Market analysis of the target population for the creation of waterproof paint to mitigate environmental impacts in Bucaramanga, Colombia

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Abstract. In this study, a target population of hardware stores that sell paint in the city of Bucaramanga, Colombia was determined. Through a survey, we proceeded to investigate in business the different uses that give expanded polystyrene that generally serves as a product packaging element. A univariate and bivariate analysis of the variables used in this study was carried out with statistical package for the social sciences to make a diagnosis of the different uses of expanded polystyrene and its use in construction materials. Therefore, use the expanded polystyrene to reduce the volume in sanitary landfills through the creation of waterproofing paint. The gradual process of industrialization of the new paint based on expanded polystyrene EPS will allow mitigating the transit of these wastes to sanitary landfills to reduce environmental impact, will allow the emergence of a new production chain as a commitment to a social industry that will receive economic benefits for the improvement of the quality of life of the actors that will intervene in said productive chain. It has not been implemented because some scientists believe that the inputs required to mix expanded polystyrene are expensive and the industry would not be willing to take on. It is observable that the scientific community is also not interested in exploring limonene alternatives so that the criteria of a mixture with environmentally friendly expanded polystyrene are maintained.

1. Introduction
The constant increase of the industry in relation to packaging for the production of appliances, food packaging and sectors such as construction, determines the highest proportion in the consumption of this material that each time, presents greater challenges in the management that is currently given in landfills [1,2].

According to the provisions of the “Cooperativa de Recicladores Bello Renacer” in Bucaramanga Colombia, expanded polystyrene (EPS) does not present a separation in the “El Carrasco” landfill, only other recyclable elements such as cardboard, plastic and glass are more common for recycling, leaving EPS without options for separation [3,4].

The lack of environmental policies and incentives by the national government that allow the classification of expanded polystyrene, are not enough to mitigate the amount of waste that reaches the urban waste dumps [5]. For this reason, the creation of paint from residual polystyrene expanded with
limonene is proposed to reduce the volume in landfills and the acceptance of distributors to acquire the product by marketing it to promote the use of waterproofing paint [6,7]. This research work represents a first step towards technological progress based on the mixing of expanded polystyrene with non-polluting natural ingredients such as limonene, which means a contribution to the scientific academic community of Colombia in the engineering of industrial materials processing.

2. Methodology

2.1. Univariate analysis

Twelve (12) variables were determined to analyze the behavior of the current status of expanded polystyrene recycling and acceptance level measurement to produce residual polystyrene based paint; With a population of 170 hardware stores and a maximum error of 10%, we obtained a sample of 62 ironmongers with a 95% confidence level in Bucaramanga, Colombia, and its metropolitan area Bucaramanga, Colombia. The results obtained from the surveys for each of the nominal and scale variables for subsequent statistical analysis are described below [8]. The 12 selected variables were considered of a relevant nature to size the scope of acceptance of the new product among potential users and primarily of a socio-economic nature.

2.2. Bivariate analysis

The analysis of two associated variables was determined from the selection of crosses of the same to establish the level of dependence between them for which the statistical package for the social sciences (SPSS) software was used, in such a way that by means of crossed tables it was verified the possible combinations of variables that allow obtaining an asymptotic significance less than 0.05 with the chi-square test for a 95% confidence with different degrees of freedom that are based on the number of rows and columns. The acceptance zone for the verification of the dependence of the variables is established in the value thrown by the area under the curve contrasted with the significance to establish the association of variables [8].

3. Analysis and discussion of results

3.1. Bivariate analysis of the variables

A favorable result according to the perception of 64.5% of the people surveyed, is the use of residual polystyrene in enamel-based paint followed by 17.7% for incorporation in materials such as bricks. Materials with additions of polystyrene are not common according to 12.9% that did not respond and this may be because there is no specific offer in the market that promotes the use of EPS in construction materials and in case of alternative materials, they are not disseminated within the construction industry as can be seen in Table 1.

| Valid | Frequency | Percentage (%) | Valid percentage (%) | Accumulated percentage (%) |
|-------|-----------|----------------|----------------------|---------------------------|
| a     | 40        | 64.5           | 64.5                 | 64.5                      |
| b     | 11        | 17.7           | 17.7                 | 82.3                      |
| c     | 2         | 3.2            | 3.2                  | 85.5                      |
| BUN   | 1         | 1.6            | 1.6                  | 87.1                      |
| NA    | 8         | 12.9           | 12.9                 | 100.0                     |
| Total | 62        | 100.0          | 100.0                |                           |

BUN: Basic unsatisfied needs  
NA: No answer

In Table 2 we can see the results obtained, on the one hand, that 12.9% is totally in agreement with the use of polystyrene to produce the paint, which is confirmed by 54.8% of people as a novel alternative
breaking the tradition for conventional materials opening the possibility of adding polystyrene as an input to produce paint. 25.8% of the respondents maintain a neutral position regarding the new product in relation to the innovation that can be offered. Only 6.4% disagree or totally disagree with the replacement of traditional paint with that based on residual expanded polystyrene. These last two percentages show some resistance to change given the weight of the traditional painting industry.

Table 2. Polystyrene-based paint can be a novel alternative to replace traditional paint.

| Valid | Frequency | Percentage (%) | Valid percentage (%) | Accumulated percentage (%) |
|-------|-----------|----------------|----------------------|----------------------------|
| a     | 8         | 12.9           | 12.9                 | 12.9                       |
| b     | 32        | 51.6           | 51.6                 | 64.5                       |
| B     | 2         | 3.2            | 3.2                  | 67.7                       |
| c     | 16        | 25.8           | 25.8                 | 93.5                       |
| d     | 2         | 3.2            | 3.2                  | 96.8                       |
| e     | 2         | 3.2            | 3.2                  | 100.0                      |
| Total | 62        | 100.0          | 100.0                |                            |

Table 3 shows that the replacement of paint by hardware stores is established in percentages that determine the amount they would be willing to purchase. 33.9% of respondents would replace 10% of their inventory, in order, the 17.7% would replace 20%, 50% of the inventory would be willing to be replaced by 16.1%; which shows a panorama of acceptance of the new product, although 8.1% decided not to accept the replacement in their supply of paints.

Table 3. Quantity of EPS-based paint that would be willing to replace.

| Valid | Frequency | Percentage (%) | Valid percentage (%) | Accumulated percentage (%) |
|-------|-----------|----------------|----------------------|----------------------------|
| 0.00  | 5         | 8.1            | 8.1                  | 8.1                        |
| 0.01  | 1         | 1.6            | 1.6                  | 9.7                        |
| 0.02  | 1         | 1.6            | 1.6                  | 11.3                       |
| 0.05  | 4         | 6.5            | 6.5                  | 17.7                       |
| 0.06  | 1         | 1.6            | 1.6                  | 19.4                       |
| 0.10  | 21        | 33.9           | 33.9                 | 53.2                       |
| 0.15  | 2         | 3.2            | 3.2                  | 56.5                       |
| 0.20  | 11        | 17.7           | 17.7                 | 74.2                       |
| 0.30  | 5         | 8.1            | 8.1                  | 82.3                       |
| 0.50  | 10        | 16.1           | 16.1                 | 98.4                       |
| 1.00  | 1         | 1.6            | 1.6                  | 100.0                      |
| Total | 62        | 100.0          | 100.0                |                            |

3.2. Bivariate analysis of the variables

By relating the contact variables of the residual expanded polystyrene and the materials likely to include this residual component (significance obtained from 0.006 less than 0.05), it was established that 53.2% of the businesses although they perform the final waste disposal are according to the elaboration of enamel-type polystyrene-based paint; This result allows inferring the possibility that these businesses would be willing to make the separation of the aforementioned waste to guide it to the manufacture of the paint as indicated in Table 4.

Table 5 shows the perception of the creation of new paint based on residual expanded polystyrene and establishes with the relation of the variable that determines the knowledge of new materials based on polystyrene and the variable that indicates the degree of acceptance that can have for the replacement of the traditional paint through a significance of 0.000 (represents that the variables studied have a direct relationship) and that 51.6% stipulates the ignorance of new materials based on EPS and are in accordance with the degree of novelty that would bring the production of paint based of polystyrene.
Table 4. Contact with expanded polystyrene vs. materials likely to include polystyrene.

| Contact EPS | EPS materials | a | B | c | BUN | NA | Total |
|-------------|---------------|---|---|---|-----|----|-------|
| a | Count | 4 | 5 | 0 | 0 | 3 | 12 |
| | % of the total | 6.5 | 8.1 | 0.0 | 0.0 | 4.8 | 19.4 |
| b | Count | 2 | 1 | 1 | 0 | 1 | 5 |
| | % of the total | 3.2 | 1.6 | 1.6 | 0.0 | 1.6 | 8.1 |
| c | Count | 33 | 2 | 1 | 1 | 4 | 41 |
| | % of the total | 53.2 | 3.2 | 1.6 | 1.6 | 6.5 | 66.1 |
| NA | Count | 1 | 3 | 0 | 0 | 0 | 4 |
| | % of the total | 1.6 | 4.8 | 0.0 | 0.0 | 0.0 | 6.5 |
| Total | Count | 40 | 11 | 2 | 1 | 8 | 62 |
| | % of the total | 64.5 | 17.7 | 3.2 | 1.6 | 12.9 | 100.0 |

Table 5. Knowledge of new materials or products that include the reuse of polystyrene vs. polystyrene-based paint can be a novel alternative to replace traditional paint.

| EPS painting | a | b | B | c | d | e | Total |
|---------------|---|---|---|---|---|---|-------|
| a | Count | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| | % of the total | 0.0 | 0.0 | 1.6 | 0.0 | 0.0 | 1.6 | 3.2 |
| b | Count | 8 | 32 | 1 | 16 | 2 | 1 | 60 |
| | % of the total | 12.9 | 51.6 | 1.6 | 25.8 | 3.2 | 1.6 | 96.8 |
| Total | Count | 8 | 32 | 2 | 16 | 2 | 2 | 62 |
| | % of the total | 12.9 | 51.6 | 3.2 | 25.8 | 3.2 | 3.2 | 100.0 |

The analysis of dependence between the variable that measures the advantages of the reuse of polystyrene in construction materials and the variable that determines the final product that can be obtained, found that 38.75% of the respondents, agree with the paint based on expanded polystyrene type enamel as seen in Table 6. The result was corroborated with an asymptotic significance of 0.001 lower than 0.05 allowed for the association of variables.

Table 6. According to the statement: the reuse of polystyrene incorporated in materials for construction has advantages vs. materials likely to include polystyrene.

| EPS materials | a | b | c | BUN | NA | Total |
|---------------|---|---|---|-----|----|-------|
| a | Count | 8 | 2 | 0 | 0 | 1 | 11 |
| | % of the total | 12.9 | 3.2 | 0.0 | 0.0 | 1.6 | 17.7 |
| b | Count | 24 | 7 | 1 | 0 | 5 | 37 |
| | % of the total | 38.7 | 11.3 | 1.6 | 0.0 | 8.1 | 59.7 |
| c | Count | 7 | 2 | 1 | 0 | 2 | 12 |
| | % of the total | 11.3 | 3.2 | 1.6 | 0.0 | 3.2 | 19.4 |
| d | Count | 1 | 0 | 0 | 1 | 0 | 2 |
| | % of the total | 1.6 | 0.0 | 0.0 | 1.6 | 0.0 | 3.2 |
| Total | Count | 40 | 11 | 2 | 1 | 8 | 62 |
| | % of the total | 64.5 | 17.7 | 3.2 | 1.6 | 12.9 | 100.0 |

In the preparation of the discussion for the present investigation, the authors consulted various studies relevant to the central topic of this paper; the market acceptance of new materials based on EPS. The authors also drew upon the study entitled “Alternative use for waste polystyrene to create a waterproof paint, for the reduction of environmental impacts” sponsored by the “Universidad de Santander (UDES)”, Bucaramanga, Colombia.

Having searched for scientific literature specific to the market acceptance of EPS-based enamel paint, the authors note that no such research was currently available. It was therefore decided to incorporate
into the discussion for the current study related literature concerning the results of market studies for other EPS-based products. This information was included to demonstrate the importance of waste EPS processing into alternative products for the reduction of environmental impacts which are common in Latin American countries.

The article entitled “Feasibility study for the creation of a company for the production and commercialization of high-density polystyrene moldings using a franchise contract. Application in the Valero group franchise” [9] finds that the construction sector in the Ecuadorian cities of Quito and Guayaquil is prepared to substitute their current wood-based production of circular moldings for EPS-based products. Construction firms have demonstrated the benefits generated by cost-reduction for raw materials and labor hours in construction projects. The results of a survey applied to 303 actors in the sector indicated a 97% acceptance rate for large and medium projects. This tendency extends across other Latin American countries with easy access to these materials.

The project entitled “Design of a sleep system using reprocessed expanded polystyrene industrial waste” [10] researched various market sectors for this product in the city of Medellin, Colombia. Of the child, youth, and adult sectors, the greatest acceptance rate was found in the youth market, between the ages of 19 and 27. These products tend to display innovative design styles that are attractive and comfortable for the increasingly environmentally-conscious youth in the study area. All (100%) of the survey respondents indicated that they considered the new sleep system to provide a comfortable accommodation for the body to reduce stress and provide maximum relaxation.

A project from Cuzco, Peru, entitled, “Production costs of expanded polystyrene for construction and pricing in the industrial firm of Tecnopor Fernando E.I.R.L. 2016” [11], is another example demonstrating the importance of EPS-based production in a large-scale firm supplying the construction sector. By means of specialized EPS production using an efficient technological base, and providing products of competitive quality, significant acceptance was achieved in the construction market while substituting for traditional materials. The firm was able to position itself successfully in the market, taking advantage of a 50% reduction in material costs for EPS production as opposed to traditional materials.

Lastly, the discussion of the present study drew upon the document, “Feasibility study for the creation of waterproofing using recycled Unicel” [12], a study carried out in Mexico City to establish the requirements of the local population for home maintenance in the face of various structural impacts such as inclement weather during a period of harsher winters, etc. It was found that approximately 80% of survey respondents were open to the use of expanded polystyrene-based waterproofing (Unicel is a generic name in Mexico), as the product was perceived to be both inexpensive and effective in the protection of their residences. These findings from Mexico are closely related to the results of the current study in that they are an example of the success of laboratory experiments to find alternative uses for EPS using non-polluting additives at a low cost that permits their easy acquisition both by construction firms as well as by smaller-scale non-commercial users.

4. Conclusions
The results obtained allowed us to identify aspects related to the current use of expanded residual polystyrene and the ignorance of alternative uses that reduce the environmental impact. Only 38.75% of the people surveyed would use EPS-based paint as it presents a degree of novelty in the construction industry. On the contrary, 8.1% of merchants did not accept the change in their inventory of paints for the new ecological product.

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