا تكرر الاقتباس من المصدر نفسه فيشار إلى اسم عائلة المؤلف الأول فقط، ويكتب بعده وآخرون مثل: (مجاهد وآخرون، 1408هـ)، على أن تكتب معلومات النشر كاملة في قائمة المصادر والمراجع.
13) تخرج الأحاديث والآثار على النحو الآتي:
(صحيح البخاري، ج:1، ص: 5، رقم الحديث 511).
14) توضع قائمة المصادر والمراجع في نهاية البحث مرتبة ترتيباً هجائياً حسب اسم العائلة، ووفق نظام جمعية علم النفس الأمريكية (APA) الإصدار السادس، وبحجم (12) للعربي و(9) للإنجليزي، وترتب البيانات الببليوغرافية على النحو الآتي:

- **الاقتباس من كتاب لمؤلف واحد:**

الخوجلي، أحمد. (2004م). ***مبادئ فيزياء الجوامد***. الخرطوم: عزة للنشر والتوزيع.

- **الاقتباس من كتاب لأكثر من مؤلف:**

نيوباي، تيموثي؛ ستيبتش، دونالد؛ راس، جيمس. (1434هـ/2013م). ***التقنية التعليمية للتعليم والتعلم***. الرياض: دار جامعة الملك سعود للنشر.

- **الاقتباس من دورية:**

النافع، عبداللطيف حمود. (1427هـ). أثر قيادة السيارات خارج الطرق المعبدة في الغطاء النباتي بالمنتزهات البرية: دارسة في حماية البيئة، في وسط المملكة العربية السعودية. ***المجلة السعودية في علوم الحياة***، *14*(1)، 53-72.

- **الاقتباس من رسالة ماجستير أو دكتوراه:**

القاضي، إيمان عبدالله. (1429هـ). ***النباتات الطبيعية للبيئة الساحلية بين رأسي تنورة والملوح بالمنطقة الشرقية: دراسة في الجغرافيا النباتية وحماية البيئة***. رسالة دكتوراه غير منشورة، كلية الآداب للبنات، الدمام: جامعة الملك فيصل.

- **الاقتباس من الشبكة العنكبوتية (الإنترنت):**

- الاقتباس من كتاب:

المزروعي، م.ر. و المدني، م.ف. (2010م). ***تقييم الأداء في مؤسسات التعليم العالي***. المعرِّف الرقمي (DOI:10.xxxx/xxxx-xxxxxxxx-x)، أو برتوكول نقل النصوص التشعبي (http://www...)، أو الرقم المعياري الدولي للكتاب (ISBN : 000-0- 00 - 000000-0)

– الاقتباس من مقالة في دورية:

المدني، م.ف. (2014). مفهوم الحوار في تقريب وجهات النظر. ***المجلة البريطانية لتكنولوجيا التعليم***، *11*(6)، 225-260. المعرِّف الرقمي (DOI:10.xxxx/xxxx-xxxxxxxx-x) أو برتوكول نقل النصوص التشعبي (http://onlinelibrary.wiley.com/journal/10.1111)، أو الرقم المعياري التسلسلي الدولي للمجلة (ISSN: 1467 - 8535).

15) يلتزم الباحث بترجمة (أو رومنة) أسماء المصادر والمراجع العربية إلى اللغة الإنجليزية في قائمة المصادر والمراجع. وعلى سبيل المثال:

الجبر، سليمان. (1991م). تقويم طرق تدريس الجغرافيا ومدى اختلافها باختلاف خبرات المدرسين وجنسياتهم وتخصصاتهم في المرحلة المتوسطة بالمملكة العربية السعودية. **مجلة جامعة الملك سعود- العلوم التربوية**، *3*(1)، 143-170.

Al-Gabr, S. (1991). The Evaluation of Geography Instruction and the Variety of its Teaching Concerning the Experience, Nationality, and the Field of Study in Intermediate Schools in Saudi Arabia *(in Arabic). Journal of King Saud University- Educational Sciences, 3*(1), 143-170.

16) تستخدم الأرقام العربية الأصلية (0، 1، 2، 3، ...) في البحث.

17) تؤول جميع حقوق النشر للمجلة في حال إرسال البحث للتحكيم وقبوله للنشر.

ثانياً: الأشياء المطلوب تسليمها

1) نسخة إلكترونية من البحث بصيغتي (WORD) و (PDF)، وترسلان على البريد الإلكتروني الآتي:

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2) السيرة الذاتية للباحث، متضمنة اسمه باللغتين العربية والإنجليزية، وعنوان البريد الإلكتروني الحالي، ورتبته العلمية.

3) تعبئة النماذج الآتية:

أ - نموذج طلب نشر بحث في المجلة.

ب - نموذج تعهد بأن البحث غير منشور أو مقدم للنشر في مكان آخر.

ثالثاً: تنبيهات عامة

1) أصول البحث التي تصل إلى المجلة لا تردّ سواء أُنْشِرَتْ أم لم تنشر.

2) الآراء الواردة في البحوث المنشورة تعبر عن وجهة نظر أصحابها.

مجلة الشمال للعلوم الأساسية والتطبيقية (JNBAS)

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المجلد الثالث - العدد الثاني نوفمبر 2018 - ربيع الأول 1440هـ

المحتويات

الأبحاث العربية

الأبحاث الإنجليزية

الأبحاث باللغة العربية

المملكة العربية السعودية
جامعة الحدود الشمالية (NBU)
مجلة الشمال للعلوم الأساسية والتطبيقية (JNBAS)
طباعة ردمد: 1658-7022 / إلكتروني ردمد: 1658-7014
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الدرجة والفروق في القلق لمرضى اضطرابات الغدة الدرقية لدى مراجعي عيادة الغدد الصماء في مستشفى الملك عبدالعزيز التخصصي بمدينة الطائف ـ المملكة العربية السعودية

أحمد سعيد الحريري[1*]، فوزية سعيد الحارثي[2]

(قدم للنشر في 18 / 10 / 1439هـ؛ وقبل للنشر في 20 / 02 / 1440هـ)

مُلخَّص الدِّراسة: نظراً لما لاضطرابات الغدة الدرقية من تأثير على الحالة النفسية للمريض، فقد حاول البحث إلقاء الضوء على العلاقة بين القلق واضطراب الغدة الدرقية لدى مرضى اضطرابات الغدة الدرقية. وقد هدف البحث إلى الكشف عن متوسط درجة القلق تبعاً لنوع اضطراب الغدة الدرقية (خمول الغدة ونشاط الغدة) ومعرفة الفروق في درجة القلق تبعاً لنوع اضطراب الغدة الدرقية والمرحلة العمرية. وقد اختيرت عينة من المراجعين لعيادات الغُدد في مستشفى الملك عبدالعزيز التخصصي في مدينة الطائف في المملكة العربية السعودية، وبلغ عددهم (600) من كلا الجنسين. وطبق مقياس تايلور للقلق (Taylor Anxiety Scale) وقد أظهرت نتائج البحث أن متوسط درجة القلق لمضطربي خمول الغدة الدرقية هو (3.23 من 5)، ومتوسط درجة القلق لمضطربي نشاط الغدة هو (3.22 من 5) ولا يوجد فروق ذات دلالة إحصائية في درجة القلق تبعاً لنوع اضطرابات الغدة الدرقية، والمرحلة العمرية. وقد أوصى البحث بعدد من التوصيات أبرزها ضرورة وجود برامج إرشادية ودعم نفسي لمرضى الغدد الدرقية.

الكلمات المفتاحية : الغدة الدرقية، القلق، مقياس تايلور للقلق.

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The Degree and Differences of Anxiety among Outpatients of Thyroid and Endocrine Disorders at King Abdulaziz Specialist Hospital in Taif City-Kingdom of Saudi Arabia

Ahmed Said Al Hariri[1*] & Fouzia Said Al Harthy[2]

(Received 02/07/2018; accepted 31/10/2018)

Abstract: According to psychological effects of thyroid disorders on the patient, the study attempts to shed light on the relationship between anxiety and thyroid disorder among sample of patients, and explore the anxiety mean based on thyroid disorder type (hypothyroidism and hyperthyroidism) and to identify the differences in anxiety mean based on thyroid disorder type and age category. A sample of 600 outpatients (both sexes) of endocrine clinics at King Abdulaziz specialist hospital in Taif city was selected, Kingdom of Saudi Arabia. Anxiety Scale Taylor was administrated. And the results show that anxiety mean for hypothyroidism patients was 3.23 out of 5.0, and anxiety mean for hyperthyroidism patients was 3.22 out of 5.0 and there are no significant differences in anxiety score based on thyroid disorder and based on age category. This study concludes with a number of recommendations, which the important one is having counseling programmers and psychological support for thyroid disorder patients.

Keywords: Thyroid; Anxiety; Taylor Anxiety Scale.

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1. المقدمة

بات واضحاً أن أسباب القلق متعددة فقد تكون فسيولوجية أو صحية أو بيئية مكتسبة أو وراثية جينية. فالقلق من أكثر الاضطرابات النفسية شيوعاً، بل يسمى مرض العصر، أو عصر القلق نتيجة لزيادة متطلبات الحياة من ناحية، وزيادة المشكلات الصحية من ناحية أخرى. ناهيك عن ضعف الخدمات العلاجية أساساً فضلا عن خدمات الصحة النفسية للمرضى المزمنين خاصة مرضى الغدة الدرقية بنوعيها؛ نشاط إفراز الغدة أو خمول إفراز الغدة.

وحسب الإحصائيات المُستقاة من الدراسات الميدانية فإن ما يُعادل (10%-16%) من السكان يُعانون من القلق، وتختلف مُعدلاته باختلاف البلد، والظروف السياسية والسكنية، والمناخية والاجتماعية (السباعي وعبدالرحيم، 1999م، ص:37). وفي المقابل تُعد الغدة الدرقية من أهم الغُدد الصماء لأنها تنظم الوظائف الحيوية خاصةً عمليتي الأيض والنمو، وتقوم الغدة الدرقية بتخزين مادة اليود (Iodine) وتفرز هرمون الثيروكسين (Thyroxin) الذي يؤثر في عمليات الأيض (Metabolism) (الفرماوي، 2007م، ص: 69).

ويذكر عبدالمُعطي (2003م) أن العلاقة بين القلق وزيادة إفراز هرمون الثيروكسين مسألة واضحة تماماً، وقد أثبتت الدراسات التي أجراها (Lidz & Whiteborn) أن "جميع المُصابين بزيادة إفراز الثيروكسين سبق أن تعرّضوا لأزمات وضغوط نفسية عنيفة" لم يملكوا إزاءها سوى كبت نوازع العدوان والقلق، مما جعل أجهزتهم العصبية دائمة الاستثارة ليلاً ونهاراً، وبالتالي تجعل غددهم في حالة اضطراب مُستمر(ص: 140) "ويؤدي القلق دوراً بارزاً في نمو شخصية الفرد كما أن له دوراً مهماً في الاضطرابات النفس جسمية، لذلك يعدُّ القلق محوراً للاهتمام الطبي في الأمراض النفسية والنفس جسمية في وقتنا الحاضر" (الزراد، 2009م، ص: 54).

وبناء عليه فقد كان من بين الأسباب التي دفعت الباحثان للقيام بهذا البحث، اطلاعهما على بعض الدراسات والبحوث النفسية الأجنبية مثل دراسة (Richard ,2007; Lyne, 2007; Robert, 2011; Gerald,2013) والتي تناولت موضوع اضطرابات الغدة الدرقية وعلاقتها باضطراب القلق، مما يشير أن هذه العلاقات جديرة بالبحث والفحص على المستوى المحلي خاصة.

2. الإطار النظري للبحث

2.1 الغدة الدرقية

الغُدد من أكثر العوامل المؤثرة في سلوك الشخصية وتطورها بسبب إفرازاتها التي تُسهم في حفظ الاتزان الكيماوي للكائن الحي (الجاموس، 2013م). "وقد سمّى (و. ل. بروان) الغدة الدرقية (Thyroid Gland) بغدة التخلق، لأن إفرازها يُنبّه النمو في الأعضاء الجنسية، والدماغ، والعظام " (الزراد، 2009م). ويعرّفها زيتون (2000م) بأنها تتكوّن من فصين يُوجدان على جانبي القصبة الهوائية في منطقة العنق، يربطهما غشاء رقيق، وتُعدّ هذه الغدة من أكبر الغُدد الصماء حجماً إذ يصل وزنها حوالي (28) غراماً في الإنسان البالغ، وتفرز الغدة الدرقية مجموعة من الهرمونات أهمها الهرمونان التاليان:

- **الهرمون المُنشط للغدة الدرقية (Thyroid Stimulating Hormone):** "يفرزه الفص الأمامي للغدة النخامية، ويؤثر في نمو ووظائف الغدة الدرقية، وينشط امتصاص عنصر اليود من الدم، الذي يُعدّ أساس تكوين هرمون الثيروكسين" (الحجاوي، 2004م).
- **هرمون الثيروكسين (Thyroxin Hormone):** "هرمون الثيروكسين أو (Tetra Iodothyronine) هو الهرمون الرئيس الذي تنتجه الغدة الدرقية وهو مسؤول عن النشاط الأيضي" (Metabolic) (Myron, 2010).

2.1.1 أمراض الغدة الدرقية

تنتشر اضطرابات الغدة الدرقية بأشكالها المُختلفة بنسبة (5%) بين الأفراد، وبخاصة لدى الإناث (Lokesh, 2013).

وقد أظهرت نتائج دراسة (Robert, 2011) أن أعلى نسبة انتشار في اضطرابات الغدة الدرقية (Thyroid Gland Disorders) في الفئة العمرية من (35 إلى 40 سنة) وتنخفض هذه النسبة بعد سن (49).

وتُعرف اضطرابات الغدة الدرقية بأنها " أحد أنواع الأمراض المُنتشرة التي قد تؤدي إلى تقلبات المزاج وتغيرات مُستمرة في الطاقة اليومية، حيث يُعاني الأشخاص المُصابين بقصور الغدة الدرقية (Hypothyroidism) من التعب والإرهاق المستمر، والشعور بانعدام الطاقة، والإحباط، والاكتئاب أو اليأس، وعلى العكس تماماً، فإن فرط نشاط الغدة الدرقية (Hyperthyroidism) يؤدي للقلق، والعصبية، وزيادة النشاط والحماس وقلة النوم" (Heymann, 2009).

2.1.2 العوامل المُؤثرة في نشاط الغدة الدرقية

1. كمية اليود في الدم تبعاً لنوع الغذاء، فالأغذية الفقيرة باليود تُحدّ من نشاط الغدة.
2. تأثرها بنشاط الغدة النخامية.
3. درجة الحرارة، حيث إن الجو البارد يُنشّط الغدة الدرقية، على عكس الطبيعي (البياتي، 2002م).

2.1.3 أسباب اضطرابات الغدة الدرقية

يرى (Rafael, 2013) أن من أهم أسباب اضطراب الغدة الدرقية نقص اليود: وهو شائع في المناطق الجبلية، حيث تقلّ نسبة اليود في الماء والغذاء، مما يؤدي إلى تضخّم الغدة الدرقية، وتغيرات الجلد الناتجة عن انخفاض هرمون الثيروكسين (Myxedema) عند الكبار، إذ يتكوّن نسيج هلامي غير طبيعي تحت الجلد، وفي حال مرضى قصور الغدة الدرقية لا تنتج الغدة النخامية ما يكفي من الهرمون المنبه لتحفيز الغدة الدرقية.

وبغض النظر عن أسباب اضطراب الغدة الدرقية فإن من الواضح لدى الباحثين أن مضطربي الغدة الدرقية يعانون من شكاوى نفسية متعددة أهمها اضطراب القلق.

2.1.4 أعراض اضطرابات الغدة الدرقية

"زيادة أو نقص الهرمون عن الحدّ العادي، يتبعه تأثير مُباشر في السلوك فيزداد توتر الإنسان وتزداد انفعالاته" (الفرماوي، 2007م).

ومع بدء زيادة إفراز الثيروكسين، يُصاب الفرد بمرض (Graves' disease) الذي يكون له أعراض جسمية، وانفعالية عديدة من أهمها القلق، وسرعة التهيج العصبي، والتوتر المستمر، وانعدام الاستقرار الانفعالي (عبدالمعطي، 2003م).

وإذا نقص إنتاجه قبل البلوغ، فإنه يؤدي إلى تعطيل النمو الجسمي، والجنسي، والعقلي (الجاموس، 2013م). وإذا نقص إنتاجه بعد البلوغ، فإنه يؤدي إلى قصور الغدة الدرقية حيث يُصاب الشخص بجفاف الجلد، وقلة الشعر، ونقص النشاط الجسمي، و زيادة مُفرطة في وزن الجسم، وتباطؤ في ضربات القلب، وانخفاض ضغط الدم، وعدم تحمّل الشخص للبرودة" (البياتي، 2002م). وفي كلا الحالتين فإن هذه الأعراض تؤدي إلى التوتر والقلق النفسي.

2.1.5 اضطرابات الغدة الدرقية وعلاقتها بالقلق

"عادة ما يكون القلق مصحوباً بمجموعة من التغيرات الفسيولوجية والنفسية" (العزة، 2004م، ص: 68) والتي قد تزيد من حدة أعراض القلق حيث أن الاستجابة الجسمية تعزز الاستجابة النفسية.

خاصةً أن "القلق يصاحبه زيادة في إفراز الغدة الدرقية، وهنا يظهر التوتر، والقلق النفسي وسرعة التأثر، والتهيّج، مع ارتجاف في الأطراف، وارتفاع في ضغط الدم، وتعرّق الأطراف، مع جحوظ في العينين، وأحياناً ورم بالغدة الدرقية" (عكاشة، 2003م، ص: 137).

2.2 القلق

يعرّف القلق (Anxiety) بأنه "عدم الاستقرار، نتيجة الضغط النفسي الذي يعاني منه الفرد ويُسبّب اضطراباً في سلوكه،

ويصاحبه أعراض نفسية وجسمية" (عبدالفتاح، 2004م، ص: 52). ويُعد القلق من أكثر المصطلحات الشائعة في مجال علم النفس عموماً، وفي مجال الصحة النفسية خصوصاً (الشبؤون، 2011م).

وقد شغلت ظاهرة الخوف والقلق قديمًا وحديثًا حيزًا كبيراً من اهتمام الإنسان، ودفعته إلى ابتكار أساليب متنوعة، لمواجهة المآزق، ودرء الأخطار التي قد تُهدّده (ميخائيل، 2003م، ص: 11). فالقلق من أكثر الأمراض شيوعاً في العالم بأجمعه، وأظهرت نتائج مسح وبائي في الولايات المتحدة أن نسبة انتشار اضطرابات القلق تصل إلى (14%) (عكاشة، 2003م ، ص: 138).

كما أن هناك دراسات عديدة تشير إلى أن انتشار القلق العام يصل إلى (2-5%) من الناس كافة، وبعض الدراسات تشير إلى أنه يكثر بين الإناث بنسبة (2:1) (حمودة، 1991م، ص: 374). وفي دراسة أجريت على (100) مريض مشخصين بقصور الغدة الدرقية أظهرت النتائج أن (63%) من هؤلاء المرضى يعانون من القلق، وكان من أهم أعراض القلق البارزة لدى الذكور المزاج المكتئب بنسبة (70%) ولدى الإناث المزاج القلق بنسبة (93%). (Bathla, Singh, & Relan, 2016).

2.2.1 أسباب القلق

2.2.1.1 عوامل وراثية

أثبتت الدراسات التي أُجريت على التوائم وبعض العائلات أن (15%) من آباء وإخوة المُصابين بالقلق مُصابون بالمرض نفسه، فالوراثة لها دور في المرض(آسيا، 2012م، ص: 161). ولعل ما يلفت الانتباه عندما ينشأ القلق من عوامل وراثية صرفة، وعوامل أخرى ترتبط باضطراب الغدة الدرقية لدى الشخص، وقد يصعب التمييز حينها بين العامل الوراثي والعامل الفسيولوجي مثل زيادة نشاط الغدة الدرقية، أو نقص هرمون الغدة الدرقية.

2.2.1.2 النواقل العصبية

بعض النواقل العصبية (Neurotransmitters) تنْشط عند الشعور بالقلق وترتبط بالخلل في منظومة (Serotonin) ومستويات (Norepinephrine) الأعلى من المعدل الطبيعي ويفرز أثناء ذلك حمض (Gamma-Aminobutyric Acid) وله دور في تقليل القلق، والخلل في وظيفة هذا الحمض يؤدي للإصابة بالقلق (آن كرينج، جون، وجيرالد، 2014م، ص ص: 366-367).

2.2.1.3 العوامل النفسية

إن الاستعداد النفسي، والشعور بالتهديد وتوقعه، والصدمات النفسية، ومواقف الحياة الضاغطة، ومشكلات الطفولة والمراهقة والشيخوخة، والتعرّض للحوادث والخبرات الصادمة كلها علاقة سببيه بالقلق (الكحيمي، حمام ومصطفى، 2007م، ص ص: 334 – 335).

2.2.2 أعراض وتفسيرات القلق

"يرافق القلق اضطرابات فسيولوجية، وجسمية، ونفسية، واجتماعية مختلفة، تتفاوت من حيث الشدة تبعًا لشدة القلق" (العزة، 2004م ، ص: 85). وتشمل أعراض القلق التوتر العضلي، وأعراض زيادة نشاط الجهاز العصبي المُستقل، والخوف والحذر (حمودة، 1991م، ص: 371).

2.2.2.1 الأساس الفسيولوجي للقلق

"تنشأ أعراض القلق النفسي من زيادة تنبيه الجهاز العصبي اللاإرادي بنوعيه: السمبتاوي (Sympathetic Nervous System) والبارا سمبتاوي (Parasympathetic Nervous System) وزيادة الأدرينالين (Adrenaline) والنور أدرينالين (Norepinephrine) في الدم، وهذا يؤدي إلى ارتفاع ضغط الدم، وزيادة ضربات القلب، وجحوظ العينان وتحرّك السكر من الكبد، وشحوب الجلد، وزيادة العرق، وجفاف الحلق، وارتجاف الأطراف، وكثرة التبول، والإسهال، و زيادة الحركات والاضطرابات" (عكاشة، 2003م، ص: 135).

وفي دراسة هدفت إلى الكشف عن العلاقة بين وظيفة الغدة الدرقية وشدة القلق، توصّلت إلى وجود علاقة ارتباطية بين

كل من هرمون الثيروكسين واضطراب القلق (Kikuchi, Komuro, Oka, Kidani, Hanaoka, & Koshino, 2007, p.77).

2.2.2.2 النظرية البيولوجية المفسرة للقلق

يمكن فهم القلق لدى العينة الحالية من خلال تفسير النظرية البيولوجية التي شرحت مفهوم المقاومة البيولوجية، والأسباب الجينية المُسببة للقلق، حيث يمكن تحديد عامل بيولوجي لتحديد الميل الفطري لنوبات الهلع Panic مثل: ملح الصوديوم للأفراد الذين يُعانون من نوبات الهلع، وآخرون لا يُعانون من نوبات هلع، واتضح أن الأفراد الذين لديهم حساسية بيولوجية لأملاح الصوديوم نتج لديهم مشاعر رهبة وهلع، أمّا بالنسبة إلى الأسباب الجينية فتعتمد على دراسة الحالة الوراثية وتحديد النسبة المئوية للأفراد الذين لديهم المرض نفسه في العائلة نفسها (الإمامي، 2010م).

3 الدراسات السابقة

اشارت العديد من الدراسات حول العالم لاضطرابات الغدة الدرقية وما يصاحبها من مشاعر وأعراض للقلق، ومن هذه الدراسات ما يلي:

أجرى Kikuchi *et al.* (2004) دراسة بعنوان "العلاقة بين القلق ووظيفة الغدة الدرقية لدى عينة من مرضى اضطراب الهلع" وطبّقت الدارسة على عينة مكوّنة من (66) من مرضى اضطراب الهلع؛ (41) منهم يخضعون للعلاج، و(25) لا يخضعون للعلاج، وتوصّلت الدراسة إلى نتائج أهمها أنه كلما زادت حدة نوبة الهلع، ارتفع مستوى الهرمون المُنشط للغدة الدرقية، ولُوحظ في عينة هذه الدراسة وجود علاقة ارتباطية دالة بين درجة وحدة القلق، وبين مستويات هرمون الثيروكسين (Thyroxin).

أمّا Krave (2007) فقد تناول دراسة بعنوان "القلق وعلاقته بالغدة الدرقية" طبّقت على عينة مكوّنة من (711) مريضاً بالقلق النفسي، ومن أبرز نتائج الدراسة أن (2%) من الذكور، و(9%) من الإناث في هذه الدراسة، لديهم خلل في الغدة الدرقية، بينما (1.3%) من الذكور، و(4.1%) من الإناث، وُجد أنهم مُصابون بالسكري، وأن انتشار مرض الغدة الدرقية في الإناث كان أعلى من المتوقع بالنسبة لبقية المرضى، وأن الذين يُعانون من اضطرابات الهلع لديهم أيضاً مرض ضمني يُسبّب لهم القلق النفسي خاصةً اضطرابات الغدة الدرقية.

وذكر Posani (2010) في دراسة بعنوان "أعراض القلق، ومُعدل الغدة الدرقية أثناء الحمل" طبّقت على عينة مكوّنة من (199) من النساء مُتابعات فيما قبل الولادة في إحدى المُستشفيات، وكل النساء كنّ في الثلث الأول، والثاني، والثالث من الحمل قد أتموا مقياس القلق. وتوصّلت الدراسة إلى نتائج مُهمة، منها: أنه يوجد علاقة بين ظهور أعراض القلق، وتركيز الهرمون المنبه للغدة الدرقية (Thyroid Stimulating Hormone) في منتصف الحمل، وأن وجود أعراض القلق مُرتبطة بشكل مُستقل بالتركيزات المُنخفضة للهرمون المُنبه للغدة الدرقية.

وقد أجرى Robert (2011) دراسة بعنوان" علاج القلق، والتشخيص المُبكر لاضطرابات الغدة الدرقية" طبّقت على عينة مكوّنة من (42) مريضاً من مرضى القلق في مركز طبي في مدينة (Charleroi) ببلجيكا، قُسّموا إلى مجموعتين متساويتين إحدى المجموعتين شخصت مبكراً باضطرابات الغدة، وتوصّلت الدراسة إلى نتائج أهمها: أن مستويات القلق تتدرج لدى أفراد المجموعتين، تبعاً لمستوى اضطراب الغدة الدرقية لدى كل فرد، وأن عدم إجراء التشخيص المُبكر لاضطرابات الغدة الدرقية لدى أفراد المجموعة الثانية، أدّى إلى تدهور حالتهم الصحية وزيادة القلق لديهم.

كما أجرى Gerald (2013) دراسة بعنوان "اضطرابات الغدة الدرقية، ودورها في زيادة تعاطي دواء (Depakine) المهدئ للتوتر والقلق" طبّقت على عينة مكوّنة من (8) أطباء ذوي خبرة أكثر من (6 سنوات) في تشخيص حالات اضطرابات الغدة الدرقية في مستشفى بمقاطعة (Brittany) شمال جمهورية الدومينيكان (Dominican Republic). ومن أبرز النتائج التي توصّلت إليها الدراسة أن هناك علاقة ارتباطية ذات دلالة إحصائية بين اضطرابات الغدة الدرقية وتعاطي دواء(Depakine) المهدئ للتوتر والقلق لدى عينة

الدراسة، وأن هناك علاقة ارتباطية ذات دلالة إحصائية بين الاستمرار في تعاطي دواء (Depakine) وزيادة خمول الجسم لدى عينة الدراسة.

وقد تناول Mark (2014) دراسة بعنوان "القلق يزيد من نشاط الغدة الدرقية لدى المرضى بمستشفى Jeritala (Mistonala" بمدينة سانتياغو بأمريكا الجنوبية، وطبّقت على عينة مكوّنة من (96) من مرضى اضطرابات الغدة الدرقية، (75) منهم يخضعون للعلاج و (21) لا يخضعون للعلاج، وقد توصلت الدراسة إلى نتائج أهمها: أنه كلما زاد مستوى القلق لدى مرضى اضطرابات الغدة الدرقية، كلما ارتفع مستوى نشاط الغدة الدرقية.

وقد اطلع الباحثان على العديد من الدراسات العالمية، ولم يجدا دراسات إقليمية واحدة تناولت العلاقة بين اضطرابات الغدة الدرقية وأعراض القلق –في حدود ما استطاعا الوصول إليه– رغم توفر الدراسات الأجنبية والتي تم الإشارة إلى بعضها.

3.1 التعليق على الدراسات السابقة

تشابهت جميع الدراسات السابقة من حيث الهدف، وهو دراسة العلاقة بين اضطرابات الغدة الدرقية وأعراض القلق مما يعكس أهمية هذا الموضوع والمُمارسة البحثية العالمية في الربط بين القلق واضطرابات الغدة الدرقية، سواء المصابين بخمول الغدة أو بنشاطها مثل دراسة Mark (2014) التي اقتصرت على دراسة القلق على مرضى نشاط الغدة الدرقية، أو عند فئة معينة من المراجعين مثل دراسة Posani (2010) التي اقتصرت على النساء الحوامل.

وقد توصلت جميع الدراسات إلى وجود القلق لدى أفراد العينة من مرضى اضطرابات الغدة الدرقية، وأغلب الدراسات استخدمت الاستبانة، والمنهج الوصفي المسحي على عينات بلغ متوسط عددها (224)، بينما هذا البحث بلغت عينته (600) شخص من المشخصين باضطراب الغدة الدرقية، وهذا قد يعد إضافة على المستوى المحلي سواء لمرضى القلق المُصابين باضطرابات في الغدة الدرقية أو مرضى الغدة الدرقية الذين ظهرت لديهم أعراض القلق المرضية.

4 إجراءات البحث

4.1 مشكلة البحث

من خبرة الباحثين وجدا أن مرضى الغدة الدرقية لا يقدم لهم في الغالب أي استشارة نفسية علاجية ويتم التعامل معهم على أساس اضطراب الغدة الدرقية وما تقتضي الحاجة من علاجات دوائية وإشعاعية ونووية فقط، لذا كان من المهم معرفة مدى الحاجة ووعي هؤلاء المرضى بالأعراض النفسية المصاحبة لاضطراب الغدة الدرقية خاصة أعراض القلق.

وترتبط مشكلة أمراض الغدة الدرقية بالعديد من المشاعر النفسية السالبة، ومن أهمها الشعور بالقلق بنسبة (38%) من العينة حيث بلغت النسبة لدى الإناث (85%) ولدى الذكور (15%)، وحيث إن الخلل في إفراز الغدة الدرقية قد يُحدث تغيرات مزاجية لدى المرضى حتى في حالات اضطراب الغدة الدرقية البسيط، (Suwalska, Lacka, Lojko, & Rybakowski, 2005, p.61) .

كما أشار Myron (Myron, 2010) إلى أن القلق ينتشر بنسبة (72%) لدى مرضى الغدة الدرقية، لذا يمكن صياغة مشكلة البحث في التساؤلين التاليين:

1. ما درجة القلق تبعًا لنوع اضطراب الغدة الدرقية لدى مراجعي عيادات الغدد في مستشفى الملك عبدالعزيز التخصصي بالطائف؟
2. هل توجد فروق ذات دلالة إحصائية بين اضطرابات الغدة الدرقية وأعراض القلق، تبعًا للمرحلة العمرية، وتبعًا لنوع اضطراب الغدة الدرقية؟.

4.2 أهداف البحث

يهدف هذا البحث إلى ما يلي:

1. الكشف عن درجة القلق تبعاً لنوع اضطراب الغدة الدرقية لدى مراجعي عيادات الغدد في مُستشفى الملك عبدالعزيز التخصصي بالطائف.
2. معرفة الفروق بين اضطرابات الغدة الدرقية وأعراض القلق، تبعاً للمرحلة العمرية، وتبعاً لنوع اضطراب الغدة الدرقية.

4.3 أهمية البحث

تكمن أهمية البحث من الناحية النظرية في أهمية الموضوع نفسه، حيث لا توجد أبحاث محلية تناولت علاقة القلق باضطرابات الغدة الدرقية، ومن حيث الأهمية التطبيقية فتكمن أهميته بما يتوصل إليه من نتائج وتوصيات تُعزّز جودة العمل الطبي في المستشفيات لمرضى الغدة الدرقية، وتحفز عمل الأخصائي النفسي مع هذه العينة من مرضى اضطراب الغدة الدرقية بنوعيه: القصور (Hypothyroidism) والنشاط (Hyperthyroidism).

4.4 حدود البحث

يقتصر هذا البحث على دراسة درجة القلق لدى مرضى اضطرابات الغدة الدرقية من مُراجعي عيادات الغُدد الصماء في مستشفى الملك عبدالعزيز التخصصي بمحافظة الطائف بمنهجه وأداته العلمية، وحيث طُبّق البحث من تاريخ 1437/6/30هـ، إلى 1438/10/30هـ، وكذلك طُبّق البحث مكانياً لدى مُراجعي عيادات الغُدد في مستشفى الملك عبدالعزيز التخصصي بالطائف، مُحافظة الطائف بالمملكة العربية السعودية.

4.5 مُجتمع البحث

يتكون مجتمع هذا البحث من المُراجعين لعيادات الغُدد الصماء بمستشفى الملك عبدالعزيز التخصصي بالطائف وهم غير محددين بسبب عدم وجود إحصائية. أمّا عينته فقد بلغت (600) مفحوصٍ من مُراجعي عيادات الغُدد الصماء في مستشفى الملك عبدالعزيز التخصصي بالطائف، وهم مقسمون إلى (39) من الذكور و(561) من الإناث الذين تتراوح أعمارهم بين (13- 78) عاماً، تم اختيارهم بالطريقة العمدية من مجتمع البحث، والجدول (1) يوضح ذلك.

يتضح من الجدول (1) أن عدد الذكور بلغ (39) بنسبة (6.5%) بينما بلغ عدد الإناث (561) بنسبة (93.5%) وقد لوحظ أن الإصابة باضطرابات الغدة الدرقية تنتشر بين الإناث بنسبة (93.5%) وهذه النسبة أعلى من الذكور، حيث كانت نسبة الذكور في هذا البحث (6.5%).

جدول 1: وصف خصائص عينة البحث.

		التكرار	النسبة
النوع	ذكر	39	%6.5
	أنثى	561	%93.5
الحالة الاجتماعية	أعزب	121	%20.2
	متزوج	429	%71.5
	منفصل	21	%3.5
	أرمل	29	%4.8
العمر	من 13 إلى أقل 18	16	%2.7
	من 18 إلى أقل 23	25	% 4.2
	من 23 إلى أقل 28	66	%11.0
	من 28 إلى أقل 33	68	%11.3
	من 33 إلى أقل 38	102	%17.0
	من 38 إلى أقل 43	92	%15.3
	من 43 إلى أقل 48	79	%13.2
	من 48 إلى أقل 53	54	% 9.0
	من 53 إلى أقل 58	42	% 7.0
	من 58 إلى أقل 63	23	%3.8
	من 63 إلى أقل 68	19	% 3.2
	من 68 إلى أقل 73	4	% 0.7
	من 73 إلى أقل 78	10	%1.7
نوع الاضطراب	نقص إفراز الغدة الدرقية	470	%78.3
	زيادة إفراز الغدة الدرقية	130	%21.7
الإجمالي		**600**	**%100.0**

وتتفق هذه النتيجة مع دراسة Robert (2011) حيث وجد أن انتشار اضطرابات الغدة الدرقية أكثرُ شيوعاً بين الإناث بنسبة (85%) وبين الذكور بنسبة (15%).

كما يتضح من خصائص العينة أن عدد المتزوجين بلغ (429) وتُمثّل النسبة الأكبر من بين نسب أفراد عينة البحث، تبعاً لمتغير الحالة الاجتماعية، حيث بلغت نسبة المتزوجين (71.5%) بينما كانت فئة المُنفصل أقل نسبة حيث بلغ عددهم (21) بنسبة (3.5%).

وكما يُلاحظ أن الفئة العمرية من (33-38) تمثل أعلى نسبة حيث بلغت (102) مُراجع بنسبة (17.0%) بينما كانت الفئة العمرية من (68-73) تمثل أقل نسبة حيث بلغت (4) مُراجعين بنسبة (0.7).

ويلاحظ أيضاً من خصائص العينة أن عدد أفراد عينة البحث الذين يُعانون من اضطراب قصور الغدة، بلغ عددهم (470) مراجع بنسبة (78.3%) يليها ذوو اضطراب نشاط الغدة، حيث بلغ عددهم (130) مُراجع بنسبة (21.7%). وتتفق هذه النتيجة مع ما أشار إليه Sapini وآخرون (Sapini, Sapini et al Rokiah, & Nor Zuraida, 2009) من أن أكثر اضطرابات الغدة الدرقية شيوعاً اضطراب قصور الغدة الدرقية بنسب انتشار تراوحت ما بين (10.5%–11.7%) لدى الإناث، ونسبة (0.9%–5.14%) بين الذكور.

4.6 منهج وأدوات البحث

استخدم الباحثان في هذا البحث المنهج الوصفي (المسحي المقارن) للإجابة عن تساؤلات البحث، واستخدم مقياس القلق لتايلور (Taylor Anxiety Scale) (تايلور، 1953؛ Taylor, 1953) ويتكوّن من (50) عبارة، ويقيس القلق الظاهر بحيث يختار المفحوص أن يجيب بإحدى إجابتين (نعم) أو (لا) وقد نقله إلى العربية وقننه في المملكة العربية السعودية (الشناوي، 1996م).

وقد اعتمد الباحثان مقياس ليكرت (Likert Scale) الخماسي في تطبيق المقياس للقلق الظاهر، كما يلي: (موافق بشدة، موافق، موافق أحيانًا، غير موافق، غير موافق أبدًا).

4.7 صدق المقياس

للتحقق من صدق المقياس تم حساب الصدقَ الداخلي لمعاملات ارتباط العبارة بالمقياس من خلال التحليل العاملي التوكيدي، وتراوحت قيم العبارات ما بين (0.323 –0.849) وهي دالة إحصائياً عند مستوى أقل من (0.05) مما يؤكد صدق نموذج البناء التوكيدي لمقياس تايلور، وكانت مؤشرات حسن المطابقة مقبولة إلى درجة كبيرة، حيث كانت قيمة اختبار مربع كاي (4179.062) ودرجات الحرية (1175) ومعامل كيزر باختبار بارتلت (Kaiser Coefficient in Bartlett's Test) (0.896) وكانت الدلالة الإحصائية دالة عند مستوى دلالة (0.01).

4.8 ثبات المقياس

تكوّن المقياس من (50) عبارة، وقد احتسب ثبات مقياس تايلور للقلق باستخدام معامل ألفا كرونباخ (Cronbach's Alpha)، ومعامل الثبات بطريقة التجزئة النصفية لـ سبيرمان / براون، ومعامل جوتمان للثبات حيث طُبّق على عينة بلغ عددها (100) من الذكور والإناث، والجدول (2) يوضح قيم معاملات الثبات للمقياس.

يلاحظ من الجدول (2) أن جميع معامل ثبات ألفا كرونباخ للاستبيان ككل، بلغت (0.824)، ومعامل ثبات التجزئة النصفية لـ سبيرمان/براون بلغت (0.867)، في حين بلغت قيمة معامل جوتمان للثبات (0.863)، مما يؤكّد ثبات الاستبيان، وبذلك يمكن الوثوق بصدق الاستبيان وثباته، وصلاحيته للتطبيق.

جدول 2: يوضح قيم معاملات الثبات لكل عبارة لمقياس تايلور للقلق، والاستبيان ككل.

عدد العبارات	معامل ألفا كرونباخ للثبات	معامل الثبات بطريقة التجزئة النصفية لـ سبيرمان/براون	معامل جوتمان
50	0.824	0.867	0.863

5 نتائج البحث ومناقشتها

وللإجابة عن تساؤلي البحث، تم حساب المتوسطات والانحراف المعياري والنسبة الموزونة للمتوسط وفق استجابات العينة على المقياس، وذلك لكل العبارات وإجمالي المقياس، والجدولين (3 و 4) يوضحان ذلك.

5.1 إجابة التساؤل الأول

التساؤل الأول: ما درجة القلق تبعاً لنوع اضطراب الغدة الدرقية لدى مراجعي عيادات الغدد في مستشفى الملك عبدالعزيز التخصصي بالطائف؟

جدول 3: درجة عبارات مقياس القلق لذوي اضطرابات الغدة الدرقية تبعاً لنوع الاضطراب.

م	العبارة	نقص إفراز الغدة الدرقية				زيادة إفراز الغدة الدرقية			
		المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب	المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب
1	نومي مضطرب ومتقطّع.	3.85	1.06	77%	6	3.61	1.10	72%	12
2	مرت بي أوقات لم أستطع خلالها النوم بسبب القلق.	3.84	1.09	77%	7	3.78	1.09	76%	6
3	مخاوفي قليلة جدًّا مقارنة بأصدقائي.	3.03	1.06	61%	35	3.00	1.09	60%	36
4	أعتقد أنني أكثر عصبية من معظم الناس.	3.77	1.11	75%	10	3.50	1.28	70%	15
5	تنتابني أحلام مزعجة أو (كوابيس) عدة ليالٍ.	3.37	1.17	67%	20	3.07	1.21	61%	35
6	لديَّ متاعب أحيانًا في معدتي.	3.78	1.04	76%	9	3.62	1.25	72%	11
7	غالبًا ما ألاحظ أن يداي ترتجفان عندما أحاول القيام بعمل ما.	3.30	1.20	66%	24	3.25	1.22	65%	26
8	أعاني أحيانًا من نوبات إسهال.	2.74	0.98	55%	44	2.94	1.05	59%	39
9	تثير قلقي أمور العمل والمال.	3.13	1.16	63%	32	3.15	1.08	63%	33
10	تصيبني نوبات من الغثيان "غمامات النفس".	3.11	1.17	62%	33	3.25	1.21	65%	27
11	كثيرًا ما أخشى أن يحمرّ وجهي خجلًا.	2.92	1.08	58%	38	2.95	1.11	59%	38
12	أشعر بجوع في كل الأوقات تقريبًا.	3.15	1.21	63%	31	3.28	1.09	66%	25
13	أثق في نفسي كثيرًا.	2.00	0.88	40%	49	2.03	0.96	41%	49
14	أتعب بسرعة.	3.99	0.92	80%	1	3.85	1.08	77%	3
15	يجعلني الانتظار عصبيًّا.	3.89	1.07	78%	3	3.82	0.99	76%	5
16	أشعر بالإثارة، لدرجة أن النوم يتعذّر عليّ.	3.47	1.09	69%	17	3.51	1.11	70%	14
17	عادة ما أكون هادئًا.	2.77	0.92	55%	42	2.65	0.98	53%	44

جدول 3: يتبع.

م	العبارة	نقص إفراز الغدة الدرقية				زيادة إفراز الغدة الدرقية			
		المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب	المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب
18	تمر بي فترات من عدم الاستقرار، لدرجة أنني لا أستطيع الجلوس طويلًا في مقعدي.	3.47	1.11	69%	18	3.45	1.21	69%	19
19	لا أشعر بالسعادة في معظم الوقت.	3.01	1.01	60%	36	2.80	1.14	56%	40
20	من السهل أن أركّز ذهني في عمل ما.	2.77	0.92	55%	43	2.67	1.00	53%	43
21	أشعر بالقلق على شيء ما أو شخص ما طوال الوقت تقريبًا.	3.98	1.09	80%	2	3.75	1.07	75%	8
22	لا أتهيّب الأزمات والشدائد.	3.26	0.98	65%	26	3.32	0.87	66%	23
23	أودّ أن أصبح سعيدًا كما يبدو الآخرون.	1.89	0.92	38%	50	2.01	1.09	40%	50
24	كثيرًا ما أجد نفسي قلقًا على شيء ما.	3.70	1.05	74%	12	3.62	1.14	72%	10
25	أشعر أحيانًا – وبشكل مؤكد– أنه لا فائدة لي.	2.50	1.07	50%	46	2.43	1.08	49%	46
26	أشعر أحيانًا أنني أتمزّق.	2.59	1.14	52%	45	2.71	1.22	54%	42
27	أعرق بسهولة حتى في الأيام الباردة.	3.22	1.29	64%	27	3.35	1.33	67%	21
28	الحياة صعبة بالنسبة لي في أغلب الأوقات.	3.51	1.19	70%	15	3.47	1.24	69%	16
29	لا يقلقني ما يحتمل أن أقابله من سوء حظ.	2.93	1.04	59%	37	3.25	1.02	65%	28
30	إنني حساس بنفسي بدرجة غير عادية.	3.73	1.03	75%	11	3.76	1.10	75%	7
31	لاحظت أن قلبي يخفق بشدة، وأحيانًا تتهيج أنفاسي.	3.62	1.16	72%	13	3.69	1.13	74%	9
32	لا أبكي بسهولة.	3.48	1.02	70%	16	3.46	1.11	69%	18
33	خشيت أشياء أو أشخاصًا أعرف أنهم لا يستطيعون إيذائي.	2.80	1.09	56%	41	2.98	1.16	60%	37
34	لديَّ قابلية للتأثر بالأحداث تأثرًا شديدًا.	3.83	0.96	77%	8	3.95	0.96	79%	1

جدول 3: يتبع.

م	العبارة	نقص إفراز الغدة الدرقية				زيادة إفراز الغدة الدرقية			
		المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب	المتوسط	الانحراف المعياري	النسبة الموزونة	الترتيب
35	كثيرًا ما أُصاب بصداع.	3.87	0.97	77%	5	3.92	0.99	78%	2
36	لا بد أن أعرف بأنني شعرت بالقلق على أشياء لا قيمة لها.	3.37	1.10	67%	21	3.47	1.7	69%	17
37	لا أستطيع أن أركّز تفكيري على شيء واحد.	3.19	0.99	64%	29	3.19	1.03	64%	32
38	لا أرتبك بسهولة.	3.05	1.03	61%	34	3.20	1.11	64%	31
39	أعتقد أحيانًا أنني لا أصلح بالمرّة.	2.33	0.91	47%	48	2.34	0.98	47%	47
40	أنا شخص متوتر جداً.	3.31	1.04	66%	23	3.25	1.16	65%	29
41	أرتبك أحيانًا، لدرجة تجعل العرق يتساقط مني بصورة تضايقني جدًّا.	2.81	1.05	56%	40	2.59	1.06	52%	45
42	يحمرّ وجهي خجلًا بدرجة أكبر عندما أتحدّث إلى الآخرين.	2.87	1.16	57%	39	2.80	1.14	56%	41
43	أنا أكثر حساسية من غالبية الناس.	3.28	1.00	66%	25	3.35	0.96	67%	22
44	مرت بي أوقات شعرت خلالها بتراكم الصعاب، بحيث لا أستطيع التغلب عليها.	3.57	1.14	71%	14	3.60	1.20	72%	13
45	أكون متوترًا للغاية أثناء القيام بعمل ما.	3.40	1.01	68%	19	3.22	1.14	64%	30
46	يداي وقدماي باردتان في العادة.	3.20	1.26	64%	28	3.32	1.17	66%	24
47	أحيانًا أحلم بأشياء أفضل الاحتفاظ بها لنفسي.	3.87	1.17	77%	4	3.84	1.31	77%	4
48	لا تنقصني الثقة بالنفس.	2.40	1.06	48%	47	2.31	0.98	46%	48
49	أُصاب أحيانًا بالإمساك.	3.36	1.05	67%	22	3.39	1.16	68%	20
50	لا يحمرّ وجهي أبدًا من الخجل.	3.16	1.00	63%	30	3.08	1.06	62%	34
	الإجمـــــــــالي	3.23	0.47	65%		3.22	0.49	64%	

جدول 4: يوضح الفروق في متوسط درجة القلق بالنسبة لنوع اضطرابات الغدة الدرقية، تبعاً للنوع والمرحلة العمرية.

درجة القلق		نوع الاضطراب بالغدة الدرقية				الدلالة الإحصائية
		نقص إفراز الغدة		زيادة إفراز الغدة		
		المتوسط	الانحراف المعياري	المتوسط	الانحراف المعياري	
النوع	ذكر	149.9	21.2	155.5	22.8	0.541
	أنثى	162.2	23.2	161.1	24.8	0.641
الفئات العمرية	من 13 إلى أقل 18	171.3	19.6	171.3	30.0	0.969
	من 18 إلى أقل 23	147.2	22.0	155.1	28.2	0.459
	من 23 إلى أقل 28	153.2	21.0	156.2	23.8	0.919
	من 28 إلى أقل 33	164.8	24.6	151.0	20.9	0.086
	من 33 إلى أقل 38	161.0	21.8	160.0	26.7	0.865
	من 38 إلى أقل 43	164.9	22.8	163.5	25.6	0.846
	من 43 إلى أقل 48	166.1	24.0	160.9	25.4	0.399
	من 48 إلى أقل 53	156.9	21.5	161.5	14.7	0.514
	من 53 إلى أقل 58	158.3	23.3	178.6	22.8	0.062
	من 58 إلى أقل 63	165.9	31.4	176.1	33.6	0.49
	من 63 إلى أقل 68	158.4	25.5	170.2	14.7	0.311
	من 68 إلى أقل 73	181.3	11.2	144.0	2.4	0.101
	من 73 إلى أقل 78	164.9	15.3	146.5	3.5	0.144
الإجمالي		161.4	23.3	160.8	24.7	0.779

ويُلاحظ من الجدول (3) أن متوسط درجة القلق لدى ذوي اضطراب نقص الغدة الدرقية بلغ متوسطه (3.23) بانحراف معياري (0.47) والنسبة الموزونة للمتوسط بلغت (65%)، كما بلغ متوسط درجة القلق لدى ذوي نشاط الغدة الدرقية (3.22) بانحراف معياري (0.49) والنسبة الموزونة للمتوسط بلغت (64%) بفروق غير دالة إحصائياً عند مستوى دلالة (0.779) > (0.05). وبلغت قيمة اختبار ت= (−0.280). وكانت أعلى عبارة في مقياس القلق المستخدم لدى ذوي اضطراب نقص الغدة الدرقية في العينة الحالية العبارة التي تنص على" أتعب بسرعة" حيث بلغ متوسطها (3.99) بانحراف معياري (0.92) والنسبة الموزونة للمتوسط بلغت (80%). تليها العبارة التي تنص على "أشعر بالقلق على شيء ما أو شخص ما طوال الوقت تقريبًا" حيث بلغ متوسطها (3.98)، بانحراف معياري (1.09)، والنسبة الموزونة للمتوسط بلغت (80%).

وكانت أعلى عبارة في مقياس القلق المستخدم لدى ذوي اضطراب نشاط الغدة الدرقية في العينة الحالية العبارة التي تنص على " لديَّ قابلية للتأثر بالأحداث تأثرًا شديدًا"، حيث بلغ متوسطها (3.95)، بانحراف معياري (0.96)، والنسبة الموزونة للمتوسط بلغت (79%). تليها العبارة التي تنص على" كثيرًا ما أُصاب بصداع" حيث بلغ متوسطها (3.92)،

بانحراف معياري (0.99) والنسبة الموزونة للمتوسط بلغت (78%).

5.2 إجابة التساؤل الثاني

التساؤل الثاني: هل توجد فروق ذات دلالة إحصائية بين اضطرابات الغدة الدرقية وأعراض القلق، تبعاً للمرحلة العمرية، وتبعاً لنوع اضطراب الغدة الدرقية؟

يُلاحظ من الجدول (4) وباستخدام اختبار (T-Test) لإيجاد دلالة الفروق بين متوسطي المجموعتين في درجة القلق تبعاً لنقص الغدة وزيادتها لكل من توزيعات النوع والفئات العمرية؛ عدم وجود فروق ذات دلالة إحصائية بين اضطرابات الغدة الدرقية والقلق تبعاً لنوع اضطرابات الغدة الدرقية، وتبعاً للمرحلة العمرية، حيث بلغ متوسط اضطراب نقص الغدة (161.4) بانحراف معياري (23.3)، بينما بلغ متوسط اضطراب زيادة الغدة (160.8) بانحراف معياري (24.7)، وبلغت الدلالة الإحصائية لكل من النقص والزيادة (0.779). أي أنه لا يوجد فروق ذات دلالة إحصائية بين اضطرابات الغدة الدرقية لكل من النقص أو الزيادة، أو العمر، وبين متوسطي درجة القلق رغم ثبوت درجة من القلق أعلى من المتوسط لدى العينة الحالية من مضطربي الغدة الدرقية.

6 مناقشة النتائج والتوصيات

6.1 النتائج

أظهرت نتائج البحث ثبوت وجود درجات من أعراض القلق، وتصل إلى أعلى من المتوسط حيث تتراوح بين متوسط يبلغ (1.89) وانحراف معياري يبلغ (0.92) ونسبة موزونة للمتوسط تبلغ (38%) في الحد الأدنى، وبين متوسط يبلغ (3.99) وانحراف معياري يبلغ (0.92)، ونسبة موزونة للمتوسط تبلغ (80%) في الحد الأعلى لدى ذوي اضطراب نقص هرمون الغدة الدرقية من عينة البحث الحالية.

وكما ثبت وجود درجات من أعراض القلق وتصل إلى أعلى من المتوسط، تتراوح بين متوسط يبلغ (2.01) وانحراف معياري يبلغ (1.09) ونسبة موزونة للمتوسط تبلغ (40%) في الحد الأدنى، وبين متوسط يبلغ (3.95) وانحراف معياري يبلغ (0.96)، ونسبة موزونة للمتوسط تبلغ (79%) في الحد الأعلى لدى ذوي اضطراب زيادة نشاط هرمون الغدة الدرقية من عينة البحث الحالية. وهذه الدرجات في حدودها العليا أو الدنيا تعكس أهمية المُساعدة النفسية لمرضى الغدة الدرقية من خلال تقديم الاستشارات النفسية، وجلسات العلاج النفسي السلوكي المعرفي.

وتؤكد هذه النتيجة دراسة (Kikuchi *et al.*, 2004) التي تشير إلى وجود علاقة ارتباطية ودالة بين درجة حدة القلق وشدته، وبين مستويات هرمون الثيروكسين، ودراسة (Richard, 2007) التي تَوصَّلَتْ إلى أنه يوجد علاقة واضحة بين التقدم في أعراض القلق والأمراض التابعة له مثل اضطرابات الغدد الدرقية.

كما اتضح من النتائج أنه لا يوجد فروق ذات دلالة إحصائية في درجة أعراض القلق تبعاً لنوع اضطراب الغدة الدرقية لدى مرضى الغدة الدرقية، ويعزي الباحثان عدم وجود فروق إلى أن طول مدة الإصابة باضطرابات الغدة الدرقية ومدة العلاج قد تؤدي إلى تكيف المريض مع حالته الصحية والنفسية، وبالتالي من الصعب تحديد درجة القلق، وتتفق هذه النتيجة إلى حد ما مع دراسة Robert (2011) والتي توصلت إلى أن مستويات القلق ترتبط بمستويات اضطراب الغدة الدرقية، كما أن هذه النتيجة تلفت الانتباه إلى عدم وعي مرضى الغدة الدرقية بأعراض القلق المتوقع لديهم وعدم طلبهم للخدمة النفسية العلاجية حيث ذكر أغلب المرضى من العينة التي تمت مقابلتها أثناء الاستقصاء، أنهم لم يعطوا أي نوع من العلاجات النفسية، ولا يعلمون أساساً مدى تأثير اضطراب الغدة الدرقية على حالتهم النفسية، وهذا يعكس أهمية العلاج النفسي المساند لمرضى اضطرابات الغدة الدرقية سواء على مستوى الوعي بالخدمة الصحية والتثقيف الصحي المفترض، أو الأعراض النفسية المصاحبة حيث أن القلق مرتبط باضطراب الغدة بغض النظر عن زيادة نشاطها أو خمولها.

كما أظهرت نتائج البحث أنه لا توجد فروق ذات دلالة إحصائية في درجة أعراض القلق تبعاً للمرحلة العمرية لدى

مرضى الغدة الدرقية، ويمكن تفسير ذلك أن أفراد العينة قد يعانون من القلق بنفس القدر بغض النظر عن أعمارهم لكن لا يعون وجود علاقة بين القلق واضطراب الغدة الدرقية، بسبب انعدام او انخفاض مستوى التثقيف الصحي والدعم النفسي.

6.2 التوصيات

وفي ضوء هذه النتائج يوصي الباحثان بما يلي:

1. تصميم برامج وقائية، وإرشادية، وعلاجية نفسية، لمرضى الغدة الدرقية، وأهمية الفحص المُبكر لاضطرابات الغدة في حال ظهور أعراض القلق.
2. تقديم الدعم النفسي لمرضى الغدة الدرقية، من قبل أطباء الغدد، وتقوية الجهود المبذولة في مجال العلاج النفسي لهؤلاء المرضى والمراجعين تحديداً.
3. التَّعرُّف على الحاجات الصحية والنفسية لمرضى اضطرابات الغدة الدرقية عن طريق إجراء مجموعة من الدراسات والبحوث الصحية والنفسية عليهم.
4. التدخل العلاجي النفسي لخفض (القلق) لمرضى الغدة الدرقية، قبل أن تزيد آثارها النفسية والجسدية من بداية تشخيص اضطراب الغدة الدرقية.
5. أهمية الأخذ بعين الاعتبار الجانبَ النفسي في المُمارسات الطبية، من أجل خدمة جيدة للمرضى، خاصةً تلك الخدمات المُقدمة لمرضى الغدة الدرقية.
6. توفير الرعاية لمريض الغدة الدرقية وتفهم حالته النفسية من قِبل الأسرة، والمجتمع من أجل تمكينهم من مواجهة الضغوط اليومية بنجاح.

7 الخاتمة

لا شك أن اضطراب الغدة الدرقية يؤثر على الحالة النفسية والمزاجية للمريض، وبالتالي أهمية وجود خدمات صحية وبحثية للعناية بهذا المريض، وهذا البحث مجرّد محاولة للإسهام في ردم هذا القصور المنهجي والخدماتي لمرضى الغدة الدرقية، ولا يسعنا إلا شكر الله أولاً على تيسيره وكرم توفيقه ثم شكر هؤلاء المرضى عينة البحث الحالي، ومستشفى الملك عبدالعزيز التخصصي بالطائف، وجميع أطباء الغدد الذي أسهموا معنا في توفير عينة البحث. ونتطلع دائماً إلى خدمات تليق بهذا الوطن العظيم، وتتفق مع رؤيتنا الوطنية 2030م، وبرامجها التحولية 2020م.

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involvement of several components, namely antibodies, antigen presenting cells, cytotoxic T cell subsets, immune cells cytokines, etc., which all plays an important role in innate and adaptive immunity; the mechanism with which a graft can avoid rejection has not been identified. However, the fetus (which is considered to be a semi-allograft), is able to survive in the maternal body for nine months, but more importantly, is protected and nourished, without causing any deleterious effects to the mother. The manner in which the fetus is able to avoid maternal rejection is still not well understood. However, if such an event is understood, this may give the field of medicine a breakthrough where organ transplantation is concerned.

8. CONCLUSIONS

This study has attempted to highlight the importance of HLA-G production through placental trophoblasts by showing the vital role the protein plays in immune-regulation at the feto-maternal interface where the protein ensures the survival and development of the fetus through various mechanisms. HLA-G molecules possibly contribute to prevent pregnancy complications, such as pre-eclampsia and unexplained recurrent spontaneous abortions. For a successful pregnancy, the maternal immune system must not only protect the allogenic fetus from rejection but must also maintain its host's defense against possible pathogens.

CONFLICTS OF INTEREST

There are no conflicts of interest.

ABBREVIATIONS

Ab: Antibody, **Ag:** Antigen, **APCs:** Antigen presenting cells, **CTB:** Cytotrophoblast, **EVT:** Extravillous trophoblast cells, **HLA:** Human leukocyte antigens, **ILT2:** Immunoglobulin like transcript receptor, **KIR:** killer immunoglobulin receptor, **KIRs:** Killer immunoglobulin-like receptors, **LIR:** Leukocyte inhibitory receptors, **MHC:** Major histocompatibility complex, **STB:** Syncytiotrophoblast, **TcR:** T cell receptor, **Unk:** Uterine Natural Killer, **β2m:** β2 microglobulin.

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6. INTERACTIONS WITH B LYMPHOCYTES

Immunoglobulin like transcript receptors (ILTs) are assumed to be the major receptors located on the T lymphocytes and antigen presenting cells that interact with HLA-G. These are also expressed on B lymphocytes, which express the ILT 2 inhibitory receptor (Colonna, *et al*., 1997; HoWangYin, Caumartin, Favier, Daouya, Yaghi, Carosella, LeMaoult, 2011). There is no evidence so far that shows the binding of HLA-G with B cells. However, the occurrence of such binding is assumed to exist as the production of antibodies to placental HLA-G occasionally happens in pregnant women.

A study carried out by Hunt *et al*. (2005) demonstrated that mothers show tolerance in terms of producing antibody against HLA-G. HLA-G Abs are absent in about 91 % of mothers, women who had never undergone pregnancy, and in men. However, according to the study, such tolerance was not absolute. Immunoblots and ELISA identified that approximately 9% of women who had been pregnant at least once generated anti-HLA-G antibodies (Ab). The possibility of this being a 'mimic' antigen or environmental molecules stimulating the production of the Ab still exists. However, as the Ab was found only in the sera of pregnant women, it is assumed to be in some way related to the state of pregnancy. Other findings include the fact that this anti-HLA Ab did not have any deleterious effect. In this respect, it was concluded that the circulating anti-HLA Abs were similar to the other HLA Abs, which are common in pregnancy and cause no harm to the developing fetus. The existence of such tolerance still needs to be elucidated. Firstly, the potential mechanisms could have been caused by the activation of B cell ILT2 receptors by circulating soluble HLA-G 5 or HLA-G 6; secondly it could have been by the activation of ILT2 receptors on the Th lymphocytes. The role of antigen presenting cells driven into a B lymphocyte- inhibiting the immunosuppressive profile should also be given high significance, as these cells, like HLA-G isoforms, are abundant at the feto-maternal interface. The data collected and studies conducted till date (though less the studies), strongly support the idea of inhibition being specific to HLA-G (Nieuwenhoven, Heineman, & Faas, 2003; Ferreira, Meissner, Mikkelsen, Mallard, O'Donnell, Tilburgs, Gomes, Camahort, Sherwood, Gifford, Rinn, Cowan, & Strominger, 2016).

HLA-G possibly interacts with both the innate and adaptive immune responses (Hunt *et al*., 2007; Favier *et al*., 2007). Therefore, HLA-G has been shown to protect fetal cytotrophoblast cells by inhibiting maternal uterine natural killer (uNK) cells through direct interaction with inhibitory receptors on immune cells (Rouas-Freiss *et al*., 1997; Rajagopalan & Long, 1999; Shiroishi *et al*., 2003; Bainbridge, 2005; Tilburgs, Crespo, van der Zwan, Rybalov, Raj, Stranger, Gardner, Moffett, & Strominger, 2015).

7. HLA IN PREGNANCY AND MEDICINE

The discovery of MHC in 1967 has significantly advanced not only the fields of immunology and reproductive immunology, but also the fields of organ and tissue transplantation; Christiaan Barnard performs world's first heart transplant at the Groote Schuur Hospital, Cape Town, South Africa on 3rd December 1967 (Davies & Hollman, 1997). However, to date, due to the very complex immunobiology of transplantation and the

an immune privileged site and thereby supports the idea that HL-G plays an integral pregnancy - specific role in the utero-placental immune tolerance (Petroff *et al*., 2002).

5. INTERACTION WITH T LYMPHOCYTES

Falk, Rötzchke, Stevanović, Jung, & Rammensee (1991) provided evidence that showed HLA-G ability to influence T cells. The study indicated that confirmed by (Shiroishi *et al*., 2003). However, both studies piloted the HLA-G binding to the αα CD8 homodimer (Gangadharan & Cheroutre, 2004). Nevertheless, T cells usually express the CD8αβ heterodimer, which also acts as a co-receptor to the T cell receptor and plays a critical role in the transduction of signals during the activation of T cells. In fact, the interaction between HLA-G and the T cell receptor (TcR) has not yet been established. Due to its limited polymorphism, studies are still being conducted to determine whether the primary function of HLA-G is the binding to TcR. In vitro studies provide a clear demonstration of HLA-G's (soluble and membrane bound) ability to regulate the release of cytokines from human allogeneic peripheral blood mononuclear cells. Researchers have also emphasized the dependant effect on the production of an allogenic cytotoxic lymphocyte response (Kapasi, Albert, Yie, Zavazava, & Librach, 2000).

In the context of acquired immune response, antigen presenting cells (APC) transfected with HLA-G 1 prevent the proliferation of CD4+ T cells and direct them towards an immunosuppressive phenotype. This observation still needs to be reconfirmed to determine whether or not these CD4+ cells are related to the CD4+CD 25^{bright} T cell regulatory phenotype (essential in mice pregnancy). Furthermore, the idea of this phenotype being a consequence of exposure to murine Qa -2, which shares structural similarities with HLA-G, is a topic for further research. Membrane bound and soluble HLA-G is also known to play a critical role in regulating CD8+ T cells during pregnancy by eliminating all reactive T cells. Studies have shown that HLA-G induces CD 8+ T cell apoptosis. The exposure of CD 8+ T cells to soluble HLA-G initiates surface expression and secretion of the Fas ligand, which results in the death of the T cells by the Fas/FasL pathway. These experiments were based on the uncanny ability of HLA-G antigens to induce Fas/FasL related deaths, that were identified in patients undergoing transplantation. The presence of soluble HLA-G has been reported by several groups, and it is assumed to be responsible for the induction of CD 8+apoptosis (Dimberg, Nilsson, & Öberg, 2000).

Another way by which HLA-G might aid in inducing maternal tolerance to the fetal antigens is via limiting or preventing the cytotoxic activity of CD 8+ T cells opposed to the target cells. The specific receptor which has the capability of binding to HLA-G still remains undefined, but is assumed to be either CD 8 molecule (Shiroishi *et al*., 2003) or the immunoglobulin like transcript receptor (ILT2) which helps in the transduction of an inhibitory signal. As, the effects of HLA-G are enormously dependent on the concentration and that cells manufacturing it are located in the placenta, the results obtained suggest that various isoforms of HLA-G can contribute to reduce the functional efficiency of cells in the pregnant uterus (Kimatrai, Blanco, Muñoz-Fernández, Tirado, Martin, Abadía-Molina, & Olivares, 2005).

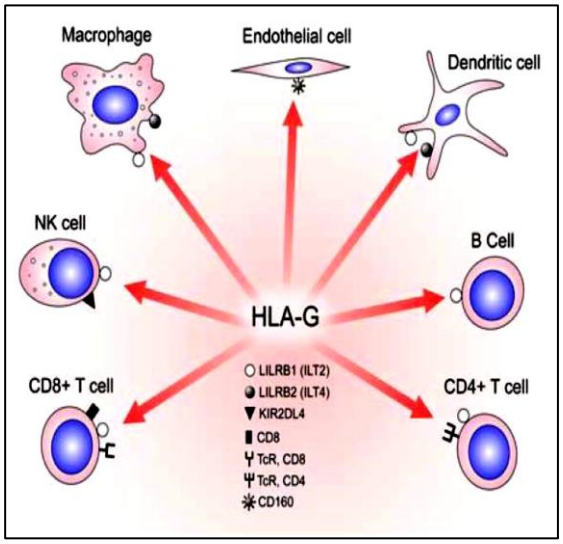

Figure 3: Potential receptors on immune cells targeted by HLA-G. The seven subsets of leukocytes believed to be targeted by HLA-G and potential receptors for HLA-G on each cell type are shown (Mark *et al.,* 2009).

The receptors for HLA-G are as much of critical importance as are its various structures. These not only provide an insight into the HLA-G antigen but also enable us to understand the process of reproduction by determining the HLA-G receptor expression on the immune system and other types of cells. HLA-G interacts with CD8 on T lymphocytes (Norwitz *et al*., 2001). The main sequence of HLA-G also binds to a lymphocyte inhibitory receptor, CD94/NKG2A, and on natural killer cells (King, Burrows, Hiby, Bowen, Joseph, Verma, Lim, Gardner, Le Bouteiller, Ziegler, Uchańska-Ziegler, & Loke, 2000). KIR2DL4 is another receptor that recognizes the soluble form of HLA-G, which has been identified on endosomes. This is an activating receptor which stimulates NK cell production of inflammatory cytokines. HLA-G also interacts with at least two other leukocyte inhibitory receptors (LIR) that were originally referred to as ***i****mmunoglobulin like transcripts* (Hunt & Orr, 1992). One of the LIRs is known as LIRB1 and is expressed highly on T and B lymphocytes and less on cells of mononuclear phagocytic lineage. The other form LIRB2 is identified mainly on monocytes, macrophages and similar cells. The activation of these specific receptors overrides the activation signals in the immune cells by causing interference in the signal transduction pathways (Kortylewski, Kujawski, Herrmann, Yang, Wang, Liu, Salcedo, & Yu, 2009).

Several experiments have been conducted to study the interactions between LIR and HLA-G; most of them have employed artificial constructs. Hence, it is of utmost importance to study the same interactions with natural structures of HLA-G proteins produced in the various subpopulations of the trophoblast cells. The results from previously conducted studies showed that LIR1 and LIR2 bind preferentially with the dimeric forms in comparison to the monomeric ones (Shiroishi *et al*., 2006). Research is still being conducted in this specific area to determine the quaternary structure of HLA-G5 and HLAG-6 and investigate the interactions of specific isoforms with LIR.

The expression patterns of LIRBs are still need to be mapped thoroughly in the decidua and placenta. Macrophages that have been selectively harvested from the early and late gestation decidua express both LIRB receptors (Petroff, Sedlmayr, Azzola, & Hunt, 2002). There is definitely a need to procure more information on these receptors among immune and other cells in health and disease so as to predict the target selection by HLA-G. In general, it is known for immune suppression. It possesses a unique ability to diminish the immunological functions of various hematopoietic cells; this in turn correlates well with the theory that following implantation, the human placenta redefines the uterus as

complish this goal, a detailed understanding of its functions and nature is required.

Multimeric structures of homodimers and homotrimers with disulphide bonds between cysteine residues have been observed with HLA-G molecules that may relate to its function particularly on the trophoblast (Carosella *et al*., 2008). Homology is shared between HLA-G and other MHC molecules, including the classical subtypes and HLA-E. HLA-G, that have a relatively limited expression around the body (Hviid, 2006). The tolerogenic functions of HLA-G at the feto-maternal interface are many. These include acting as an inhibitory ligand for various receptors present on white blood cells, such as ILT-2, ILT-4 and KIR2DL4 receptors on the uterine natural killer (uNK) cells, and suppressing their potentially harmful effect, such as cytolysis (Clements *et al*., 2005; Shiroishi, Tsumoto, Amano, Shirakihara, Colonna, Braud, Allan, Makadzange, Rowland-jones, & Willcox, 2006). HLA-G may even have an upregulating effect on these receptors (LeMaoult *et al*., 2005), on NK cells, antigen presenting cells (APCs) and $CD4^+$ T helper cells, suggesting that the maternal immune system might be suppressed by HLA-G. Fournel *et al.* (Fournel, Aguerre-Girr, Huc, Lenfant, Alam, Toubert, Bensussan, & Le Bouteiller, 2000) observed that sHLA-G can induce apoptosis in activated maternal $CD8^+$ cytotoxic T cells but not resting $CD8^+$ T cells.

4.4 Functional Significance of HLA-G

The structural difference is of considerable importance as data showed that ILT 2 and ILT 4 binding sites of HLA-G dimers are more accessible than monomers (Shiroishi *et al*., 2006). It has been proved with the help of biochemical data that ILT 2 usually binds to cell surface dimers in vitro and in vivo and these dimers signalled better with ILT 2 than monomers (Apps *et al*., 2008).

These observations have opened several avenues in the field of immunological research as, before these studies were conducted, the possibility of functional heterogeneity of the HLAG1/HLAG5 pool had not been considered (Bingaman, Patke, Mane, Ndejembi, Bartlett, & Farber, 2005). Even though these studies have been formulated, the complete structural diversity of HLA-G molecule is still unknown. As all isoforms of HLA-G contain Cys 42 residue (which is responsible for the dimer formation), all translated isoforms possess the ability of forming membrane bound homodimers, soluble homodimers, β2-microglobulin free homodimers, and even homotrimers. The formation of functional heterodimers between monomeric isoforms of HLA-G is also possible. Thus, the main goal of the analytical strategies nowadays is to detect most of the HLA-G pool and not differentiate between its monomer and dimer forms. However, due to the functional significance of HLA-G multimers, it is assumed that its specific titration might be of higher importance than its monomeric form. Hence, it is essential that the relationship between HLA-G structure and functional relevance be formulated in vivo. In order to achieve this goal, new analytical tools are required that specifically detect and study the most active HLA-G structure. This would entail a reanalysis of the previously obtained data and confirmation of the pathological significance of HLA-G. Figure (3) illustrates that the HLA-G probably targets all the major immune cell subsets. Figure (3) also displays the range of cells at the feto-maternal interface whose functions are affected by the protein (Mark, Ghyselinck, & Chambon, 2009).

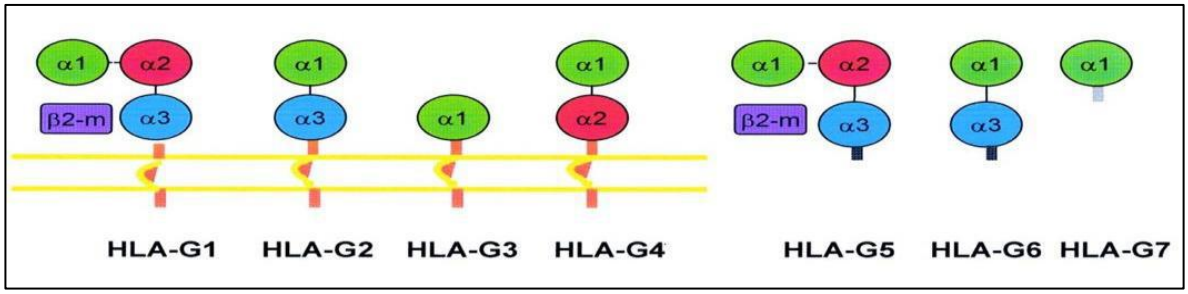

Figure 2: HLA-G structural isoforms. It is known to exist in seven structural isoforms due to the alternative splicing of its primary transcript. These seven isoforms include four membrane bound and three soluble forms. (Clements, Kjer-Nielsen, Kostenko, Hoare, Dunstone, Moses, Freed, Brooks, Rossjohn, & McCluskey, 2005).

α3. This heavy chain is non-covalently associated with β2-microglobulin (β2-m). The peptide binding groove is formed by α1 and α2 helices and the peptide is bound to the floor formed by an antiparallel β sheet derived from the α1 and α2 domains (Bjorkman & Parham, 1990; Clements *et al*., 2005; Rodgers & Cook, 2005). HLA-G has a highly restricted expression and low polymorphism (Kirszenbaum, Djoulah, Hors, De Oliveira, Prost, Dausset, & Carosella, 1997; LeMaoult, Zafaranloo, Le Danff, & Carosella, 2005). A very strong expression of HLA-G has been reported in the invasive trophoblast cells of the placenta (Le Bouteiller & Blaschitz, 1999).

4.2 Expression of HLA-G

An expression of HLA-G has also been found in healthy tissues such as cornea (Le Discorde, Moreau, Sabatier, Legeais, & Carosella, 2003), adult thymus (Mallet, Blaschitz, Crisa, Schmitt, Fournel, King, Loke, Dohr, & Le Bouteiller, 1999), pancreas (Cirulli, Zalatan, Mcmaster, Prinsen, Salomon, RicordiI, Torbett, Meda, & Crisa, 2006) erythroid and endothelial precursors (Menier, Rabreau, Challier, LeDiscorde, Carosella, & Rouas-Freiss, 2004). Moreover, various pathological conditions, such as malignancy, organ transplant, various infections and autoimmune diseases upregulate the expression of HLA-G (Carosella, Moreau, LeMaoult, & Rouas-Freiss, 2008).

HLA-G possibly interacts with both the innate and adaptive immune responses (Hunt, Morales, Pace, Fazleabas, & Langat, 2007; Favier, LeMaoult, Rouas-freiss, Moreau, Menier, & Carosella, 2007). Therefore, the role of HLA-G has been found in the protection of fetal cytotrophoblast cells by inhibiting the maternal uterine natural killer (uNK) cells via interaction with inhibitory receptors present on immune cells (Carosella, Dausset, & Kirszenbaum, 1996; Rouas-Freiss, Goncalves, Mener Dausset, & Carosella, 1997; & Rajagopalan & Long, 1999; Bainbridge *et al*., 2001; Shiroishi, Tsumoto, Amano, Shirakihara, Colonna, Braud, Allan, Makadzange, Rowland-jones, & Willcox, 2003).

4.3 HLA-G in Human Pregnancy

In addition, the importance of HLA-G production by placental trophoblasts is also evident. HLA-G plays a pivotal role in feto-maternal interface by immune-regulation. Its molecules possibly contribute to the prevention of pregnancy complications, such as pre-eclampsia and unexplained recurrent spontaneous abortions (Hviid, 2006). Multiple research studies are required to understand the importance of HLA-G in transplantation, autoimmunity and cancer, so that it therapeutic potential may be understood. To ac-

In 1987, HLA-E was discovered as HLA-6.2 and it was mapped in between HLA-A and HLA-C loci on chromosome 6p21.3 (Koller, Geraghty, Shimizu, DeMars, & Orr, 1988). The general structure of HLA-E is identical to the MHC Class Ia molecules but the gene has a limited polymorphism and a lower level of expression. Moreover, this gene encodes a class I heavy chain of 41kDa that can associate with β2m (Tripathi, Naik, & Agrawal, 2006). HLA-E is expressed on the majority of cells that are seen to express other HLA Class I molecules, including trophoblast cells (Ishitani, Sageshima, Lee, Dorofeeva, Hatake, Marquardt, & Geraghty, 2003). The HLA-E expression is reported in a vast range of tissues and their associated cells, such as T cells, B cells and activated T cells subsets (Tripathi *et al*., 2006). The HLA-E needs a highly conserved monomer peptide derived from the leader sequence of other Class I molecules including HLA-A, -B, -C and -G (Lee, Goodlett, Ishitani, Marquardt, & Geraghty, 1998). For that reason, the HLA-E molecule requires a low level of cell surface expression (Wainwright, Biro, & Holmest, 2000). It is less polymorphic, and has only five alleles suggesting that it does not play a key role in antigen presentation (Tripathi *et al*., 2006). At the feto- maternal interface, expression of these five alleles is implicated in successful pregnancies because of its ability to down-regulate the maternal immune response.

HLA-F has very low allelic polymorphism, and was initially found to be retained intra-cellularly in a number of cell lines (Wainwright *et al*., 2000; Lepin, Bastin, Allan, Roncador, Braud, Mason, Merwe, Mcmichael, Bell, & Powis, 2000) and is seen to be expressed primarily on trophoblasts (Ishitani *et al*., 2003). Moreover, surface expression has also been demonstrated in vivo on extra villous trophoblast of the placenta (Ishitani *et al*., 2003). Various researches have revealed that HLA-F tetramers directly interact with ILT2 (LIR1) and ILT4 (LIR2) receptors (Lepin *et al*., 2000), therefore indicating their possible role in regulating the activity of immune effector cells.

4. STRUCTURAL FEATURES OF HUMAN LEUKOCYTE ANTIGE – G

HLA-G was the first HLA-Ib to be identified and still holds great interest (Hunt, 2006). Due to its features HLA-G can be considered as a very unique molecule. The gene that encoded HLA-G (*HLA-G)* is comprised of 8 exons, which are arranged in a similar sequence as that of the other Class I genes. These 8 exons can suffer from alternative splicing that can produce seven transcripts, i.e. in Exon 6, a premature stop codon during the translation can cause a HLA-G with a truncated cytoplasmic tail which can explain why this isoform has a slower turnover rate, and a prolonged cell surface expression (Hunt *et al*., 2005).

4.1 HLA-G Isoforms

The genomic structure of HLA-G is identical to other MHC Class I genes, Alternative splicing of HLA-G gene is known to generate seven messenger RNAs (mRNAs) that encode four membrane bound (HLA-G1, -G2, -G3, and –G4) and three soluble (HLA-G5, -G6, -G7) protein isoforms (Figure 2) (Ishitani & Geraghty, 1992; Paul, AdrianCabester, Ibrahim, Lefebvre, Khalildaher, IVazeux, MoyaQuiles, Bermond, Dausset, & Carosella, 2000; Vercammen, Verloes, DeVelde, & Haentjens, 2008; Ferreira, Meissner, Tilburgs, Strominger, 2017).

The HLA-G molecule consists of a heavy chain that is composed of three domains: α1, α2 and

human trophoblast tissue (King, Boocock, Sharkey, Gardner, Beretta, Siccardi, & Loke, 1996).

HLA-C, though highly polymorphic compared to MHC class Ib, is expressed in low levels on the surface of first trimester human extravilloustrophoblast cells (King *et al*., 1996).

Surface levels of HLA-C on normal human first-trimester extravillous trophoblast (EVT) are comparatively 10 times lower compared to HLA-A and HLA-B. In trophoblasts, HLA-C is present both as β2 microglobulin (β2m) associated forms as well in the form of free heavy chains (Hiby, Regan, Farrell, Carrington, & Moffett, 2008). HLA-C may play an important role during pregnancy in optimal NK recognition and allograft protection along with other Class Ib molecules. Thus, the presence of HLA-C on the trophoblast prevents an attack and killing of the trophoblast cells by NK cells through the "missing self" hypothesis (King *et al*., 1996).

In contrast to the NK cell inhibitory role, the HLA-C has also been reported to be associated with pre-eclampsia and recurrent miscarriages. An immuogenetic study indicated that the HLA-C2 group is associated with the maternal killer immunoglobulin receptor (KIR) (AA genotype), which is an increased risk of preeclampsia. Furthermore, the interaction between the HLA Class I molecules located on the trophoblast and maternal KIR NK cells seems to play a physiological role in placental development (Moffett & Loke, 2004; Hiby *et al*., 2008; Apps, Murphy, Fernando, Gardner, Ahad, & Moffett, 2008). However, the Class Ib (or non-classical) molecules that encode for HLA-E, -F, and -G genes are less polymorphic, oligomorphic and have a restricted cell distribution (Shawar, Vyas, Rodgers, & Rich, 1994; Colonna *et al*., 1997).

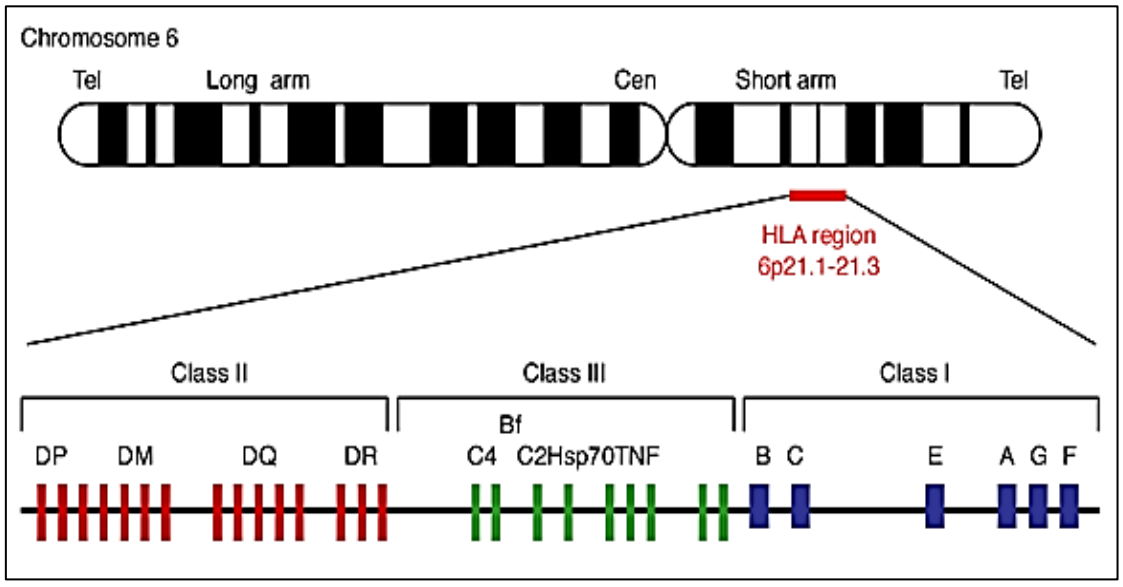

Figure 1: Gene map of the human leukocyte antigen (HLA) region.
The HLA class I encodes the classic (class Ia) and the non-classic (class Ib), highlighted in light blue shading. The classic encoded by the HLA-A, -B, and HLA-C genes and are expressed on somatic cells. The non-classic is less polymorphic and encoded by HLA-E, -F, and HLA-G. The class III genes are located between class I and II and encode for complement system (C2, C4A, C4B, and B1), highlighted in green shading. The HLA class II encodes the HLA-D family of molecules, HLA-DR, HLA-DQ, HLA-DM, and HLA-DP, highlighted with dark red shading. The HLA class II expressed only on antigen-presenting cells (APCs) adapted from (Yie *et al*, 2006).

blast cells play an important role in acting as an interface mediating maternal-to-fetal nutrient transfer (Loke & King, 1995; Baergen, 2011).

The key component for successful human reproduction depends on the formation of the human placenta (placentation) (Wildman, Chen, Erez, Grossman, Goodman, & Romero 2006). The human placenta might play several roles and functions throughout pregnancy, including the transport of fetal nutrients such as glucose which is considered the primary energy source for the developing fetus, as well as the metabolic products, such as oxygen and carbon dioxide (Jansson & Powell, 2007; Zhang, Chen, Lu, Zhou, Zhang, Lin, Duan, Zhu, Tan, & Wang, 2013). Importantly, the human placenta and fetal membranes are where direct contact between the maternal and fetal tissues occurs, thus forming the human feto-maternal interface. This interface is composed of three basic structures or layers: (1) the decidua, the maternal tissue layer of the human placenta and fetal membranes which is derived from the endometrium; (2) the amnion, a translucent membranous tissue adjacent to the amniotic fluid and (3) the chorion, a more opaque membrane attached to the decidua which is composed of two layers: an outer reticular adjacent to the amnion and more importantly, an inner epithelial layer composed of trophoblast cells (Benirschke Burton, & Baergen, 1995; Bryant-Greenwood, 1998).

Placental trophoblast cells are specialized cells of the fetal-placental unit that are in direct communication with the maternal tissues at the maternal-fetal interface (Yie, Xiao, & LibrachI, 2006). Consequently, they play an imperative role in immune tolerance being the sole group of specialized extra-embryonic cells that play a role in the selective transport of the maternal antibodies across the placenta. Moreover, trophoblast cells have the ability to secrete pregnancy factors and hormones that provide local immune suppression (Fernández *et al*., 1999). The absence of MHC class I as well as the expression of these non-classical antigens has long been hypothesized to be a major factor in immune tolerance.

3. HUMAN TROPHOBLAST AND THE MAJOR HISTOCOMPATIBITY COMPLEX

The human major histocompatibility complex (MHC) is a set of molecules encoded by approximately 130 functional genes, which span the length of 4 Mbp on the short arm of chromosome 6. The MHC can be divided into three classes, each of which is different in terms of their structural and functional properties as shown in (Figure 1). Both MHC Classes I and II encode the human leukocyte antigen (Klein, 1986; Fernández *et al*., 1999; Hviid, 2006). MHC Class I can be subdivided into two groups: classical (or Ia) and non-classical (or Ib). Class Ia includes HLA-A, -B, and –C, which are found on the body's nucleated cells (Townsend & Bodmer, 1989). On the other hand, Class Ib includes HLA-G, HLA-E and HLA-F genes, which have a lower polymorphism and allele number (Colonna, Navarro, Bellón, Llano, García, Samaridis, Angman, Cella, & López-Botet, 1997).

The Class Ia molecules are involved in presenting peptide antigens to the T lymphocytes (Zinkernage & Doherty, 1974). It is widely believed that the trophoblast cells lack typical MHC Class Ia (HLA-A and HLA-B) products expect HLA-C (Redman, Mcmichael, Stirrat, Sunderland, & Ting, 1984; Hutter, Hammer, Blaschitz, Hartmann, Ebbesen, Dohr, Ziegler, & Uchańska-ziegler, 1996; Fernández *et al*., 1999). Moreover, HLA-C is expressed in low levels on both the surface and intracellular space of the

fore bringing it to life' (Dey, Lim, Das, Reese, Paria, Daikoku, & Wang, 2004).

The aim of this review; HLA class I has been reported to be expressed at the feto-maternal interface by the trophoblast cell. The expression of these HLAs is pivotal of the fetus is to avoid maternal rejection. However, these proteins are not the only factors used by the semi-allograft to avoid rejection, as the fetomaternal interface is a site of complex interactions, where several factors work together not only to protect the fetus, but also to ensure the well-being of the mother. In the present review, attention is first focused on the current knowledge of the effects of feto-maternal tolerance on the immune response, both peripherally and in decidua, and this is followed by a discussion of the role of the HLA class I (HLA-G) product that may protect the fetus from maternal immune attack.

2. FETO-MATERNAL TOLERANCE

Numerous studies have been carried out to understand the immunological status of the fetus and the mechanisms by which it successfully evades the maternal immune system and survives in 'this' foreign environment (Billingham, Brent, & Medawar, 2010). Medawar (1953) proposed three major strategies to explain 'why the foreignness of a fetus is most likely to be betrayed to its mother' (Bainbridge, 2005).

The various theories which have been formulated are: (1) the lack of MHC antigen expression on the trophoblast cells; (2) the anatomical separation between the mother and fetus within the placenta, and (3) the maintenance of an immunologically favourable system, such as the immunosuppression of maternal lymphocytes (Medawar, 1953; Raghupathy, 2001; Hunt, Petroff, MacIntire, & Ober, 2005). In addition to these theories, another hypothesis was presented by Billingham *et al.* (2010), which introduced the concept of the uterus as an 'immune privileged site' during pregnancy. There is now evidence that all three of the above- mentioned processes were invalidated, and hence over time slowly abandoned. The fourth one is being redefined to understand the existence of the 'immune barrier' elaborated by the placenta. The placenta is not a static immunological barrier; it does allow transport of maternal and fetal cells during gestation (Bonney & Matzinger, 1997). As, the placenta is the main point of interaction between the fetus and the maternal system, it is presumed to be involved in making certain immunological adaptations essential for the process of implantation and fetal survival.

2.1 Embryo Implantation

The process of fetal implantation is complex and strictly regulated by both maternal and embryonic signals (Norwitz, Schust & Fisher, 2001; Georgiades, Ferguson-Smith, & Burton, 2002). Following a successful implantation, two layers of trophoblasts are distinguished from the outer cell mass: inner cytotrophoblast (CTB, mononuclear cells) and outer syncytiotrophoblast (STB, multinucleated cells) that form a syncytium, both of which remain throughout the process of gestation. The syncytotrophoblast continues to grow till it completely surrounds the implanted embryo and gets into direct contact with the blood of the mother (Huppertz & Borges, 2008). Around day 14 after implantation, CTB cells break through the STB layer from which extravillous trophoblast (EVT) cells arise to account for almost all the invasive characteristics belonging to the human placenta. These tropho-

1. INTRODUCTION

The immune system is much like the other body systems. It is composed of a number of different cell types, tissues and organs. Many of these cells are organized into separate lymphoid organs or glands that maintain communication through cell contact and molecules they secrete. The cells and molecules responsible for immunity constitute the immune system and their collective and coordinated response to the introduction of foreign substances is called the *immune response*.

The immune system is composed of two major subdivisions: innate and the adaptive one. The characteristics of the immunological system in human pregnancy that suggests that the pregnant mother does not reject a semi-allogeneic fetus was first highlighted in Medawar (1953). Since then, the immunology of human pregnancy has gained a significant relevance in reproductive immunology and many researchers have worked on this topic. The idea regarding a recognized human pregnancy is taken to be very much associated with the maternal immune system whereby mother and fetus interact with each other. So, during human pregnancy, the maternal immune system is active as it does not only protect the allogenic fetus from rejection but also against possible pathogens that can cause fetal infections. Mother and fetus then must tolerate each other genetically and immunologically as well as be able to cope with infection (Fernández, Cooper, Sprinks, Abdelrahman, Fiszer, Kurpisz & Dealtry, 1999).

The human immune system is a complex entity which can generally distinguish "self" from "non-self," or what is foreign. Human embryonic tissues express antigens encoded by polymorphic major histocompatibility complex (MHC) genes inherited from the father. These are considered 'non-self' paternal antigens for the maternal immune system (Bainbridge, Ellis, Le Bouteiller, & Sargent, 2001). The expression of 'non-self' paternal antigens on the fetus may protect against rejection by the maternal immune attack (Koch & Platt, 2003). The human immune system is the body's defence against foreign invaders such as pathogens and cancerous cells. The immune response has two main arms: innate (non-specific) immunity and adaptive (specific). Essentially, the first line of defence is the innate immune response which is rapid but non- specific to the reaction. Its effector cells and molecules are mainly monocytes, macrophages and cytokines which are the basic elements of the immune system. On the other hand, the adaptive immune system functions mainly through T lymphocyte (cellular immunity) and B lymphocyte (humoral immunity), which are regulated by MHC and produced via antigen specific reaction. The human immune response is the evolutionary process required to sustain life, as it involves the fundamental proprimarily produced by leukocytes and their antigens/Human Leukocyte Antigens (HLA) (Janeway, 2001). Studies by (Tafuri, Alferink, Möller, Hämmerling, & Arnold, 1995; Aït-azzouzene, Gendron, Houdayer Nemazee, & Kanellopoulos-langvin, 1998) have suggested that the main immune response triggered by the semi-allogeneic fetus is the adaptive response, where there is antigen representation. So, during pregnancy the cells of the semi-allogeneic fetus are in direct connection with those from the maternal immune system. Due to this reason, there are distinctive mechanisms that must be available to moderate and modulate the maternal immune response and protect the developing embryo from rejection (Hviid, 2006). Mammalian reproduction is an immensely important part of these of 'nurturing the offspring within the body be-

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بحث مرجعي

دراسة مرجعية : دور مستضدات الكريات البيضاء البشرية (HLA-G) في التجاوز المناعي بين الأم والجنين

وليد إبراهيم العبدالمنعم [1*]

(قدم للنشر في 1439/07/26هـ؛ وقبل للنشر في 1440/01/26هـ)

مُلخَّص الدِّراسة: التفاعلات المناعية التي يشترك فيها المركب النسيجي التوافقي الأكبر الأنتجيني (MHC) والتي تأخذ مكانها عند الحد الفاصل بين الأم والجنين والمرتبطة بنجاح التكاثر في الانسان. وحيث تكون الأنتجينات للمركب النسيجي التوافقي الأكبر عند المستوى الأول (MHC class Ib)، والذي يتواجد على سطح الخلايا الجذعيه الجنينيه (التروفوبلاست) مهمة في هذا الشأن. ولنجاح هذا الدور الهام لمستضدات الكريات البيضاء البشرية (HLA-G) والتى تعمل مع المكونات الأخرى للمركب النسيجي التوافقي من الصنف الأول، وذلك لتحفز من تثبيط سمية الخلايا القاتلة (NK cells) التي توجد على سطح خلايا المشيمة. ووفقا لقوانين علم المناعه الانجابي يكون الرفض للجنين النامي بدلا من الحماية، ومع تلك الآلية المناعيه المعقده التي توضح قبول جسم الأم للجنين النامي، والذى لايتشابه من الناحية الجينية كلياً (Semi-Allogenic) مع مشيمتها، غير مفهومة تماما حتي الان. وفي هذا الصدد يبرزاهميه االمركب النسيجى التوافقى الأكبر لأنتجينى(MHC) والمتواجد على سطح خلايا التروفوبلاست والتي تتغافل عن اعتبار الجنين جسما غريبا بل شبه متماثل أثناء التطور داخل رحم الأم، وبالتالي لا يتم لفظه خارج الرحم، وفي نفس الوقت يساعد في تطوير الجهاز المناعي للأم والجنين. هذا البحث العلمي يركز على أهمية ودور مستضدات الكريات البيضاء البشرية (HLA-G) فى عملية التجاوز المناعى بين الأم والجنين.

الكلمات المفتاحية: المركب النسيجى التوافقى الأكبر الأنتجينى، الحمل في الانسان، مستضدات الكريات البيضاء البشرية (HLA-G)، الخلايا الجذعية الجنينية التروفوبلاست، المناعة الانجابية.

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Review Article

A Review on the Role of HLA-G in Fetal-Maternal Immuno-Tolerance

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Abstract: Immunological interactions that involve Major Histocompatibility Complex (MHC) antigens at the fetal-maternal interface are associated with reproductive success. MHC Class Ib antigens present on the trophoblast cell-surface structurally resemble HLA-G suggesting that Human Leukocyte Antigen G (HLA-G) might be working in association with other MHC Class I partners to promote the inhibition of the cytotoxicity of Natural Killer (NK) cells at the fetal-maternal interface. As per the laws of Immunology, the developing fetus should be rejected rather than protected. The development of the fetus in the uterine environment is a classic example of a semi-allogenic graft. However, the complex immunological mechanisms that involve the acceptance of the fetus and the placenta that are actually semi-allogenic to the mother- are not completely understood. In this study, the graft is assumed to be granted with immune privilege by the controlled trophoblast MHC expression in the fetal-maternal interface. The study also reviews the importance of HLA-G production at the fetal-maternal interface and discuss its relevance to human embryonic development.

Keywords: MHC antigens, Human pregnancy, Human Leukocyte Antigens (HLA-G), Human trophoblast, Reproductive immunology.

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tural barriers were identified and discussed. A survey monkey tool was employed in this study to distribute the questionnaire to respondents across Saudi Arabia and invite respondents of different ages, educational levels, and genders to take part. The analysis was structured to include the public perceptions on the heritage villages in Al Baha, conditions of historical facilities, and the influence of heritage villages on tourism. The results highlighted the impact of heritage villages and historical facilities on tourism and economic income, and showed how these factors can help to develop both heritage villages and the economy. These factors relate to the readiness of historical facilities to receive tourists, restoration of historical facilities, and general tourism and city facilities. The influence of the community and barriers to the development of heritage villages have also been highlighted.

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- **Tourism facilities:** heritage villages will play a significant role in development of the local economy through attracting visitors and improving the tourism industry. Therefore, tourists still need to be attracted by the other tourism facilities with offering high quality of services. As highlighted in the analysis, hotels, shops and the other essential services need to be improved to meet the satisfactions of tourists where all these facilities will create a tourism system and attract visitors to the region.

6. FUTURE WORKS & RECOMMENDATIONS

Developing heritage sites is a large-scale project, which needs to be guided through different stages of study. Hence, the future work of the present author will involve identifying particular heritage villages in different locations in Saudi Arabia in order to investigate the specific factors that need to be developed in practice, from the point of view of experts. Site visits will include a physical survey of the building in the selected heritage sites, in order to assess the current situation and conditions, the practical uses of these sites, and to identify how the selected cases can be developed. In the next stage, several experts will be invited to contribute to establishing a framework for developing heritage villages and historical facilities in Saudi Arabia. The study concludes with the following recommendations:

Recommendations for professionals

- The studies carried out in developed countries with many historical facilities have shown that it is important to allocate budget to develop heritage in Al Baha and improve tourism facilities in Saudi Arabia.
- Specialist contractors who can work with historical facilities in Saudi Arabia should be trained, and these projects allocated to specific contractors who have experience in maintaining and restoring heritage sites and building.
- Invite expert contractors, planners, and architects from EU countries who specialise in historical facilities and heritage villages to transfer their experiences to Saudi Arabia.
- Allocate and develop a built environment curriculum in schools in Saudi Arabia to include how to maintain historical facilities and heritage villages.

Recommendations for investors

- Develop a framework for development heritage villages in Saudi Arabia by investors; these investors can be local or international.
- Allocate lands in the heritage boundaries for investment from international developers to promote the heritage in their countries.
- Rehabilitate some larger historical buildings by giving them to local investors and using them to sell traditional products.

7. CONCLUSION

Due to the impact of development of sustainable heritage villages on the environment and the economy, this study has analysed and identified factors associated with the development of heritage villages in Al Baha. A public survey investigation was carried out to highlight public points of view and their experiences of tourism, heritage villages, and historical facilities in Al Baha in order to identify any weaknesses and issues that need to be considered. Through the public survey and analysis of the 534 responses, a number of weaknesses of heritage villages and cul-

Al Baha region will need its own development plan from local government to enhance, manage and support the utilisation of immovable heritage villages across the region, as confirmed by Kalamarova *et al*. (Kalamarova, Loucanova, Parobek, & Supin, 2015), who studied different perceptions pf cultural heritage for conserving historical buildings, taking into account the local culture. They highlighted that cultural capital possess economic and cultural value (Kalamarova *et al*., 2015), and aimed to identify and evaluate cultural heritage as having development potential for a region, which is a key factor for local government to consider in its attempt to regulate, manage and support the utilisation of immovable cultural heritage in order to develop and enhance the region (Kalamarova *et al*., 2015).

Some social and cultural challenges can hinder the development of heritage villages in Al Baha. Some of these are related to historical properties and the tribal social structure. Heritage buildings reflect their historical records and architectural and urban identity. Social structure can be a useful element and/or barrier to the development of heritage and historical facilities. Many studies have been conducted on the role that social structure and culture play in heritage development, which directly influences other income sources, particularly tourism (Carrà, 2016). Vasile *et al*. (2015) investigated the role of the public in managing heritage, and stressed that the public must identify appropriate historical facilities, link heritage with key stakeholders and other topics, develop heritage sites into a proper service, and sell this new service to users (Vasile *et al*., 2015). The results of this study highlight many factors that are strongly needed to engage local cultural and social activities in rehabilitating heritage villages. This in turn will also advertise the local traditions and historical products.

Social activities will reflect the traditional culture of a region. Hence, these social activities will play a major role in rehabilitating heritage villages in Al Baha. Most heritage sites and historical facilities across the world have an element portraying the social activities of the past, for example agriculture, transportation, manufacturing, sewing, and other activities. In the Middle East, the Pharaonic Village in Cairo is one example of a famous historical facility featuring social activities. The site attracts visitors and tourists from across the world, generating significant income. Some challenges can be faced when developing heritage villages in Al Baha such as;

- **Property issues:** to develop heritage villages in Al Baha, a property issues are one of challenges can be faced. Some heritage sites are inherited for local citizen who still live within or around the village. Heritage villages need to be conserved in their locations without any new building within the heritage to protect its historical features and identity. It is essential to take into account the property issues of these facilities to involve the owners in the development and investments process.
- **Archeology and construction:** restoration heritage villages need to be performed by specilised companies that deal with archeology. These villages need to be restored and conserved using its original construction materials to preserve vernacular built heritage. Hence, restoration heritage villages need local specialised companies and citizens to deal with (a) Archeology; (b) social structure and (c) vernacular architecture.

one place to another, depending on the local conditions.

5.4 Socio-Cultural Barriers to Heritage Development

Cultural heritage reflects the human skills resulting from local community activity and practices, which are also instruments for transferring and communicating the local culture (Bakar, Osman, Bachok, & Ibrahim, 2014). Due to importance of developing heritage villages in Saudi Arabia in order to protect conservation buildings, tourism, and the economy, cultural contributions and barriers should also be taken into account as influencing factors (Yung, Zhang, & Chan, 2017). The social structure in Saudi Arabia plays an important role in development, where most traditions and social legacies have tribal roots. Public contributions must be sought to develop heritage sites, due to their experience regarding social legacies and local traditions. Many different researchers have confirmed the significance of social contributions to heritage development. Stakeholders influence heritage development and value. Each historical building has cultural heritage significance, and the value of these historical buildings by different various of stakeholders (Bakri, Ibrahim, Ahmad, & Zaman, 2015). As confirmed by Bakri *et al.* (2015), the value of heritage depends on the public and the community, not only on professionals and experts (Bakri *et al.*, 2015). Furthermore, Akri *et al.* (2015) confirmed that the points of view of both the public and experts regarding cultural heritage are similar and play a significant role in contributing to sustainable development for heritage conservation (Bakri *et al.*, 2015). To involve the public in heritage development in Al Baha, it is important to take into account the social tribe structure and community where some heritage development can face property-related barriers. Deeds are the most important evidence of property ownership. When developing specific heritage, old deeds or ownerships can be observed that resulting on social barriers. Policies and regulations for construction require valid deeds, and in some suburbs historical facilities will need to provide valid deeds and/or have permission from owners.

The impact of heritage conservation in historical areas has recently been recognised as enhancing the sense of community and identity, as well as urban development (Yung *et al.*, 2017). A study was carried out by Yung *et al.* (2017) to identify the impact of community and social traditions on development and conservation of heritage in urban renewals (Yung *et al.*, 2017). The authors investigated whether there was variation in social factors in different locations and districts, on the basis of density of population as well as the socio-demographic information (Yung *et al.*, 2017). They observed that socio-demographics, the type and characteristics of traditional buildings, local urban identity and vernacular architecture, and the level of urban regeneration do not have a significant effect on the composition of social factors (Yung *et al.*, 2017). Bakar *et al.* (2014) analysed the relationship between the level of community involvement in Intangible Cultural Heritage and 10 socio-economic factors in Malaysia, using the Malacca community as case study (Bakar *et al.*, 2014). The factors included age, religion, marital status, gender, origin, age, education level, geographical location, household income, and occupation (Bakar *et al.*, 2014). They confirmed that local community and socio-economic factors contribute to deterioration in local cultural practices. Thus, the

they highlighted that rehabilitated buildings have their usage value restored and their obsolescence reversed. They concluded that, in order to effectively restore the use value, the rehabilitation of the building must be integrated with environmental, social and economic indicators (Munarim & Ghisi, 2016).

5.3 Enhancement and Conservation

Since historical facilities play a major role in tourism as well as the local economy, the UNESCO badge is a significant marketing tool in the tourism industry (Bernardi, 2016; Caust & Vecco). It indicates that the heritage site is authentic and transmits the local culture, traditions, and activities. Moreover, it confirms that heritage sites have been built in accordance with environmental requirements and conditions (Fabbri & Pretelli, 2014; Varas-Muriel, Fort, Martínez-Garrido, Zornoza-Indart, & López-Arce, 2014). Conservation easement has become an instrument for protecting cultural heritage, as confirmed by Owley (2015) (Owley, 2015). Restoration and conservation of heritage must be achieved through utilising local experience and local construction materials to reflect the vernacular architecture of Al Baha and Saudi Arabia. This can be supported by privatising the protection of heritage villages based on social structure in Al Baha. Privatising protection can minimise the ability of appointed members of public to be involved in the decision on which cultural sites need to be protected.(Owley, 2015).

Hence, Al Baha, which has over 400 heritage villages across the region, in which the social structure can support the protection of these legacies by conserving these facilities, as well as enhancing the surrounding areas. Moreover, Al Baha has its own identity, where one of the challenges is how historical facilities can be protected and conserved whilst retaining their identity. Principles of vernacular architecture will support the decision-makers and Ministry of Municipality professionals to rehabilitate heritage villages. Vernacular architecture and urbanism plays an important role in illustrating heritage and conserving historical facilities, whilst also taking into account environmental challenges, as confirmed in (Alves, 2017; Ortega *et al*., 2017). A study by Ortega *et al*. (2017) highlighted that particular architectural elements can be identified in constructions located in different regions depending on their exposure to earthquakes (Ortega *et al*., 2017). They provided the example of the Portuguese vernacular heritage, which reflects Portuguese culture and takes local climatic conditions into account. Al Baha also has its own construction materials that are used to respond to local climatic conditions and generate less CO2 emissions. The fabric of historical buildings has been designed and constructed to suit the environment, where higher thermal resistance reduces the heat transmission from external atmosphere to internal (Bojic, Yik, & Leung, 2002; Dombaycı, Gölcü, & Pancar, 2006; Fontanini, Olsen, & Ganapathysubramanian, 2011; Li & Chow, 2005).

Town centres are typically the most popular destinations for tourists and visitors, and have many historical facilities that may need to be repaired, taking into account the original design and construction materials used. Alves (2017) investigated the architectural values of the historical zone in the city centre of Oporto (Alves, 2017). The main construction materials used differ from

tected, conserved, and rehabilitated. The importance of cultural heritage conservation and rehabilitation has been confirmed by many previous researchers, and this responsibility should be assumed in the case of heritage villages in Al Baha. A study conducted by Piñero *et al.* (Piñero, San-José, Rodríguez, & Losáñez, 2017) investigated the rehabilitation of a historic city centre using a multi-criteria decision-making approach (Piñero, *et al*., 2017). The authors analysed the conditions of the culturally protected World Heritage Site of the Historic Centre of La Habana (Piñero, *et al*., 2017), case and identified that 1033 historical buildings required emergency actions, 169 needed restoration, and 597 buildings required less restorative steps. A similar condition persists in Al Baha; there are over 400 heritage villages, and different castles, mosques and palaces are available for restoration and investment, as an urgently required step. This will have the result of protecting these legacies and conserving the buildings using original local construction materials, which will minimise embodied energy and CO2 emission rates. Each location has its own character, culture, and climatic condition, and thus will need individual assessment depending on its unique condition and challenges. This is confirmed by Ornelas *et al.* (Ornelas, Guedes, & Breda-Vázquez, 2016), who provided several criteria to support a holistic policy that ensures optimal conservation of heritage villages.

Local policies, economic income, and financing options, as well as local culture, must all be taken into account in order to support heritage development. Saudi Arabia has different hot climatic conditions:, a hot arid climate (Aldossary, Rezgui, & Kwan, 2014a), and a hot humid climate (Aldossary, Rezgui, & Kwan, 2014b), and the southern region has a mountainous topography. Each region has its own urban identity based on the local topography. Different construction materials are used in different parts of Saudi Arabia; for instance, mud is a construction material that is traditionally used in the desert areas of central Saudi Arabia, and the northern and eastern regions, which have hot arid climatic conditions. On the other hand, stone is the most commonly used construction material in the Al Baha region, where all historical facilities have been built with local stone in response to environmental challenges, as it has a high thermal resistance (R-Value).

Environmental responsibility is another important factor that must be considered when rehabilitating historical buildings. Local materials and vernacular architects should be used for heritage projects (Mahmoud, 2016), and care must be taken to reflect the architectural style and identity of different time periods, as well as being suitable for the local environment and climatic challenges (Ortega, Vasconcelos, Rodrigues, Correia, & Lourenço). Development of the heritage village in Al Baha must take into account the environmental responsibilities, social requirements, and traditions, and use local construction materials for the retrofitting of individual historical buildings. They should be supported by expert construction companies to source local construction materials from mountains across the region; this is essential in terms of environmental responsibility and minimising CO2 emissions. A study conducted by Ulisses and Enedir (2016) investigated the rehabilitation of heritage and historical buildings and explained that restoring a building is a unique chance to achieve optimum levels of sustainable and environmental performance (Munarim & Ghisi, 2016). Moreover,

the impact of heritage villages on tourism and the economy. Cuccia *et al*. (Cuccia, Guccio, & Rizzo, 2016) explored the role of cultural heritage in supporting the tourism industry through a case study of one Italian region between 1995 and 2010. They reported that the World Heritage List can create positive expectations and increase tourism demand and supply based on local rules (Cuccia *et al*., 2016). Another study, carried out by Barrère (2016), provided a definition of the term 'heritage' and its influence on economic and social life. The study concluded by stating that:

"*Informal heritages are at work in the economy and in social life as much as – and even more than – formal heritages, it is high time we extended economic analysis to these new fields and came up with new ways of managing informal heritages*" (Barrère, 2016).

This further demonstrates that heritage can play a major role in improving and managing tourism, as confirmed by Alazaizeh *et al.* (Alazaizeh, Hallo, Backman, Norman, & Vogel, 2016). The authors further emphasised that the importance of heritage tourism is related to the motivations for tourist visits (Alazaizeh *et al*., 2016).

As was seen in the analysis, most tourists visit Al Baha for personal or social purposes. The development of heritage needs to involve creating attractive features within the heritage villages, such as historical hotels, museums, and market places that sell traditional products, as is found in other countries. On this basis, tourism in Saudi Arabia can be increased through development and investment in these facilities, resulting in increased income.

Due to the poor condition of the heritage villages in Al Baha and negative feedback from visitors, serious efforts are to develop and rehabilitate the heritage villages and historical facilities. There are many possible approaches to this and developing a framework for planning and redesigning heritage villages is one important step that should be taken. Drawing on international experiences can also contribute to the development of heritage culture, resulting in more successful investment and a better developed tourism industry. The economies of many developed countries depend on tourism, historical tourism in particular. Local policies should be aligned with development aims, and provide flexibility for investors and tourists. Visitors will be more likely to visit towns or suburbs when flexible and attractive facilities are available. Factors that increase engagement in historical places include creating resorts out of historical hotels and mosques open to the public, and historical facilities in heritage villages, such as castles and famous palaces. As illustrated in the analysis, developing these factors can increase tourism and economic revenue through efficient investment. A study was conducted by Bashi (2015) (Bashi, 2015) to investigate the impact of unique culture on sustainable economic development in Albania. The author highlighted that the cultural heritage in this country was under pressure from the environment and the obliteration of human, requiring protection in order to save culture, as the raw material of the economy and tourism.

5.2 Restoration and Rehabilitation of Heritage Villages

Restoration and rehabilitation of heritage is an important step in developing heritage villages for conservation and tourism purposes (Darmawan & Enis, 2016). Al Baha has many heritage villages across the region, which needs to be pro-

opment of tourism industry due to its role on creating jobs in local industry sectors (Kadiyali & Kosová, 2013). Many studies have confirmed the relationship between heritage, local tourism, and the economy and confirmed that heritage plays a significant role driving both (Ginting, 2016; Naselli, 2016; Rasoolimanesh, Jaafar, Ahmad, & Barghi, 2017). There is potential for heritage villages in Saudi Arabia to be developed to become a source of sustainable income through tourism. These social legacies are raw materials that can be invested in to conserve culture for future ages, adapt the presentation of historical facilities to suit the current urban development, as well as rehabilitate heritage villages.

Economical and Social developments in country states discussed the strategies to deal with redundant cultural and traditional buildings (Bamert, Ströbele, & Buchecker, 2016; Brocx & Semeniuk, 2017). Heritage development is an influencing factor and an investment tool in the tourism industry. Many studies have sought to diagnose and measure the impact of heritage development on tourism, local economies, the conservation of historical facilities, and the development of local urban planning systems.

- **In Jordon;** many studies dealt with heritage culture and its impact in tourism industry. A study has been conducted by Al Haja (2011) who investigated the social culture between tourism industry and local citizens in historical towns in Jordan (Al Haija, 2011). The author aimed to identify the challenged that can be faced in tourism development. He found that, there is an interrelation among government, local citizen and tourists depending on the involvement of tourism plans and policies in territorial planning (Al Haija, 2011). Heritage factors could contribute to set the policy of the urban and regional planning to include the tourism purpose (Al Haija, 2011).
- **In Ethiopia and Mali;** A study by Farid (2015) discussed the management of tourism in World Heritage Sites, and the effect of tourism on economic development (Farid, 2015). The author studied Ethiopia and Mali in Africa as case studies, and identified a positive relationship between the presence of heritage sites and the number of visitors (tourists) to these countries (Farid, 2015). Historical facilities also play a significant role in the tourism industry. According to Ismagilova *et al.* (Ismagilova, Safiullin, & Gafurov, 2015), historical facilities and cultural heritage play a major role in the development of local tourism (Ismagilova *et al.*, 2015). The authors highlighted that cultural heritage and historical facilities are a key factor and advantage for cities, and have a significant impact on local economic development (Ismagilova *et al.*, 2015).
- **In Albania**; Cultural heritage is not shaped wholly by the presence of historical facilities; it also includes the local culture and social activities, as has been highlighted different studies. A study has been performed by Seidl (2014) who investigated the income from tourism industry by employing world heritage sites. The author estimated the local income of Albania from World Heritage Sites concluding that it could reach €95 million annually through investment in Albania's cultural and natural heritage (Seidl, 2014)".

From an economic perspective, tourism in the Al Baha region needs to be developed via investing in heritage villages and conservation of cultural legacies. Previous researchers have confirmed

Table 3: Identified factors influencing the development of heritage villages in Al Baha.

Category	Description	Number of factors	Statement
Urban facilities	Factors related to availability of services, price of hotels, furnished apartments and other tourist facilities	4	Action needed to develop the urban planning facilities while controlling the accommodation cost
Urban sustainable and architectural design	Factors related to the readiness of heritage villages and other historical facilities	5	Action needed to restore heritage villages, castles and other historical facilities
Accessibility and transportation	Factors related to the locations of heritage villages, such as accessibility and views	5	Action needed to link heritage villages and historical facilities to public transportation network
Historical conditions	Factors related to the role of local social activities	6	Action needed to restore heritage villages, castles and other historical facilities
Social traditions and activities	Factors related to the role of local social activities	6	Participation of the public needs to be increased to present local products, traditions, and history

5. DISCUSSION

In order to answer the research questions, the main research problem must be addressed, and related factors discussed. Saudi Arabia is known as an oil rich country where economic income is dependent on the raw materials of petroleum, but many other resources can be invested in to achieve the aim of establishing multiple income resources and creating a balance through opening up and investing in other income sources. The tourism industry is one source of economic income, and one which many invest in to benefit their economy. The Al Baha region is a tourist destination in Saudi Arabia as it is cooler that other regions, as well as having many tourist attractions, such as heritage villages and historical facilities.

These attractions need to be conserved and invested in to develop the local economy of the region. Following the analysis and illustration of the survey results, this discussion will link the output of the study with a recommended solution, and benchmark it against some previous studies carried out in other countries. Hence, the discussion will focus on:

a. The impact of heritage on tourism and the economy.
b. Restoration and rehabilitation of heritage villages.
c. Enhancement and conservation.
d. Socio-cultural barriers to heritage development.

5.1 The Impact of Heritage on Tourism and the Economy

Heritage culture plays a significant role in urban development, and has an impact on the tourism industry and thus the economy (Petronela, 2016). Moreover, heritage sites influents in surrounded land value resulting in development of real state and property price (Fritsch, Haupt, & Ng, 2016). One of factors influence local economy is devel-

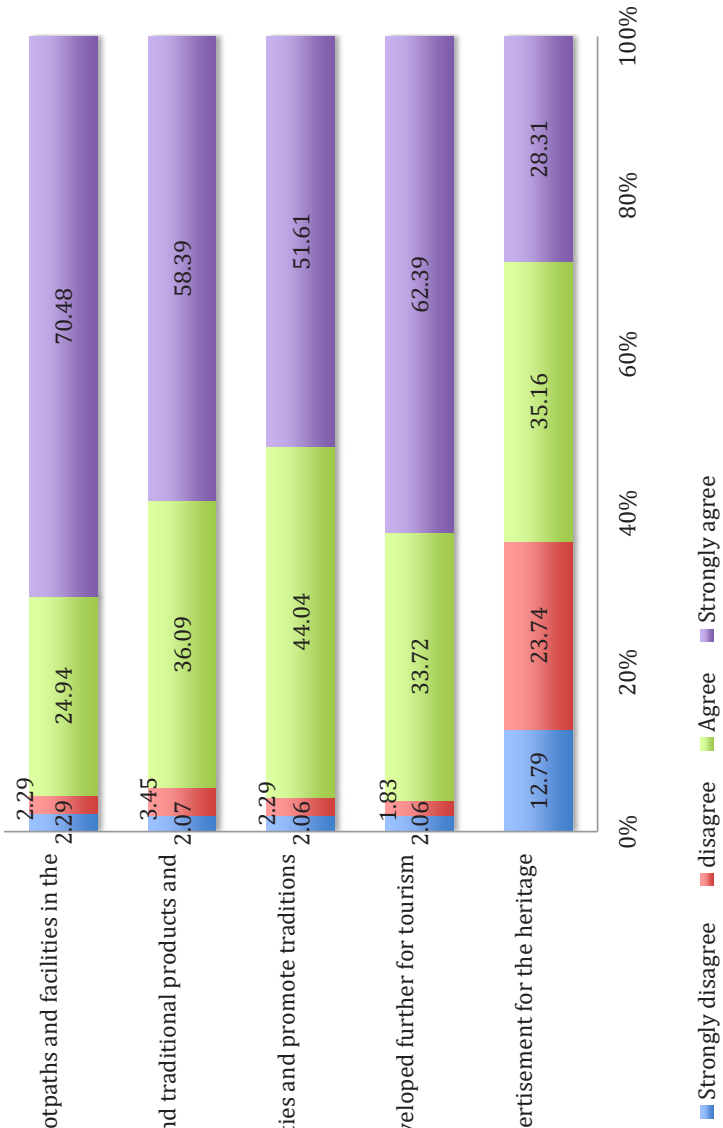


Figure 16: Responds point of view of heritage restoration.

The local municipality, governmental sector, and businesses can also play a major role in the development of the region, from the perspective of tourism and tradition. The respondents assessed their role in development and participation in the development of heritage villages, and they highlighted approximately 54% as positive and very positive, as seen in Figure (15).

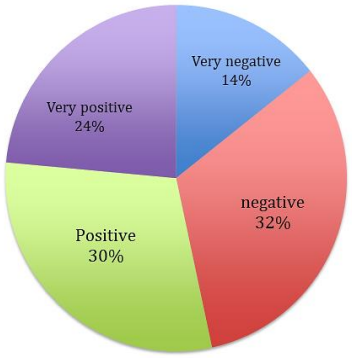


Figure 15: The current development and redesign of heritage villages in Al Baha.

The development of heritage villages is the responsibility of the local municipality, the owners, developers, and businessmen. The figure indicates a positive view about the steps that must be taken by local government to redesign heritage village in Al Baha. Approximately 54% of respondents rated the development undertaken by local municipality as either very positive or positive. However, this figure shows how development of heritage can be improved in the future, followed by development of tourism and sustainable economic income.

Many steps have been identified and assessed by the public survey as being able to attract visitors and develop heritage villages. The questionnaire included multiple questions intended to identify the factors influencing development, from the public point of view. The details of these factors are shown in Figure (16). First, restoration of individual building is an important step that can be undertaken by expert contractors. Over 95% of respondents either agreed or strongly agreed that development of heritage should be considered in order to promote tourism. This can be achieved by establishing attractive historical facilities and social activities.

Investment in heritage and the involvement of the local public are important factors that must be considered in order to develop heritage village from the perspective of developing the economy by increasing tourism. These factors were analysed, and the results are presented in Figure (16). Most of the respondents either agreed or strongly agreed that restoration is needed to develop heritage further, taking tourism into account, as well as investing in heritage for these purposes. Hence, society in Al Baha must be engaged to present social activities in order to promote traditional activities and reflect the local tribe history. Figure (16) shows that over 95% of respondents either agreed or strongly agreed with heritage restoration.

The development of heritage villages will differ from one to another depending on the current condition, location, and specific requirements. These factors are related to the redesign, restoration, and conservation of villages and individual buildings. Some other important factors are related to local activities, social traditions, environments, tourism, and transportation. Hence, many factors have been identified and illustrated, and these must be considered in any development efforts, from the public perspective. Table (3) summarises the factors that must be considered and taken into account when developing and investing in heritage villages and historical facilities in in Al Baha for environmental and tourism purposes.

Figure 14: Military castle in Al-Malad.

Development of heritage villages and historical facilities are factors that play a significant role in tourism development and income generation, while conserving the historic traditions. As seen in Figure (13), there are many factors that have influenced the condition of existing heritage and historical facilities in Al Baha. First, Al Baha is known to have many castles across the region, each of which has its own history and local culture as well as social structure. Most of these castles are deserted as seen in Figure (14).

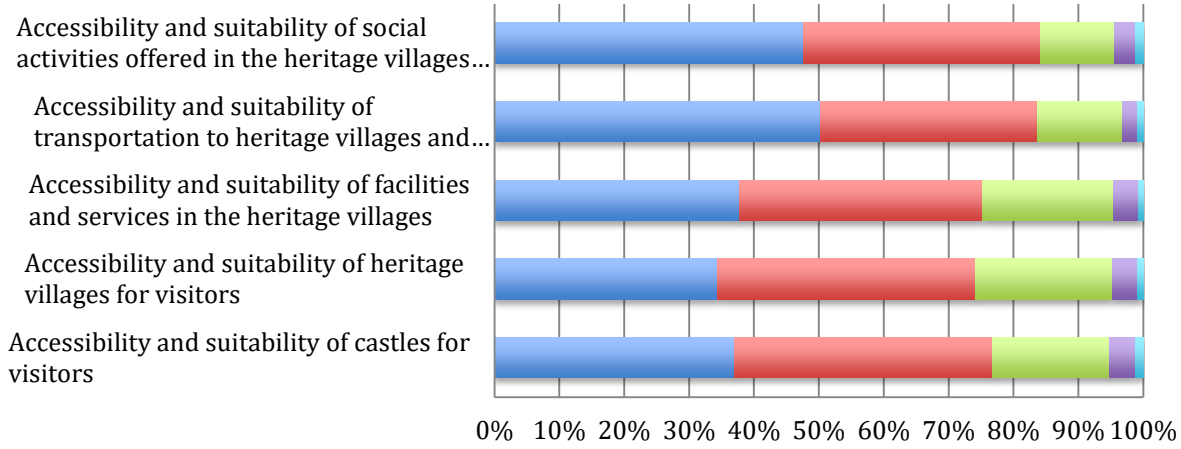
The survey highlighted that the accessibility and suitability of these castles for visitors are poor. Castles are an important facility, which attract visitors and are good destinations for tourist that want to learn about the local traditions and history. This also applies to heritage villages, most of which have castles. Thus, the accessibility and suitability of historical facilities must be taken into account when developing castles and palaces for visitors. These developments should consider linking the location with the main roads in and out of the closest city.

As can be seen in Figure (13), over 70% of respondents rated the accessibility and suitability of historical facilities and heritage villages between poor and fair. This shows how important it is to develop these facilities and redesign restoration heritage villages from the perspective of environmental principles and social requirements, in order to attract more visitors. Social activities that reflect local traditions are another important factor to be promoted in heritage village. The Figure (13) illustrates that over 70% of these activities were ranked between poor and fair. In general, it is important that a city has tourist services and facilities in order to attract visitors. These services and facilities can be related to transportation and other facilities. As seen in Figure (13), over 80% of respondents rated this factor as poor or fair. However, heritage villages and historical facilities are only two factors and must be developed alongside other factors to attract visitor sand develop tourism in Al Baha.

As seen in Figure (12), most of the public will visit a specific heritage village that has been developed by the local Authority for Heritage and Tourism in the municipality of Al Baha. Most visitors in Al Baha do not visit to experience heritage villages where they can have their own social plane and social activities. Figure (12) is positive, in that it suggests that the public will engage in and encourage internal tourism if historical facilities are developed to level that is acceptable in Saudi Arabia and abroad.

4.3 Current and Existing Conditions and Development of Heritage Villages in Al Baha

The design and restoration of heritage village must meet the environmental requirements of tourism development. Determining the current condition of heritage villages was an important step in identifying the factors that influence tourism development and heritage restoration. A number of survey questions were designed to assess the current condition and availability of heritage villages in Al Baha. The survey results indicate the currently poor condition of heritage villages in Al Baha, including historical facilities, as seen in Figure (13).



	Accessibility and suitability of castles for visitors	Accessibility and suitability of heritage villages for visitors	Accessibility and suitability of facilities and services in the heritage villages	Accessibility and suitability of transportation to heritage villages and historical sites	Accessibility and suitability of social activities offered in the heritage villages for visitors
Poor	36.99	34.32	37.76	50.23	47.7
Fair	39.73	39.82	37.53	33.49	36.41
Good	18.04	21.05	20.14	13.07	11.52
Very Good	4.11	3.89	3.89	2.29	3.23
Excellent	1.14	0.92	0.69	0.92	1.15

Figure 13: Factors related to heritage village and historical facilities.

ents assessed these factors between poor and fair as seen in Figures (10 and 11).

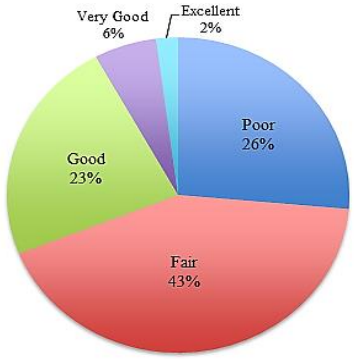


Figure 9: Cost of tourism in Al Baha.

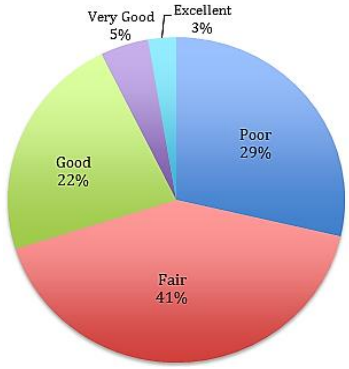


Figure 10: Tourist facilities in Al Baha.

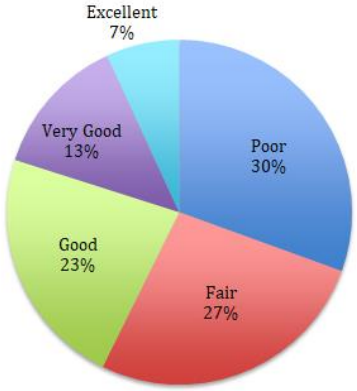


Figure 11: Historical facilities in Al Baha.

Figure (12) illustrates the willingness of the public to visit heritage villages and historical facilities in Al Baha. First, it is important to highlight that most of the respondents were not satisfied with the historical facilities in Al Baha. This may be due to the poor condition of heritage villages, and/or the ability of these facilities to accommodate tourists. Moreover, the general tourist facilities, such as hotels and catered apartments can play a significant role in attracting tourism.

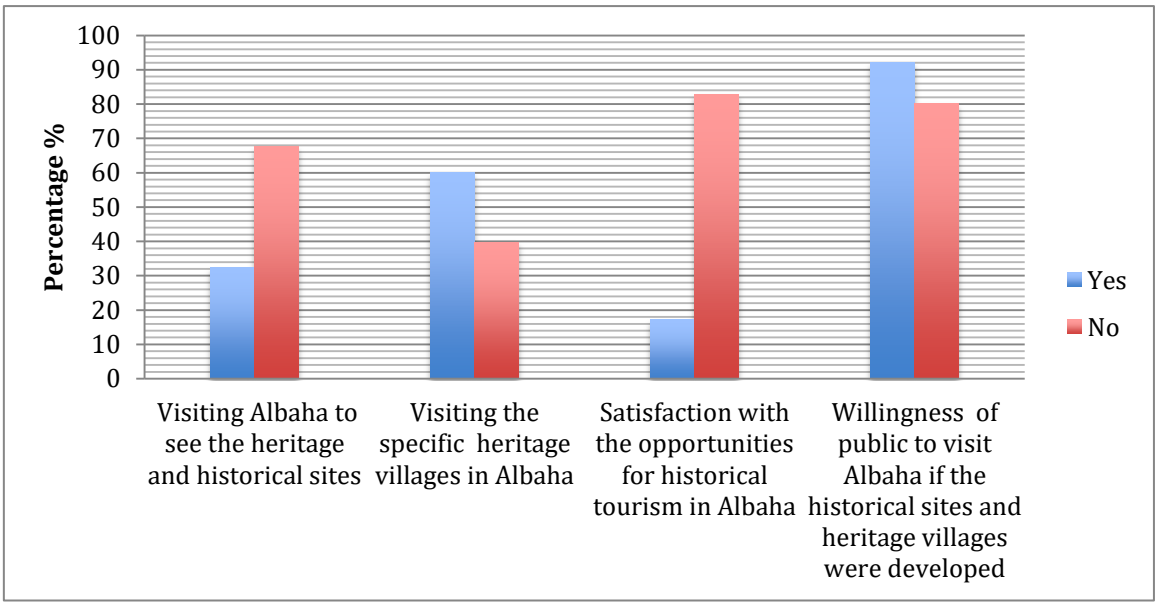


Figure 12: Willingness of the public to visit heritage villages and historical facilities in Al Baha.

Developed countries have particular traditions and heritage sites that attract tourists and generate income for the economy. These countries, such as Egypt, EU nations, and the USA have a long history and are extremely experienced in developing heritage villages, which play a major role in generating tourism and economic income. These experiences can be transferred to Al Baha, where investment is needed in the historical facilities, including castles, villages, and palaces in order to develop the tourism industry. Figures (6 and 7) show how the internal citizen is interested in visiting and experiencing historical facilities, where Saudi Arabia has a wealth of heritage sites, especially in the southern region, where Al Baha is located. As seen in Figure (6), approximately 80% of respondents had experienced heritage abroad. Their experiences were analysed in order to identify the factors that encourage internal tourism. On the other hand, most of the respondents had not visited Al Baha in order to visit the historical facilities and heritage villages. This is due to the poor condition of tourism facilities in this region (Figure 8). Most of respondents were not satisfied with the condition of heritage villages, nor the facilities available for visitors. The respondents compared the current condition of heritage villages in Al Baha with those they had experienced abroad, as a benchmark. The positive aspect is highlighted in this figure, indicating the willingness of the public to visit Al Baha if the heritage villages were properly planned and developed.

On a related point, multiple questions were designed to assess the quality of tourism from the point of view of tourists (respondents), as seen in Figure (8) and Figure (9). These questions related to the cost of tourism in Al Baha, the condition and availability of hotels and facilities, including historical and tourist facilities.

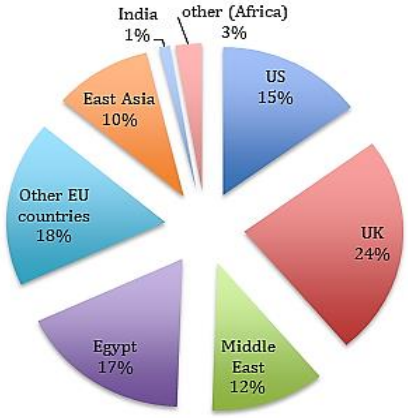


Figure 7: Details of herit-age visiting abroad.

Figure 8: Hotels and facilities in Al Baha.

Figure (8) shows that approximately 37% of respondents assessed the quality of facilities in Al Baha as poor, while 43% of respondents rated it as fair. This indicates that the quality of the hotels and other facilities must be improved in order to support and encourage tourism, and thus the economy, in Al Baha. Furthermore the cost of hotels in Al Baha is quite high when compared with other tourist destinations, as reflected in Figure (9).

In addition, both of tourism and historical facilities in Al Baha are not developed; the respond-

4.1 Public Perceptions of Tourism in Al Baha

It is well known that tourism plays a significant role in the economy of a country, where historical facilities and heritage villages can function as raw materials, and factors, which can impact for this purpose. Hence, this section will present the survey results regarding the frequency of visits made by members of the public to Al Baha, and the reasons for these visits. In general, the Al Baha region is a popular tourist destination due to the local natural environment and topography in comparison to other regions of Saudi Arabia. Most of the respondents assessed Al Baha to be a good tourist destination. Figure (4) illustrates the frequency of visits to Al Baha, while Figure (5) presents the reasons for visiting.

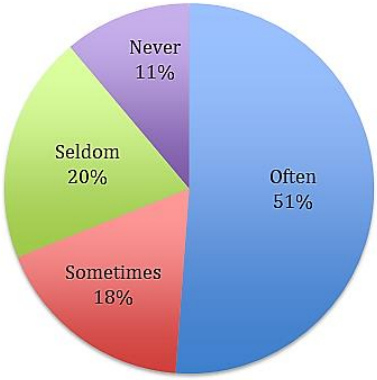


Figure 4: Frequency of visits to Al Baha.

It is clear that most of the respondents visited Al Baha for social purposes, whereas only 23% visited as tourists. This may be due to a lack of tourist facilities compared with other destinations. Due to the presence of Al Baha University, certain governmental sectors, and companies, approximately 14% of respondents visited Al Baha for work. This highlights how the number of people visiting Al Baha for tourism can be increased in the future. Moreover, it is clear that the social media plays a major role in motivating visits to Al Baha.

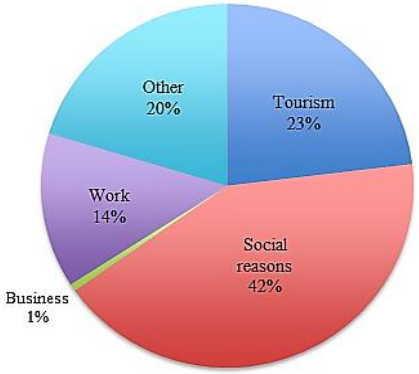


Figure 5: Reasons for visiting Al Baha.

4.2 Impact of Heritage Villages in Sustainable Environment and Tourism

There is a strong relationship between historical facilities, heritage villages, tourism, and the economy. The survey data revealed that over 80% of the respondents had visited historical facilities and/or heritage villages in other countries (Figures 6 and 7). These figures indicate that these facilities play an important role in attracting tourism and income, and show how historical facilities and heritage villages can be utilised to generate additional income for the region.

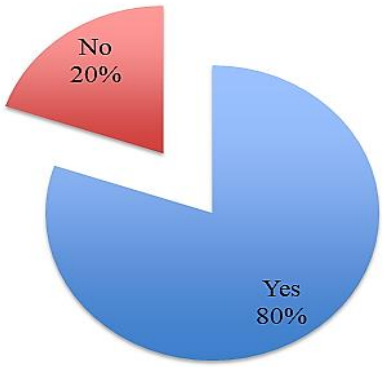


Figure 6: Percentage of visiting heritage abroad.

participants, the seeds, were asked to identify acquaintances (Illenberger & Flötteröd, 2012) to take part; these acquaintances were then asked to take part in the survey and also pass it on to their own acquaintances. The ego-centric method is restricted to first degree associations, whereas snowball sampling enables a more intricate grid (Illenberger & Flötteröd, 2012). Surveymonkey (*www.surveymonkey.com*) was used to distribute the questionnaire. The link to the online questionnaire was distributed via email to the public in Saudi Arabia. This web tool facilitates the wide distribution of questionnaires using the snowball technique (Biernacki & Waldorf, 1981). It creates the questionnaire and distributes it via an online link, which can then be more widely distributed in many different ways using the snowball technique. The responses can be monitored, viewed, and then analysed.

4. RESULT AND ANALYSIS

The questionnaire was distributed to people of all genders and different ages and education levels, across Saudi Arabia. The sample will thus reflect the point of view of the public regarding their experiences of heritage in Al Baha, any perceived weaknesses, and what would encourage them to visit Al Baha for tourism purposes. One of the benefits of distributing the questionnaire via the Surveymonkey tool using the snowball technique was the ability to reach a large number of respondents, enabling a more accurate picture to be obtained. In total, 534 respondents began the questionnaire; of these, 490 (80%) completed and submitted it. (Table 2) presents the demographics of the respondents who completed the survey.

In order to clearly present the survey data, the analysis will be divided into four main categories; (a) the impact of heritage and historical facilities on tourism; (b) factors influencing heritage developments; (c) the role of the local public and their willingness to develop historical facilities; and (d) challenges, and cultural and official barriers.

Table 2: Demographics of the respondents.

Age	Percentage	Gender	Percentage	Education Level	Percentage	Location	Percentage
18 to 24	8.43%	Male	86.52%	High School	11.80%	Central Regions	24.61%
25 to 34	41.95%			Bachelor's Degree	50.56%	Northern Regions	2.25%
35 to 44	30.15%					Southern Regions	30.14%
45 to 54	12.92%	Female	13.48%	Master's Degree	25.66%	Eastern Regions	12.17%
55 to 64	5.62%					Western Regions	27.21%
65 and older	1%			Ph.D.	11.99%	Outside Saudi Arabia	3.37%

Table 1: Al Baha climatic condition as recorded at Al Baha meteorological station during Jan – Dec 2015 (Al-Robai, Mohamed, Howladar, & Ahmed, 2017).

Month / Weather	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temperature (°C)	22.9	25.6	27.5	29.9	32.9	35.5	35.6	35.8	33.9	29.7	26.1	23.7
Min Temperature (°C)	10.4	12.2	14.3	17.4	20.2	22.9	23.4	23.5	21.7	17.2	13.3	10.4
Relative humidity (%)	59	49	46	48	39	25	29	31	27	31	51	55

The following overarching research questions were determined to guide this study:

- RQ1: Identify factors influencing heritage development and rehabilitation in Al Baha.
- RQ2: Determine the effect of heritage and historical facilities on tourism in Al Baha.
- RQ3: Identify challenges, barriers, and factors preventing the development of heritage villages in Al Baha.

A quantitative methodology was used to address the above research questions. A survey questionnaire was designed, piloted, and distributed to people of different ages, education levels and locations in order to obtain comprehensive information related to building design, site characteristics, socio-cultural aspects, and public perceptions about sustainability across Saudi Arabia.

3.2 Questionnaire Design and Description

The questionnaire was designed to be appropriate for people of different ages, educational levels, genders, and in different locations across Saudi Arabia. In order to gather a wealth of data the questionnaire was divided into three main categories. Each category fulfilled specific objectives, where all categories and questions were intended to address the aforementioned research questions.

- The first section of the questionnaire contained different questions to estimate how frequent the public visit Al Baha for tourism purposes; in order to identify the points of weakness that could suggest areas of possible improvement for tourism in Al Baha, and determine the role historical heritage plays in attracting tourism and income to the region.
- The second category of questions focused on heritage facilities in Al Baha. The questions in this category were designed to determine the current condition of heritage villages and historical facilities in Al Baha. These questions were intended to highlight the weaknesses of heritage villages in Al Baha, and in what ways the heritage and historical facilities need to be developed.
- The final questionnaire category focused on cultural barriers, the willingness of the local public to participate in analysing their point of view of how heritage villages can be developed. The questions in this category were intended to highlight the steps that are needed, and to clarify the role of the public in the development of heritage villages in Al Baha.

3.3 Distribution the Questionnaire

An online questionnaire distribution technique was employed in this study, as it is faster and more flexible than manually distributing hard copies of the survey (Stanton, 1998; Weible & Wallace, 1998), and is also lower cost (Huang, 2006). The snowball technique (Biernacki & Waldorf, 1981) was also used to distribute the questionnaire in Saudi Arabia. The first set of

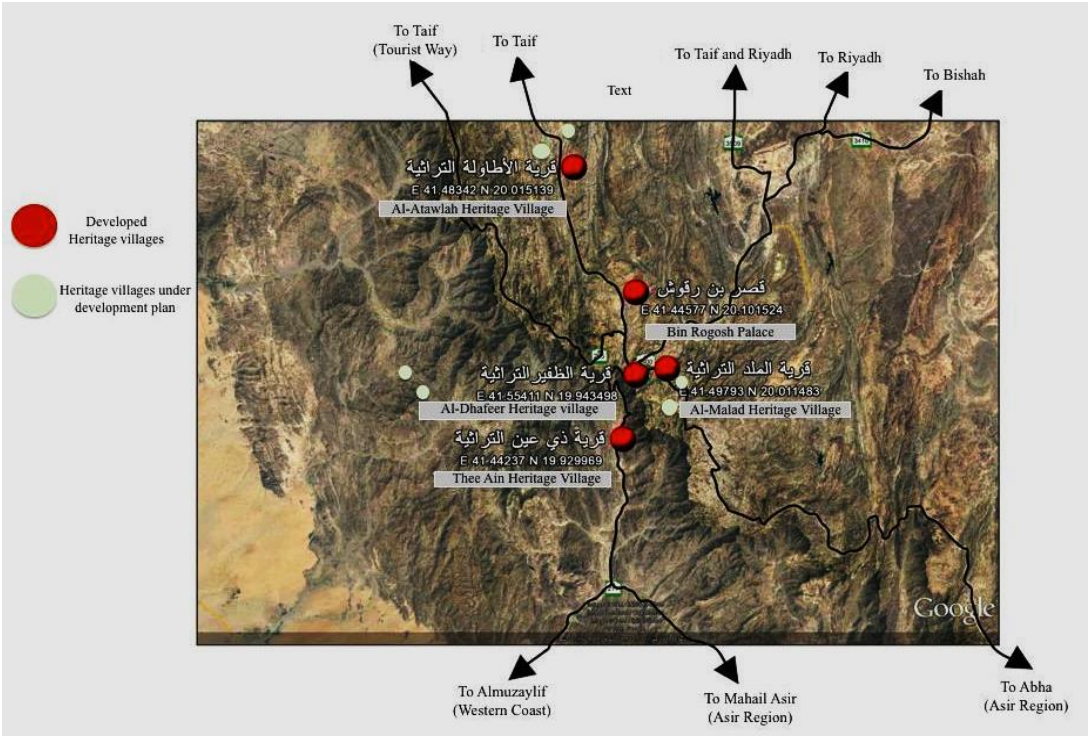


Figure 2: Map of Al Baha region and the distribution of developed heritage villages.

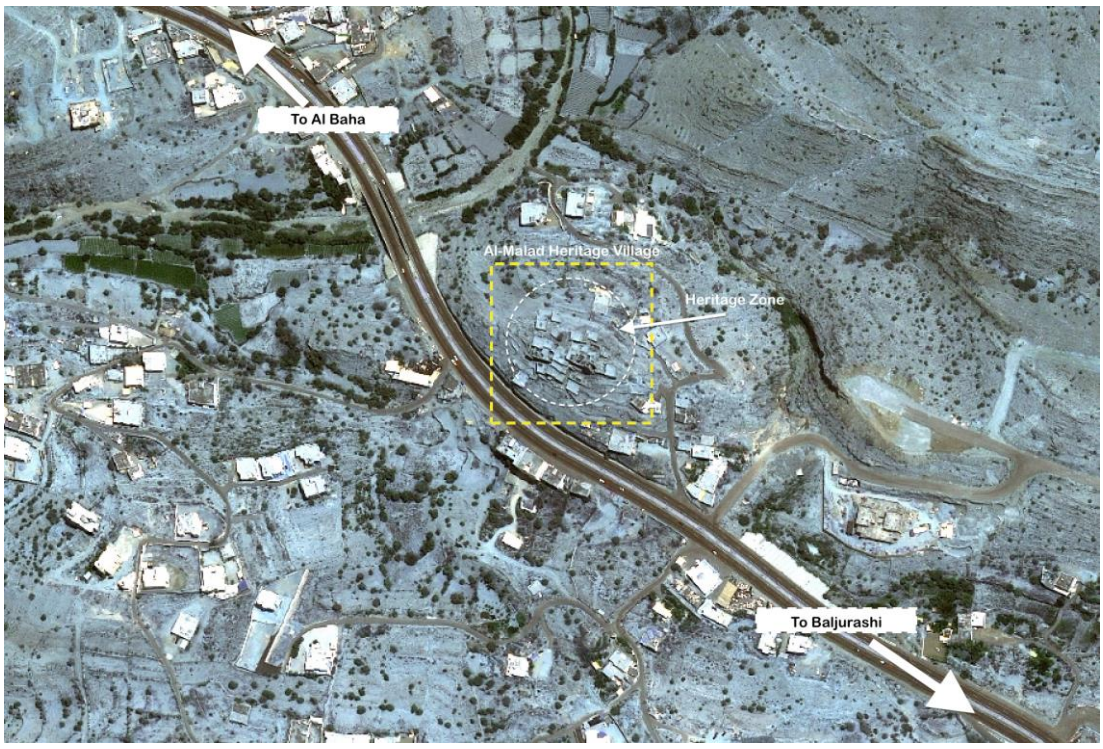


Figure 3: Map of Al-Malad heritage village.

market place in each heritage village, which helps to attract tourists. This is included in the design strategies for planning and developing heritage villages in Al Baha. As highlighted in the design strategies established in this study, application of these strategies on historical facilities will result in the development of these facilities, the protection of social legacies, and the rehabilitation of historical villages.

The Al Baha region was chosen as representative of the mountainous regions of Saudi Arabia; despite being colder than other regions of the Kingdom, this region is still hot and arid in comparison with many other countries. The Table (1) illustrates the typical weather conditions in this region.

3.1 Approach

In order to identify the factors influencing heritage development and rehabilitation in this area, a public survey and perception analysis method was selected as the main data collection and analysis approach. Surveys are the most popular data collection method (Huang, 2006; Loo, 2009); according to Huang (2006) (Huang, 2006), a survey is a data collection method that aims to discover exact estimations of the prevalence of significant variables. A snowball sampling method was used, also known as chain-referral or link-tracing. In this approach, the first set of participants are called 'seeds', and the seeds then suggest other participants (Illenberger & Flötteröd, 2012). This approach has been used in many past studies of various regions in Saudi Arabia, and was utilized in this study order to collect relevant data in the Al Baha region, and included people of different ages, education levels, and genders (Aldossary, Rezgui, & Kwan, 2015).

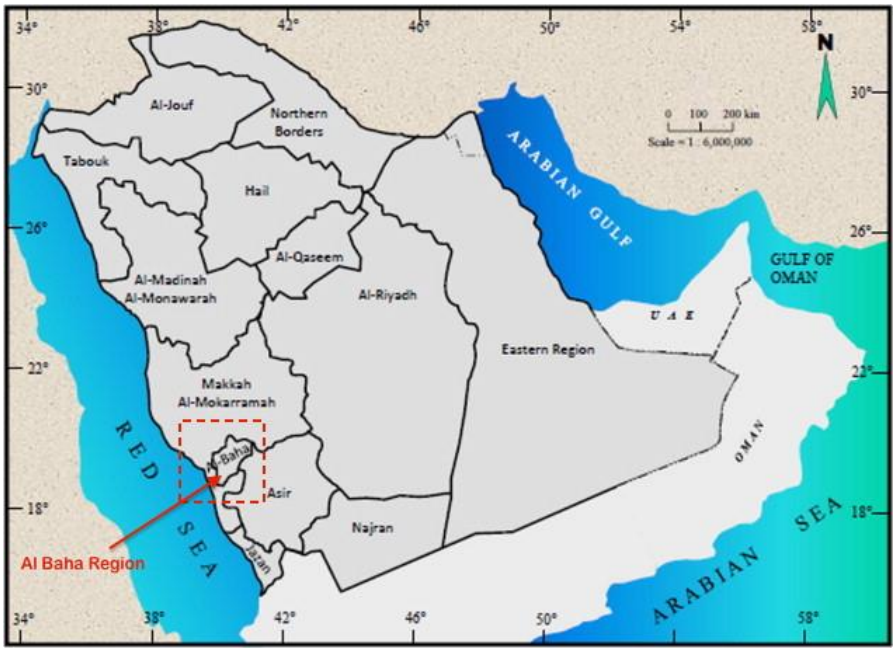


Figure 1: Map of Kingdom of Saudi Arabia, Al Baha region (Chowdhury, Al-Zahrani, & Abbas, 2013).

overcome the unprecedented changes in the basis of a re-evaluation of traditional practices. They used traditional settlements as a case study of previous practices and the current situation with the aim of helping direct future planning efforts (Eben Saleh, 2002b).

Another study was conducted by Abdullah Eben Saleh (Saleh, 1998), who reviewed the influence of Islamic culture and traditions rooted in the religion on urban form and architectural style. The author highlighted that the existing urban form evolved as a response to religious roots, and to fulfil the basic need to defend the social structure as well as fulfil environmental responsibilities (Saleh, 1998).

In a later study, Abdullah Eben Saleh (Saleh, 2000) examined building form, architectural style, and landscape as harmonic entities in the vernacular architecture of settlements in the southern region of Saudi Arabia (Eben Saleh, 2000). The author confirmed the qualities of vernacular settlements, and explained how they integrate with the local community, culture, environment, and economy (Eben Saleh, 2000). One of the most significant findings of this study was the identification of many features of new village extensions and landscape elements that improve the interaction between the environment and society; typically, these are valued by ordinary people, but there are elements of vernacular villages and landscape that the publics regret to lose, such as cultivation (Eben Saleh, 2000).

Researchers have confirmed that the Islamic built environment offers a precedent for any new practice related to neighbourhood design for an Islamic society (Eben Saleh, 2002a). Abdullah Eben Saleh (2002a) analysed the traditional features and attributes of contemporary neighbourhood design in Saudi Arabia in order to observe how the concept of 'New Urbanism' is applied in this context. The author argues that space design, either public, semi-public, semi-private, or private can fulfil and/or inhibit cultural and environmental requirements (Eben Saleh, 2002a).

3. METHODOLOGY

In order to achieve the aims of this study, a quantitative methodology was used to identify the factors influencing the development of heritage sites and facilities in Saudi Arabia, specifically in the Al Baha region. The Al Baha region is located in the south west of Saudi Arabia, giving it a hot, arid climate as illustrated in Figure (1).

The area is wealthy, and has a number of heritage villages and historical facilities across the region where some of these villages are located near the main highway and can be invested in tourism industry (Figures 2 and 3).

Economic development is one of the primary aims of developing heritage villages and historical facilities in Al Baha. Local income in Al Baha is mainly derived from tourism and agriculture. Tourism and national heritage rehabilitation is one of the vision 2030 for Saudi development. Hence, tourism facilities in Al Baha include heritage villages, which is one of important factors that must be considered. Heritage villages require urban development for conservation and investment purposes. Local culture reflects the local history, and most tourists would prefer to observe a different culture and history. Presentation of the local tradition, such as the local products, weapons, dress, and activities will play a significant role in operating heritage villages in Al Baha. This can be achieved through the contributions of local citizens and the community to help present their history, and the allocation of a

1. INTRODUCTION

The development of heritage, including suburban landscape changes, has become an important factor in an economic perspective (Zhang, Min, Zhang, He, Zhang, Yang, Tian, & Xiong, 2017). Recently, the eligibility of sites to be world cultural heritage sites was evaluated by the United Nations Educational Scientific and Cultural Organisation (UNESCO) (Gullino & Larcher, 2013). Local rules, urban policies and regulations deal with abandoned heritage and historical facilities in their jurisdictions (van Duijn, Rouwendal & Boersema, 2016) The increasing interest in local development was due to global political, social, and economic changes, especially for policy makers (Bercu, 2015). Sustainable development of architectural and urban heritage is, currently a concepts utilized by professionals in the fields of patrimony and urbanism (AbdelKader, 2011).

Heritage culture has different developmental possibilities that can be associated with sustainable development. These possibilities are not necessarily related to the economy, and also have environmental, social, and cultural dimensions (Vasile, Hribar, Bole, & Pipan, 2015). Urban design and architectural style takes into account local traditions, climatic features, and local construction materials. Thus, heritage villages and historical buildings reflect how a particular people relate to their culture, climatic challenges, and traditions. Many towns and cities in developing countries across the world have historical features and facilities including streets and historical buildings, as well as traditional social activities that are now facing, and often resisting, modernization (Throsby, 2016). Saudi Arabia has many such heritage sites across the country that reflects the local culture, traditions, and climatic conditions. These need to be developed and rehabilitated in keeping with the design style of their surroundings, in order to reflect and transfer traditional culture to new generations. Furthermore, while Saudi Arabia is known as an oil rich country, it has local traditions and is rich with historical facilities and heritage villages. These traditions and heritage sites can be invested in in order to help develop the tourist industry and generate income, as well as keep the traditions alive.

Hence, this paper will discuss the development of heritage villages and historical facilities in Saudi Arabia in order to identify the factors that need to be addressed in practice to rehabilitate these sites and facilities. To this end, the paper will be divided into four main sections: (a) related studies; (b) methodology; (c) results and analysis; (d) discussion; and (d) conclusion and recommendations for future works.

2. RELATED STUDIES

Studies of sustainable development must consider both social structure and environmental responsibilities. All urban design and architectural styles will reflect the environmental responsibilities and social needs, structure, and traditions of the particular society. Many studies have been conducted on heritage across the world, including in Saudi Arabia. For instance, a study was carried out by Eben Saleh (2002b) in order to assess planning efforts in the southwest region of Saudi Arabia during three different phases of development: traditional, transitional, and contemporary (Eben Saleh, 2002b). The author suggests a new relationship between planning authorities and the local community in order to

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التخطيط العمراني المستدام لتطوير وإعادة تأهيل القرى التراثية في منطقة الباحة: تصور جودة الخدمة والرضا

نايف علي رشيد الدوسري[1*]

(قدم للنشر في 1439/06/05هـ؛ وقبل للنشر في 1440/07/14هـ)

مُلخَّص الدِّراسة: إن التنمية المستدامة للتراث العمراني والمعماري وإعادة تأهيل القرى التراثية من الأهداف الأساسية على الصعيد البيئي والاقتصادي، ولذلك تهدف هذه الورقة العلمية إلى دراسة وتحليل وتشخيص الوضع الراهن للقرى التراثية والمرافق التاريخية وتأثيرها على السياحة في منطقة الباحة - جنوب المملكة العربية السعودية. لأن المملكة العربية السعودية تعتبر من الدول القديمة والغنية بالتراث العمراني والمرافق التاريخية التي تعكس تقاليدها الاجتماعية وهويتها العمرانية والمعمارية. وذلك لتحديد العوامل العمرانية والتراثية التي تساهم بدفع عجلة التنمية المستدامة اقتصادياً وبيئياً مع التركيز على تقييم مستوى رضى المجتمع عن الوضع الراهن للقرى التراثية في المنطقة. وقد تم توظيف منهجية المسح وتوزيع الاستبيانات كمنهجية أساسية لهذه الدراسة وذلك لعمل استطلاع رأي المجتمع المحلي عن الوضع الراهن للقرى التراثية والتنمية السياحية في منطقة الباحة والذي شمل 534 من المشاركين من مختلف الأعمار ومن جميع مناطق المملكة العربية السعودية. تم بناء وتوزيع الاستبيان باستخدام التقنية والإنترنت وذلك من أجل؛ (أ) تحليل الوضع الراهن للقرى التراثية في منطقة الباحة من واقع التصور العام لنظرة المجتمع؛ (ب) تحديد العوامل المؤثرة على تنمية العمرانية والسياحية في منطقة الباحة ودور القرى التراثية في التنمية العمرانية؛ (ج) تشخيص الحواجز الاجتماعية التي تعيق إعادة تأهيل القرى التراثية والمرافق التاريخية؛ (د) تشخيص مستوى الوعي بالتراث الثقافي في المجتمع السعودي. خلصت الدراسة إلى إبراز العوامل العمرانية والهندسية التي تحتاج تطبيقها في القرى التراثية لتحقيق متطلبات إعادة التأهيل القرى التراثية والمرافق التراثية واستثمارها في المنظومة السياحية لمنطقة الباحة. إضافة الى ذلك، تقترح الدراسة ثلاثة أنواع من الدراسات لمستقبلية المهمة التي تحتاج إجراءها لتطوير وإعادة تأهيل القرى التراثية في المملكة العربية السعودية.

الكلمات المفتاحية: التنمية المستدامة للتراث العمراني، إعادة تأهيل القرى التراثية، الحفاظ على التراث، صيانة المباني التراثية، منطقة الباحة.

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Sustainable Urban Planning for the Development and Rehabilitation of Heritage Villages in Al Baha Region: Service Quality Perception and Satisfaction

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Abstract: Sustainable heritage development and rehabilitation is an important environmental and economic target. Saudi Arabia is old country rich in heritage and historical facilities that reflect its social traditions and its urban and architectural identity. This paper analyses the current condition of heritage villages and historical facilities in Saudi Arabia in order to identify factors associated with sustainable development of cultural heritage sites. The main aim was to evaluate the current condition of heritage villages and historical facilities and the impact of heritage culture on tourism, with a focus on the public perception of sustainable heritage in tourism and the economy. A public survey was conducted between May and August 2016, which involved respondents (n= 534) from across Saudi Arabia. An online distribution tool was used to (a) analyses public perception of heritage villages in Al Baha; (b) identify the factors influencing the development of heritage and historical facilities; (c) highlight the cultural barriers that affect the rehabilitation of historical facilities; and (d) determine the level of awareness of cultural heritage in the Saudi community. The study concludes by highlighting factors that need to be developed in order to meet the rehabilitation requirements of historical facilities in Saudi Arabia. Moreover, the study suggests three important types of studies that still need to be conducted on developing and rehabilitating heritage villages in Saudi Arabia.

Keywords: Heritage culture, Sustainable development of heritage, Heritage rehabilitation, Heritage conservation, Al Baha region.

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the high nutrient content of the baobab fruit pulp. However, Sudanese "Gongulaze powder" has not been studied extensively. Only a few authors have presented a (general) literature review and only a few of these concerns to the nutritional and medicinal value of baobab products exclusively.

Many studies in the literature have recommended further studies on baobab. This study agrees with those authors who have mentioned that there is great potential for this indigenous wild fruit tree of Africa in regional and even world markets (Buwalda, Otsyina, Filson, & Machadon, 1997). Sudan is one of these countries. This study hopes that it will encourage and stimulate Sudanese and other researches towards a better understanding, utilization and better efforts concerning *Adansonia Digitate*, particularly the Sudanese "Gongulaze powder". Further studies are needed to support any health claims.

10. CONCLUSION

The Baobab tree is a unique tree regarding its size, shape, and uses. Baobab fruit is a good nutritional and medicinal material as a valuable source of vitamin C, containing about 5-7 times more vitamin C as an orange. There are great variations in the values of nutrient contents of baobab parts, but the causes of these variations are not well known; however, several assumptions have been made. The Sudanese utilize baobab fruits and powder in their natural state as a cold drink called Tabaldi or Gongulaze.

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more health enhancing effects concerning stimulation of other secretions in the body-- this needs more investigation.

The most medicinal traditional utilization of baobab in Sudan is for treating diarrhea and dysentery, particularly in children. This fact was obtained from a survey done on Sudanese families and from scientific published researches (though they are few). This fact is in accordance with what stated by Kamatou *et al*. (2011) that the usage of baobab as a treatment of diarrhea and dysentery in many African countries may be due to its immuno-stimulating, anti-inflammatory, analgesic, insect repelling and pesticidal properties. In several African countries, baobab has been evaluated as a substitute for imported western drugs (El-Rawy *et al*., 1997; Ramadan *et al*., 1994). Some Sudanese studies indicate that for diarrhea treatment baobab drink can substitute the WHO dehydration solutions.

9.1 Final Notes

Some traditional information about baobab "exceeded the limits" by saying that the various parts of the baobab tree (leaves, bark, and seeds) are used to treat almost any disease. Specific documented uses include the treatment of malaria, tuberculosis, fever, microbial infections, diarrhea, anemia, dysentery, toothache, etc. (Watt & Breyer-Brandwijk, 1962; Van Wyk & Gericke, 2000; Nguta, Mbaria, Gakuya, Gathumbi, & Kiama, 2010). The leaves and fruit pulp of baobab are used as febrifuge as well as an immune stimulant. The various parts of the tree (leaves, bark and seeds) are also used as a panacea to treat almost any disease. The fruit of the baobab is the most important foodstuff and probably the most useful in all (Kruger National Park, 2017).

Some researchers consider baobab as one of the wild fruits help solve Africa's malnutrition crisis; they use the sentence: "A bit of baobab a day keeps the doctor away". The fruits of the giant baobab tree have up to 20 times the Vitamin C of mangoes and 30 times the calcium (Ouya, 2012).

Most of the literature this study reviewed discussed either the unique nature of the baobab tree or its multipurpose usage. The most frequently cited reference is Sidibé & Williams (2002), which this study also used as a main reference and source of data about baobab. Further research is needed as there is really not enough evidence at this stage to make any definitive health claims.

Constraints on the full use of baobab's economic potential have been mentioned as: limited availability of planting material (fruits are mainly harvested from natural stands), lack of knowledge on management techniques, poor fruit processing technologies and the lack of well-organized market chains (Wickens, 2008). Value chains and marketing pathways are poorly developed and the species is largely neglected by research, development and extension institutions.

Because: Sub-Saharan African countries are at the tail-end of fruit consumption rates in the world: no region meets the World Health Organization's recommended daily intake of 200 grams per person. East Africa has the lowest intake, at 36 grams of fruit per day (Ouya, 2012); *therefore:* in Sudan there is a need for baobab fruits, the soft, pale, powdery pulp, which is extremely nutritious, containing high levels of vitamin C, calcium, vitamin B complex, magnesium, iron, phosphorus and complex carbohydrates, components from which baobab fruits earned the reputation as a "super fruit". It is recommended to improve processing technologies for maintaining

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9. DISCUSSION

Adansonia digitata L., which is known as Baobab, is a unique tree that produces unique fruits. The different plant parts are widely used as food, medicine and the bark fibers are also used (Sidibé & Williams, 2002). The tree has a large stem of many meters in diameter. Although some differences in the shape of the tree exist between countries, such as Senegal, Madagascar, Benin, Sudan and outside Africa, such as Australia, all these trees have the common characteristics of a wide stem and the ability to produce the same fruits.

Baobab trees in Sudan are located in Kordofan region (western Sudan), which is rich with many similar cultivates, such as Gum Arabic and Hibiscus and many others. Many studies mentioned African countries as producers of Baobab, but few mentioned Sudan as one of them, in spite of the large production of Baobab in Sudan. This neglect may be due to the local consumption of this product, and the weak exporting efforts to European countries.

The baobab tree has been described in the literature by many common names. The most commonly used names of baobab in Sudan are "Tabaldi" for the tree and “Gongulaze” for the fruit and its juice. That drink (pulp beverage), which has a citrus flavor, is obtained by soaking the fruit pulp in water. Preparing Baobab fruit powder is simple; it can be accomplished just by removing the seeds from the pulp and grinding them into a fine powder. No heat is necessary; so, it is a very natural process that retains the flavor and nutrients.

Sudanese people use the powder in its raw state without any processing. They dissolve about 2 -3 teaspoons of powder into a cup of water, adding about 2 teaspoons of table-sugar, and drink as a cold delicious juice. The drink is very refreshing, delicious, and full of health with a tropical lemonade flavor. The drink can be described as a milky solution.

Comprehensive reports on a baobab nutritional profile (e.g. vitamin, fatty acid, mineral) justifies reasons for calling it a “super fruit”. It is a majestic tree of multipurpose. But actually most of the Sudanese people use Baobab as a nutritional refreshing drink rather than for therapeutic or medicinal purposes, particularly in Ramadan – the Muslim month of fasting.

Although the use of various methods highlights variations in the content of baobab constituents, the major trend is that baobab fruit pulp is rich in vitamin C and the anti-oxidant capacity of the fruit pulp is greater than that of other common fruits known for their high anti-oxidant activity. There is no doubt that baobab pulp is a valuable source of vitamin C, baobab contains about 5-7 times as much vitamin C as an orange. Improving baobab handling quality and storage stability by using adequate methods might promote a better organization of the food chain in Sudan. However, the impact of processing on the nutritional value of the end product needs to be investigated. The literature review has revealed a great variation in reported values of nutrient contents of baobab parts. According to Chadare *et al.* (2009), the causes of these variations are not well known, however the study made several assumptions.

Sudanese baobab drink gives a nice feeling when drunk after a long period of thirst; it stimulates the secretion of salivary glands in the mouth. This stimulation may indicate the presence of

content of the baobab was pectin 56% and crude fiber 5.7% (Omer, 2002).

8. MEDICINAL USE OF BAOBAB

A survey conducted in two villages in Sudan revealed that homemade fluids including rice water, custard, pap and Tabaldi juice were used by 45% of the mothers (Ahmed, Karrer, & Gibril, 1994). Baobab solution has been used by the Sudanese for management of diarrhea and dysentery. However, few studies have been carried out to evaluate it as a remedy for diarrheal diseases when compared with the standard formulation (WHO/ORS). A study conducted in Sudan by Abdel Galil (1996) compared the anti- diarrheal activity of Tabaldi with that of World Health Organization (WHO) dehydration solutions (WHO/ORS). The study found that the baobab solution provided a distinct home management of diarrhea to the extent that it exceeded the WHO/ORS standard. The study concluded that the use of baobab solutions for home management of childhood diarrhea suggested a new relationship between traditional medicine and public health.

Baobab solution is an effective early home management for diarrhea. At this stage there is no need for a base, such as is added in Oral Rehydration Salts (ORS) to correct acidosis. The acidic nature of the baobab pulp is due mainly to its high content of acids, particularly ascorbic acid (337 mg/l00g) (Abdel Galil, 1996). The study is in accordance with the one carried out by Tal-Dia, Toure, Sarr, Sarr, Cisse, Garnier, & Wone (1997), in which the efficacy of a traditional local solution made up of dried baobab fruit with water and sugar was compared to the WHO standard solution used to treat children with acute diarrhea. Although, results obtained in the study revealed that the WHO solution was found to be superior to the baobab mixture, there was no statistical difference between the two solutions in terms of duration of diarrhea and weight gain. Gruenwald & Galizia (2005) have suggested that baobab may also play a role in the effects against diarrhea.

The results of our pilot survey indicated that more than 50% of the capital cities of Sudan had used Baobab drink (as juices) (particularly in Ramadan – the Muslim month of fasting), most of them (about 70%) using it on a daily basis. Also, they use baobab in the treatment of diarrhea, dysentery and blood vessel diseases. The fact is that many Sudanese people use Baobab as a nutritional refreshing drink rather than for therapeutic or medicinal purposes.

Rahul *et al*. (2015) catalogs the traditional medicinal uses of *Adansonia digitata* in different types of aliments, with data collected from many references (Kamatou *et al*., 2011). The study claimed that Baobab leaves can be used for the treatment of diarrhea, fever, inflammation, kidney and bladder diseases, blood clearing, asthma, and malaria. Baobab seeds mixed with water can be used for the treatment of fever and diarrhea (Watt & Breyer-Brandwijk, 1962). Baobab Fruits used for treatment of microbial diseases (Jumelle and Perrier, 1909). Baobab powdered seeds can also be used for the treatment of Coughs (Watt & Breyer-Brandwijk, 1962).

Abiona, Adedapo, & Suleiman (2015) studied the antibacterial activity of the baobab aqueous extract and showed that as the concentration of baobab extract increases, the zone of inhibition increases and vice versa. Also, the inhibitory effect was more pronounced on Staphylococcus aureus and less in pseudomonas aeruginosa and

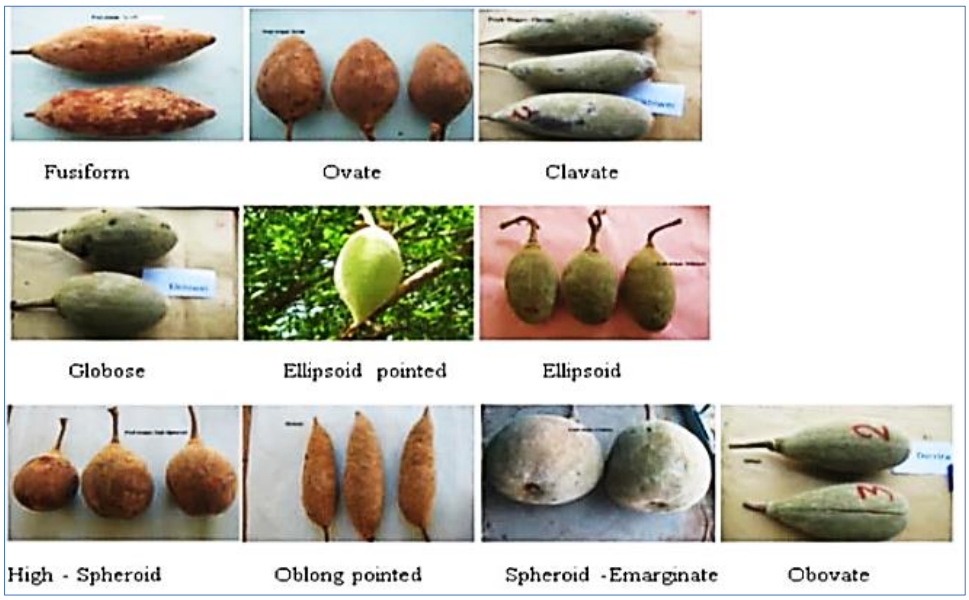

Figure 6: Diversity in fruit shape of *Adansonia digitata* L. (Omer, 2002).

soft paste, then eat it either with their fingers or spoon or even suck it from a plastic bag; they drink it during break-time in primary school. Although it tastes slightly acidic, the Tabaldi drink rarely causes an acidic stomach feeling. It has a somewhat acidic flavor, described as 'somewhere between grapefruit, pear, and vanilla' (Lange, 2010). Baobab (Gongulaze) drink is full of goodness.

7. SUDANESE BAOBAB FRUIT POWDER COMPOSITION

Gurashi *et al*. (2016) reported a relation between fruit pulp and fruit shape, type and location in Sudan. Their results showed that dry matter (86.5±0.7), crude protein (10.44±0.15), fat content (1.70±0.14) and carbohydrate (62.58±0.17) were found to be the lowest with the spheroid emarginated fruit shape (The Diversity in fruit shape shown in Figure 5). The study revealed that there were slight differences (P≤ 0.05) in baobab pulp minerals related to fruit shape (as potassium calcium, sodium, phosphorus and magnesium) and vitamin C in variable proportions.

Biochemical studies have shown that the baobab fruit pulp contains 2.6% protein, 0.2% fat, 2.61% fructose, 2.9% glucose, 12.8% sucrose. Previous studies on the chemical composition of baobab showed higher results in total sugars and similar protein and fat contents (Abdel Galil, 1996).

A study done in Sudan by Abdel Galil (1996) showed that baobab is a nutritious solution, containing the four groups of nutrients: energy-yielding protein 2.6%, fat 0.2%, fructose 2.6%, glucose 2.9%, and sucrose 12.81. The electrolyte and inorganic content of baobab showed it to be a rich source of K (450 ppm), Ca (670 ppm), Fe (53 ppm), Mn (57 ppm), Se (10 ppm), and Zn (10 ppm). Unusually high contents of the trace elements Ti (865 ppm) and Cr (297 ppm) were observed. The vitamins studied were ascorbic acid (335 mg/l00g), free nicotinic acid (50 mg/l00g) and vitamin B^ (10 mg/l00g). The fiber

sules. It is filled with pulp that dries, hardens, and falls to pieces which look like chunks of powdery, dry bread (National Research Council, 2006). The seed are hard, black and kidney-shaped (Hankey, 2004) (Figure 5). The mean fruit length is in the range of 13.9–16.5 cm in Sudan (Sanchez, De Smedt, Haq, & Samson, 2011) and from 15.7–22.2 and 12.9–17.6 cm in Mali and Malawi, respectively (Munthali, Chirwa, & Akinnifesi, 2012).

Figure 5: Seeds of the baobab tree, with and without fruit pulp (Rahul *et al*., 2015).

Ventricose, crescent-shaped, globose and fusiform fruit types were identified (Figure 6). The fruit shape varied between trees but was consistent within each individual tree. The percentage of fruit pulp varied between the different fruit types with 14, 15, 18, and 21 % recorded for ventricose, fusiform, crescent-shaped and globose fruits, respectively.

The fruits are capsules, ellipsoid, avoid or globor 15.2 cm long, 4.5-8 cm in diameter, numerous yellowish-brown seeds are embedded in a dry acid edible pulp. The edible fruit pulp is enclosed in a woody fruit capsule which is oblong and slender with different sizes 12-27cm long, 4.6 - 10.5 cm in diameter. The seeds are hard, black, and kidney-shaped (Hankey, 2004).

The Sudan Tabaldi fruits have a natural shelf-life of 3 years (Nour *et al*., 1980), so there are no additives or preservatives added to them, just 100% pure baobab fruit pulp powder. It also has a delicious sweet and citrusy flavor - a bit like healthy sherbet. It is a healthy and delicious recipe; the taste is nice and not overbearing.

In Sudan, the baobab pulp is separated from the pods and seeded manually. The most commonly used processing techniques is soaking in water. The fruit capsule is broken, the pulp is then separated from the seeds and the pulp is also eaten fresh. The dried pulp is scraped from baobab fruits and made into a solution. These processing techniques may rob a food item of some nutrients. On the other hand, processing may enhance food nutritional quality by reducing or destroying the anti-nutrients present in it.

The baobab drink is not kept for a long period because it may ferment or deteriorate. A study for the utilization of the *Adansonia digitata* fruit pulp by the soft drink industry in Nigeria showed fast deterioration of the fruit pulp even when exposed to a limited supply of humid air. This occurred even when each pulp was kept intact in the pod (Ibiyemi *et al*., 1988). Whole fruits or just the fruit pulp can be stored for months under dry conditions. The pulp powder is extracted and stored in polyethylene bags which protect it against ambient moisture (Sidibé *et al*., 1996). The fruit pulp drinks are used in rural areas and have recentlybecome a popular ingredient in ice products in urban areas (Sidibé *et al*., 1996). *Adansonia digitata* fruit pulp is processed locally to obtain sweets (Ibiyemi*et al*., 1988). Sudanese children suck these instead of unhealthy sweets and love them, as do adults; they like to eat Tabaldi paste; they add a small amount of water to a bulk of Tabaldi powder forming a thick

ence of betacarotene (Ibiyemi, Abiodun, & Akanji, 1988). The levels of some nutritional constituents of baobab fruit pulp were presented in Table 1.

Table 1: The levels of some nutritional constituents of baobab fruit pulp (mg/100 g) (Rahul *et al*., 2015; Manfredin *et al*., 2002).

Constituent	Content (mg/100g)
Ascorbic acid (vitamin C)	280.00-300.00
Calcium	293.00
Phosphorus	96.00-118.00
Carbohydrates	75.60
Soluble and insoluble dietary fibers	52.00
Potassium	2.31
Protein	2.30
Lipids	0.27

5. VITAMIN C IN BAOBAB FRUIT

One of the major interests in baobab products is as a result of its ascorbic acid and dietary fiber content. The exact vitamin C content depends on the individual tree. Sidibé, Scheuring, Tembely, Sidibé, Hofman, & Frigg (1996) and Hills (2008) reported that baobab contains more antioxidants than any other whole fruit, and full of vitamin C. Carr (1955) reported that Baobab fruit pulp has among the highest vitamin C or ascorbic acid content found in any fruit. Sidibé & Williams (2002) recommended that baobab leaves should be stored as whole leaves rather than ground leaf powder in order to preserve the high vitamin content.

Chadare *et al*. (2009) demonstrated that the consumption of 40 g of baobab pulp provided 100% of the recommended daily intake of vitamin C in pregnant women (19–30 years), and 40gprovides from 84 percent to more than 100 percent of the Recommended Daily Intake (RDI).

Kamatou *et al*. (2011) stated the vitamin C content in baobab is seven to ten times higher than the vitamin C content of oranges, i.e., 51 mg/100g (Manfredini *et al*., 2002; Täufel, Ternes, Tunger, Zobel, Lebensmittel-lexikon, Aufl (1993). This compares to a vitamin C content of 46 mg/100g in oranges, a well-documented source of vitamin C (Vertuani, Braccioli, Buzzoni, & Manfredini, 2002).

The level of vitamin C contained in the fruit pulp of *Adansonia digitata* ranges from 2.8 to 3 g/kg (Vertuani *et al*., 2002), and 337 mg/100 g of ascorbic acid (Diop, Franck, Grimm, and Hasselmann, 1988; Eromosele, Eromosele, & Kuzhkuzha, 1991; Gebauer *et al*., 2002). In Malawi, the fruit pulp was found to have the highest ascorbic acid content out of twenty-two wild fruit species (179 mg/100g) (Diop *et al*., 1988). In Nigeria, the concentration of baobab ascorbic acid was found to be 337.0 mg/100g and the fruit is used as sweetener for many local foods and as a curding agent for milk (Ibiyemi *et al*., 1988). However, the vitamin C content of the bulk fruit pulp varies from 1623mg/kg in one tree to 4991mg/kg in another (Sidibé *et al*., 1996).

6. BAOBAB FRUIT 'GONGLASE' AND DRINK IN SUDAN

The vernacular names for the baobab tree in the Sudan are: 'Humar', 'Homeira' and 'Tebeldi'. The fruits are most commonly named 'Gonglase', while the trees are called 'Tebeldi' (Gebauer *et al*., 2002). The powder of the fruit can be dissolved or soaked in water and used as a drink making Tabaldi juice.

The Sudan baobab fruit is described by Hankey (2004) as follows: fruit is large, egg-shaped cap-

Baobab is called "Fruit of Africa's Tree of Life" because its leaves, bark, roots, pulp and seeds are used for multiple medicinal purposes in many parts of Africa and have been found to show interesting medicinal properties including antioxidant, prebiotic-like activity, anti-inflammatory, analgesic, antipyretic activity, anti-diarrhea, anti-dysentery activity.

Baobab's green, prickly, velvet-like coating transforms into a smooth, brown, coconut-like shell. Inside its hard casing (usually a hammer is used to crack it open), is the dry whitish pulp of the fruit which contains no moisture whatsoever. It is simply harvested and sieved to produce a 100% natural and organic powder that is exceptionally nutrient-rich, with an equally impressive range of benefits.

The pulp (powder) can be dissolved in water or milk. The liquid is then used as a drink and sauce for food, a fermenting agent in local brewing, or as a substitute for cream of tartar in baking. The pulp is either sucked or made into a drink and has been found to be acidic. The seeds are removed and ground into a powder that can be added to food products, (Figure 4).

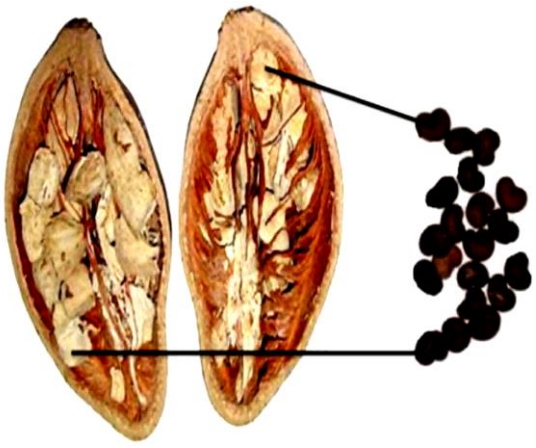

Figure 4: Fruit and seeds of *Adansonia digitata* (Rahul *et al*., 2015).

Kehlenbeck *et al*. (2015) reported that the naturally dry, whitish fruit pulp is high in sugars, vitamin C and minerals, such as calcium, magnesium and iron.

De Caluwé et *al.* (2010) noted that Baobab leaves are superior in nutritional quality to fruit pulp, and contain significant levels of vitamin A. The world agro forestry website has reported that baobab is high in minerals, such as calcium, magnesium and iron.

Previously published biochemical analyses reveal that the leaves, seeds and pulp from baobab are rich in nutrients with some variations between different baobab trees (Becker, 1983; Glew, Vander, Lockett, Grivetti., Smith, Pastuszyn& Millson, 1997; Diop *et al*., 2005; Nkafamiya, Osemeahon, Dahiru, and Umaru, 2007; Chadare *et al*., 2009; Sidibé & Williams, 2002; De Caluwé *et al*., 2010).

The fruit pulp contains a high amount of carbohydrate, low protein, and extremely low fat, and Baobab fruit pulp is a rich source of calcium (Osman, 2004). According to Murray, Schoeninger, Bunn, Pickering, & Marlett, 2001, Baobab fruit contains sugars but no starch and is rich in pectin. The simple sugars in baobab pulp account for about 35.6% of the total carbohydrate content. The low water content, strong acidity and high sugar content was confirmed by Cisse, Sakho, Dornier, Diop, Reynes and Sock (2009). The pulp is acidic, due to the presence of the organic acids citric, tartaric, malic, succinic and ascorbic, with pH 3.3 (Nour *et al*., 1980). Baobab fruit pulp supplies a quantity of soluble (22.54% dry weight) and insoluble (22.04% dry weight) fibres (Manfredini, Vertuani, & Buzzoni, 2002).

In Sudan, the seed was found to contain 19% oil, and further studies in Nigeria reported the pres-

down tree" (since its bare branches look like roots) and "Cream of tartar tree" (due to the acidic taste of its fruits) (Sidibé & Williams, 2002).

The baobab has been referred to as "arbre a palabre", meaning the place in the village where the elders meet to resolve problems (Kamatou *et al.*, 2011). It has also been referred to as a small pharmacy or chemist'stree, as many authors have reported that all parts of the baobab plant are valuable (Gebauer *et al*., 2002; De Caluwé *et al*., 2010).

However, most scientists believe that the vernacular name "baobab" derived from the Arabic name buhibab بو حِباب (būḥibāb), meaning "fruit with many seeds" (Diop *et al*., 2005) or "father of many seeds" (Ajayi, Dawodi, & Oderinde, 2003) (Figure 2). The common names of the African baobab in the United Arab Republic are: Buhibab, hamao-hamaraya and gangoleis (Sidibé & Williams, 2002).

Rahul, Manish, Shishu, Rakesh, Anuradha, Aliya, Anup Kumar, & Sujeet (2015) mentioned different common names of baobab in different languages, and suggested that the scientific name "*digitata*" may refer to the digits of the hand.

Figure 2: Baobab seeds (Ajayi *et al*., 2003).

4. BAOBAB USES AND NUTRITIONAL VALUE

The large egg-shaped fruit capsule is covered with velvety hairs that can reach 12 cm (Wickens, 1982). It is composed of an outer shell (epicarp) (45%), fruit pulp (15%) and seeds (40%) (Shukla, Dubey, Jainand, & Kumar, 2001). The woody epicarp or pod contains the internal fruit pulp (endocarp) which is split in small floury, dehydrated and powdery slides that enclose multiple seeds and filaments; the red fibres subdivide the pulp in segments (Nour, Magboul, & Kheiri, 1980; Besco, Bracioli, Vertuani, Ziosi, Brazzo, Bruni, Sacchetti, & Manfredini, 2007), (Figure 3).

Figure 3: Baobab fruit (De Caluwé *et al*., 2010).

Baobab fruits are wild edible fruits that hold great potential for improving human diets, especially in agricultural societies of the developing world. The fruit pulp is of high nutritional value, especially regarding calcium and vitamin C, it has pre-biotic and antioxidant functions and high dietary fiber content (Gebauer *et al*., 2002).

Figure 1: Tabaldi (Baobab) tree (Seeds for Africa, 2018).

1982). Baobab is little-known elsewhere outside Africa (National Research Council, 2006).

Many populations of Africa use baobab as a source of food, medicine and other uses,such as the use of the fibers. Most of baobab products (e.g. fruits, seeds, leaves, bark) contribute to the livelihood of these populations (Wickens, 1982; Sidibé & Williams, 2002; Chadare *et al*., 2009; De Caluwé, Halamová, & Van Damme, 2010). They have traditionally been used as immunostimulants, anti-inflammatory agents; analgesics, insect repellents and their pesticidal properties have also been used in the treatment of diarrhea and dysentery and have been evaluated as a substitute for imported western drugs (El-Rawy, Gergis, Bazaid, & El-Mougy, 1997; Ramadan, Harraz, & El-Mougy, 1994). Therefore, the Baobab is a multipurpose and majestic tree revered in Africa for its medicinal and nutritional value, with its fruits and leaves being the most important for food and nutrition security of local communities.

In recent years, the European Commission has considered the baobab fruit pulp as a novel food, and permits its importation to Europe (Buchmann *et al*., 2010; Addy, 2009). Baobab fruit was certified and generally recognized as safe (GRAS) by the U.S. Food and Drug Administration in 2009 (Rdnld, 2018).

Sudan is a country located in East Africa. In Sudan, different baobab populations are found in Kordofanand parts of the Nuba Mountainsin southern- west Sudan, comprsing Kordofan, Darfur, Blue Nile, Upper Nile and Bahr El Ghazal (Gurashi, Kordofani, Abdelgadir, & Salih (2016). Baobab is the third most abundant (16%) indigenous fruit tree species (Wiehle, Prinz, Kehlenbeck, Goenster, Mohamed, Finkeldey, Buerkert, & Gebauer, 2015), and it is of particular importance for local food and nutrition security of the local communities.

3. NAMES OF BAOBAB

Baobab has several indigenous names depending on geographical location, such as “Tree of life” “magic tree”, “chemist tree”, “symbol of the earth”, “upside-down tree”, and “monkey bread of Africa” (Wickens, 1982; Diop, Saho, Dornier, Cisse, & Reynes, 2005; Vermaak, Kamatou, Komane-Mofokeng, Viljoen, & Beckett, 2011; Hills, 2008). Africa’s wooden elephant (Gebauer *et al*., 2002). It is also known as “Dead-rat tree” (based on the appearance of the fruits), "Upside-

1. INTRODUCTION

Baobab is the common name (in English and French) of a genus of *Adansonia*. Baobab (*Adansonia digitata* L.) plant trees belonging to the Malvaceae family (Baum, 1995). The baobabs are comprised of many species; the ninth species was described in 2012, and is found in the upland populations of southern and eastern Africa (Pettigrew, Bell, Bhagwandin, Grinan, Jillan, Meyer, Wabuyele, & Vickers, 2012). The Baobab trees are culturally and religiously important in many areas. The naturally hollow or excavated trunks of these trees often serve as water reserves or temporary shelters and have even been used as prisons, burial sites, and stables (Petruzzello, 2018). The Zambezi tribes believe that when the Gods became angry, they uprooted the tree and threw it back into the ground upside-down (or they threw it over the wall of Paradise onto the earth below) but the tree landed upside down and continued to grow because baobabs were upright and too proud, and they are still growing in the Gods' garden, However, an Arabian legend has it that "the devil plucked up the baobab, thrust its branches into the earth, and left its roots in the air". The African Bushman legend states that Thora Evil spirits will cause bad luck to anyone who picks up the sweet white flowers of the tree; more specifically, a lion will kill them. The history of known references to African baobab is well documented (Baum, 1995; Wickens, 2008).

This study covers the published literature on the baobab tree and fruits, concentrating on those researches conducted in Sudan and Africa, organized in parts, beginning with an introduction, then a part about the baobab tree, names, uses and nutritional value, with special emphases on Sudanese baobab. The study discusses the composition of baobab fruits and illustrates with photos of the tree and fruits. The main objective of the study is to provide a comprehensive and well-organized profiling information about a famous fruit regularly used worldwide and particularly in Sudan, i.e., the baobab, which is also called Tabaldi and Gongulaze in Sudan.

2. BAOBAB TREES

Baobab trees (Figure 1) are the largest in the world, having a diameter of up to 12 m and a height of about 23 m or more (Wickens, 1982; Chadare, Linnemann, Hounhouigan, Nout, & Van Boekel, 2009). Several studies in different African countries have highlighted baobab as an indigenous fruit tree and a species of priority for domestication (used as food and home building) beside various expanded uses (Gebauer, El-Siddig, & Ebert, 2002).

Baobab is indigenous to the hot and dry regions of the semi-arid and sub-humid zones of tropical Africa (FAO, 2005). It is found in countries of western Africa (e.g. Senegal, and Niger), southern African countries, such as Namibia and South Africa, and also in eastern African countries (e.g. Sudan, Ethiopia, Kenya, Tanzania) (Stapleton, 2015; Buchmann, Prehsler, Hartl, & Vogl, 2010).

Baobab fruit is wildly harvested; it is collect from its natural environment. It is the only fruit in the world that dries naturally on the branch, baking in the sun for 6 months (Gebauer *et al*., 2002).

Baobab is a traditional food plant and considered in African culture as a physically majestic tree (Kamatou, Vermaak, & Viljoen, 2011). African baobab is associated with the savannah, especially the drier parts of Africa, and occurs naturally in traditional agroforestry systems (Wickens,

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بحث مرجعي

أشجار الباوباب الاستوائية بالسودان

نهى محمد الحسن ساتي[1*]

(قدم للنشر في 1439/11/17هـ؛ وقبل للنشر في 1440/02/10هـ)

مُلخَّص الدِّراسة: أشجار الباوباب هي الأكثر انتشارًا في جميع أنحاء المناطق الحارة والجافة لأفريقيا الاستوائية، حيث تسيطر على المناظر الطبيعية. ويطلق عليها "ثمار أفريقيا وشجرة الحياة"، لأنها واحدة من أكبر الأشجار في هذه المناطق، ويمكنها تخزين كمية كبيرة من المياه في جذوعها. كما تستخدم أوراقها ولحاؤها وجذورها ولبها وبذورها في أغراض طبية متعددة، فهي تحوي مضادات أكسدة ونشاطًا شبيهاً بالمضادات الحيوية ومضادات التهابية ومسكنات وخافض للحرارة ومضاد للإسهال ومضاد للدسنتاريا. فواكه الباوباب تستخدم كغذاء أو عصير مشروب، وللباوباب قيمة غذائية عالية من حيث البروتين، ومحتويات الكربوهيدرات، كما أنها تحتوي على المعادن مثل الكالسيوم والمغنيسيوم والبوتاسيوم والفوسفور والصوديوم وهو مصدر جيد لفيتامين C. و يهدف هذا المقال إلى إلقاء الضوء على الأدبيات حول باوباب، خاصة من السودان. أشجار باوباب معروفة جيدا في السودان بالأسماء المحلية (القنقليز والتبلدي).

الكلمات المفتاحية: الباوباب، تبلدي، قنقليز، ادنوسينا، قيمة غذائية.

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Review Article

Sudanese Baobab (*Adansonia digitata*)

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(Received 30/07/2018; accepted 21/10/2018)

Abstract: The baobab tree is widespread throughout the hot, drier regions of tropical Africa, where it dominates the landscape and reveals the presence of a watercourse from afar. The baobab fruit is referred to as "The fruit of Africa's Tree of Life" because it is one of the biggest trees in the continent and can store huge amounts of water and its trunk. Baobab leaves, bark, roots, pulp and seeds are used for multiple medicinal purposes, such as antioxidant, anti-inflammatory, analgesic, antipyretic, anti-diarrhea, anti-dysentery. The baobab fruit is used as food or drinking juice; baobab pulp has a high nutritive value in terms of protein and carbohydrate contents and also contains minerals, such as calcium, magnesium, potassium, phosphorus, sodium, and it is a good source of vitamin C. This article aims to shed light on the baobab literature, particularly baobab from Sudan. Baobab trees are well known in Sudan by the local names of Gongulaze and Tabaldi.

Keywords: Baobab, Gongulaze, Tabaldi, *Adansonia digitata*, Nutritive value.

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7. CONCLUSION

A double acceptance sampling plan based on a truncated life test is proposed to make a decision for rejecting or accepting of the lot. It is supposed that the life time of the product follows a Quasi Lindley distribution. Tables of minimum sample sizes of the first and second samples are obtained. The operating characteristic values and minimum ratios of the mean life to the specified life are presented. It turns out that that the sample sizes decrease as the experiment time increases. The suggested sampling plan is recommended for researchers.

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Table 4: Producer's risk with respect to time of experiment for double acceptance sampling based on QL Distribution for $c_1 = 0$ and $c_2 = 2$

P^*	t / μ_o	n_1	n_2	μ/μ_0					
				2	**4**	**6**	**8**	**10**	**12**
0.75	0.628	3	6	0.328472	0.083012	0.031374	0.014968	0.008254	0.005019
	0.942	2	4	0.307742	0.074470	0.027638	0.013056	0.007155	0.004333
	1.257	2	3	0.373341	0.095152	0.035894	0.017088	0.009407	0.005713
	1.571	1	3	0.284337	0.067359	0.024744	0.011619	0.006342	0.003830
	2.356	1	2	0.318952	0.076587	0.028151	0.013205	0.007200	0.004343
	3.141	1	2	0.494571	0.145960	0.057804	0.028143	0.015687	0.009602
	3.927	1	2	0.643611	0.229289	0.097730	0.049397	0.028157	0.017491
	4.712	1	2	0.757337	0.318952	0.145993	0.076587	0.044646	0.028151
0.90	0.628	4	8	0.508354	0.161067	0.066450	0.033190	0.018824	0.011667
	0.942	3	5	0.518032	0.160224	0.065229	0.032327	0.018241	0.011266
	1.257	2	4	0.479015	0.141455	0.056477	0.027694	0.015523	0.009543
	1.571	2	4	0.625564	0.221525	0.094943	0.048297	0.027683	0.017275
	2.356	1	3	0.521013	0.164713	0.067325	0.033373	0.018819	0.011612
	3.141	1	2	0.494571	0.145960	0.057804	0.028143	0.015687	0.009602
	3.927	1	2	0.643611	0.229289	0.097730	0.049397	0.028157	0.017491
	4.712	1	2	0.757337	0.318952	0.145993	0.076587	0.044646	0.028151
0.95	0.628	6	9	0.693561	0.273367	0.123294	0.064562	0.037698	0.023831
	0.942	4	6	0.685437	0.262848	0.116805	0.060634	0.035205	0.022166
	1.257	3	5	0.706090	0.278756	0.125228	0.065351	0.038061	0.024012
	1.571	2	4	0.625564	0.221525	0.094943	0.048297	0.027683	0.017275
	2.356	2	3	0.782053	0.335529	0.155056	0.081958	0.048066	0.030455
	3.141	1	3	0.701483	0.284180	0.128711	0.067308	0.039207	0.024724
	3.927	1	2	0.643611	0.229289	0.09773	0.049397	0.028157	0.017491
	4.712	1	2	0.757337	0.318952	0.145993	0.076587	0.044646	0.028151
0.99	0.628	8	12	0.848243	0.438424	0.224845	0.126395	0.077168	0.050292
	0.942	6	8	0.879217	0.473531	0.246798	0.139839	0.085770	0.056065
	1.257	4	6	0.844869	0.422014	0.211317	0.117007	0.070712	0.045750
	1.571	3	5	0.829351	0.402201	0.198242	0.108753	0.065327	0.042086
	2.356	2	4	0.853011	0.437623	0.221436	0.123120	0.074544	0.048272
	3.141	2	3	0.913144	0.516901	0.272893	0.155021	0.095048	0.062055
	3.927	2	3	0.967434	0.668676	0.398035	0.242205	0.155084	0.104290
	4.712	1	3	0.891365	0.521013	0.284232	0.164713	0.102261	0.067325

6. MINIMUM MEAN RATIOS TO THE SPECIFIED LIFE AND PRODUCER'S RISK

The producer's risk is known as the probability of rejection of a good lot $(\sigma \geq \sigma_0)$. Based on the suggested DASP and for a given value of the producer's risk β, we aim to find the minimum quality level of σ/σ_0 that will ensure the producer's risk to be at most β. Thus, σ/σ_0 is the smallest positive number for which $p = F(t;\sigma) = F\left(\frac{t}{\sigma_0}.\frac{\sigma_0}{\sigma}\right)$ satisfies the inequality

$$\sum_{i=0}^{c_1}\binom{n_1}{i}p^i(1-p)^{n_1-i} + \sum_{j=c_1+1}^{c_2}\binom{n_1}{i}p^i(1-p)^{n_1-i}\left[\sum_{i=0}^{c_2-j}\binom{n_2}{j}p^j(1-p)^{n_2-j}\right] \geq 1-\beta \quad (7)$$

For the proposed acceptance sampling plan $(n_1, n_2, c_1 = 0, c_2 = 2, t/\mu_o)$ at a specified consumer's confidence level P^*, the smallest values of μ/μ_0 satisfying (7) are summarized in Table (4).

Assume that the researcher wants to ensure that the true mean life is at least 1000 hours with confidence level 0.90 with $c_1 = 0$ and $c_2 = 2$ when the sample sizes are $n_1 = 4$ and $n_2 = 8$. The lot is accepted if during 628 hours no failure is noted in a sample of size 4. From Table 2, the probability of acceptance of the lot based on the proposed DASP for these measurement is 0.933550 when the ratio of unknown mean life to specified life is 4, while it is 0.988333 when the ratio is 12.

The Producer's risk with respect to time of experiment for double acceptance sampling based on Quasi Lindley Distribution for $c_1 = 0$ and $c_2 = 2$ are reported in Table 4 for $P^* = 0.75$, 0.90, 0.95, 0.99. Based on Table 3, when $\mu/\mu_0 = 6$, that is if unknown average life is six times of specified average life, when the time of the experiment is 628 hours, the producer's risk is 0.19316 for $P^* = 0.99$. Based on Tables 1 and 2, it is clear that the minimum sample sizes of the first sample are less than the minimum sampling sizes obtained from the second sample. Also, the quality level of the product increases, the producer's risk decreases.

Table 3: Minimum ratio of μ/μ_0 for the acceptability of a lot with producer's risk of 0.05.

P^*	**0.628**	**0.942**	**1.257**	**1.571**	**2.356**	**3.141**	**3.927**	**4.712**
0.75	14.230	14.060	18.761	11.273	16.905	22.537	28.177	33.810
0.90	22.975	25.633	22.414	28.013	19.834	26.443	33.060	39.668
0.95	38.236	37.997	37.785	31.069	46.593	29.741	37.184	44.616
0.99	59.596	66.763	59.092	55.103	54.506	72.666	90.850	51.742

Table 2: OC values of the sampling plan $(n_1, n_2, c_1, c_2, t/\sigma_o)$ for a given P^* under the QL distribution with $\alpha = 2$

P^*	t/μ_0	n_1	n_2	μ/μ_0					
				2	**4**	**6**	**8**	**10**	**12**
0.75	0.628	3	6	0.671528	0.916988	0.968626	0.985032	0.991746	0.994981
	0.942	2	4	0.692258	0.92553	0.972362	0.986944	0.992845	0.995667
	1.257	2	3	0.626659	0.904848	0.964106	0.982912	0.990593	0.994287
	1.571	1	3	0.715663	0.932641	0.975256	0.988381	0.993658	0.996170
	2.356	1	2	0.681048	0.923413	0.971849	0.986795	0.992800	0.995657
	3.141	1	2	0.505429	0.854040	0.942196	0.971857	0.984313	0.990398
	3.927	1	2	0.356389	0.770711	0.902270	0.950603	0.971843	0.982509
	4.712	1	2	0.242663	0.681048	0.854007	0.923413	0.955354	0.971849
0.9	0.628	4	8	0.491646	0.838933	0.933550	0.966810	0.981176	0.988333
	0.942	3	5	0.481968	0.839776	0.934771	0.967673	0.981759	0.988734
	1.257	2	4	0.520985	0.858545	0.943523	0.972306	0.984477	0.990457
	1.571	2	4	0.374436	0.778475	0.905057	0.951703	0.972317	0.982725
	2.356	1	3	0.478987	0.835287	0.932675	0.966627	0.981181	0.988388
	3.141	1	2	0.505429	0.854040	0.942196	0.971857	0.984313	0.990398
	3.927	1	2	0.356389	0.770711	0.902270	0.950603	0.971843	0.982509
	4.712	1	2	0.242663	0.681048	0.854007	0.923413	0.955354	0.971849
0.95	0.628	6	9	0.306439	0.726633	0.876706	0.935438	0.962302	0.976169
	0.942	4	6	0.314563	0.737152	0.883195	0.939366	0.964795	0.977834
	1.257	3	5	0.293910	0.721244	0.874772	0.934649	0.961939	0.975988
	1.571	2	4	0.374436	0.778475	0.905057	0.951703	0.972317	0.982725
	2.356	2	3	0.217947	0.664471	0.844944	0.918042	0.951934	0.969545
	3.141	1	3	0.298517	0.71582	0.871289	0.932692	0.960793	0.975276
	3.927	1	2	0.356389	0.770711	0.90227	0.950603	0.971843	0.982509
	4.712	1	2	0.242663	0.681048	0.854007	0.923413	0.955354	0.971849
0.99	0.628	8	12	0.151757	0.561576	0.775155	0.873605	0.922832	0.949708
	0.942	6	8	0.120783	0.526469	0.753202	0.860161	0.914230	0.943935
	1.257	4	6	0.155131	0.577986	0.788683	0.882993	0.929288	0.954250
	1.571	3	5	0.170649	0.597799	0.801758	0.891247	0.934673	0.957914
	2.356	2	4	0.146989	0.562377	0.778564	0.876880	0.925456	0.951728
	3.141	2	3	0.086856	0.483099	0.727107	0.844979	0.904952	0.937945
	3.927	2	3	0.032566	0.331324	0.601965	0.757795	0.844916	0.895710
	4.712	1	3	0.108635	0.478987	0.715768	0.835287	0.897739	0.932675

Table 1: OC values of the sampling plan $\left(n_1, c_1 = 0, t/\mu_0\right)$ for a given P^* under the QL distribution with $\alpha = 2$.

P^*	t/μ_0	n_1	μ/μ_0					
			2	**4**	**6**	**8**	**10**	**12**
0.75	0.628	3	0.421437	0.653347	0.754078	0.809679	0.844835	0.869050
	0.942	2	0.416503	0.651217	0.752944	0.808981	0.844364	0.868711
	1.257	2	0.306260	0.561846	0.683444	0.752771	0.797338	0.828346
	1.571	1	0.473366	0.695742	0.787393	0.836812	0.867644	0.888696
	2.356	1	0.316757	0.575330	0.695797	0.763637	0.806905	0.836844
	3.141	1	0.209182	0.473484	0.613350	0.695825	0.749670	0.787454
	3.927	1	0.136608	0.387939	0.539380	0.633084	0.695775	0.740418
	4.712	1	0.088487	0.316757	0.473445	0.57533	0.645246	0.695797
0.9	0.628	4	0.315968	0.566924	0.686365	0.754658	0.798661	0.829328
	0.942	3	0.268799	0.525519	0.653347	0.727624	0.775880	0.809679
	1.257	2	0.306260	0.561846	0.683444	0.752771	0.797338	0.828346
	1.571	2	0.224075	0.484057	0.619987	0.700254	0.752806	0.789780
	2.356	1	0.316757	0.575330	0.695797	0.763637	0.806905	0.836844
	3.141	1	0.209182	0.473484	0.613350	0.695825	0.749670	0.787454
	3.927	1	0.136608	0.387939	0.539380	0.633084	0.695775	0.740418
	4.712	1	0.088487	0.316757	0.473445	0.575330	0.645246	0.695797
0.95	0.628	6	0.177609	0.426862	0.568633	0.655580	0.713746	0.755248
	0.942	4	0.173475	0.424083	0.566924	0.654450	0.712950	0.754658
	1.257	3	0.169486	0.421139	0.565007	0.653122	0.711974	0.753907
	1.571	2	0.224075	0.484057	0.619987	0.700254	0.752806	0.789780
	2.356	2	0.100335	0.331005	0.484134	0.583142	0.651096	0.700308
	3.141	1	0.209182	0.473484	0.613350	0.695825	0.749670	0.787454
	3.927	1	0.136608	0.387939	0.539380	0.633084	0.695775	0.740418
	4.712	1	0.088487	0.316757	0.473445	0.575330	0.645246	0.695797
0.99	0.628	8	0.099836	0.321403	0.471096	0.569509	0.637860	0.687785
	0.942	6	0.072253	0.276170	0.426862	0.529437	0.601989	0.655580
	1.257	4	0.093795	0.315670	0.467095	0.566664	0.635748	0.686157
	1.571	3	0.106069	0.336778	0.488173	0.585981	0.653167	0.701875
	2.356	2	0.100335	0.331005	0.484134	0.583142	0.651096	0.700308
	3.141	2	0.043757	0.224187	0.376198	0.484172	0.562005	0.620084
	3.927	2	0.018662	0.150497	0.290930	0.400795	0.484103	0.548219
	4.712	1	0.088487	0.316757	0.473445	0.575330	0.645246	0.695797

are observed from the two samples, i.e., $n_1 + n_2$, accept the lot. Otherwise, the lot is rejected.

Based on the above procedure, the DASP consists of the parameters n_1; c_1; n_2 *and* c_2, and due to these parameters, the probability of acceptance $L(p_1)$ and $L(p_2)$ for the sampling plans $\left(n_1, c_1, \frac{t}{\sigma_0}\right)$ and $\left(n_2, c_2, \frac{t}{\sigma_0}\right)$ can be calculated under the assumption that the lot is large enough to use the Binomial probability distribution respectively, as

$$L(p_1) = \sum_{z=0}^{c_1=0} \binom{n_1}{z} p^z (1-p)^{n_1 - z} \qquad (4)$$

$$L(p_2) = \sum_{y=0}^{c_2=2} \binom{n_2}{y} p^y (1-p)^{n_2 - y} \qquad (5)$$

Where;

$p = F(t;\mu) = F\left(\frac{t}{\mu_0}.\frac{\mu_0}{\mu}\right)$ is given in (1).

Then the probability of acceptance in general will be

$$F(z;\alpha,\delta) = 1 - \frac{1+\alpha+\delta z}{\alpha+1} e^{-\delta z}, \quad \text{if } z>0, \delta>0, \alpha>-1, \qquad (6)$$

We considered the case of $c_1 = 0$ and $c_2 = 2$, then the probability of acceptance is the total of three different probabilities where

$P(A) = P$(no failure occurs in sample 1) + P(1 failure occurs in sample 1 and 0 or 1 failure occurs in sample 2) + P(2 failures occur in sample 1 and 0 or 1 failure occurs in sample 2).

In this paper, values of the probability of acceptance for the new DASP are obtained at $P^* = 0.75,\ 0.90,\ 0.95,\ 0.99$ for $t/\sigma_o = 0.628,$ 0.942, 1.257, 1.571, 2.356, 3.141, 3.927, 4.712 with $\alpha = 2$ and δ =2 are presented in Table 4. The same choices are consistent with that of Gupta (1962), Gupta & Groll (1961), Balakrishnan, Leiva, & Lopezet (2007), Kantam, Rosaiah & Rao (2001), Al-Nasser & Al-Omari (2013), Al-Omari, Al-Nasser & Gogah (2016), Al-Nasser & Gogah (2017); & Baklizi, El Masri & Al-Nasser (2005).

5. OPERATING CHARACTERISTIC FUNCTION

The operating characteristic function (OC) is an important tool in the acceptance sampling plans because it gives the probability of accepting a lot. The OC measures the efficiency of a statistical hypothesis test in order to accept or reject a lot. The researchers prefer the sampling plan if its OC increase more sharply to one. The probability of accepting for the first sample using Quasi Lindley distribution with $\alpha = 2$ and δ =0.5 is placed in Table 1, while the results of the proposed DASP is provided in Table 2. Table 3 gives the values of the operating characteristic for the suggested DASP for the Quasi Lindley distribution. It is noted that the OC values increase to one relative to σ/σ_0. The high probability based on the proposed DASP is noted for $\sigma/\sigma_0 \geq 8$.

and

$$f(z;\alpha,\delta)=\frac{\delta\alpha+\delta^2 z}{\alpha+1}e^{-\delta z},\quad \text{if } z>0,\delta>0,\alpha>-1. \tag{2}$$

The QL distribution is positively skewed. The Figures (1) and (2) describe the CDF and PDF of the QL distribution for different values of the distribution parameters, respectively.

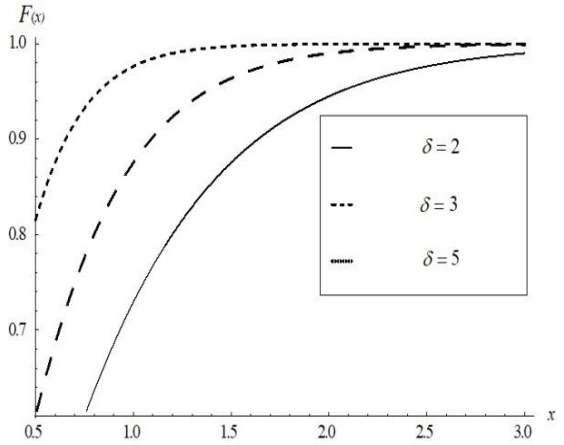

Figure 1: The CDF of the QL distribution $\alpha=1$, and $\delta=2,3,5$

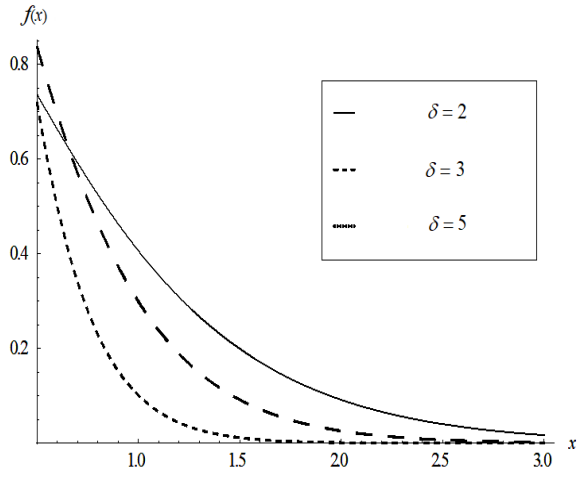

Figure 2: The pdf of the QL distribution with $\alpha=1$, and $\delta=2,3,5$

Also, the wth moment about origin is defined as;

$$E\left(Z^w\right)=\frac{\alpha+w+1}{\delta^w\alpha+\delta^w}\Gamma(w+1),\quad w=1,2,3,..., \tag{3}$$

The kurtosis, hazard rate functions, mode, and mean residual life of the QL distribution respectively, are defined as

$$Ku=\frac{3\left(3\alpha^4+24\alpha^3+44\alpha^2+32\alpha+8\right)}{\left(\alpha^2+4\alpha+2\right)^2},$$

$$h(z)=\frac{\delta\alpha+\delta^2 z}{1+\alpha+\delta z},\ Mode=\frac{1-\alpha}{\delta},\ |\alpha|<1,$$

and

$$m(z)=\frac{2+\alpha+\delta z}{\delta+\alpha\delta+\delta^2 z}.$$

The method of moments estimator of δ in the QL distribution is $\hat{\delta}=\left(\frac{\alpha+2}{\alpha+1}\right)\frac{1}{\bar{Z}}$, see Shanker & Mishra (2013) for more details.

4. PROCEDURE FOR DASP with QL DISTRIBUTION

The DASP based on truncated life time and can be described as follows:

1. Select a first random sample of size n_1 and test it during time t_0. If there are c_1 or fewer failures, accept the lot. If c_2+1 failures are observed, stop the test and reject the lot; i.e., $c_1<c_2$.
2. If the number of failures by t_0 is between c_1+1 and c_2, then draw a second sample of size n_2 and then test the selected items during another time t_0. If at most c_2 failures

1. INTRODUCTION

Acceptance sampling planning is a substantial field of statistical quality control. The quality level of products is very important for the produces and consumer. Since the screening of products is impossible and infeasible due to the cost and time, a decision about the product can be made based on a selected sample from the lot. This paper suggests a double acceptance sampling plan (DASP) based on truncated life tests when the lifetime of a product follows the Quasi Lindley distribution. The DASP is used to reduce the sample size or producer's risk in the field of quality control. DASP should be used if the decision cannot be taken based on the first sample. Therefore, a second sample should be selected from the lot to make a decision. See, e.g. Duncan (1986). The main idea of this article is to use a new reliability distribution namely quasi Lindley distribution to develop a new double acceptance sampling plan. One can refer to Khan and Islam (2012) for more details on using quasi distributions in an acceptance sampling context.

This paper is organized as follows: the acceptance sampling plan in Section 2, the quasi Lindley distribution is discussed in Section 3. The procedure for double acceptance sampling plan is presented in Section 4. The operating characteristic function and its properties are presented in Section 5. The minimum ratios to the specified are provided in Section 6. The conclusions are summarized in Section 7.

2. ACCEPTANCE SAMPLING PLANS

Acceptance sampling plans based on truncated life tests have been investigated by many authors. Sobel & Tischendrof (1959) who considered the life test based on the exponential distribution. A single acceptance sampling plan based on different life time distribution are considered by many researchers, for example the Gompertz distribution is investigated by Gui & Zhang (2014), and Al-Omari (2014) suggested a single acceptance sampling plan based on three parameter kappa distribution. Al-Nasser and Al-Omari (2013) proposed an acceptance sampling plan in truncated life tests for the exponentiated Fréchet distribution. Al-Omari (2015) considered the time truncated acceptance sampling plans using the generalized inverted exponential distribution. Moreover, several authors considered the double acceptance sampling plan (DASP) in their research. Aslam (2005) suggested a double acceptance sampling plan based on truncated life tests in a Rayleigh distribution. Aslam & Jun (2010) studied the generalized log-logistic distribution in double acceptance sampling plan. Rao (2011) proposed DASP based on truncated life tests for the Marshall–Olkin extended exponential distribution. Ramaswamy & Anburajan (2012) suggested a double acceptance sampling plan in truncated life tests using generalized exponential distribution. A double acceptance sampling plan for the Maxwell distribution with truncated life tests was suggested by Gui (2014).

3. QUASI LINDLEY DISTRIBUTION

The cumulative distribution function (CDF) and probability density function (PDF) of the two-parameter Quasi Lindley (*QL*) distribution are defined as

$$F(z;\alpha,\delta)=1-\frac{1+\alpha+\delta z}{\alpha+1}e^{-\delta z}, \quad \text{if } z>0,\delta>0,\alpha>-1, \tag{1}$$

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خطة قبول العينات المزدوجة لتوزيع شبه ليندلي

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(قدم للنشر في 1439/05/04هـ؛ وقبل للنشر في 1440/02/27هـ)

مُلخَّص الدِّراسة: يقترح هذا البحث خطة أخذ العينات المزدوجة القبول اختبارات وقت الحياة المقتطعة على افتراض أن عمر المنتج يتبع توزيع شبه ليندلي ذو المعلمتين. بشكل رئيسي تم التحقق من مخطط الفشل الصفري والثنائي. حيث تم في هذا البحث الحصول على الحد الأدنى لحجم العينة المناسب للعينات المزدوجة الاولى والثانية لتوضيح أن متوسط الحياة الحقيقي لم يعد على مستوى ثقة المستهلك المحدد. وتم أيضا في هذه الدراسة حساب قيم الخصائص التشغيلية والنسب الدنيا لمتوسط العمر ومقارنتها مع العمر الثابت الحقيقي للمنتج.

رقم تصنيف الموضوع في الرياضيات (*MSC*): 62D05.

الكلمات المفتاحية: خطة قبول العينات المزدوجة، اختبارات الحياة للوقت المقتطع، توزيع شبه ليندلي، اقتران الخصائص التشغيلية، مخاطر المستهلك.

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A Double Acceptance Sampling Plan for Quasi Lindley Distribution

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Abstract: A Double Acceptance Sampling Plan (DASP) for the truncated life time tests is proposed assuming that the lifetime of a product follows a two-parameter Quasi Lindley (QL) distribution. The zero and two failure schemes are mainly investigated. The minimum sample sizes of the first and second samples are obtained to assert that the true mean life is no longer than the given life at the specified consumer's confidence level. The operating characteristic values and the minimum ratios of the mean life to the fixed life are also studied. The findings are significant in maintaining quality in any industry.

***MSC Number*:** 62D05.

Keywords: Double Acceptance Sampling Plan (DASP), Time truncated life tests, Quasi Lindley distribution, Operating characteristic function, Consumer's risk.

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that there were no irreversible adsorbent sites on the surface of the adsorbent. The results demonstrate that maghemite NPs can be used for the removal of Cr(VI) species over a significant number of cycles, hence their suitability for the design of a continuous process to remove Cr(VI)–bearing wastewaters.

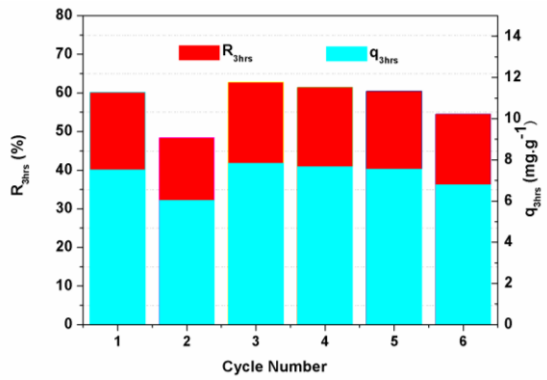

Figure 6: Reusability of the maghemite NPs for adsorption–desorption of Cr(VI) during six cycles. pH: 1.0; Initial concentration of Cr(VI): 100 $mg.L^{-1}$; NPs dose: 8.0 $g.L^{-1}$; Contact time: 3 hrs; Regenerating solution: NaOH 0.5 M.

4. CONCLUSION

The present study provides a clear determination of the effect of a number of physicochemical parameters on the removal efficiency of hexavalent chromium from synthetic wastewaters by maghemite (γ-Fe_2O_3) NPs. The pH parameter was found to be of major influence on the uptake efficiency of Cr(VI). The best removal efficiency was observed in the acidic region around pH 0-1. The effect of the majority of the coexisting ions on the Cr(VI) removal efficiency by the maghemite NPs is negligible, whereas, Pb^{2+}, PO_4^{3-} and SO_4^{3-} were found to compete with Cr(VI). Additionally, it was observed that the NPs can be used for the removal of Cr(VI) species over an important number of cycles. Based on these findings, the study concludes that from a technological point of view, a high removal percentage of Cr(VI) from wastewaters (in particular, for diluted effluents) can be achieved by subsequent treatments whereby the effluent passes in a cascade system of nanoparticles beds appropriately placed in a High Magnetic Gradient Separation system.

ACKNOWLEDGMENT

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dium, an additional phenomenon happens whereby Pb^{2+} cations combine with $HCrO_4^-$ anions in a complete chemical reaction, resulting in the formation of lead chromate as a white precipitate, as follows:

$$Pb^{2+} + HCrO_4^- \rightarrow PbCrO_4 + H^+$$

3.2.4 Effect of Salinity

Figure (5) shows the effect of salinity on the removal of Cr(VI) by γ-Fe_2O_3 NPS s. Increasing salinity from 0 to 5.0 % NaCl (the salinity of seawater is about 3.5%) had no significant effect on the removal of the negatively charged Cr(VI) species. No interaction occurred among NaCl, NPS s and Cr(VI) species, and the chemisorption of Cl^- on the surface of the NPs was much weaker than that of the Cr(VI) species. Similar results have recently reported by other researchers (Liu, Zhaou, & Jiang, 2008).

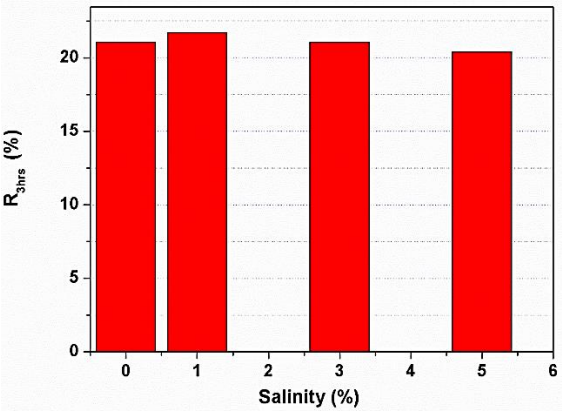

Figure 5: Effect of the salinity on the sorption efficiency of 50 $mg.L^{-1}$ Cr(VI) solution onto 2.0 $g.L^{-1}$ maghemite NPS s.

3.2.5 Reusability of the Nanoadsorbent

Adsorption–desorption–regeneration tests were conducted at pH 1.0 on 10 mL Cr(VI) solution of an initial concentration of 100 $mg.L^{-1}$ and a NPs dosage of 8.0 $g.L^{-1}$. To test the reusability of the nanoadsorbent, the following procedures were followed: (1) First, the NPs were shacked with the Cr(VI) solution for 30 mins. The mixture was then allowed to stand for about 150 mins. Then, the absorbance of the supernatant was measured after decantation with the aid of an NdFeB magnet. (2) In order to remove the adsorbed Cr(VI), the Cr(VI)–loaded NPs were dispersed in excess of 0.5 M NaOH (about 30 mL) and then the mixture was sonicated for 5 mins. Clearly, the supernatant shows the characteristic yellow color of water soluble Cr(VI) entities. (3) The last step was repeated until no detectable Cr(VI) was observed in the washing as confirmed by UV–visible. Here, the nanoadsorbent was first thoroughly washed with ultrapure deionizer water under sonication until the pH of the washed water became neutral. Following this process, it was noticed that the supernatant appeared colorless indicating the particularly high chemical stability of the NPs; otherwise, a red-brick color would have appeared due to the liberation of iron (III) cations (Fe^{3+}) ions in consequence of the partial dissolution of the ferrite NPs. Then, the washed nanoadsorbent was dried at 60 ^oC for 24 hrs. to be re–used for the subsequent adsorption–desorption–regeneration cycle as described above. Six consecutive cycles of adsorption–desorption–regeneration were carried out to validate the reusability of the produced nanoferrite for the removal and recovery of Cr(VI). Figure (6) shows the removal efficiency and quantity of Cr(VI) during six cycles of adsorption–desorption–regeneration.

As can be seen, a good reproducibility of the adsorption capacity (Mean value ≈ 58, SD < 6) in the adsorption capacity of the nanoadsorbent during the six cycles was achieved, which meant

Consequently, 20 mg of NPs were added to a mixture of 5 mL 100 mg.L^{-1} of each ion and 5 mL 100 mg.L^{-1} Cr(VI) and then stirred at pH ~ 1.0 for about 3 hrs. For comparison, a ''without coexisting ions'' preparation was also prepared simultaneously by adding 20 mg of NPs to 10 mL of 50 mg.L^{-1} Cr(VI). Then, each supernatant was separated from the Cr(VI)-loaded NPs using a strong magnet and the UV-vis absorbance of each solution was measured (Figure 3).

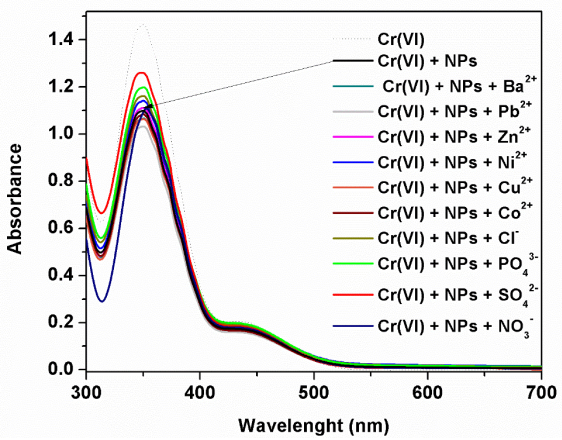

Figure 3: Absorbance spectra of supernatants of a mixture of 50 mg.L^{-1} Cr(VI) solution and 2.0 g.L^{-1} NPs in the presence of a variety of 50 mg.L^{-1} coexisting ions.

The absorbance of the supernatants occurs in both sides of the ''without coexisting ions'' Cr(VI) solution that was treated with the 2.0 g.L^{-1} NPs (denoted as ''Cr(VI) + NPs''). The absorbance of the supernatants in the presence of PO_4^{3-} and SO_4^{2-} ions is higher than that of the supernatant of ''Cr(VI) + NPs''). On the other hand, the absorbance of the supernatant in the presence of Pb^{2+} ions is noticeably lower than the supernatant of ''Cr(VI) + NPs''); the yellowish color of the supernatant appears less intense than that of the ''Cr(VI) + NPs'') preparation and produces a small amount of white precipitates at the bottom of the test tube. The results of Cr(VI) removal and coexisting ions-free supernatant are plotted in Figure (4).

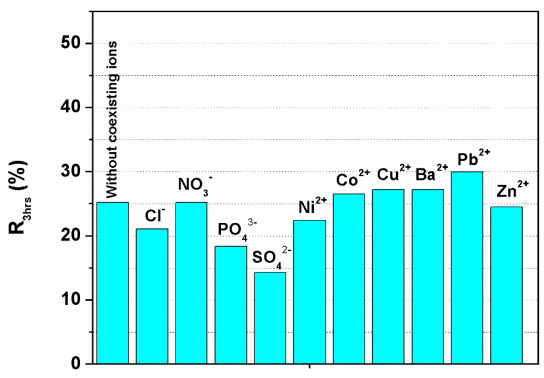

Figure 4: Effect of coexisting ions on the sorption efficiency of 50 mg.L^{-1} Cr(VI) solution onto 4.0 g.L^{-1} NPs in the presence of a variety of 50 mg.L^{-1} coexisting ions.

From the observed results a number of interpretations can be made: (1) The effect of the majority of the coexisting ions (Cl^-, NO_3^-, Ni^{2+}, Co^{2+}, Cu^{2+}, Ba^{2+}, Zn^{2+}) on Cr(VI) removal efficiency by the maghemite NPs is negligible. Their influence doesn't exceed 10% of the removal percentage of Cr(VI) in a ''free coexisting ions'' solution. (2) The effects of phosphate (PO_4^{3-}) and sulfate (SO_4^{2-}) ions noticeable; their effect is negative but with a more pronounced effect in the case of SO_4^{2-} ions. The removal efficiency of Cr(VI) by the NPs is relatively lower than that of the removal efficiency of Cr(VI) in the absence of coexisting ions, which may be attributed to the competition of the highly negatively charged PO_4^{3-} and SO_4^{2-} ions with Cr(VI) species(which in acid pH exist mainly (which in acid pH exist mainly in the form of $HCrO_4^-$) for the binding sites on the positively charged NPs surface. (iii) The apparent effect of lead cations (Pb^{2+}) is opposite to that observed with the PO_4^{3-} and SO_4^{2-} ions; the removal efficiency appeared to be enhanced in the presence of Pb^{2+}. According to (Riege, 1994, p. 177), in an acidic aqueous me-

than those of diatomite, ~11 $mg.g^{-1}$ (Dantas, Neto, & Moura, 2001), anatase, ~14 $mg.g^{-1}$ (Weng, Wang, Huang, 1997), and commercial activated carbon, ~15 $mg.g^{-1}$ (Sandhya & Tonnin, 2004).

3.2.2. Effect of NPs dosage

The effect of an adsorbent dosage was investigated by adding various amounts (1.0-7.0 $g.L^{-1}$) of the NPs to 5 mL of 50 $mg.L^{-1}$ chromium solutions under pH 1.0 at a contact time of 3.0 hrs. The study on the effect of an adsorbent dosage is important to get the trade-off between the adsorbent dosage and the percentage removal of Cr(VI) resulting in an optimum adsorbent amount. Figure (2) illustrates the effect of an adsorbent dosage on the absorbance spectra of Cr(VI) supernatants and the inset depicts the dependence on the NPs dosage of both Cr(VI) removal efficiency and the uptake capacity.

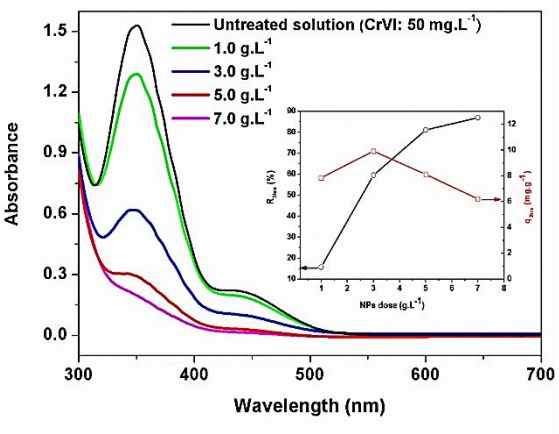

Figure 2: Effect of NPs dosage on sorption efficiency and capacity of a 50 $mg.L^{-1}$ Cr(VI) species on maghemite NPs.

As Figure (2) illustrates, the intensity of the characteristic absorbance band of the Cr(VI) species decreased drastically with the increase in NPs dosage indicating a significant decrease in Cr(VI) concentration. The inset indicates that as the NPs dosage increases, the Cr(VI) removal percentage also increases until it reaches an almost stable level, which may be attributed to the increased number of active sites on the surface of the maghemite NPs as their absorbency increased. An adsorption capacity at 3.0 hrs. of contact is also depicted in the inset. As the dose of the adsorbent increases, the adsorbed Cr(VI) quantity initially increases to reach a maximum of about 10.0 $mg.L^{-1}$ for the NPs dosage of 3.0 $g.L^{-1}$. Subsequently, the adsorbed Cr(VI) capacity decreases in a monotonous manner to reach a value of about 6.0 $mg.g^{-1}$ for the highest NPs dosage (7.0 $g.L^{-1}$). Such a trend in adsorption yield in terms of adsorbate quantity per unit mass of adsorbent may be attributed to the increase of physical inter-particle interactions: the higher the NPs quantity, the higher the physical (van der Waals and magnetic) interactions, and consequently the higher the degree of agglomeration. The increase in the degree of agglomeration implies a decrease in a free specific area per unit mass of NPs and therefore a reduction in active sites per unit mass for Cr(VI) adsorption.

3.2.3. Effect of coexisting ions

Generally, Cr(VI)–bearing wastewaters, such as chrome-plating and leather tannery wastewaters, contain dissolved salts in their corresponding cations and anions. Thus, the presence of other cations may interfere in the removal efficiency of Cr(VI). As previously stated, the objective of this study was to examine the effects of the commonly coexisting anions (Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}) and cations (Pb^{2+}, Ni^{2+}, Ba^{2+}, Co^{2+}, Cu^{2+}) on the removal efficiency of Cr(VI) by maghemite NPs.

2.5 Statistical Analysis

All experiments were performed at least three times (*n=3*) and data were presented as means.

3. RESULTS AND DISCUSSION

3.1 Maghemite Nanoparticles Characterization

The maghemite nanoparticles (γ-Fe_2O_3) were recently characterized in terms of chemical structure, crystal structure, morphology, thermal stability, and magnetic properties (Tahar *et al.*, 2018). TEM analysis revealed the formation of ultra-small NPs with a mean particle size of ~ 15 nm. Additionally, the NPs showed superparamagnetic behavior and reasonable room-temperature saturation magnetization (67 $emu.g^{-1}$ at 300 K).

3.2 Adsorption Study

3.2.1 Effect of pH

The relationship between the initial pH values and the quantities of Cr(VI) ions adsorbed on the nanoadsorbent for three initial Cr(VI) concentrations at a contact time of 3 hrs. are presented in Figure (1).

Based on Figure (1), it is obvious that pH affected the adsorption remarkably. The general trend of both the removal efficiency (R_{3hrs}) and uptake capacity (q_{3hrs}) ~~a~~ decreased with the increase of pH. The maximum removal efficiency for Cr(VI) using maghemite NPs was achieved at about pH 0-1. The result can be interpreted as follows: with the pH increase, the NPs surface became more and more negatively charged by hydroxyl ions (OH^-), which repulsed the negatively charged dichromate ions ($Cr_2O_7^{2-}$), thereby lowering the amount of the adsorbed Cr(VI) onto the surface of the maghemite NPs. Furthermore, it is clear from Figure (1) that the adsorption process was highly dependent on the initial concentration of Cr(VI) solution. Hence, at pH 1.0, the maximum removal percentage observed for the Cr(VI) concentration of 25 $mg.L^{-1}$ was about 70 % while the uptake capacity indicated the opposite trend compared to the removal efficiency by decrease. At pH 1.0 also, the maximum removal percentage for the Cr(VI) concentration of 100 $mg.L^{-1}$ occured at 10 $mg.g^{-1}$. Thereafter, we chose pH 1.0 since, as demonstrated before, at pH values of ~ 0-1 our maghemite NPs displayed the highest Cr(VI) removal efficiency.

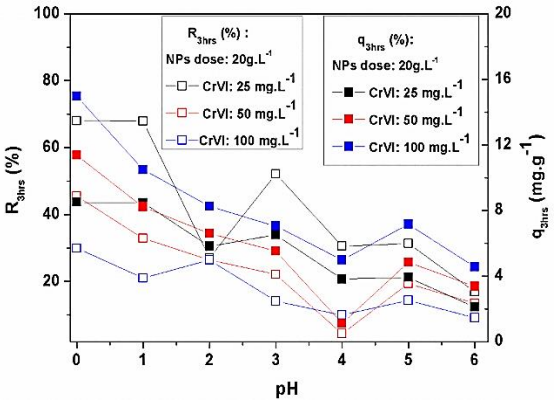

Figure 1: Effect of pH on sorption efficiency (R_{3hrs}) and sorption capacity (q_{3hrs}) of Cr(VI) ions on maghemite NPs, for selected initial Cr(VI) concentrations.

A direct comparison of maghemite NPs with other adsorbents is difficult. However, as can also be seen in Figure (1), due to the different experimental conditions applied, the adsorption capacity of nanoscale maghemite for Cr(VI) using equilibrium experiments at pH of 0-1 and a room temperature of 25°C, was determined as ~17 $mg.g^{-1}$ of maghemite NPs, which is higher

on the Cr(VI) adsorption efficiency that had been arrayed onto the NPs. 100 mg.L^{-1} was also studied. The solutions of selected cations (Cu^{2+}, Pb^{2+},…) and anions (SO_4^{2-}, PO_4^{3-},…) were prepared from their associated salts of chloride and sodium, respectively.

2.2. Synthesis of Maghemite Nanoparticles

Maghemite (γ-Fe_2O_3) NPs were obtained by a moderate calcination of polyol-made magnetite NPs. The last NPs were synthesized starting from the analytical grade precursors $FeCl_2.4H_2O$ and $FeCl_3$ using the diethyleneglycol as a main solvent. Further details on the preparation procedure were recently reported in Tahar *et al.* (2018).

2.3 Adsorption and Recycling Experiments

Adsorption and recycling experiments were carried out at room temperature using a batch equilibrium technique. The mixing of maghemite NPs with Cr(VI) solutions was performed in Pyrex glass test tubes with screw caps. For the proper mixing and dispersing of the NPs in the Cr(VI) solutions, a power Sonic 240 ultrasound device was intermittently used with a vortexing apparatus. After mixing, the NPs were separated from the supernatant using a strong NdFeB magnet (1.2T, 10 cm x 10 cm x 2cm). In order to recover the adsorbed Cr(VI) and regenerate the adsorbent for further use, Cr(VI)–loaded NPs were dispersed in excess of 0.5 M NaOH and the mixture was sonicated for about 5 mins. The liquid phase was then separated by magnetic decantation and the NPs were thoroughly washed with distilled water until a neutral pH. Finally, the NPs were dried in an oven for their successive reuse as adsorbents for Cr(VI).

2.4. Absorbance Experiments

The concentration of Cr(VI) in the experimental solutions was determined colorimetrically using a UV-Visible double-beam spectrophotometer (Jasco V-670) that covered a spectral range from 190 to 800 nm and equipped with 1 cm wide quartz cells. The absorbance of the obtained supernatants was measured in the spectral range 300–700 nm and the concentration of the residual Cr(VI) was determined from the maximum absorbance (λ_{max} = 350 nm) based on pre-plotted calibration curves using standard $K_2Cr_2O_7$ solutions. It is worthy of note that for the study of the influence of the pH, since UV absorbance of Cr(VI) solution is pH dependent, for each pH, a calibration curve was used to determine Cr(VI) concentration in each supernatant. Further, for the study of the influence of the coexisting ions, the absorbance of each supernatant was measured against a 50 mg.L^{-1} solution of the corresponding coexisting ion.

The removal efficiency (R_t) and uptake capacity (q_t) of the Cr(VI) species by maghemite NPs can be calculated through the following equations (Eq.1 & Eq.2), respectively:

$$R_t\,(\%) = \frac{C_0 - C_t}{C_0} x100 \qquad (1)$$

$$q_t = \frac{C_0 - C_t}{m_{NPs}} xV \qquad (2)$$

where C_0 and C_t are the concentrations of Cr(VI) (mg.L^{-1}) before (t = 0) and after t hours of contact with the maghemite NPs respectively, and V is the volume (in Liters) of the Cr(VI) supernatant, and m_{NPs} is the mass (in grams) of NPs sorbent used.

only contains the non-oxidizable Fe(III) ions and, therefore, characterized by a high chemical stability. Tahar, Oueslati, & Abualreish (2018) recently reported the results of their investigation of Cr(VI) removal using two polyol-made magnetite derivatives: a magnetite-rich phase and a pure maghemite phase. At room temperature and a pH set at ~2, the authors observed that the pure maghemite NPs were chemically very stable and possessed reasonable Cr(VI) removal capacity with a very fast kinetics (in particular, in the case of low Cr(VI) concentration) compared to conventional adsorbents, such as activated.

The goal of the current research was to determine the optimum physicochemical conditions that enable improved efficiency of Cr(VI) removal on maghemite NPs when a number of parameters, such as pH, salinity, and NPs dosage, are varied. The influence of specific competitive anions and cations on the removal percentage of Cr(VI) was also explored. For economy of process, regeneration tests of the produced maghemite NPs were conducted.

2. MATERIALS AND METHODS

2.1. Materials

The chemicals used in this no further purification. These were: Iron (II) chloride ($FeCl_2.4H_2O$, 98%, Sigma-Aldrich), anhydrous iron (III) chloride ($FeCl_3$, 97%, Sigma-Aldrich), anhydrous sodium acetate ($NaCH_3CO_2$, 99%, Sigma-Aldrich), potassium dichromate ($K_2Cr_2O_7$, Sigma-Aldrich, ≥ 99%), lead chloride ($PbCl_2$, > 99%, Panreac), barium chloride ($BaCl_2.2H_2O$, > 99%, Loba Chemie, India), cobalt chloride ($CoCl_2.6H_2O$, > 97-101%, Loba Chemie, India), zinc chloride ($ZnCl_2$, > 98 mins. CDH, India), nickel chloride ($NiCl_2.6H_2O$, > 97 mins. %, CDH, India), cupper chloride ($CuCl_2$, > 98 mins. %, Panreac), sodium nitrate ($NaNO_3$, 99%, CDH, India), sodium chloride (NaCl, 99%, CDH, India), trisodium phosphate ($Na_3PO_4.12H_2O$, 97.5%, Fluka), sodium sulfate (Na_2SO_4, 99%, Fluka), sodium hydroxide (NaOH, 99%, Fluka), hydrochloric acid (HCl, 37% w/w, CDH, India), nitric acid (96-72% w/w, CDH, India), diethyleneglycol ($C_4H_{10}O_3$, 99%, Across Organics). All aqueous solutions were prepared with ultra-pure deionizer water and electrical conductivity below 50 $\mu S.cm^{-1}$. Glassware were cleaned with 6M HC l and rinsed with ultra-pure water to remove any contaminants. For adsorption experiments, a Cr(VI) stock solution (1000 $mg.L^{-1}$) was prepared from potassium dichromate. Then, appropriate volumes of the solution were diluted to prepare standard solutions of different Cr(VI) concentrations ranging from 0 to 100 $mg.L^{-1}$. To determine the optimum pH value for the best Cr(VI) removal efficiency of the produced maghemite NPs, Cr(VI) was prepared in HNO_3 solutions that had different concentrations. The pH of each HNO_3 solution was measured using a benchtop pH meter (Hach, Sension), the pH was adjusted to the desired value (1.0–6.0) and the procedure was carried out using either 0.1 mol L^{-1} HCl or 0.1 mol L^{-1} NaOH.

In order to study the influence of NPs dosage at the optimum pH, different amounts (1.0–7.0 $g.L^{-1}$) of the nanoadsorbent were suspended in 5 mL Cr(VI) solutions in which the concentration of chromium was fixed at 50 $mg.L^{-1}$. For the optimum pH, the influence of the salinity (0–5%) on the Cr(VI) uptake efficiency was investigated by adding appropriate amounts of a 100 $mg.L^{-1}$ NaCl stock solution to 100 $mg.L^{-1}$ Cr(VI) solutions. The influence of different coexisting ions

1. INTRODUCTION

Chromium (Cr) is one of the major environmental pollutants emitted by various industrial activities, such as mining, wood treatment, electroplating and leather tannery (Eckenfelder, 2000; Rodríguez, Rangel, González, Zárate, & Juárez, 2015). Cr exists in the environment most prevalently as trivalent (Cr(III)), hexavalent (Cr(VI)) and metallic (Cr(0)). Industrial processes generally produce Cr(VI) and Cr(0); however, the primary sources of Cr(VI) in drinking water are discharges from steel and pulp, and erosion of natural deposits of Cr(III) (Rodríguez, Rangel, González, Zárate, & Juárez, 2015).

There is a great difference between Cr(III) and Cr(VI) with respect to toxicological and environmental properties, and they must always be considered separately. Cr(VI) species are more toxic than Cr(III) types due to their high water-solubility and mobility. The most soluble, mobile and toxic forms of Cr(VI) in soils are chromates (CrO_4^{2-}, $HCrO_4^-$) and dichromates ($Cr_2O_7^{2-}$). It is important to realize that in acidic pH (1.0–6.0), the predominant Cr(VI) species exist mainly in the $HCrO_4^-$ form where they have proved to have varying adverse effects, such as irritation and cancer (Kimbrough, Cohen, Winer, Creelman, & Mabuni, 1999; European Commission DG ENV. E3 Project ENV.E.3/ETU/2000/0058, 2002; Seng, & Wang, 1994).

The removal of pollutants from contaminated water is an urgent need for providing clean and affordable water to meet human demand. The existing methods have several drawbacks, such as inability to completely remove pollutants, high-energy consumption, and production of huge amounts of sludge. In various conditions, the sludges are themselves toxic and require further treatments (Nassar, Ararb, Marei, Ghanim, Dwekat, & Sawalha, 2014; Sharma, Srivastav, Singh, Kaul, & Weng, 2009). Therefore, the adaptation of highly advanced technologies to augment traditional processes may offer new opportunities for technological developments in **(**waste) water(s) treatment(s) (Ali, 2012; Bora, & Dutta, 2014; Qu, Alvarez, & Li, 2013). Taking advantage of its simplicity and relevancy to the industrial application, an adsorption technique that utilizes various kinds types of sorbents is increasingly used for the removal of metal ions and other hazardous species from waste water (Qu, Alvarez, & Li, 2013; Roy, 2015).

Presently the application of nanomaterials has garnered interest as a viable solution for the removal and/or reduction of metallic pollutants from **(**waste) water (s) (Tiwari, Behari, & Sen, 2008; Samanta, Das, & Bhattachajee, 2016).

Several studies (Xu, Zeng, Huang, Feng, Hu, Zhao, Lai, Wei, Huang, Xie, & Liu, 2012; Hua, Zhang, Pan, Zhang, Lv, & Zhang, 2012; Lu, Wang, Stoller, Wang, Bao, & Hao, 2016; R. Zhang, Wang, Shen, & Zhao, 2013; Tahar, Oueslati, & Abualreish, 2018) have suggested that specific characteristics of spinel-type nanoferrite based materials (with the general chemical formula MFe_2O_4, where M is a simple bivalent cation such as Fe(II), Co(II), etc., or a combination of the cations), such as their ability to cover specific wide areas, dispersibility, surface modifiability, tunable magnetic properties, biocompatibility, ease of decantation with the help of an external magnetic field, reusability, cost-effectiveness, etc.), provide them the immense potential for the adsorption and/or reduction of soluble heavy metals.

Maghemite (γ-Fe_2O_3) is considered to be a Fe(II)-deficient form of magnetite (Fe_3O_4). It

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تأثير عوامل فيزيوكيميائية على كفاءة إزالة الكروم السداسي بواسطة جسيمات نانوية للمغمايت قابلة للتدوير

لطفي محمد بنطاهر [1*]

(قدم للنشر في 1439/07/26هـ؛ وقبل للنشر في 1440/01/26هـ)

مُلخَّص الدِّراسة: تم دراسة تأثير عدة عوامل فيزيوكيميائية بما في ذلك الرقم الهيدروجيني وتركيز الكروم السداسي ((Cr (VI)، وجرعة المادة الممتزة، ودرجة الملوحة، والأيونات المنافسة على قدرة امتزاز Cr(VI) على الجسيمات النانوية للمغمايت (γ-Fe_2O_3) في درجة حرارة الغرفة وفي زمن تلامس 3.0 ساعات. كذلك تم اختبار كفاءة إعادة استخدام تلك الجسيمات النانوية في ست دورات امتزاز – اعادة تدوير بهدف دراسة استعمالها مصنعياً. وقد تمت دراسة تأثير الأس الهيدروجيني في المجال 0-6 وقد سجلت أعلى كفاءة إزالة وقدرة امتصاص في المنطقة الأكثر حمضية حول درجة الحموضة 0–1. عند درجة الحموضة 1.0، تم كذلك دراسة تأثير جرعة الأجسام النانوية للمغمايت وذلك بتغيير كميتها 1.0 من إلى 7.0 مغ/ل عند تركيز أولي ثابت لأيونات الكروم 50 مغ/ل. من ناحية أخرى، لم يكن لدرجة الملوحة (0 إلى 5.0 ٪ كلوريد الصوديوم) تأثير يذكر على كفاءة المغمايت في عملية إزالة الكروم. كما تم أيضا دراسة تأثير مجموعة متنوعة من الأيونات المنافسة (Ba^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, Zn^{2+}, NO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}) على قدرة امتزاز Cr(VI) جسيمات المغمايت، و تبين وجود تأثير ملحوظ لأيونات الرصاص (Pb^{2+}) و الفوسفات (PO_4^{3-}) والكبريتات (SO_4^{2-}) فقط. أما باقي الأيونات فقد كان تأثيرها ضعيفاً.

الكلمات المفتاحية: جسيمات نانوية، المغمايت، كروم، امتزاز، إزالة، إعادة تدوير، عوامل فيزيوكيميائية.

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Effect of Physicochemical Parameters on the Efficiency of the Removal of Hexachromium by Reusable Maghemite Nanoparticles

Lotfi Ben Tahar[1*]

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Abstract: The effects of various physicochemical parameters on the removal efficiency of Cr(VI) on maghemite NPs (γ-Fe_2O_3 NPs) were examined, in particular, the pH, hexachromium concentration (Cr(VI)), adsorbent dosage, salinity and the commonly coexisting ions Ba^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, Zn^{2+}, NO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}, at room temperature for a contact time of 3 hrs. For an industrial, economic and environmental aims, the reusability efficiency of the NPs was tested for six adsorption–desorption–regeneration cycles. The pH effect was studied in the range of 0–6. The maximum removal efficiency and uptake capacity were observed in the acidic region around pH 0–1. The influence of the adsorbent dosage was studied at pH 1.0 by varying the concentration of NPs in the range 1.0–7.0 $g.L^{-1}$ at a fixed initial Cr(VI) concentration of 50 $mg.L^{-1}$. In the dosage range (20.0–100.0 $g.L^{-1}$) of the explored NPs, the removal efficiency increased in a monotonous manner. On the other hand, increasing salinity from 0 to 5.0 % NaCl had no significant effect on the efficiency of Cr(VI) removal. An investigation of the effects of the commonly coexisting ions (Ba^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Pb^{2+}, Zn^{2+}, NO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}) indicated noticeable effects only with the Pb^{2+}, SO_4^{2-} and PO_4^{3-} ions.

Keywords: Nanoparticles, Maghemite, Chromium, Adsorption, Removal, Reusability, Physicochemical Parameters.

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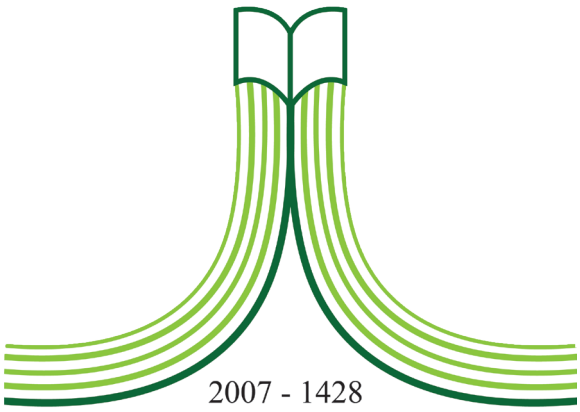

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