

Conference Paper

Neglected Wools: Fundamental Steps to Counteract the Loss of Potentially Valuable Materials Derived from Native Sheep Breeds

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In order to enhance the textile value of Italian native and local wools, research projects were carried out by starting mapping wools from some Italian sheep breeds through a preliminary morphological characterization of wool fibres. Furthermore, textile processing procedures differing from the commonly used woolling techniques have been set up. The results have shown that, at national level, native and local wools, beyond being more widely employed in the carpets production, could be also used in the higher added value sector of clothing and fashion.

1. Introduction

Many of the European livestock breeds have been greatly altered, and today a high percentage of local or traditional breeds are extinct or marginalized. As about 30% of the farm-animal breeds are currently at high risk of extinction [1], it is essential for their efficient and sustainable use, development, and conservation to understand the diversity, distribution, basic characteristics, comparative performance, and the current status of the animal genetic resources for each country [2].

Despite this situation, which is common to many wool producers all over Europe, local and autochthonous wools could be exploited to make them profitable for both wool producers and textile industries. However, it should be noted that it would be very difficult to develop a market because EU does not recognize wool as an agricultural product, as reported by Harmsworth [3]. Even so, in November 2011, Shetland wool produced in the Shetlands gained Protected

Geographical Status with Protected Designation of Origin (PDO) classification as “Native Shetland Wool” after accreditation from EU.

The focus on autochthonous wools is justified by economic, environmental, and cultural reasons. According to FAO [4], the consistency of autochthonous sheep breeds, which are characterized by different productive attitudes, has strongly decreased in recent years with severe consequences on rural areas.

The consensus concerning the conservation of animal genetic resources by maintaining a certain variation of local breeds within their production systems is large [5]. Genetic resources conservation is also one of the strongest reasons for breed preservation [6], with the purpose of meeting future market demands as well as being an insurance against future changes in production circumstances [4].

Furthermore, at global level, the sheep industry is currently undergoing major breed adjustments as climate changes can affect changes in pasture yields [7]. According

to Harle et al. [7], the quality of coarser (merinos) wools is less vulnerable to the impact of drier conditions than finer wools, as future scenarios due to climate changes show. Although research on wool production should integrate climate changes with factors such as market influences and socioeconomic dynamics [7], also at global dynamics level there could be reasons for textile industries to focus on local resources represented by autochthonous wools.

It is well known that fiber diameter, among other quality parameters, is crucial in determining the economic value of, for example, Merino wool [8, 9]. Whiteley [10] has graded the 10 major raw wool characteristics for processing importance. A number of processing trials indicated that 80–90% of variation in processing performance and yarn and fabric quality may be explained by its variation [9]. Variation in fiber diameter accounting for 61% wool characteristics for processing importance was also found by Atkins et al. [11] and Wuliji et al. [12].

Understanding the diversity of sheep breeds can facilitate understanding different quality and quantity of wools produced. In fact, the high variability of wools (usually produced by small herds located in sparse mountain areas) represents a difficulty in terms of logistics and adequate amount of wool supply to the manufacturing system. Furthermore, the lack of wool selection and difficulties in wool management, at agricultural level, as well as technical difficulties in the textile industrial processing, make coarse wool market very weak with consequences on sheep breeding economies. In this respect, local wools are a practical and economic burden for breeders, as the income from wool sale does not even cover shearing expenses.

This situation is also framed in the European regulation context with EC 1069/2009 and EU 142/2011 ruling wool production and management and defining wool as an animal byproduct that must be thrown into landfill, if it is not directed towards the textile supply chain. Italian local wools often either are thrown into landfill or even incorrectly disposed of in the environment.

Italian native and local wools (the production is estimated about 14.000 tons/year) are mostly assessed as “coarse wools” and are not enough appraised by clothing and fashion market that requires fibers of such quality standards as those provided by Merinos wool.

The full utilization of Italian wool in all the different branches of the textile industry (from green building to the clothing-fashion sector) could contribute to reducing the import of wool, thus benefiting rural economies and the environment with the decrease of raw materials import (Merinos wool) and export (e.g., local wools are often directed towards Asian countries). The utilization could also help textile producers in more easily tracing products, thus providing consumers with better knowledge about the origin of textile products.

In this sense, the multifunctional and innovative use of local wools could support the protection of autochthonous sheep breeds that is also directly associated with sustainable agriculture with all the benefits on the adaptation of animal populations to adverse environmental conditions, high biological efficiency, and traditional management.

In the larger perspective to grant Italian wool, an economic and environmental value, assuring both a right profit to sheep breeders and benefits to the environment, research was carried out by verifying the feasibility of a local textile production chain that could generate additional income for all the stakeholders involved in the textile sector (from farmers to apparel manufacturers).

In particular, the present work aims at showing that, at national level, native and local wools, beyond being more widely employed in the textile furnishing (for instance, carpets production) or green building sectors, could be also used in the higher added value sector of clothing and fashion.

In order to achieve this purpose, a basic qualitative characterization of wool from different Italian native sheep breeds has been carried out, and the results obtained from the study of the industrial processing of the Sardinian wool, the most significant coarse wools in terms of potential available amounts of raw material, are discussed. Furthermore, textile processing woolling techniques have been set up and tested on Sardinian sheep breed in Tuscany.

2. Material and Methods

2.1. Wool Samples. Wool samples were collected from the following sheep breeds.

- (1) The Sardinian sheep, an autochthonous dual-purpose sheep (milk and meat) breed of Sardinia Island (more of 3 million ewes). Wool production is approximately 1,3–1,5 kg per capita. Sardinian sheep is also raised in other Italian regions, such as Tuscany.
- (2) The Arbus black sheep, a small-sized animal. About 1.000 ewes are located in the Medio-Campidano district (Sardinia). The ancestral traits suggest that the population escaped the selection process that was mainly oriented toward milk yield and the white color of the fleece, for which the predominant white strain of Sardinian sheep was established [13].
- (3) The Vissana sheep, a white medium-small sized autochthonous sheep breed coming from Visso in Mount Sibillini (Marche) and belongs to the Apennine group. It is reared in the central Umbrian Apennine, in Marche, Latium, and some areas of southern Tuscany (<http://eng.agraria.org/>). The production attitudes are meat, milk, and wool.
- (4) The Amiata sheep or “sheep from Crete Senesi and the Amiata Mountain”. It derives from the Vissana sheep widely diffused in the central and southern Tuscany since the first half of the XIX century. It is a large-sized animal showing triple production attitudes: meat, milk, and wool. Most of the studied population is white.
- (5) The Appennine sheep, a medium-large sized animal from Central Italian Apennine. It is a rustic breed, able to exploit forage available resources, even in disadvantaged areas of the Centre-South Italian Apennine.

- (6) The Bergamasca sheep, a large-sized animal mainly selected for meat production. It is an Alpine breed that is not only mainly spread in the area around Bergamo (Lombardy) but, nowadays, also diffused in other Italian areas.
- (7) The Biellese sheep, mainly selected for meat production, even if it has also a good wool and milk production. The wool quality is adapted for bedding and carpet manufacturing. It is similar to the Bergamasca sheep and is diffused in the region of Piedmont.
- (8) The Gentile di Puglia sheep (or Apulian Merinos), mainly selected, in the past, for wool production, even if nowadays it is used for meat production. It is mainly spread in the Apulia, Calabria, and Basilicata regions. It is a Merinos sheep crossbred from local and Spanish Merinos sheep breeds.
- (9) The Altamura sheep (or Murge sheep), bred mainly for milk production (in the past it was used also for meat and wool productions). It comes from Altamura in the province of Bari (Apulia).
- (10) The Massese sheep (or Formese sheep) bred mainly for milk production. It is a native sheep breed coming from Massa (Tuscany). Nowadays, it is diffused in Tuscany and Liguria regions. Its fleece is dark and cannot be dyed. This could result in a benefit for the textile production of natural colored wools.
- (11) The white Garfagnina sheep. It probably derives from the Appennine strain. It shows triple production attitudes: meat, milk, and wool. It is typical of the Garfagnana area in the province of Lucca (Tuscany), even though it was spread in different areas of Tuscany and Emilia Romagna.
- (12) The Villnoesser Schaf (or Fiemmese or Tingola) sheep, a crossbreed between Bergamasca sheep and Padovananer Seidenschaf, that is spread in the Dolomiti Valleys and the Trentino province. Some sheep breeders are working in order to exploit wool and produce traditional clothing.
- (13) The Zerasca sheep. It derives from an Apennine strain that has been isolated for a long time in the Zeri area in Lunigiana (Tuscany) and in the areas close to Liguria. After the II World War, it has been crossed with other local breeds, such as the Massese.

2.2. Wool Fibers Fineness and Wool Fibers Length Measurements. Wool fibers fineness measurements were performed according to UNI 5423-64 rules. A subsample of carded and combed fibers weighing between 1,2 and 1,5 g was placed in parallel according to length classes with an aligned extreme (comb sorter system). Groups of fibers were extracted according to classes of length expressed in millimeters. Every group of fibers was weighed in order to obtain a distribution based on weight. Length measurements were reported as mean and maximum values, together with standard deviation.



FIGURE 1: Dyed Sardinian wool flecks.



FIGURE 2: Dyed Sardinian wool cones.

2.3. Wool Processing Procedures. 50 kg of scoured Sardinian wool (bred in Tuscany) was spun by woolen ring through the standard carding cycle.

100 kg of scoured Sardinian wool (bred in Tuscany) was carded by the combed cycle, and a card sliver with parallel fibers was obtained. After some spinning test, the wool sliver was then cut every 5 cm so as to remove >10 cm fibers that emerged from the web divider during the production of roving to be spun on the woolen ring. The material obtained was carded again.

A small amount of combed carded wool was processed into roving without being cut. The uncut roving was combed, and >10 cm fibers (almost 40%) were discarded. The obtained combed roving was spun by using a hollow spindle spinning machine suited for processing high titred fancy yarns directed to the interior decoration sector.

In order to obtain the final fabrics, the yarn underwent the following steps: weaving; bleaching (this step is particularly important for light colors dyeing); calendaring; dyeing procedures. With regard to the latter, wools were dyed as flock (Figure 1), yarn cones (Figure 2), and fabric (“inflow” procedure, Figure 3).

Both 5.6 Nm titred yarn (100% wool) and 8,5 Nm titred yarn (70% wool and 30% nylon) were dyed. Synthetic dyes satisfying the GOTS specifications (the mark regarding textile commodities produced by organic material) were used following spring-summer 2102 color trends. Natural dyes were applied only on flock wools.

TABLE 1: Morphological characteristics of wool fibers of some Italian native sheep breeds.

Sheep breed	Mean diameter (μm)	CV%	Average length fibers (mm)	CV%
Sardinian sheep (Tuscany region)	18.9	143.5	109.7	25.0
Sardinian sheep (Sardinia region)	41.0	39.1	125.2	68.4
Tingola (or Fiemmese)	39.7	99.2	96.3	18.8
Bergamasca	39.0	117.9	88.0	50.2
Arbus black sheep	35.7	42.8	125.7	72.5
Zerasca	34.7	179.8	63.9	19.1
Brianzola	34.2	122.0	58.5	18.8
Vissana	32.7	108.5	35.8	17.8
Apennine	30.6	131.3	56.1	20.3
Amiata	30.4	125.7	41.4	20.1
Gentile di Puglia	26.7	133.4	40.0	21.2
Biellese	25.5	231.4	92.1	24.0
Altamura or Murge	26.7	158.6	65.2	20.8
Massese nera	22.6	184.2	43.4	16.9
Garfagnina Bianca	18.1	116.2	85.5	25.9



FIGURE 3: “Inflow” dyeing procedure for fabric dyeing.



FIGURE 5: Wool fabrics obtained from white Sardinian sheep wool.



FIGURE 4: Scoured white Sardinian wool.



FIGURE 6: Tailoring phase.

3. Results and Discussion

3.1. Native Wool Characterization. Table 1 reports standard parameters (mean diameter and length) of wool fibres quality of some Italian native sheep breeds. The few available

wool samples collected did not allow statistical elaborations. Among all the analysed wools, Sardinian wool showed the highest mean diameter, representing the maximum extreme of this wool range where the Garfagnina Bianca resulted in the lowest.

Nevertheless, values of wool fibres diameters from the Sardinian sheep grown in Tuscany showed a very high variability and seemed to be much thinner than those from



FIGURE 7: Jacket for woman (a) and gilet for man (b) made by fabrics produced with Sardinian wool.



FIGURE 8: Jackets (a) and gilet (b) for man made by fabrics produced with Sardinian wool.

native Sardinian. Moreover, values of length of Sardinian wool fibres tended to be higher than those detected in other wools. As length negatively affected the processing phase, only the wool from Sardinian white sheep (from Tuscany region) was tested for yarn production.

3.2. Implementation of Textile Industrial Processing Method for Coarse Wools. The wool derived from Sardinian sheep breed forms the highest amount of local wool produced in Italy by sheep breed, compared to other local and native wools. Because of that, the object of the study has been the textile industrial processing of this type of wool. Research on methods for improving the Sardinian wool processing—its most critical being the spinning phase—can help understand the technical problems that can be common to other coarse wools.

One of the major problems faced in this study was represented by kemp fibers, as nowadays, in the Italian textile manufacturing industry, no technical device is available to remove them.

Kemp fibers, either as long or short fibers, are very coarse and can be found in large amounts in Sardinian wools. During spinning, they are hard to be aligned together with the other fibers, thus resulting in an unpleasant stinging sensation when touching threads and fabrics. Furthermore, kemp fibers are difficult to dye, thus causing inhomogeneous colors as results of the dyeing phase.

In this study, ca. 150 kg of Sardinian wool (Figure 4) was used, and 250 m of carded fabric weighing between 300 and 350 g/m² was produced (Figure 5).

These fabrics were made with different weave patterns. They were used in the manufacturing of garments, such as



FIGURE 9: Weaving phase.



FIGURE 10: Ink jet printing applied on wool fabrics.

clothing for men and women that passed tailoring (Figure 6) and wearing testing, after being worn in winter time (Figures 7 and 8).

3.3. Yarn Obtained through Woollen Cycle. The yarn obtained through woollen cycle resulted in a coarse irregular, quite furry, shaggy yarn, and 3.5–3.7 Nm titred, thus, not suitable to obtain fabrics to be employed in the clothing garments industry. One of the causes for yarn irregularity was the inhomogeneous fiber length ranging from 2-3 cm to 15 cm, and resulting hard to process through the post carder divider and, afterwards, the spinning phase.

3.4. Yarn Obtained through a Mixed Cycle (Combing Cycle + Woollen Cycle). Yarn obtained through a mixed cycle (combing cycle + woollen cycle) resulted as being very regular, little furry yarns, 5.6 Nm titred (100% wool) yarn.

8.5 Nm titred yarn was also obtained using 70% wool and 30% nylon.

Combing roving using a hollow spindle spinning machine produced high titred fancy yarns to be possibly employed in the interior decoration sector.

Part of the yarn was bleached and depigmented. After several tests, high quality standard yarns were obtained.

Following the weaving phase (Figure 9), the carded fabrics underwent carbonization in order to remove almost all vegetal residues (they could not be completely removed from the fleece).

Dyes applied on fabrics not always showed pleasant results due to the high frequency of black hair. Furthermore, in order to dye with light colors, these fabrics needed to be bleached to take off the yellowish colored background. Calendering was applied to evaluate the level of “smoothing of rather rough textile surfaces.” Such good levels have been also demonstrated by the good results obtained by ink jet printing such fabrics (Figure 10).

4. Conclusions

The achievement of 5.6 Nm titred (100% wool) and 8.5 Nm titred (70% wool and 30% nylon) yarns obtained from applying a mixed cycle processing procedure on coarse wools, such as those derived from the Sardinian sheep breed, opens new horizons towards the use of this type of wool.

All the dyeing, printing, weaving, and finishing tests confirmed that yarns and fabrics produced with coarse wools can undergo the same textile processing phases as those applied to wools commonly used in the clothing-fashion sector.

The tests, developed at laboratory and industrial scale, have shown that, from a technical point of view, wools from native sheep breeds can be employed for several textile productive purposes including those regarding the textile furniture sector and also the clothing-fashion industry ones.

Therefore, in order to further improve the results obtained, coarse wools and native sheep breeds deserve more attention and investment on behalf of the textile industries as well as of the textile and animal production research.

If this will be accomplished, coarse wools will be no more neglected—being, nowadays, considered almost as a waste material—and will rise to be properly acknowledged and defined as feedstock of interest of the manufacturing industry.

Conflict of Interests

The authors declare that they have no conflict of interests with regard to the paper.

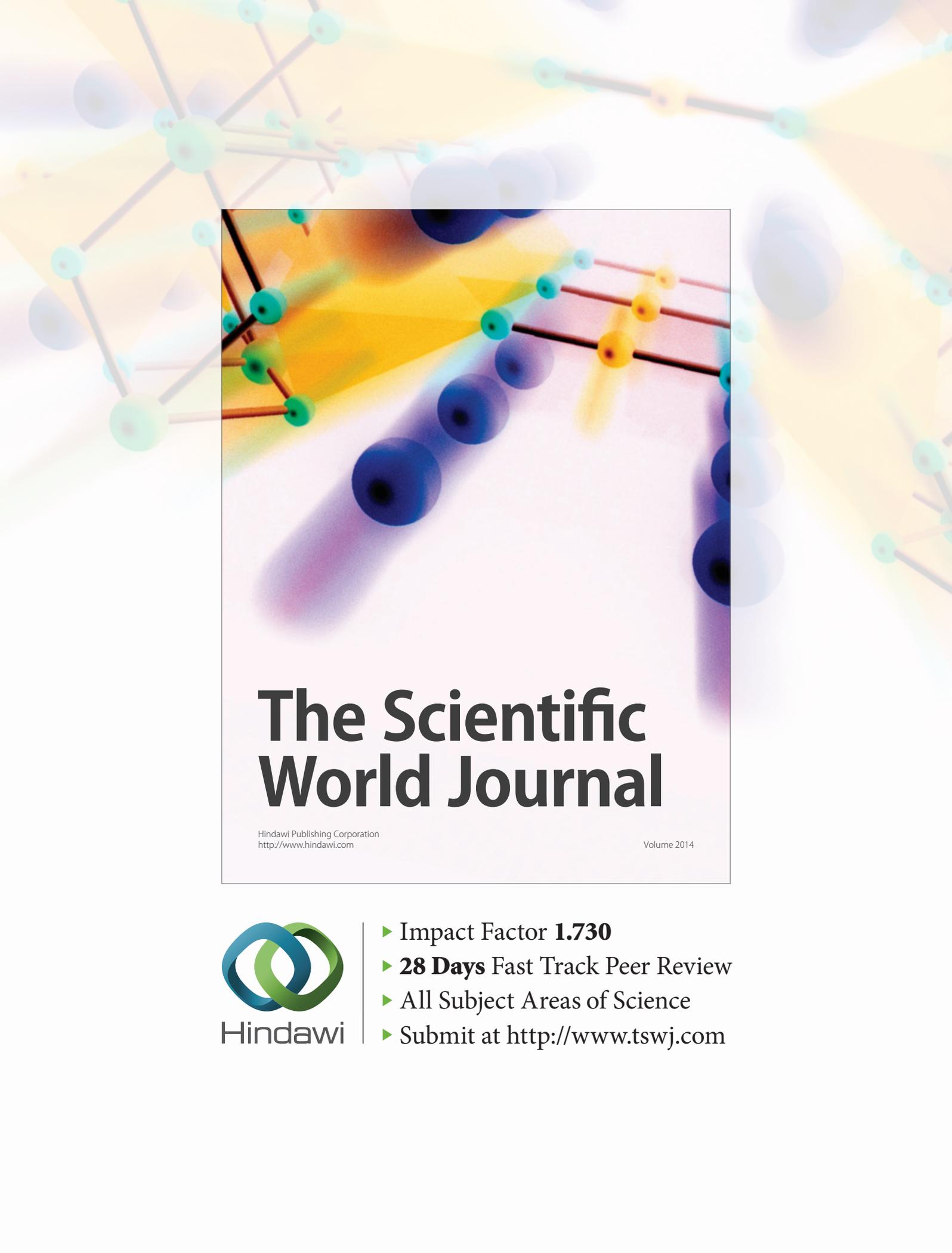
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