Investigation on Indigenous Absorbent Core for use in Baby Diaper

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Abstract— Although disposable diapers are superior in performance when compared with their reusable counterparts, a majority of Ethiopian parents use the latter for their babies. The key factors for this choice are limited availability (in rural areas) and high cost. This research proposes to reduce the cost of disposable diapers by making them semi-reusable. The objective was to prepare alternative inside absorbent core from indigenous materials and replace the core from normal disposable diapers after use (especially liquid insult). Such replacement would retain some functionalities of the disposable article while reducing the overall cost to parents. The materials investigated for producing the alternate core were eucalyptus bark and paper (A4 waste paper). It was found that treatment of alternative core material with a hydrophilic softener such as glycerin greatly enhanced the absorbent capacity. The average performance of diapers with the alternate core was comparable to those of original diapers. Then the alternative inside core performs better than commercial diaper. The remaining water volume was less than the commercial diaper. Similarly the weight of inside core and speed of absorption proved that was developed core than a commercial as compare to that is estimated that the cost of using normal disposable diaper is about 80 ETB per day which is probable cost of 17 ETB per day case of developed core. It may be concluded from this investigation that the abundant waste paper (from offices and universities in Ethiopia) is an excellent low-cost source to produce alternate absorbent core in baby diapers.

Key words: Liquid Absorbent, Disposable Diaper, Reusable Diaper, Indigenous Diaper Product, Hydrophilic Softener

I. INTRODUCTION

Among all the recent developments in the absorbent core technology area, the most prominent one has been the application of the preformed structures of one type or another. In sanitary napkin products, the use of preformed airlaid materials with short fibers has grown rapidly, but in baby diapers and adult incontinence products their adoption has been much slower than generally expected [1,2]. One of the major applications of disposable nonwovens is in absorbent materials, which constitute a broad range of products, including baby diapers, personal hygiene and adult incontinent pads, tampons, paper towels, tissues and sponges. In designing absorbent products such as diapers and sanitary pads, one of the aims is to reduce the size or weight without compromising the fluid holding capacity. This is usually accomplished in some structures by incorporating a percentage of superabsorbent polymer along with the main material in the core. In such instances, because of the enormous capacity of the superabsorbent to absorb fluid into its internal structure and swell while maintaining high gel strength, the thickness of the web could be expected to actually increase. There has been a general tendency towards using the so-called superabsorbent material in such products as sanitarynapkins, baby diapers, and adult incontinent pads [3,4]. Traditionally, superabsorbent used has been in the form of powder, or very short fibers, but in recent years the material has also become available in the form of staple fibers. The idea of using fibers is novel in the sense that the material could be controlled and handled better than possible with the powder. The superabsorbent fiber could be blended with the bulk and dispersed uniformly throughout the structure or positioned biased at strategic points in the product. The superabsorbent materials have great capacity to swell and retain fluids many times their weight by chemical bonding [4-8].

Disposable diapers are mostly made using the following components and Materials viz., Bottom back sheet, Polypropylene Non-woven – Hydrophobic and Hydrophilic, Absorbent core - Wood pulp fluff, Super Absorbent Polymers, Elastics – Lycra/Spandex, Quick wicking layer, Adhesive – Hot melts and Elastomeric, Fastening tape – Stick type/Hook and loop type, Moisturizer lotions and fragrance lotions and Breathable/Cloth-like back sheet. Among all parts, first four are very essential layers in a diaper. Most disposable diapers are made with these basic components [9-14].

In Ethiopia, as in other parts of the world, baby hygiene uses either disposable or reusable diapers. But disposable diapers are generally expensive (about 600 ETB; Ethiopian Birr, per pack of 100 diapers) and available mostly in urban areas. As a majority of Ethiopian babies are in rural areas they use normal cloth diapers. Further, cloth diaper absorbency characteristics and design are not satisfactory. Hence the new idea is to prepare indigenous absorbent core for use in a disposable diaper and reduce the cost.

In Ethiopia, babies use disposable diapers to protect their health. But babies in rural areas use normal cloth diaper because of high cost and non-availability of disposable diaper. Based on the fact that a baby uses 4-8 diaper in a day the average expense amounts to about 30 ETB. Hence, there is a need for a cheaper alternative.

A. Justification of the research

- Reduce the cost of diaper In Ethiopia without affecting the performance.
- Reduce the quantity of imports and thereby helping the government.
- Improve baby hygiene in the rural area.

B. Scope of the work

- Create absorbent core from indigenous material.
- Produce absorbent core by using grinder machine to create pulp from waste materials.
- Improve absorbent properties of pulp

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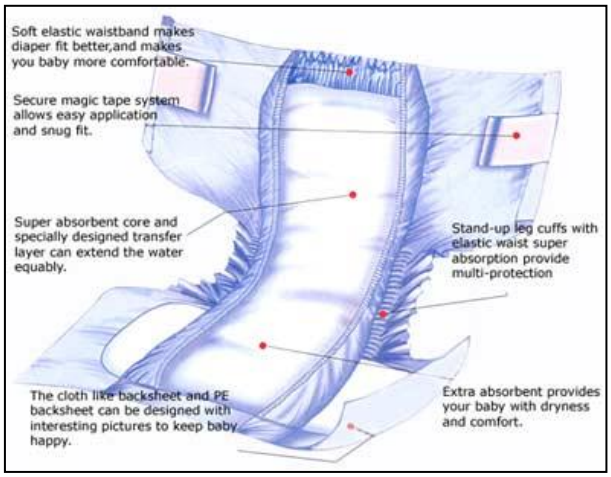

Fig. 1: Components of a disposable baby diaper.

C. *Limitation*

- Doing only lab scale (not field trial)
- Not having a detail cost comparison
- Technology transfer possibility has not been investigated

D. *Specific Objective*

- To determine the types of disposable products available in local market.
- To create absorbent core from indigenous material.
- To evaluate absorbency characteristic of developed core.

II. MATERIALS AND METHODS

A. *Research Design and Data Collection Procedure*

1) *Design of Core:*

Research design indicates the typical structure to produce inside core of disposable diaper from indigenous alternate material

2) *Data Collection Procedure:*

Collected information on diapers available in Ethiopia about brands, price, etc. valuate the absorbency and liquid retention capacity of available diapers in Bahir Dar. This information was used for comparison with modified diaper that uses indigenous absorbent core. Absorbent core was made from pulp obtained from different papers like A4 paper and from eucalyptus bark.

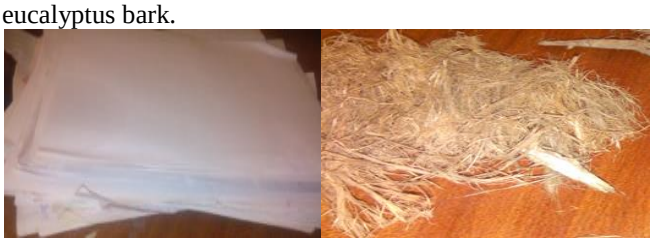

Fig. 2: Papers and eucalyptus brake

B. *Material and Equipment*

- A4 paper: it is types of hared paper after change in to powder it is used as absorbent core
- Eucalypts bark: developing eucalypts bark use to as absorbent pulp and anti-microbial agent so there is high advantage for customer.
- Chemicals: glycerin used to increase absorbency
- Grinder machine: is used to change any materials in to powder form
- Electronic balance: for measuring chemicals or powder
- Filter paper: used to separate water from paper powder
- Manual sprayer: used to uniformly spray PVA solution on the fabric

C. *Methodology*

1) *Steps preparation of inside core*

- Step 1: Paper converted in to powder form

First different papers and eucalyptus bark is collected, cleaned and stored, the raw material was cut into small pieces. Then by using dry grinder machine changed in to powder (pulp) form.

Fig. 3: Paper and eucalyptus powder after powdering in machine

- Step 2: Test the absorption and compare modified core with commercial core

Most common synthetic polymers are said to be water fearing, which means that they do not absorb water. There are also water-loving polymers. Many natural polymers such as cotton fibers are hydrophilic. However, the polymer found in the diaper is an example of a synthetic, hydrophilic polymer. Therefore, from this comparison absorbent capacity of waste paper and eucalyptus bark was less than the commercial diaper. Hence, paper needs the treatment of hydrophilic softener.

- Step 3: Treatment with the powder for increasing absorbency by hydrophilic softener

Test three samples by taking any amount of gram pulp. Prepared 20, 40 and 60 g of glycerin dissolved 1liter of water with the pulp dip from the bottom of beaker. Squeeze and dry by 105-degree centigrade for 30min and repeat until test three sample. Finally measure the absorbent pulp by treated glycerin.

a) 20g b) 40g c) 60g of glycerin

Fig. 4: Different recipes of glycerin

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a) Without glycerin b) use glycerin and filter
c) dry d) check absorbency

a) Without glycerin b) use glycerin and filter
c) dry d) check absorbency

Fig. 5: The absorbency of powder before and after treating with glycerin

Here, before untreated absorbent core of waste paper and eucalyptus bark was less than the original or the commercial diaper but after treated by using hydrophilic softener they have the same absorbent level.

– Step 4: Testing the maximum liquid absorbent by using absorbency test

1) Wettability/absorbency test: Drop of water is place on the sample of fabric and the time it takes for the drop to penetrate the fabric is record. Wettability is determined by counting the second between the contact of the water drop with the fabric and disappearance of the drop in to the fabric (ISO 9073-13:2006).
2) Sinking time test: The sample will be sinking at the required time from the bottom of beaker.
3) Capillary test: is used for Wettability/absorbency determination. In this test, know the length web, which absorbed water in 5 minute

Type of test	Sample 1 20g glycerin	Sample 2 240g glycerin	Sample 3 60g glycerin	Average sample
Water drop absorbency test (3-5 sec.)	4 sec.	5 sec.	6 sec.	5 sec.
Sinking time test (5-10 sec.)	9 sec.	10 sec.	10 sec.	Above 9 sec.
Capillarity test (5 min.)	5min.	5 min.	5 min.	5min.

Table 1: The maximum liquid holding capacity after treating with glycerin

III. RESULTS AND DISCUSSION

Figure below shows the images of both paper and eucalyptus bark powder. These are the two basic materials used across this study. The images show the pulp or powder for inside cores. A summary of this result is found in each table. In particular, eucalyptus -based materials have two excellent functions namely as absorbent core and as anti-microbial agent.

Fig. 6: Inside absorbent core

A. Types of tests for determination of fluid handling capacity

Test one: Iinside core, added in the solution

Test the absorbent capacity of 50 grams of absorbent core by soaking in the 75 ml of water. After ten minutes, out the absorbed core in the solution and measure how much solution is remaining in the beaker (ISO 9073-17:2008).

Fig. 7: Inside core added to the solution

Comparison of diaper	*Sample*	*Brand Name*	*Test 1*	*Test 2*	*Test 3*	*Total*	*Average*
Original diaper	1	Pampers	1.2	2	1.7	4.9	1.6
	2	Super soft	1.3	1.1	1	3.1	1.1
	3	Predo	2.3	2.4	2.3	6.1	2.0
	4	Molfix	2.3	3.1	3.2	8.6	2.9
	5	Can baby	1.2	1.2	1.3	3.4	1.2
	6	Sleepy	1.8	2.2	1.5	5.5	1.8
Modified diaper	1	New diaper	1	1.1	1.2	3.3	1.1

Table 2 Remaining water in the beaker after water absorption in the inside core

– The mean comparison and independent samples test for inside core, added in the solution between pampers diaper and new diaper was not significantly different. Therefore, they have equal performance and equal value. Thus, the customers can use either modified diaper or commercial diaper.
– The mean comparison independent samples test for inside core, added in the solution between super soft diaper and new diaper was not significantly different. Therefore, they have equal performance and equal value. Thus, the customers can use either modified diaper or commercial diaper.
– Since 0.000< 0.05 as conclusion it has enough evidence to that the mean of remaining water for predoand new diaper is different particularly the remaining water new diaper is less than the remain water of predodiaper.

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- Since 0.004 < 0.05, as conclusion it has enough evidence to conclude that the mean remaining water for morfix and new diaper is different, particularly for independent samples test for inside core, added in the solution the remaining water new diaper is less than remain water of morfix diaper.
- The mean comparison independent samples test for inside core, added in the solution between a baby diaper and dew diaper was not significantly different. Therefore, they have equal performance and equal value. Thus, the customers can use either modified diaper or marketing diaper
- Since 0.025 < 0.05, indicating that the mean remaining water for sleepy and new diaper are different. Particularly the independent samples test for add solution on the inside core remain water of new diaper is less than remaining water of sleepy diaper.

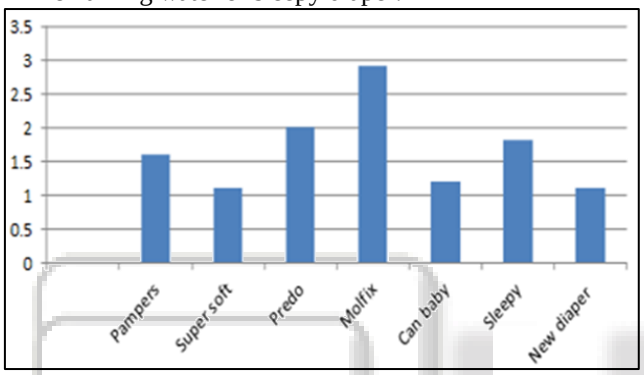

Fig. 8: Comparison of remaining water in *ml* in different diapers

B. Test two: Adding solution on the inside core

Test the absorbent capacity of by taking 50 gram of absorbent core diaper and 75 ml of water. The water pours directly onto the center of the diaper. This show effectively tests how well the liquid is absorbed and dispersed throughout the absorbent core(ISO 9073-17:2008)

Fig. 9: Solution added on the inside core

- Since 0.001 < 0.05 it indicates that the mean remaining water for pampers and new diaper is different. Particularly the independent samples test for add solution on the inside core of the remaining water of new diaper is less than the remaining water of pampers diaper.
- The mean comparison and independent samples test for added solution on the inside core between Supper soft diaper and new diaper was not significantly different. Therefore, they have equal performance and equal value. Thus, the customers can use either modified diaper or marketing diaper.
- Since 0.000< 0.05, as conclusion, independent samples test for added solution on the inside core that the mean remaining water for prido and new diaper are different, particularly the remaining water of new diaper is less than the remaining water of prido diaper.
- Since 0.000< 0.05 as conclusion, independent samples test for added solution on the inside core that the mean remaining water for molfix and new diaper is different, particularly remain water of new diaper is less than the remaining water of molfix diaper.
- The mean comparison and independent samples test for added solution on the inside core between can baby diaper and new diaper was not significantly different, therefore they have equal performance and equal value. Hence the customers can use either modified diaper or commercial diaper.
- Since 0.003<0.05, as conclusion independent samples test for added solution on the inside core, that the mean of remaining water for sleepy and new diaper are different, particularly the remk8aining water new diaper is less than the remaining water of sleepy diaper.

Comparison of diaper	Sample	Name of diaper	Test 1	Test 2	Test 3	total	Average
Original Diaper	1	Pampers	2.2	2.3	1.9	6.4	2.13
	2	Super soft	1.1	1.1	1.0	3.2	1.06
	3	Predo22	3.3	3.4	3.3	10	3.3
	4	Molfix	3.3	3.1	3.2	9.5	3.17
	5	Can baby	1.2	1.2	1.1	3.5	1.17
	6	Sleepy	1.9	2.2	1.8	5.9	1.97
Modified Diaper	1	New diaper	1.0	1.5	1.4	3.9	1.30

Table 3: Remaining water in the beaker after water absorption

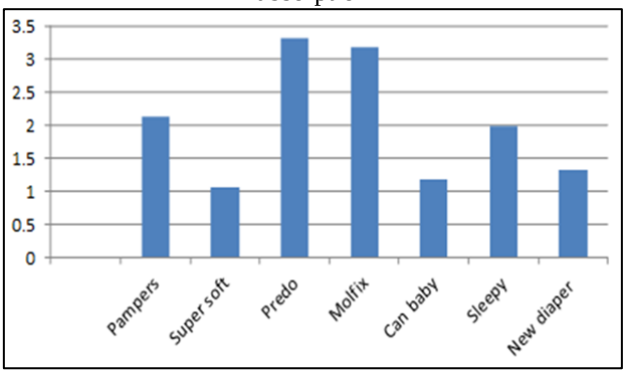

Fig. 10: Comparison of remaining water

C. Test three: Weight difference between the dry and the wet

By calculating the difference between the dry weight and the wet weight and determining the amount of liquid that was absorbed by subtract in dry (initial weight) from the wet (final weight), the mass was determined. Since the weight of the

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actual diaper materials does not change, the difference in these two weights is the weight of liquid absorbed (ISO 9073-6:2000).

Since 0.001< 0.05, as conclusion, the independent samples test for weight of inside core, after water absorption indicates that the mean of weight for pampers and new diaper are different, particularly the weight of new diaper is higher than the pampers diaper.

The mean comparison and independent samples test for weight of inside core, after water absorption between supper soft diaper and new diaper was not significantly different, there for they have equal performance and equal value, thus customers can use either modified diaper or commercial diaper.

Dry weight wet weight

Fig. 11: Absorption test by incorporating diaper in the solution, the solution added on diaper and weight difference

Comparison of diaper	Sample	Name of diaper	Test 1	Test 2	Test 3	total	Average
Original diaper	1	Pampers	149	147	150	446	148
	2	Super soft	157	154	155	466	155
	3	Predo	145	147	144	436	145
	4	Molfix	147	146	143	436	145
	5	Can baby	154	157	156	467	156
	6	Sleepy	151	154	153	458	153
Modified diaper	1	New diaper	156	158	157	471	157

Table 4: Weight of inside core after water absorption

- Since 0.001< 0.05 as conclusion, the independent samples test for weight of inside core, after water absorption indicates the mean weight for predo and new diaper are different, particularly the weight new diaper was higher than the predo diaper.
- The mean comparison and independent samples test for weight of inside core, after water absorption between molfix diaper and new diaper was not significantly different, therefore they have equal performance and equal value, Hence, customers can use either modified diaper or commercial diaper.
- The mean comparison and independent samples test for weight of inside core, after water absorption between commercial baby diaper and new diaper was not significantly different, therefore, they have equal performance and equal value, Hence, customers can use either modified diaper or commercial diaper.
- The mean comparison and independent samples test for weight of inside core, after water absorption between Sleepy diaper and new diaper was not significantly different, therefore, they have equal performance and equal value, thus the customers can use either modified diaper or commercial diaper.

D. Test four: Speed of absorption test

The samples are prepared in the same way as that of horizontal rewet test and the solution being applied without pressure. The absorption speeds of each solution are recorded to provide a Performance Indicator for this character (ISO 9073-6:2000).

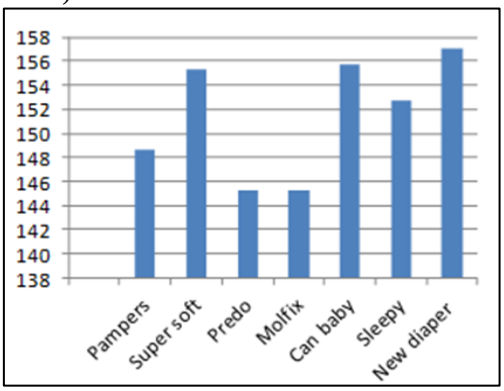

Fig. 12: Comparison of weight

Comparison of diaper	Sample	Name of diaper	Test 1	Test 2	Test 3	Total	Average (ml)
Original diaper	1	Pampers	270	271	273	814	271
	2	Super soft	293	290	294	877	292
	3	Predo	270	271	270	811	270
	4	Molfix	265	270	267	802	267
	5	Can baby	284	287	282	853	284
	6	Sleepy	288	286	289	863	287
Modified diaper	1	New diaper	290	292	292	874	291

Table 5: Absorption Speed of inside core (ml/min)

- Since 0.000< 0.05, as conclusion, independent of samples test for absorption speed of inside core indicates ,the mean speed of absorption for pampers and new diaper are different, particularly the speed of absorption new diaper is higher than the pampers diaper.
- The mean comparison and independent samples test for absorption speed of inside core, between supper soft diaper and new diaper was not significantly different, therefore, they have equal performance and equal value, Hence, customers can use either modified diaper or commercial diaper.
- Since 0.000< 0.05, as conclusion, independent of samples tested for absorption speed of inside core, the mean speed of absorption for predo and new diaper are different, particularly the speed of absorption of new diaper is higher than the predo diaper.
- Since 0.000< 0.05, as conclusion, independent samples test for absorption by speed of inside core, the mean speed of absorption for molfix and new diaper are

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different; particularly the speed of absorption new diaper is higher than the molfix diaper.

– The mean comparison and independent samples test for absorption speed of inside core, between sleepy diaper and new diaper was not significantly different, therefore they have equal performance and equal value, Hence, customers can use either modified diaper or marketing diaper.

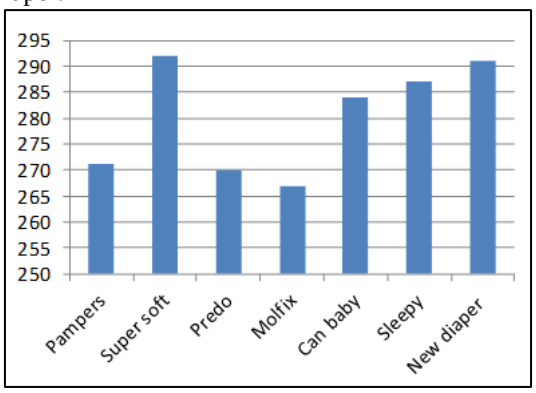

Fig. 13: Comparison absorption speed

E. Test five: Rewet or retention test

First, modified absorbent core was prepared, 40ml of water and 5kg of weight was used. 40ml of water was added in the front of (in side) diaper and wait 10 minute. Place copper salt for treated filter papers about 5kg of Weight and wait 2minute.Remove weight and check by coloring method and Calculation method. If the color of filter paper is blue it predicted to have rewet so it is bad and if the color of paper is white it cannot present rewet so it is good and continue the test by adding 40ml of salt water at 45minutes, 90minutes and 135minutes (ISO 9073-12:2002).

Calculation rewet or retention test

Rewet value (g) = wet weight of filter papers (g) - dry weight of filter papers (g)

Rewet value (g) = 249 - 100 (g) =147

Both the paper powder and eucalyptus bark have a similarity of high absorption. As previously mentioned, diaper absorption is directly related to diaper retention. However, the relative difference between retention and absorption is not constant. In particular, paper absorbs about six times as much liquid as it retains whereas eucalyptus powder absorbs about four times. Paper powder and eucalyptus almost absorbs and retains the same amount of liquid.

a) 40ml of water b) copper salt added c) 5kg of weight added d) check the color

Fig. 14: Rewet or retention test

Then, the alternative inside core performs better than prido, molfix, sleepy and pampers. The remaining water volume was less than the commercial diaper. Similarly, the weight of inside core and speed of absorption proved that it was better in developed core than the commercial.

Total material cost of new diaper

– 400gram of inside core = 4 ETB (50gram with marketing diaper used for one time, totally 400 gram of inside core with marketing diaper used for 8 times in one a day
– 100 gram of hydrophilic softener (glycerin) =3 ETB
– Original (marketing) diaper =10 ETB
– Total cost of new diaper =17 ETB

As compared to the estimated cost of using normal disposable diaper at about 80ETB per day, which is probable, the cost has come down to 17ETB per day in case of developed core.

IV. Conclusion

Based on the investigation, it was concluded that test of inside absorbent core was getting different absorptions without mixing or combining any foreign products (bamboo fiber). After preparing inside core from indigenous product, with addition of Hydrophilic softener, it reaches the maximum liquid holding capacity. The main target of this work to create inside absorbent core from indigenous product was successfully established that inside absorbent core can be made by combining or mixing different indigenous (local available) products. However, in these cases, the absorbent core predictably yeilded the expected result. Mixing different inside core products can make the improvement in absorbency

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